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Accounting Information System

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Highlights

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A Combination of Data Augmentation Techniques for Mango Leaf Diseases Classification

By Demba Faye, Idy Diop, Nalla Mbaye & Doudou Dione
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Abstract- Mango is one of the most traded fruits in the world. Therefore, mango production suffers from several pests and diseases which reduce the production and quality of mangoes and their price in the local and international markets. Several solutions for automatic diagnosis of these pests and diseases have been proposed by researchers in the last decade. These solutions are based on Machine Learning (ML) and Deep Learning (DL) algorithms. In recent years, Convolutional Neural Networks (CNNs) have achieved impressive results in image classification and are considered as the leading methods for image classification. However, one of the most significant issues facing mango pests and diseases classification solutions is the lack of availability of large and labeled datasets. Data augmentation is one of solutions that has been successfully reported in the literature. This paper deals with data augmentation techniques namely blur, contrast, flip, noise, zoom and affine transformation to know, on the one hand, the impact of each technique on the performance of a ResNet50 CNN using an initial small dataset, on the other hand, the combination between them which gives the best performance to the DL network. Results show that the best combination classifying mango leaf diseases is 'Contrast & Flip & Affine transformation' which gives to the model a training accuracy of 98.54% and testing accuracy of 97.80% with an f1_score > 0.9.

Keywords: data augmentation, mango, disease, classification, deep learning, resnet50.

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A Combination of Data Augmentation Techniques for Mango Leaf Diseases Classification

Demba Faye [α], Idy Diop [σ], Nalla Mbaye [ρ] & Doudou Dione [ω]

Abstract- Mango is one of the most traded fruits in the world. Therefore, mango production suffers from several pests and diseases which reduce the production and quality of mangoes and their price in the local and international markets. Several solutions for automatic diagnosis of these pests and diseases have been proposed by researchers in the last decade. These solutions are based on Machine Learning (ML) and Deep Learning (DL) algorithms. In recent years, Convolutional Neural Networks (CNNs) have achieved impressive results in image classification and are considered as the leading methods for image classification. However, one of the most significant issues facing mango pests and diseases classification solutions is the lack of availability of large and labeled datasets. Data augmentation is one of solutions that has been successfully reported in the literature. This paper deals with data augmentation techniques namely blur, contrast, flip, noise, zoom and affine transformation to know, on the one hand, the impact of each technique on the performance of a ResNet50 CNN using an initial small dataset, on the other hand, the combination between them which gives the best performance to the DL network. Results show that the best combination classifying mango leaf diseases is 'Contrast & Flip & Affine transformation' which gives to the model a training accuracy of 98.54% and testing accuracy of 97.80% with an f1_score > 0.9.

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I. INTRODUCTION

Mango or Magnifera Indica L. (scientific name) is a lucrative fruit widely cultivated in tropical countries. It belongs to the family anacardiaceous. Its overall consumption in 2017 was estimated at 50.65 million metric tons [1]. This fruit was in 2021, in terms of quantities exported, the third most traded tropical fruit after pineapple and avocado [2]. Mango fruit is very appreciated because of its richness in nutrients (vitamins A, B, C, K, ...), flavorful pulp and alluring aroma [3,4]. This fruit contributes enormous economic benefits to exporting countries and mango growers.

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However, mango production suffers severely from pests and diseases witch lead to a reduction of both quality and quantity. This influence mango price in the international market.

In the last decade, several solutions for automatic diagnosis of these pests and diseases have been proposed by researchers. These solutions are first based on image processing (IP) and machine learning (ML) techniques and finally, in the last five years, on deep learning (DL) algorithms DL based solutions have achieved state-of-the-art performance on Image Net and other benchmark datasets [5]. In recent years, Convolutional Neural Networks (CNNs) have achieved impressive results in image classification and are considered as the leading methods for object detection in computer vision [5,6].

However, one of the biggest issues facing mango pests and diseases identification solutions is the lack of availability of large and labeled datasets [7,8,9,10]. The limited training data inhibits performance of DL based models which need big data on which to train well to avoid overfitting and improves the model's generalization ability. Overfitting happens when the training accuracy is higher than the accuracy on the validation/test set. The generalizability of a model is the difference in performance it exhibits when evaluated on training data (known data) versus test data (unknown data). The use of data augmentation process is one of solutions that has been successfully reported in the literature [1]. This overfitting solution generates a more comprehensive set that minimizes the distance between training and validation sets.

A data augmentation process based on image manipulation is presented in this paper for improving the quality of a small dataset of mango leaves presented in [1]. The specific contributions of the paper include:

- Generate a dataset for every data augmentation strategy except affine transformation. The DL model is trained in each generated dataset to know the impact of each data augmentation technique in the performance of the model.
- Generate multiple datasets from pair wise sequential combination of data augmentation techniques, namely blur, contrast, flip, noise and

zoom. This is to know the combinations which give the best performance to the DL model.
- Apply affine transformation technique to the previous best combinations to determine the final combination which is better to classify diseased mango leaves.

The rest of the paper is organized as follows: Section 2 is an overview of the literature review, Section 3 deals with the data acquisition and data augmentation techniques and the CNN model used, Section 4 presents and discusses the results of the data augmentation techniques. The last section concludes the paper and announces the futures works of the authors.

II. Ralated Works

The literature review presented in this paper concerns only data augmentation strategies used for ango pest or diseases classification and mango or other fruits quality grading.

Shorten et al. [11] presented a survey dealing with image data augmentation algorithms such as color space augmentations, geometric transformations, mixing images, kernel filters, random erasing, adversarial training, feature space augmentation, generative adversarial networks (GAN), meta-learning and neural style transfer. They also discussed the application of augmentation methods based on GANs and others characteristics of data augmentation such as curriculum learning, test-time augmentation, resolution impact, and final dataset size. Dandavate et al. [12] applied data augmentation techniques namely rotation, scaling and image translation to a fruit dataset to avoid overfitting and obtain better performances with their simple CNN model. Agastya et al. [13] used VGG-16 and VGG-19 for an automatic batik classification. Applying random rotation in a certain degree, scaling and shearing, they improve the accuracy of their models up to 10%. Bargoti et al. [14] presented a fruit (mangoes, apples, and almonds) detection system using Faster R-CNN. They used image flipping and scaling to improve the performance of their model with an F1-score of $>$ 0,9 achieved for mangoes and apples. Wu et al. [15] investigated several deep learning-based methods for mango quality grading. VGG-16 is found to be the best model for this task. During the training of their models, authors applied, at each epoch, randomly data augmentation strategies such as horizontal or vertical image flipping, rotation, brightness, contrast and zoom in/out. Zang et al. [16] developed a fruit category identification by using a 13-layer CNN and three data augmentation strategies namely noise injection, image rotation and Gamma correction. The final obtained overall accuracy is 94.94%, at least 5 percentage points higher than state-of-the-art approaches. Supekar et al. [17] performed a mango grading system based on ripeness, size, shape and defects. They used K-means clustering for defect segmentation and Random Forest Classifiers. To avoid overfitting with an initial training dataset of 69 images, authors applied image rotation on angle of 90,180 and 270. The final training dataset obtained consists of 522 images which allows their model to obtain an overall accuracy of 88,88%.

III. Methodology and Model

a) Data aquisition

The dataset used in this paper is a part of 'MangoLeafBD' dataset produced by Ahmed et al. [18] and downloadable from 'Mendeley Data'' platform (https://data.mendeley.com/datasets/hxsnvwty3r).

MangoLeafBD dataset contains height classes, seven of which correspond to mango leaf diseases and one contains healthy leaves.

In this paper, four diseases namely anthracnose, Gall Midge, Powdery Mildew and Sooty Mold are treated as they are among the most mango leaf diseases treated by researchers during the last five years [19] (Fig.1andFig.2). The dataset used contains four classes corresponding respectively to these diseases and a class of healthy leaves. There are 500 RGB leaf images of 240x320 pixels in each class making a total of 2,500. Images are in JPG format.

b) Data augmentation

Data augmentation is a powerful solution against overfitting. It allows a model with a small dataset to become robust and generalizable. There are two categories of data augmentation: the first is based on image manipulations and the second on DL (generative adversarial networks (GANs), feature space augmentations, adversarial training, Neural Style Transfer, Meta Learning Data Augmentation) [11].

This research focuses on the first category because i) the second is generally used to generate synthetics images from quite a large dataset, ii) mango leaf images taken under real-world conditions suffer mainly from the problems of temperature variation, shadowing, overlapping of leaves, and presence of multiple objects. The first category can allow us to generate images in these cases.

This papers deals with following techniques:

- Noise injection

Image noise is a random disturbance in the brightness and color of an image. Noise injection is an effective way to avoid overfitting and improves the test ability of a machine learning model [13]. There are several ways to add noise to an image (e.g. Gaussian noise, Salt and Pepper noise, Speckle noise, …). Gaussian noise is performed fixing mean parameter to 0 and sigma parameter to 0.05.

- Blur

Blurring an image means make it less sharp. Photographic blur occurs with movement in the model

or scene relative to the camera, and vice versa. To realize this, Gaussian blur was carried out using a kernel size (5,15).

- Contrast and Brightness

The Contrast and Brightness function improves the appearance of an image. Brightness improves the overall clarity of the image and contrast adjusts the difference between the darkest and lightest colors. Contrast parameters used are {0.5;2;2.5} and brightness parameters are {1;4;5}. For each original image, three new images are generated with respectively the following parameters contracts, brightness {c; b}: {0.5; 1}, {2; 4}, {2.5; 5}.

- Zoom

Zooming an image means enlarging it in a sense that the details in the picture became more visible and clear. Each image is zoomed three times and from the center using zoom parameters {3;5;7}.

- Image flipping

To flip or mirror an image means to turn it horizontally (horizontal flip) or vertically (vertical flip). Flip function generates an image so that the left side becomes the right side or the top becomes the bottom. The images are vertically and horizontally flipped using flip parameter 0 and 1 respectively.

- Affine transformation

An affine transformation is, in general a combination of translations, rotations, shears and dilations [12]. It s used to simulate images captured from different camera projections nd positions. Affine transformation is performed using an input matrix (In) of size 2x3 and an output matrix (Out) of the same size. The input matrix corresponds to three points in the input image and the second matrix is their corresponding locations in the output image. In the training dataset, twenty additional images are randomly generated for each image. But after that, the generated images on which there is no part of mango leaf are removed.

Fig.3 shows an example of a diseased mango leaf (anthracnose) on which all these data augmentation techniques are applied.

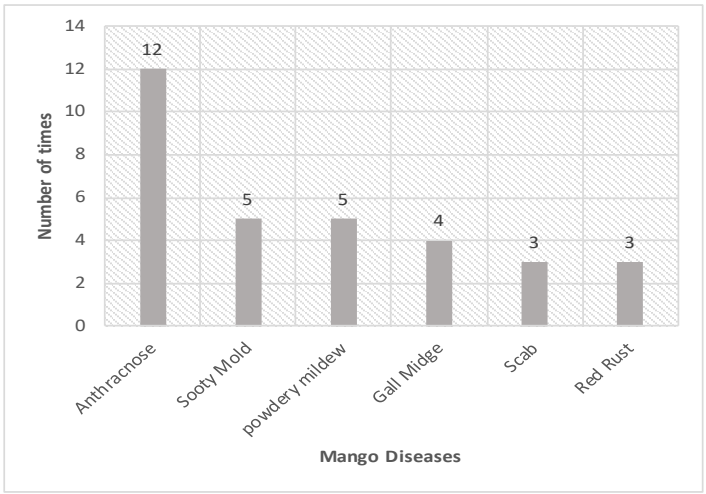


Fig. 1: Ranking of the most common and treated mango diseases [19]

Fig. 2: Dataset image composition

The data augmentation process (Fig. 4) is carried out as follow:

First step: For each of the above mentioned data augmentation strategies (except affine transformation), a new dataset for training and validation is generated (Fig. 3, Table 2). Images of the original dataset are added to the generated one. This is to know the impact of each data augmentation strategy on the overall performance of the model.

Second step: Every strategy (except affine transformation) is combined respectively by the 4 others sequentially to generate new datasets (Table 2).

Final step: Affine transformation is applied to the best combination that gives the best performance to the DL model (Table 3).

The augmentation techniques are carried out using python Open Source Computer Vision Library (OpenCV).

Table 1: Composition of the datasets in the first step

	Original	Original & Blur	Original & Contrast	Original & Flip	Original & Noise	Original & Zoom
Train	1600	3200	6400	4800	3200	6400
Validation	400	800	1600	1200	800	1600
Test	500	500	500	500	500	500
Total	**2500**	**4500**	**8500**	**6500**	**4500**	**8500**

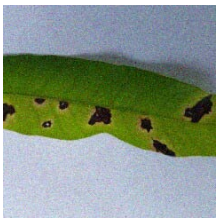
Table 2: Composition of the datasets in the second step

	Blur & Contrast	Blur & Flip	Blur & Noise	Blur & Zoom	Contrast & Flip	Contrast & Noise	Contrast & Zoom	Flip & Noise	Flip & Zoom	Noise & Zoom
Train	8000	6400	4800	8000	9600	8000	11200	6400	9600	8000
Validation	2000	1600	1200	2 000	2400	2000	2800	1600	2400	2000
Test	500	500	500	500	500	500	500	500	500	500
Total	**10500**	**8500**	**6500**	**10500**	**12500**	**10500**	**14500**	**8500**	**12500**	**10500**

Original image

Noised image

(mean: 0.1, std: 0.5)



Blurred image

(std: 0.5, kernel: (5,15))

Contrast; {c,b} = {2, 4}

Zoomed image (param: 5)

Vertical flipped image

Horizontal flipped image

Affine Transformation In; Out = [50,70; 230,50; 50,220] ; [50,70; 230,50; 50,220]

Fig. 3: An example of generated images

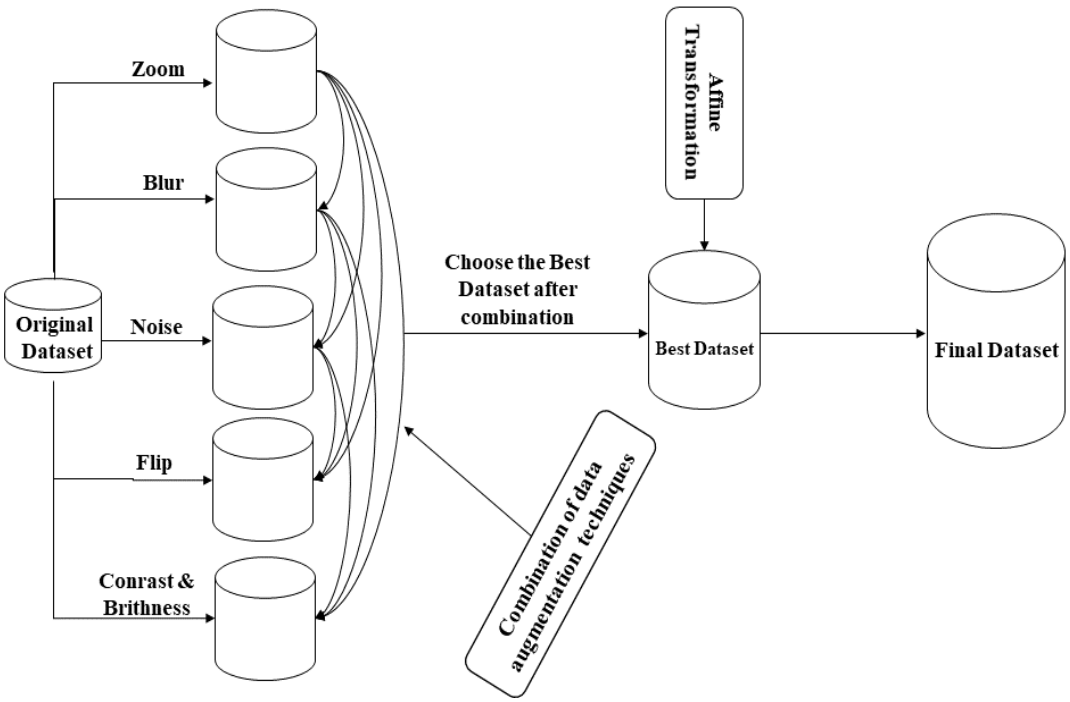


Fig. 4: Workflow of the data augmentation task

c) CNN model

Use Residual neural network (ResNet) is proposed in 2015, by He et al. [20]. ResNet won the first place at the ImageNet Large Scale Visual Recognition Challenge (ILSVRC 2015). To preserve knowledge, reduce losses and boost performance during the training phase, ResNet introduced residual connections between layers. A residual connection in a layer means that the output of a layer is convolution of its input plus its input [21]. ReNet50 is used in this research. It consists of 50 layers as it is shown by the Fig. 5.

The model is updated by replacing the number (1000) of nodes of the softmax output layer by 5 (corresponding to the number of treated mango leaf diseases).

d) Implementation details

The data augmentation process and ResNet50 model are all carried out using respectively, OpenCV and Keras labreries. Model's training parameters used include Adam optimizer with a learning rate of 0.001, binary cross-entropy (loss function) and epochs of 8. The model is trained on a server with an NVIDIA GPU and 32 GB of RAM.

IV. Result and Discussion

The initial small dataset is splitted as follow: 64% for training, 16% for validation and 20% for testing. After randomly splitting the dataset, we have 1,600 images for training, 400 images for validation and 500 images for testing. Results sho that the training accuracy (87.18%) is greater than the testing accuracy (39.34%). So the model overfitted as it is shown by the Fig. 6.

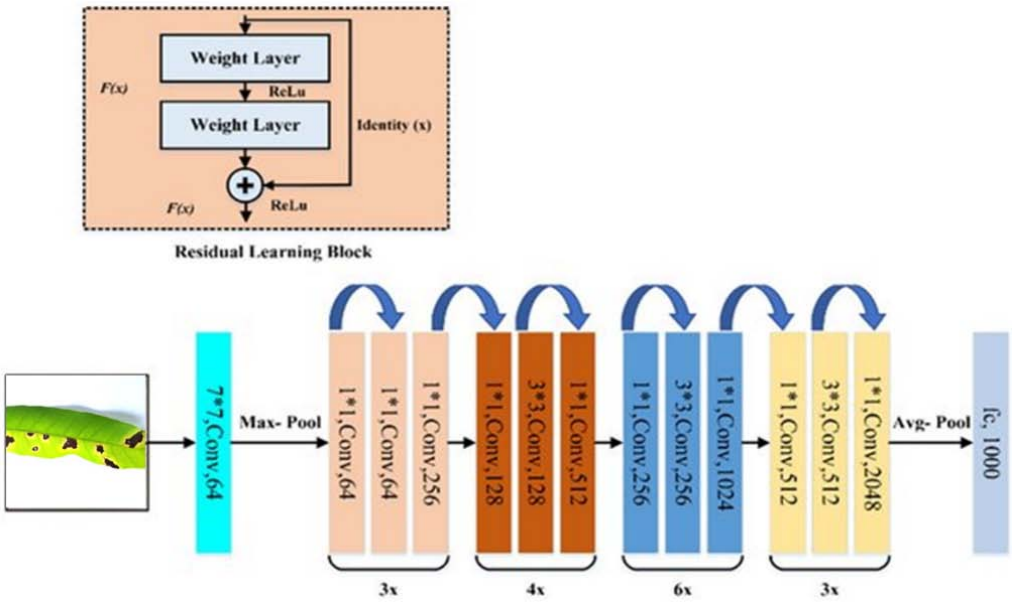


Fig. 5: The architecture of ResNet50 [21]

Since the dataset is not enough to train robustly the DL model, data augmentation process is carried out. This ask concerns only training and validation data [22]. Test data remains equal to 500 images.

In the first step, after training phase, results show that the DL model overfits on all datasets except 'Original & Contrast' which gives a training and testing accuracy of 90.56% and 86.23% respectively (Table 3, Fig. 7).

In the second step, training the model on the combined datasets yielded the results in Table 4. The model is not overfitted on the 'Contrast & Flip' (training: 95.29%; testing: 91.39%) and 'Flip_Zoom' (training: 93.15%; testing: 90.59) datasets. These two datasets are the best ones in the second step since they give best results to the DL model.

Finally, affine transformation strategy is applied to 'Contrast & Flip' and 'Flip_Zoom' datasets. Results show that 'Contrast & Flip' gives the best performances with an accuracy of 97.80% and a f1_score> 0.9 (Table 5, Fig. 8, Fig. 9).

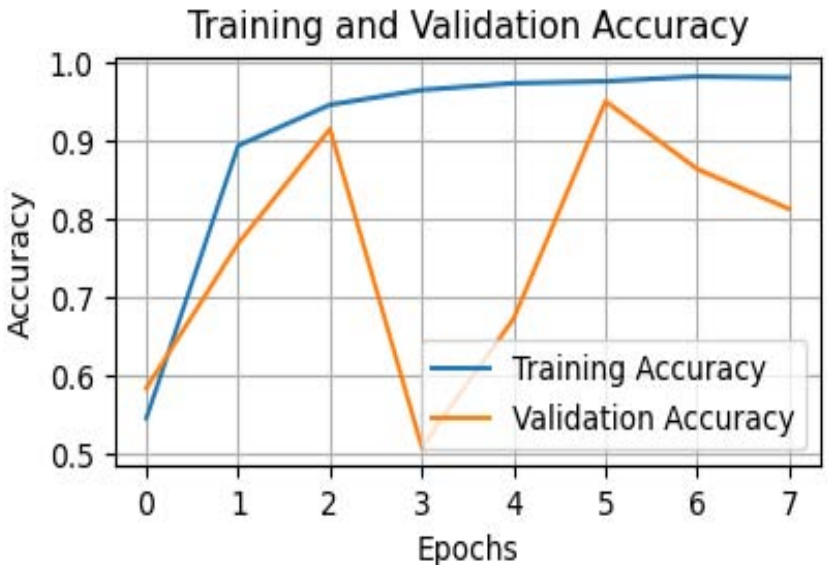


Fig. 6: Training result of the original dataset

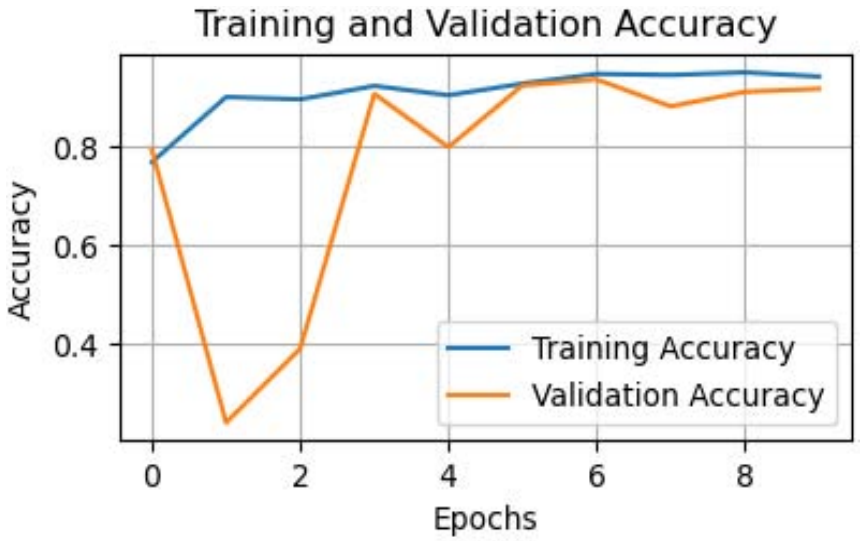


Fig. 7: Training result of the dataset 'Original & Contrast'

Following the results presented previously, in the first step, the model overfitted in the generated datasets, except'Original and Contrast' dataset which resulted in an accuracy of 86.23%. Concerning data augmentation strategies namely blur, contrast, noise and zoom, the best cominations for classifying mango leaf diseases are 'Contrast & Flip' and 'Flip & Zoom', according to the results in the second step. These two strategies yielded accuracies of 91.39% and 90.59% respectively. In the final step, applying the 'Affine Transformation' strategy to the datasets generated by these two strategies revealed that the best combination for mango leaf diseases classification is 'Contrast & Flip & Affine Transformation' since it yielded an accuracy of 97.80%.

Table 3: Results of the first step

	Original & Blur	Original & Contrast	Original & Flip	Original & Noise	Original & Zoom
Training Accuracy (%)	98.25	**90.56**	95.35	76.36	92.76
Testing Accuracy (%)	84.21	**86.23**	80.60	34.84	84.80
Result	overfitting	**ok**	overfitting	overfitting	overfitting

Table 4: Results of the second step

	Blur & Contrast	Blur & Flip	Blur & Noise	Blur & Zoom	Contrast & Flip	Contrast & Noise	Contrast & Zoom	Flip & Noise	Flip & Zoom	Noise & Zoom
Training Accuracy (%)	87.28	94.14	78.29	92.08	**95.29**	84.25	88.71	78.80	**93.15**	82.48
Testing Accuracy (%)	65.45	85.30	63.32	65.82	**91.39**	31.74	58.23	645.85	**90.59**	78.47
Result	overfitting	overfitting	overfitting	overfitting	**ok**	overfitting	overfitting	overfitting	**ok**	overfitting

Table 5: Results of the final step

	Original & Blur	Original & Contrast
Training dataset	50 056	51 315
Validation dataset	12 514	12 828
Test dataset	500	500
Total	63 070	64 643
Training Accuracy (%)	**98.54**	97.44
Testing Accuracy (%)	**97.80**	93.98

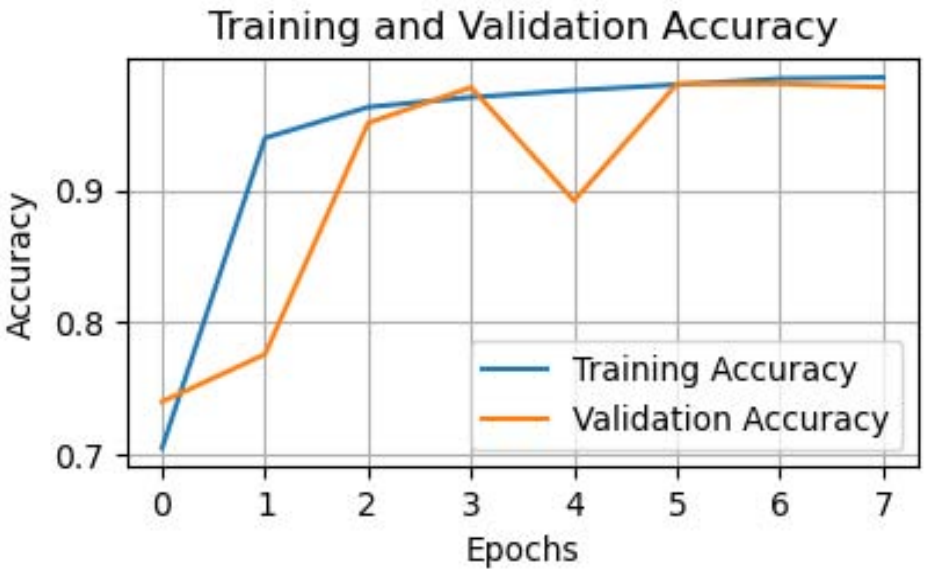


Fig. 8: Training result of the 'Contrast & Flip & Affine Transformation' dataset

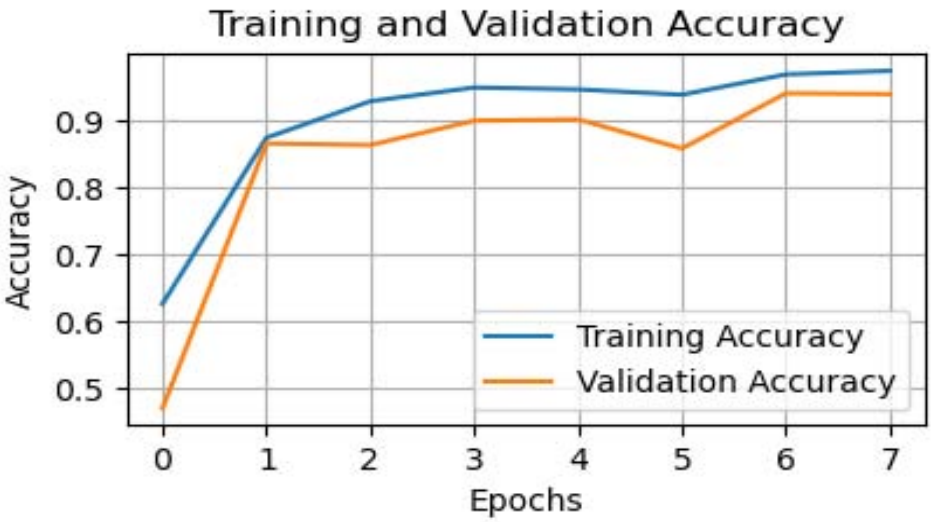


Fig. 9: Training result of the 'Flip & Zoom & Affine Transformation' dataset

V. Conclusion and Future Works

This paper presented three contributions. The first allowed us to know the impact of data augmentation techniques namely blur, contrast, flip, noise and zoom in mango leaf diseases classification. The second is to know the best combinations between these techniques which give the best performance to the deep learning model. The last one reveals that applying 'affine transformation' technique to the combination 'Contrast & Flip' gives the best performance to the Resnet50 CNN with an accuracy of 97.80%.

This solution can be used to improve the performance of DL models for image classification with small datasets.

Our future work, is to propose a dataset of mango leaf diseases with images captured in mango orchards of a sahelian country like Senegal. Applying

this combination as a data augmentation technique to this dataset will allow us to achieve excellent results in mango leaf disease classification using a deep learning model such as ResNet50. Then, this model will be deployed in mobile and web applications to allow mango growers to diagnose diseases in their crops without expert intervention.

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Emotion Detection in Arabic Text using Machine Learning Methods

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Abstract- Emotions are essential to any or all languages and are notoriously challenging to grasp. While numerous studies discussing the recognition of emotion in English, Arabic emotion recognition research remains in its early stages. The textual data with embedded emotions has increased considerably with the Internet and social networking platforms. This study aims to tackle the challenging problem of emotion detection in Arabic text. Recent studies found that dialect diversity and morpho- logical complexity in the Arabic language, with the limited access of annotated training datasets for Arabic emotions, pose the foremost significant challenges to Arabic emotion detection. Social media is becoming a more popular kind of communication where users can share their thoughts and express emotions like joy, sadness, anger, surprise, hate, fear, so on some range of subjects in ways they'd not typically neutralize person. Social media also present different challenges which include spelling mistakes, new slang, and incorrect use of grammar. The previous few years have seen a giant increase in interest in text emotion detection. The study of Arabic emotions might be a results of the Arab world's considerable influence on global politics and thus the economy. There are numerous uses for the automated recognition of emotions within the textual content on Facebook and Twitter, including company development, program design, content generation, and emergency response. in line with recent studies, it's possible to identify emotions in English-language information.

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I. Introduction

Currently, social media plays a necessary role in way of life and practice. immeasurable individuals use social media for various purposes. Every second, a major amount of knowledge flow via online networks, containing valuable information that may be extracted if the information are correctly processed and analyzed[8]. Social networking media became essential for expressing emotions to the planet due to the fast growth of the web. Several individuals use textual content, audio, video, and images to express their emotions or perceptions[9]. The Affective Computing research field has been an energetic research domain and recently gained great popularity. It aims at providing machines with a human-like ability to grasp and answer human emotions, with more natural interaction between humans and machines[10]. Emotions are a vital component of human life. Emotions affect human decision- making and can enable us to speak with the planet in a very better way. Emotion detection, also called emotion recognition, identifies an individual's feelings or emotions, for instance, joy, sadness, or fury [9]. "Emotion detection," "emotion analysis," and "emotion identification" are all expressions that are periodically used interchangeably. The sentiment analysis could be a means of evaluating if data is negative, positive, or neutral. In contrast, emotion recognition specifies different human emotion types, like joy, love, sadness, happiness, anger, and surprise[9]. quite 400 million people speak Arabic, the official language of twenty-two countries. It is the Internet's fourth most generally used language [10]. Languages utilized in social media, such as Twitter, differ wildly from that utilized on other platforms, like Wikipedia. The English language has been highly determined within the emotion detection field, including datasets and dictionary availability, in contrast to the Arabic, which has minimal resources[11]. Emotion analysis has different applications in every aspect of our existence, including making efficient e-learning frameworks in step with the emotion of scholars, enhancing human-computer interactions, observing the mental state of people, enhancing business strategies supported customer emotions, analyzing public feelings on any national, international, or the political event, identifying potential criminals by analyzing the emotions of individuals after an attack or crime, and improving the

performance of chatbots and other automatic feedback frameworks[4]. In Additionally, text emotion analysis has been a promising research topic. Analyzing the texts and identifying emotion from the words and semantics could be a difficult challenge. The paper aims to automatic recognition of emotions in texts written in the Arabic language by employing a model for Emotion Classification (EC) into emotion classes: Sadness, joy, fear, and anger with the algorithms of machine learning. This approach utilized the SemEval- 2018 Task1 reference dataset and focused on four emotion classes (Joy, Sad, Angry, and fear). Five forms of algorithms are used supported the machine learning approach, namely K-Nearest Neighbor (KNN), Decision Tree (DT), Support Vector Machine (SVM), Naive Bayes (NB), and Multinomial (NB). KNN, DT, SVM, NB, and Multinomial NB classifiers are utilized in the classification process since they offer the foremost satisfactory and better accuracy results among all other classifiers. The findings showed that the choice Tree and K-Nearest Neighbor classifiers have the best accomplishment regarding accuracy, 0.74, While the NB and Multinomial NB classifiers acquired 0.69, and also the SVM obtained 0.63. The structure of this study continues to section II, which presents Problem Definition and Algorithm while section III offers the recent related work on Arabic emotion recognition. Section IV describes the Methodology and results of emotion analysis from Arabic texts and discusses the results. Section V provides the conclusion and future work.

II. Problem Definition and Algorithm

This section briefly presents the Problem Definition and Algorithm for the detection of emotion in texts written in the Arabic language.

a) Problem Definition

Most research papers in this field focus on negative or positive emotion analysis and do not go deeply into emotion analysis, especially in Arabic. Research in emotion analysis for Arabic has been minimal compared to other languages like English. This paper addresses the emotion detection problem in Arabic tweets and presents a model to categorize emotions into sadness, joy, anger, and fear. Furthermore, the current work can provide many benefits for governments, health authorities, and decision-makers to monitor people's emotions on social media content. Additionally, it can improve business strategies according to customers' emotions and recognize potential criminals when analyzing people's emotions after an attack or crime.

b) Algorithm Definition

The Machine Learning approach learns from the info and tries to hunt out the relation between a given input text and also the corresponding output emotion by building a prediction model. This approach is split into two categories:

i. *Supervised learning approach*

Based on a labeled or annotated dataset, the supervised approach takes a component of this data for the training process using an emotion classifier. This trained data is then examined, and a model is made. The remaining data within the dataset is classed supported this previously trained classifier into the emotion category.

ii. *Unsupervised learning approach*

The unsupervised approach relies on a non-labeled dataset. The approach inherent the drawbacks of the ML algorithm. It requires an oversized dataset for the training process to be accurate. The Machine Learning approach solves the emotion detection issue by categorizing texts into various emotion classifications using the mentioned algorithms. This process is usually done employing a supervised or unsupervised ML technique. To categorize the tweet into each categorization (anger, joy, sadness, and fear), we applied five different supervised machine-learning approaches: KNN, DT, SVM, NB, and NB. Following could even be an inventory of the classifiers discussed during this work:

a. *K-Nearest Neighbor (KNN)*

KNN is addition- ally a fairly AI supported machine learning algorithms in classification, processing, statistical pattern recognition, and much of more. This method in our experiment can classify an emotion correctly[15]. KNN classifies a replacement instance within the test set supported the shortest distance between it and numeric neighbors (k) stored within the training set using the Euclidian Distance equation[13].

b. *Decision Tree (DT)*

A Decision Tree could even be a mode of a tree structure utilized in classification and regression models. It breaks down the datasets into smaller subsets and incrementally develops them into nodes and leaves. The branches of the selection tree represent the category of the datasets. the selection tree is split into four emotion classes: joy, sadness, anger, and fear. The selection tree's goal is to substantiate it achieves maximum separation among classes at each level.

c. *Support Vector Machine (SVM)*

SVM could even be a supervised ML algorithm. The model is straightforward, and far of individuals value more highly to use this model thanks to its less computational power and it gives significant accuracy. SVM conducts linear classification and performs non-linear classification alright [6]. This model's idea is straightforward: The algorithm plots each data item as some extent in n-dimensional space representing the

number of features. Then, it'll use hyper-plane to differentiate between features and classes of emotion.

d. *NB*

NB includes several algorithms of classification based on the Bayes Theorem. The NB classifier presents significant results when it is used for text analyzing data. Such an algorithm offers a prospect examining the study's dataset [12].

e. *Multinomial (NB)*

Multinomial NB classifier works on the concept of term frequency, which suggests what percentage times the word occurs during an extremely document. MNB is specially designed for text data and a particular version of Naive Bayes [6]. MNB tells two facts about whether the word appears during a very document and its frequency there in document.

III. Literature Review

Although there are many studies during this domain, one amongst the tough challenges for all researchers during this domain is to use emotion analysis and classification for Arabic tweets, which remains limited, most Arabic studies specialise in sentiment analysis to classify tweets into positive/negative classes, underestimating the utilization of emotion detection and analysis to draw down different emotions. The literature review presents the foremost recent works on emotion detection in languages.

Mansy, A et al.[1] researchers proposed an ensemble deep learning approach to research Emotion from user text in Arabic Tweets. They evaluated using the SemEval-2018-Task1- dataset published in a very multilabel classification task. The proposed model was supported three deep learning models. Two models are particular styles of Recurrent Neural Networks (RNNs), the Bidirectional Gated Recurrent Unit (Bi-GRU) and Bidirectional Long Short Term Memory Model (Bi-LSTM). The third may be a pretrained model (PLM) supported Bidirectional Encoder Representations from Transformers (BERT) NAMED MARBERT. The results of the proposed ensemble model showed outperformance over the individual models (Bi- LSTM, Bi-GRU, and MARBERT). They showed an accuracy of 0.54, precision of 0.63, 0.55 in an exceedingly recall, 0.70 in Macro F1 Score, and 0.52 in micro F1 Score.

In addition, Khalil et al. [2] proposed a Bi-LSTM deep learning model for EC in tweets written in Arabic that were employed in the SemEval-2018 dataset. The Aravec with CBOW for the word embedding phase has been employed in feature extraction. Their results have shown an Accuracy of 0.498, and a Micro F1 score of 0.615.

Another study on Arabic emotion analysis was proposed in [3]. The authors addressed the emotion detection problem in Arabic tweets. A tweet may have multiple emotional states (for example, joy, love, and optimism). during this case, the emotional classification of tweets is framed as a multilabel classification problem. The proposed approach combined the transformer-based Arabic (AraBERT) model and an attention- based LSTM-BiLSTM deep model. The approach used a publicly available benchmark dataset of SemEval-2018 Task 1, where the dataset is formed for multilabel detection of emotion in these tweets. The findings show that such an approach presents accuracy of nearly 54.

A multilabel classification was employed to detect emotions in Arabic tweets by [4]. The authors proposed three models: the Deep Feature-based (DF), the Human engineered feature- based (HEF) model, and the Hybrid model of both models (HEF and DF). They assessed the execution of the proposed model on the SemEval-2018, IAEDS, and AETD datasets. For feature extraction, they used Hourglass of emotions, frequency-inverse document, Lexical sentiment features, and Lexical emotion features. the most effective performance results for the hybrid model were achieved when combining the TF-IDF of unigrams, TF-IDF of the Part of Speech (POS) tags, HGE, LSF, and LEF with the DF model. The findings report that the hybrid model exceeded the HEF and DF models in the datasets. The hybrid achieved for every IAEDS, AETD, and SemEval-2018 datasets an accuracy of 87.2, 0.718, and 0.512, respectively.

Ref no.	Authors\Year	language	Approach	Detection method	Emotion model	Features	Dataset	Evaluation metric and Results
[1]	Mansy, A et al.,2022	Arabic	Deep Learning approach	Bi-LSTM, Bi-GRU, and MARBERT	Arabic Multilabel Emotions Classification	Word Embedding features	SemEval -2018-Task1-Ar-Ec dataset	Accuracy: 0.540 Macro F1 Score: 0.701 Precision: 0.634 Recall: 0.550 Micro F1 Score: 0.527
[2]	Khalil, E. A. H et al.,2021	Arabic	Deep Learning approach	BiLSTM	Multilabel Arabic Emotions Classification model	Word Embedding features	SemEval -2018-Task1 dataset	Validation accuracy=0.575%
[3]	Elfaik et al.,2021	Arabic	Deep Learning approach	LSTM-BiLSTM	Anger,anticipation, disgust, fear, joy, love, optimism, pessimism, sadness, surprise, and trust	Embedding features	SemEval -2018 dataset	Accuracy =(53.82%)
[4]	Alswaidan el al.,2020	Arabic	Hybrid approach	Deep feature based(DF)model and Human engineered feature based(HEF)model	Plutchik's model+love,optimism, and pessimism emotions	Stylistic,lexical, syntactic, and semantic features.	SemEval -2018 dataset	Accuracy, HEF 44.8% DF 50.5% Hybrid(HEF+DF) 51.20%
[5]	AlZoubi et al., 2020	Arabic	Ensemble and Deep learning approach	Bidirectional GRU_CNN, conventional neural networks,and XGBoost regressor	Anger, fear ,joy,and sadness	TF-IDF, word-level embedding, and lexicon features	SemEval -2018 dataset	Precision , Ensemble=(69.%)
[6]	Hussein, A et al., 2020	Arabic	Machine learning approach	Naïve Bays, k-Nearest Neighbors (KNN), and Support Vector Machine (SVM).	Happy, Sad, Angry, fear	Word Embedding, TF-IDF features	Text Mining Data	Accuracy, NB =70%, SVM =68.33%, KNN=51.67%
[7]	Saad, M. M et al.,2018	Malay language	Machine learning approach	Support Vector Machine (SVM) and Decision Tree (DT)	Four types of emotions Happy, angry, fearful) and sad)	Term Frequency-Inverse Document Frequency (TF-IDF)	200 Malay children short stories datasets	Accuracy, SVM=30.0%, DT=62.5%

Fig. 1: Summary of the emotion detection in Text

Furthermore, deep learning detects emotions. For instance, AlZoubi et al. [5] have implemented an ensemble approach that contains Conventional Neural Networks (CNN), Bidirectional GRU-CNN (BiGRU-CNN), and XGBoost regressor (XGB) to be utilized in solving the EC of the SemEval-2018 dataset written within the Semitic. The ensemble approach used TF-IDF, word-level embedding, and lexicon features. Results show that their model achieved a precision of 69. In addition, Hussein, et al. [6] followed the machine learning method to detect emotion in Text Mining Data supported Arabic Text. They collected text mining data from the internet while focusing on four emotion classes (sad, happy, afraid, and angry). Three sorts of techniques are used supported machine learning approaches include KNN, NB, and SVM algorithm. The findings also showed that NB had the best accomplishment regarding accuracy. NB classifiers achieved 70, comparing to SVM that obtained 68.33, while KNN yielded 51.67. Saad et al. [7] proposed a similar model to categorize emotions from the Malay language. The dataset used consists of Malay children's short stories. over 200 short stories were collected, each story varying from 20-50 words. The TF-IDF is extracted from the text and classified using SVM and DT. Four common emotions, happy, angry, fearful, and sad, are classified using the 2 classifiers. Results showed that the choice Tree outperformed the SVM by a 22.2 accuracy rate.

Fig 1 summarizes the acceptable emotion methods reviewed during this paper and sorted on the most recent date.

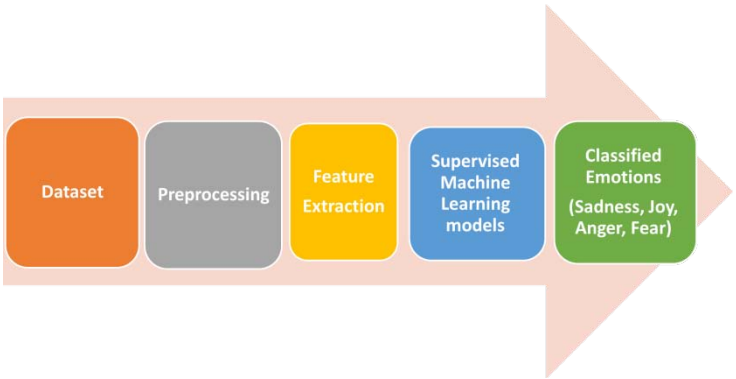

Fig. 2: Shows the main phases of the methodology

	ID	Tweet	Affect Dimension	Intensity Class
1	2018-Ar-00759	@mnwry1 ش ! أنتي ساقطه ! لا ما يحتاج أعطيح هنا...	anger	3: high amount of anger can be inferred
3	2018-Ar-03121	... فعل #قطر من غدر وخيانة ذكرنا بفعل صدام الأسود	anger	3: high amount of anger can be inferred
10	2018-Ar-04092	...فيصل قاسم وقناه الجزيره سبب خراب سوريا ربنا ين	anger	3: high amount of anger can be inferred
17	2018-Ar-03289	@Al3mriRami @Holyliviuss كل مافي الأمر أني غاض...	anger	3: high amount of anger can be inferred
28	2018-Ar-02472	@mm_888s ... انا ضد هذا الكلام كل واحد ظروفه ليش	anger	3: high amount of anger can be inferred
...	...	...	...	...
854	2018-Ar-03946	...القلب ما يسكنه غير الهم و بوح و بكى #الهم من ا	sadness	3: high amount of sadness can be inferred
856	2018-Ar-03206	...أنا إنسان #ضائع هنا أتحدث عن أوجاعي وربما سأتح	sadness	3: high amount of sadness can be inferred
865	2018-Ar-00640	أوحش أنواع #الزعل انك تكون زعلان علي #نفسك	sadness	3: high amount of sadness can be inferred
886	2018-Ar-02781	... يقتلني الحنين ليك حتى تعجز عيوني ذرف آخر دموع	sadness	3: high amount of sadness can be inferred
888	2018-Ar-01328	...الوجع الحقيقي هو الذي يفضحك من صوتك من غصة الو	sadness	3: high amount of sadness can be inferred

Fig. 3: Snapshot of the training dataset before preprocessing

	ID	Tweet	Affect Dimension	Intensity Class
5	2018-Ar-01214	...روحى غيرة حفاظتك ي مجرمه اتفوه عليكى عميله وسخ	anger	3: high amount of anger can be inferred
7	2018-Ar-01154	فليتقوا غضب الحليم إذا غضب	anger	3: high amount of anger can be inferred
15	2018-Ar-04217	...والله انها بصمت عار علي جبين الامه العربيه الذ	anger	3: high amount of anger can be inferred
16	2018-Ar-03520	... امي: ميخالف\n*اخوي: *يصرخ على امي يسبها يزفها	anger	3: high amount of anger can be inferred
19	2018-Ar-03153	... يشووش على ايش الخيانه عبادة ايران خيانة الجار	anger	3: high amount of anger can be inferred
...	...	...	...	...
333	2018-Ar-04365	... شعور حزين : اذا كنت تضحك وفجأة تتذكر و تسكت -	sadness	3: high amount of sadness can be inferred
353	2018-Ar-01900	...إن قلبي ليتمزق تمزقا متى تذكرت أن عيني لا تملك	sadness	3: high amount of sadness can be inferred
361	2018-Ar-01312	...ومن "خيبة الـn\ والكلامn\، من كثر المعاتبn\تعبت	sadness	3: high amount of sadness can be inferred
365	2018-Ar-04247	...انا حزين و ما أخفي عليك حزني وأنت داري إن غياب	sadness	3: high amount of sadness can be inferred
366	2018-Ar-01398	...ياقلبي المسكين لااحد يحس بغمرة وجعك الدفين جمر	sadness	3: high amount of sadness can be inferred

Fig. 4: Snapshot of the testing dataset before preprocessing

IV. Experimental Evaluation

This section discusses the used dataset and the method- ologies to identify emotions of tweets written in Arabic by utilizing (5) algorithms of machine learning: KNN, DT, SVM, NB, and Multinomial NB. The final section highlights the outcomes of this process.

The main phases of the methodology are shown in Fig. 2. The methodology consisted of the dataset, preprocessing, features engineering, supervised machine learning, and classified emotions based on four emotions (anger, joy, sadness, and fear).

a) Dataset

This section discusses the used dataset in which the experiments are performed using the reference emotion detection SemEval-2018 (Affect in Tweets) dataset. The dataset is the public benchmark dataset created for the detection of emotions in tweets written in Arabic. Each tweet is labeled as one of the emotions (joy, anger, sadness, and fear.). All these tweets are in Arabic text. We used only the Eloc for our experiment with four basic emotion categories. The training dataset trains the classifier and the test dataset examines the structured model to show identify the value of trained model. Figure (3) highlights the training dataset and Figure (4) highlights testing dataset.

b) Preprocessing

Data preprocessing is taken into account one among the essential phases in machine learning to avoid misleading results and obtain better insights. during this section, the preprocessing steps are discussed as follow: The tweet from the SemEval2018 dataset has been preprocessed using the foremost common preprocessing techniques, like removing stop words, repeating chars, English characters, mentions, punctuation marks, and Arabic diacritics. Also, text normalization has been added.

- English Characters Removal: during this step, all English characters in both lower and upper cases (A-Z, a-z) are removed.
- Stop words Removal: Removing all stop words that may not influence the tweet's meaning.
- Arabic Normalization: Returning chars to their original.
- Arabic Diacritics Removal: Removing all diacritics like [Fatha,Tanwin Fath, Damma, Tanwin Damm, Kasra,Tanwin Kasr,Sukun] .
- Mentions Removal: Removing any mentions like @ from the tweet.
- Repeated Chars Removal: Any repeating characters are removed during this step.
- Punctuations Removal: Removing all punctuation marks like/:".', +¦!—. . . ""–

c) Features Extraction

Feature extraction techniques aim to represent the text's emotional value which is able to help classify the emotions into the right category. Feature extraction is essential before EC from the documents, which can be found in method such as Term Frequency-Inverse Document Frequency (TF-IDF). The next section describes the feature extraction method utilized in our proposed approach:

- TF-IDF

TF-IDF is one in every of the foremost used text feature extraction techniques because it provides helpful insight into the essential features of text documents. during this paper, TF IDF is chosen because the feature extraction technique. It computes the merchandise of the 2 statistics: TF-IDF describes how the word is important to a tweet in an exceedingly collection of tweets. the worth of TF-IDF increases correspondingly to the quantity of times a word appears within the tweets. The more a term occurs in tweets belonging to some category, the more it's relative there to category. TF-IDF's function is more developed and offers ideal outcomes as it can identify an emotional Arabic term. Figure (5) highlights the characters' number in tweets.

d) Experiment

The experiment describes the approach to predicting users' emotions from their tweets. To categorize the tweet into (anger, joy, sadness, and fear), we apply different machine-learning approaches: K-Nearest Neighbor, Decision Tree, Support Vec- tor Machine, Naive Bayes, and Multinomial Naive Bayes. This work has been implemented on a cloud- based environment, "Google Colab," owned by Google. The experiment's first and most essential phase is preprocessing the tweets for training and test sets. mostly, Arabic text needs more preprocessing because of its nature and structure. Therefore, the preprocessing techniques for every tweet are performed for the training and testing phases. We used the dataset of the Arabic tweets presented by Semi-Eval 2018. Then classified, each tweet was placed into one in all four categorizations, given an emotion and a tweet. This dataset includes (934) tweets for the provided emotions: Fear, anger, sadness, and joy. The TF- IDF is extracted from the text and classified using KNN, SVM, DT, NB, and Multinomial NB. We randomly split our dataset into testing and training with 20-80 ratios. the proportion of every class within the dataset is shown in Fig.6. We used the training datasets to point the classifiers. In contrast, (unseen to the model), the test dataset was reserved for examining the structured model to identify the suitability of the trained model. After splitting our dataset into the testing and training process, 747 samples are within the training dataset and 187 within the testing dataset. The results of 5 machine learning models are compared within the result section.

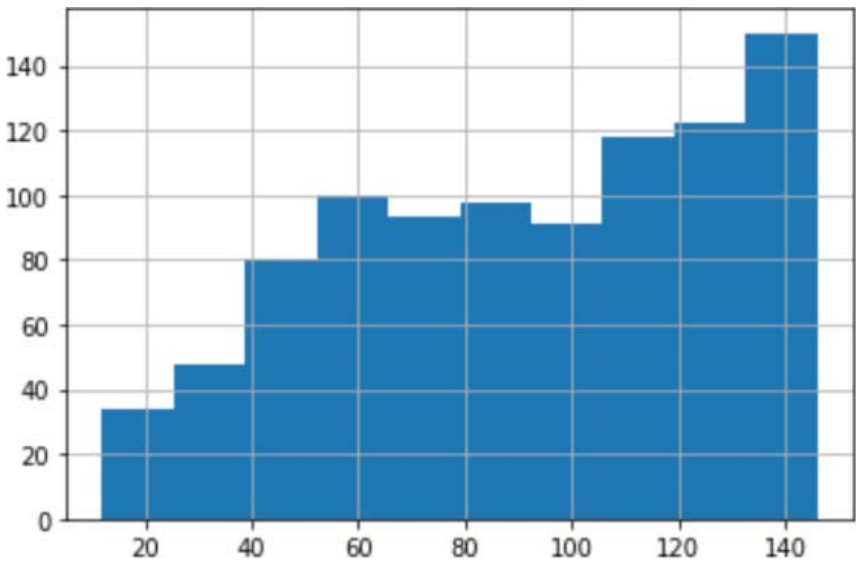

Fig. 5: The number of characters in tweet

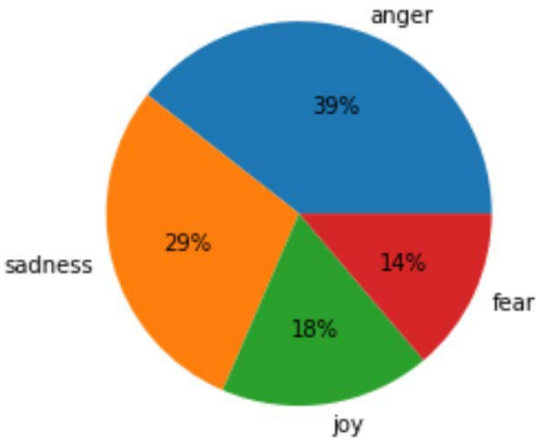

Fig. 6: The percentage of each class in the dataset

Accuracy	$\frac{True\ Positive + True\ negative}{True\ Positive + True\ negative + False\ Positive + False\ negative}$
Recall	$\frac{True\ Positive}{True\ Positive + False\ negative}$
Precision	$\frac{True\ Positive}{True\ Positive + False\ Positive}$
F-measure	$2 \times \frac{Precision \times Recall}{Precision + Recall}$

Fig. 7: Evaluation Metrics

V. Evaluation Metrics

We use precision, accuracy recall, and F- score accuracy, in this study, to measure the EC's performance. Precision, also named positive predictive value, is the documents' number labeled correctly as belonging to the positive class. Sensitivity, or recall, is the documents' number that is not labeled as belonging to the positive class. Another measurement that combines recall and precision is F-score. The F-score indicates how accurate the classifier is (how many instances are correctly classified) and its robustness (it does not miss many instances). The last measure is accuracy, which indicates the suitability of a given classifier[13]. Calculations of the measurements are given in Fig. 7.

VI. Results and Discussion

This section reports the performance results and discusses the model. We trained the model on the training dataset for the SemEval- 2018 dataset, and reported on the model performance on the test dataset. The Decision Tree and K- Nearest Neighbor classifier's accuracy was 0.74, the NB and Multinomial NB classifiers obtained 0.69, and the SVM 0.63. The results could be more encouraging regarding accuracy. Fig. 8 displays the accuracy comparison of various machine learning models.

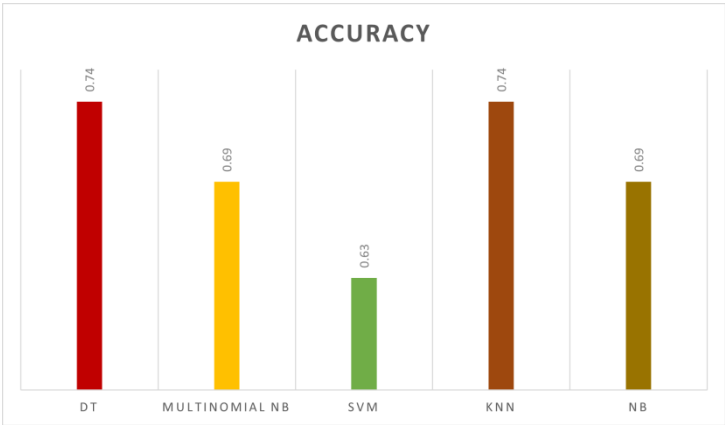

Fig. 8: Results of the accuracy using different Classifiers

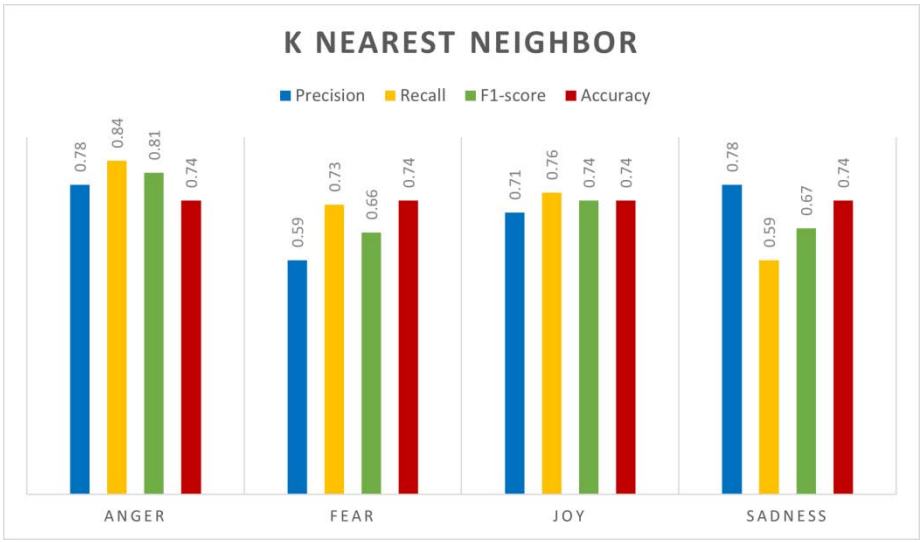

Fig. 9: The findings of the KNN algorithm

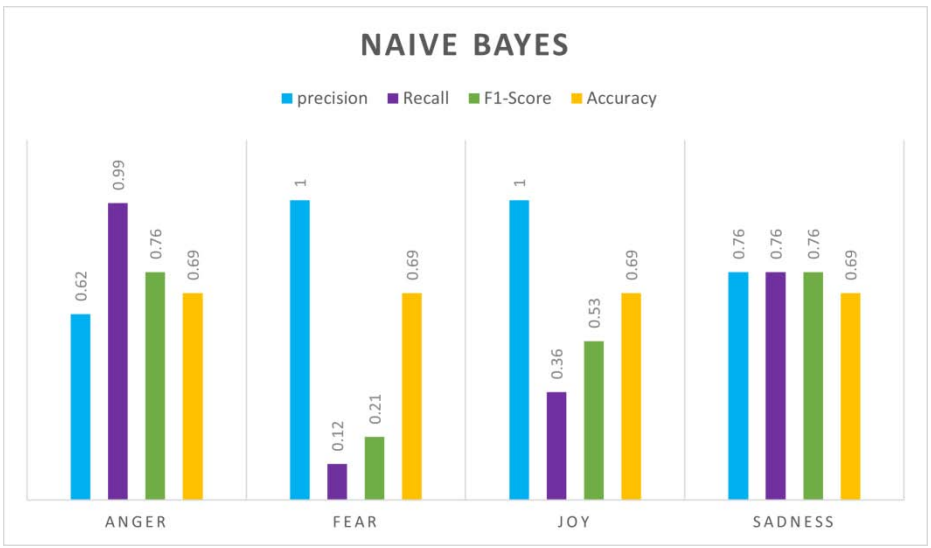

Fig. 10: The NB algorithm's results

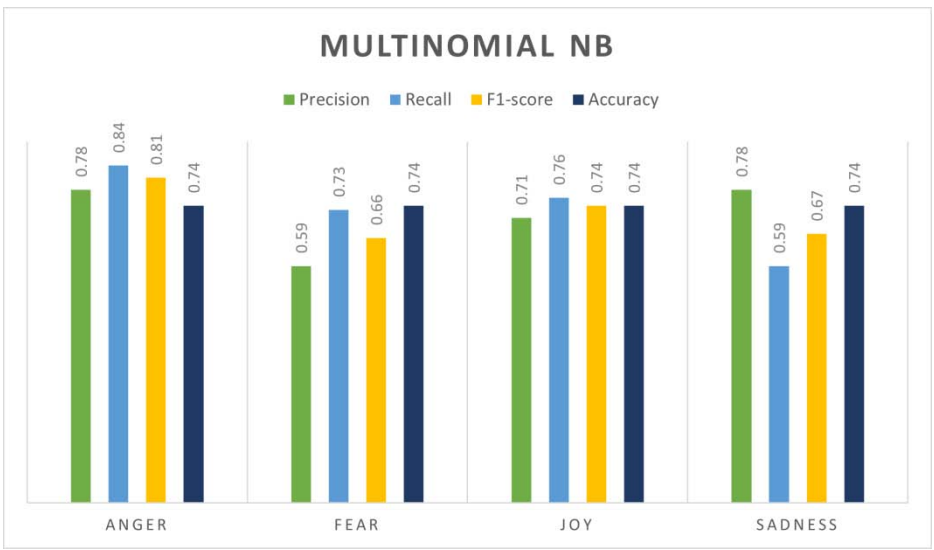

Fig. 11: The Multinomial NB algorithm's results

Fig. 12: The DT algorithm's results

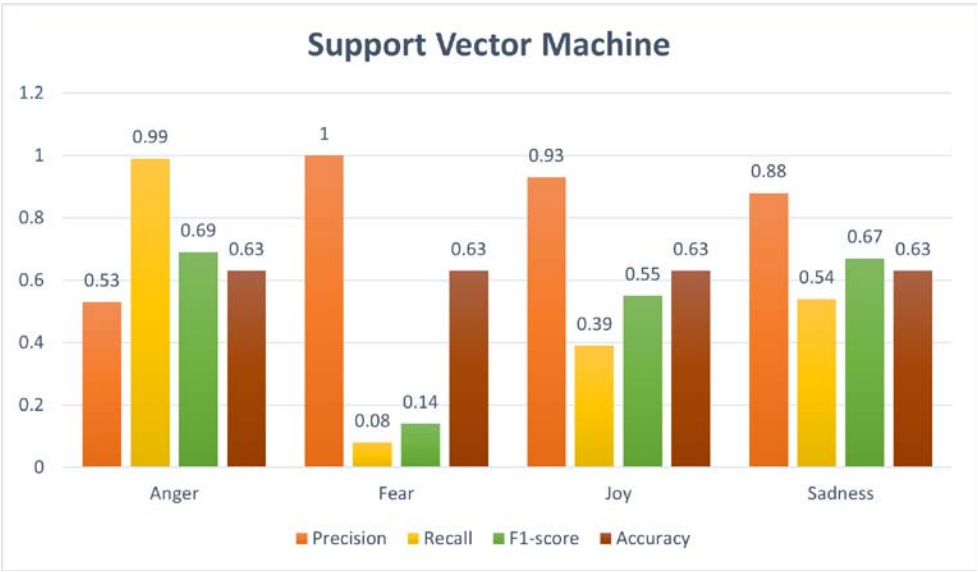

Fig. 13: SVM algorithm's results

VII. Conclusion

EC is a text categorization approach that aims to identify human feelings conveyed through texts. In recent years, Arab users have expressed their emotions on many of the issues raised through the Twitter platform. Therefore, this paper focused on the common classification algorithms such as DT, KNN, SVM, NB, and Multinomial (NB) and applied them to a tweet's dataset as short text content. This study presented the approach for categorizing the emotions of tweets written in Arabic while utilizing the machine learning model. We used the dataset of Arabic tweets presented by SemEval-2018 for EI-oc task. This process used (4) emotion categories: Anger, joy, fear, and sadness. The approach achieved acceptable results with 0.74 for each of the KNN and DT, while the NB and Multinomial NB acquired 0.69; finally, the SVM achieved 0.63. Therefore, future research, including deep learning, is promising, primarily if provided with a large, good, annotated dataset. Also, future research on constructing and finding an Arabic dataset that is labeled correctly will aid and increase the advancements in textual emotion detection, because it will offer a dataset that can be utilized to compare various suggested investigations.

VIII. Future Work

The authors intend to examine this model on bigger datasets, assess the outcomes, and employ a hybrid approach that depends on deep learning and machine learning to classify emotions in texts written in Arabic and compare multiple methodologies.

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Research on Path of Blockchain Enabling Accounting Information System

By Muteng Zhong & Jing Tie
Yunnan University of Finance and Economics

Abstract- This paper first describes the blockchain technology is the current national support for new technologies, has an important position in the national development strategy; then, combined with the national accounting development plan, it analyzes the opportunities and challenges faced by the accounting information system and the theoretical basis and advantages of the integration of blockchain technology and accounting information system. Finally, the path of blockchain enabling accounting information system is analyzed.

Keywords: *blockchain technology, accounting information system, enabling path.*

GJCST-G Classification: *DDC Code: 332.178 LCC Code: HG1710*

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Research on Path of Blockchain Enabling Accounting Information System

Muteng Zhong [α] & Jing Tie [σ]

Abstract- **This paper first describes the blockchain technology is the current national support for new technologies, has an important position in the national development strategy; then, combined with the national accounting development plan, it analyzes the opportunities and challenges faced by the accounting information system and the theoretical basis and advantages of the integration of blockchain technology and accounting information system. Finally, the path of blockchain enabling accounting information system is analyzed.**

Keywords: blockchain technology, accounting information system, enabling path.

I. Introduction

Blockchain is a new application mode of computer technology such as distributed data storage, point-to-point transmission, consensus mechanism and encryption algorithm. Since the advent of blockchain technology, its development prospects have received great attention. Relevant parties have also invested a lot of research energy and funds here, and its application scope and field are more and more extensive. Blockchain technology is now also gradually applied to accounting information systems. At present, there are many drawbacks in the accounting information system of enterprises, including the problem of information technology, the conservative problem of reporting mode and the lack of supervision. These problems have been greatly alleviated to a certain extent due to the emergence of blockchain technology. There is a natural connection between blockchain technology and accounting, because blockchain technology is a big data ledger, and accounting itself is an economic information conversion technology that specializes in bookkeeping. Therefore, studying the connection between the two has a huge boost to the optimization and progress of accounting information systems.The advocacy and support of the state has greatly promoted the integrated development of blockchain and accounting technology.

At present, the development of accounting information system affected by the new normal economic development, can not meet the requirements of economic development, further development has encountered bottlenecks. The national' 14th Five-Year' accounting development plan puts forward new requirements for accounting information system. The' 14th Five-Year Plan for Accounting Reform and Development (Draft)' has made a new development plan for the development of accounting, including promoting the digital transformation of accounting, accounting management and audit work. One is the digitization of accounting work. Planning pointed out that to design a good transformation of the top-level structure, improve the' enterprise accounting information work norms', to achieve the unity of all enterprises and administrative institutions norms, and to make accounting information is applied to both accounting processes, but also in business activities to use. Establish a data standard including the whole process of accounting information input, processing and output, and apply it to the construction of accounting database of state-owned enterprise financial statements, industry management digital platform and fiscal and taxation sharing platform, so as to effectively accelerate the pace of digital transformation of accounting and auditing, and provide new engines and new advantages for the development of accounting. Second, digital accounting management. The plan puts forward new requirements from the establishment of an integrated management platform for accounting personnel information, credit management, CPA industry information, accounting firms, and agency accounting institutions. It is hoped that through the accounting data standard, the data of each platform will be integrated, and the accounting industry management big data technology will be used to empower the improvement of national governance capabilities; The third is the digitization of audit work. Formulate correspondence data standards, establish a digital platform for correspondence, give play to the functions and roles of modern technology to solve the problem of false correspondence, and improve audit efficiency. Use information technology and means to strengthen the anti-counterfeiting management of audit reports and solve the problem of false audit reports.

The 2035 vision for accounting reform and development places new demands on accounting information systems. The country's vision of accounting reform and development clearly states that the dream of an accounting power will be realized by 2035. This requires the improvement of the accounting legal system so that it is consistent with the level of economic

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development and capital flow at home and abroad; Establish accounting and auditing system standards, and ensure stable operation, significantly expand the right to speak in the formulation of international accounting and auditing standards, achieve high-quality accounting development, and be in a leading position in the world; Gradually optimize the structure of accounting talents, improve the professional ethics, ability level and knowledge level of accounting personnel, so that they can adapt to the identity of China's accounting power; Complete the digital transformation of accounting and auditing, basically solve the problem of accounting trust, ensure the quality of accounting and auditing work, strengthen the accounting service economy and society, and transform to the value chain, so that accounting can play an active role in building a digital China, building a high-standard market system, and improving the ability of national economic governance. In the new normal and new environment of the economy, the accounting information system should adapt to the new needs and new environment, find a breakthrough in the bottleneck that hinders the development, and blockchain technology is an inevitable choice, so this paper studies how the blockchain empowers the accounting information system in order to promote the further development of accounting.

II. The Accounting Information System Faces Challenges and Opportunities

a) The problems existing in the accounting information system

Centralized mode The current accounting mode still adopts centralized mode, such as financial service sharing center and cloud mode. The model of accounting center has many disadvantages. All accounting information is centralized in the center, tampering cost is low, trustworthiness is questioned; All accounting information is concentrated in the center, poor transparency and openness, easy to be subjected to hackers and other network attacks, information theft, disclosure and other high risks, there are security risks; Fewer people participate in accounting data processing, it is difficult to play the collective wisdom, wisdom finance is difficult to develop; Financial report is only a fixed balance sheet, income statement, cash flow statement, difficult to meet the needs of various parties, the degree of information sharing is not high.

In the current accounting information system, the financial department and the business department are still separated obviously, and the integration is not high. Nowadays, information technology is developed and information exchange is convenient. However, the lack of professional information exchange platform and the lack of awareness of the integration of business departments and financial departments lead to the obstruction of information sharing and communication. The cross-departmental business ability of financial personnel and business personnel needs to be improved. Financial personnel do not understand business, business personnel do not understand finance, and the knowledge and business skills of staff need to be transformed and upgraded. The enterprise management system is not perfect, the evaluation system is defective, the business department and the financial department only consider the problem from their own perspective, the business only considers the increase of performance and sales, does not consider the financial risk, the financial only considers the control of risk, does not consider the increase of business performance, these problems are not conducive to the integration of industry and finance.

There are many problems in the development of accounting. Compared with the needs of economic and social development, there are still gaps in the construction of accounting auditing standard system. Compared with the requirements of the reform of "release regulation and service", the management of accounting service market still needs innovation; Compared with the construction of a high standard market system, the quality of accounting audit work still needs to be improved; Compared with the requirements of high quality development, the supply of high-end accounting talents is still insufficient; Compared with the comprehensive rule of law requirements, accounting rule of law construction still needs to be strengthened; Compared with the requirement of digital development, the informatization level of accounting audit work still needs to be improved. These problems need to be solved by institutional innovation, institutional optimization and institutional reform during the 14th Five-Year Plan period. During the "14th Five-Year Plan" period, accounting, as a foundational work in the macroeconomic management and allocation of market resources, faces rare development opportunities in the course of deepening reform comprehensively and integrating deeply into economic globalization in our country.

Opportunities and challenges brought by the new international situation From the international perspective, the international situation is undergoing profound and complex changes, will profoundly affect the existing international accounting order; International economic and trade exchanges and cross-border capital flows have raised new requirements for cross-border accounting, auditing cooperation and supervision; New business models emerge in endlessly in economic development, which will profoundly affect the development trend of accounting standards. From the domestic point of view, in the steady and slow economic operation situation, accounting audit illegal behavior has a trend of rising, capital market financial fraud cases, causing widespread concern from all walks

of life; With the development of science and technology and the wide application of new technology, accounting challenges and opportunities coexist.

In the face of these new situations, new problems, new challenges and new opportunities, it is required that the accounting law and accounting standards are constantly perfected and effectively implemented, that the accounting practitioners continue to improve their quality, accelerate their transformation, and that the accounting management departments continue to change their ideas and improve their methods.

III. The Integration of Blockchain and Accounting

a) The macro environment of integration

In December 2016, The State Council issued the 13th Five-Year National Informatization Plan, which for the first time included blockchain technology as a strategic technology in the plan. The plan emphasizes the strategic layout of basic R&D and frontier of new technologies such as blockchain. In March 2021, the "14th Five-Year" National Informatization Plan is being formulated to promote the implementation of the plan from nine aspects such as information infrastructure construction and the deep integration of digital technology and the real economy. The decentralized point-to-point value delivery transaction mode of blockchain technology is a natural digital technology, and accounting is an effective tool to calculate digital value. The two have a natural basis for integration. The strategic layout of the country also provides a good macro environment for the integration of blockchain and accounting.

b) The theoretical basis of integration

First of all, accounting is a technology that processes the procurement, production, inventory and sales business information of an enterprise into value information with professional accounting technology. It is a professional business processing information technology and belongs to the information category. Blockchain is an information technology that processes all economic information in accordance with the contract and consensus mechanism. It also belongs to the information category, so accounting and blockchain both have the attributes of information and information technology. Secondly, blockchain solidifies and stores all transaction information with timestamp and asymmetric encryption algorithm to preserve information completely and accurately and ensure authenticity. The goal of accounting is to confirm, measure and report the actual transactions or matters, truthfully reflect the various accounting elements and other relevant information that meet the requirements of recognition and measurement, and ensure that the accounting information is true and reliable and the content is complete. Therefore, they are consistent in attribute and target, which provides a theoretical basis for fusion.

c) Advantages of integration

"Blockchain + Accounting" will improve the quality of accounting information Blockchain technology can optimize the path of accounting information generation and improve the quality of accounting information. At present, Kingdee, Yonyou and other accounting software have designed a set of automatic accounting system according to the principle of double-entry bookkeeping and the process of confirmation, measurement, bookkeeping and reporting: The cashier will input the information of fund receipt and payment into the system based on invoices, bank payment slips, bank receipts, expense claims, etc., and the system will automatically register the cash journal and bank deposit journal according to the procedures designed by the system. The accountant will input the purchase invoice, sales invoice, production document, inventory document and expense document into the system manually, and the system will automatically register all kinds of subsidiary ledger and general ledger according to the designed process. The statement system will issue three major statements (balance sheet, income statement and cash flow statement) according to the designed statement template. Therefore, the current accounting information system is only the man-machine collaboration mode, rather than the machine mode and artificial intelligence mode of blockchain technology. The former can still be tampered with according to human intervention methods such as replication, deletion, recovery of bookkeeping and cancellation of bookkeeping, and the general ledger type of centralized mode is extremely easy to tamper with, which brings great challenges to the reliability of accounting information. However, blockchain uses the value Internet technology which is completely different from the information Internet technology. It is the transmission of value rather than the replication of information, so tampering is bound to leave traces. In addition, blockchain records all the information of each transaction through the time stamp and consensus mechanism. According to the time sequence, it can not only trace forward, but also continuously extend backward, which makes it technically difficult to modify and steal data and other tampering behaviors, so as to ensure the integrity and authenticity of information technically.

"Blockchain + Accounting" will improve the intelligent level of accounting treatment. The recording and verification of accounting information under blockchain will be automatically completed by a pre-set computer program, which improves the intelligent level of accounting treatment. Kingdee, ufida software stand-alone mode, financial Shared schema or cloud model, on the business process, in the accounting process, all

need audit personnel to check the information and check, this is human-machine collaborative mode, is not completely machines, automation, prone to error, the manipulation of information as well as the low efficiency and so on. And block chain accounting information system, through the embedded intelligent contract (by the financial contracts, supply, supervision, auditing, production and sales contracts, etc), contract layer embedded code, when the business to the expected contract rule conditions and check, the system will automatically perform significantly improve the processing efficiency and accuracy of accounting information system.

Block type chain would promote accounting accounting information system to intelligent accounting information system accounting accounting information system, only the computer outside accounting into the computer, through the technique of artificial scans or entry input source documents, each business in the accounting software to the original credentials in accordance with the accounting theory is processed into accounting information, Through the establishment of a good accounting system to automatically complete the subsequent accounting processing, such as the registration of detailed accounts, issuing accounting statements, etc. Computer in the transmission, inquiry, sorting out accounting data, processing efficiency has been greatly improved, to a certain extent, improve the level of accounting information, but there is still a big gap with the management accounting goals. The objectives of management accounting include strategic accounting, intelligent accounting and intelligent accounting. The transformation and upgrading of financial accounting into management accounting cannot be done without the help of blockchain.

IV. Opportunities and Challenges Brought by Blockchain to Accounting Information System

The accounting information system has shortcomings such as information island, information lag, centralization and separation of industry and finance, and the enabling of blockchain can fundamentally improve or even eliminate these shortcomings. The whole process of blockchain is open and transparent, resistant to tampering and self-trust, which can meet the requirements of obtaining authentic and reliable original vouchers of accounting information system, and also meet the new requirements of economic development on the acquisition automation of accounting information system. Blockchain decentralization and distributed accounting can solve the requirements of intelligent accounting voucher preparation, and solve the problem of information lag; The advantages of blockchain traceability and easy accountability can easily solve the problems and requirements of accounting information system book registration automation; The advantages of financial integration and synchronization of blockchain business and timely information sharing bring opportunities to break through the bottleneck of accounting reports, which can meet the new requirements of current economic development and solve the shortcomings of separation of industry and finance and insufficient integration. Of course, the application of blockchain technology in accounting also has certain challenges. Blockchain technology itself is immature, application scenarios are limited, it cannot solve the problem of off-chain data security, the digitalization of financial business needs to use other technologies, and the data on-chain is not sufficient.

V. The Path of Accounting Information System Enabled by Blockchain

a) Information fidelity

The trust of accounting information system ensures that the characteristics of blockchain technology, such as decentralization, distributed bookkeeping and resistance to tampering, coincide with the requirements of true and reliable accounting information, and can fully guarantee the authenticity of accounting information. However, computer hardware and software technology insufficiency, system related parties, malicious hackers and so on have brought great security risks to the accounting information system. In addition, the current financial sharing service center and cloud accounting mode are both centralized processing methods, with low tampering cost, which is a big problem for accounting information system to provide true and reliable information. Therefore, the embedding of multi-node two-layer blockchain technology and the construction and operation of the vertical and horizontal bidirectional degree model can play the role of firewall and booster, and promote the construction of the credit guarantee mechanism of accounting information system. In addition, blockchain plays a role in solidifying the original transaction information and the accounting processing process. Making full use of blockchain technology to process accounting data and using artificial intelligence mode will enable the information fidelity of accounting information system.

In terms of ensuring the fidelity of accounting information, blockchain can achieve dissemination fidelity and a certain degree of release fidelity in general application scenarios; In the field of audit, a scheme to improve the quality of accounting information can be constructed, which can protect the privacy of reasonable accounting information, detect false participants, eliminate unnecessary human influence and avoid bias in audit reports, so as to provide a more powerful guarantee for the fidelity of information.

The application of blockchain technology can optimize the accounting information system. For example, in the purchase and sale business, the information process can be reconstructed from internal and external aspects, and then the optimization of its security, information risk and other aspects under the blockchain technology can be deeply discussed. In particular, environmental accounting is severely restricted by the bottleneck of technology, reporting mode and supervision mechanism, and the integration of blockchain technology will break the bottleneck and promote the further optimization and development of environmental accounting information system.

b) Information sharing

Accounting information system of the intelligent block distributed record and store chain, each node record all transactions in chronological order, the relationship between all nodes are equal, open and transparent operation rules, abide by the same consensus algorithm trading rules, the point-to-point connections, jointly safeguard, the trust, information sharing, intelligence, wisdom, for the accounting information system laid a foundation. Because of the self-trust, all users on the chain give full play to the wisdom of free trade, innovation of production mode, change the production relationship, each enterprise to optimize the accounting information system, and business integration, the whole economy will be a great wisdom of the accounting information system. No matter which industry, to achieve a high degree of information sharing, we can analyze the advantages and disadvantages of the company's accounting system and business system, and then explain how to integrate the information system process and business process through process optimization and transformation, so as to achieve the purpose of wisdom.

Blockchain technology can promote the optimization of accounting information system. For example, the enterprise procurement system can analyze the optimization application value of blockchain technology in financial accounting and management accounting by constructing the procurement activity accounting model. According to the analysis results, the procurement system can be taken as the entry point to play a role in system optimization. In terms of optimizing accounting supervision, first of all, it is necessary to analyze the necessity of building a blockchain accounting supervision system. Then, according to the characteristics of business processes, it is necessary to analyze how blockchain can help standardize the supervision process, optimize accounting supervision and play a role in optimizing the system.

c) Application of information

Value creation of accounting information system Accounting information system has the disadvantage of information island, while blockchain technology enables accounting information sharing, openness and transparency, facilitates the operation and use of accounting information, and creates value from it. Block chain is combined with "big, smart, mobile, cloud, things" and other technologies to build a blockchain management accounting digital skills ecosystem, making it possible for management accounting to build a value creation platform for enterprises. From the perspective of intelligent management accounting, the technology of "big, smart, mobile, cloud, material" can also be used to transform the accounting information system into an intelligent financial sharing platform, so as to provide real-time useful information for all parties with information needs, predict risks, and realize the value creation of accounting information. The management accounting report system is constructed through the technology of physical layer, definition layer, network layer, collaboration layer and application layer of blockchain, so that the function of management accounting to create value by information becomes a reality. Moreover, the management accounting information system based on the core technology of blockchain, including data physical layer, data definition layer, data storage layer, data processing layer, data link layer and data application layer, can make the management accounting information information and promote the accounting information system to create value.

The application of blockchain technology in the value creation of accounting information, referring to the practice of Deloitte Rubix platform in the operation process of cross-border payment, accounting, data storage and business audit, can analyze how to deal with challenges and opportunities through SWOT matrix analysis model, in order to better play the role of this platform. Blockchain has been applied in strategic management accounting and has made some breakthroughs. For example, the use of blockchain to establish the framework of management accounting tools, from the application target, application platform, application evaluation system to form a systematic and integrated system application of management accounting tools, can promote the value creation of accounting information system. The application of blockchain technology in the preparation of management accounting report is also practical and feasible. As long as it is feasible in theory and reality, the application of blockchain technology in the preparation of management accounting report is within reach.

VI. Conclusion

Blockchain technology is a very hot technology in today's society, and its application in the accounting industry has also attracted wide attention. More and more scholars have begun to study the application of blockchain technology in the accounting field. Its

advantage is to establish distributed ledger, improve the quality of accounting information, strengthen enterprise supervision and management, so as to promote the optimization of enterprise accounting management information system. To sum up, with constant innovation and development block chain technology, in the future the technology will be increasingly perfect and mature, it will give the accounting field brings a huge innovation, so as to promote its transformation, promote reform and innovation of accounting management information system, improve the enterprise's management method, management, operation mode, makes in the chain of blocks technical background, Enterprise accounting management information system has been further optimized and improved.

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Critical Success Factors of Remote ERP Implementation: From System Users' Perspective

By Kasun Kodithuwakku & Naduni Madhavika

Abstract- The study explores critical success factors of remote ERP implementation in the Sri Lankan context from system users' perspective. As a result of the Covid-19 pandemic, ERP implementation has become more complicated, and ERP software vendors have shifted to remote ERP implementations. Although, there are several studies on identifying Critical Success Factors (CSFs) in ERP implementation, there is a void in the literature on identifying CSFs in remote ERP implementation. As a result of the literature review, it was discovered that only a small amount of research has been done on remote ERP implementation. Therefore, the current study tries to bridge these gaps by identifying the CSFs of remote ERP implementation during Covid-19 by taking Sri Lanka as a case study.

Keywords: remote ERP implementation, top management commitment, change management, communication, user training and education, implementation strategy, project management.

GJCST-G Classification: LCC: HD30.2

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Critical Success Factors of Remote ERP Implementation: From System Users' Perspective

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Abstract- The study explores critical success factors of remote ERP implementation in the Sri Lankan context from system users' perspective. As a result of the Covid-19 pandemic, ERP implementation has become more complicated, and ERP software vendors have shifted to remote ERP implementations. Although, there are several studies on identifying Critical Success Factors (CSFs) in ERP implementation, there is a void in the literature on identifying CSFs in remote ERP implementation. As a result of the literature review, it was discovered that only a small amount of research has been done on remote ERP implementation. Therefore, the current study tries to bridge these gaps by identifying the CSFs of remote ERP implementation during Covid-19 by taking Sri Lanka as a case study.

The study adopted positivism philosophy by having followed deductive approach. The study sample is consisted of system users who had used the remotely implemented ERP systems. Based on the convenience sampling technique study collected responses from 269 system users. SPSS V 21.0 correlation and regression analysis techniques were used, and it was found that although all the six considered independent factors as Top Management Commitment, Change Management, Project Management, User Training and Education, Implementation Strategy, and Communication have been positively correlated with the remote ERP implementation success. However, the User Training and Education, Implementation Strategy, and Communication were found to be significantly impacted on the remote ERP implementation success based on regression results. Thus, the current study concludes that User Training and Education, Implementation Strategy, and Communication are critical success factors of remote ERP implementation success. These findings could be used by both the customers and ERP software vendors to ensure ERP implementation success in a remote setting.

Keywords: remote ERP implementation, top management commitment, change management, communication, user training and education, implementation strategy, project management.

I. Introduction

The Enterprise Resource Planning (ERP) system enables enterprises to manage their resources in more efficiently and effectively (Nah, et al., 2001). Additionally, ERP systems allow the presence of a comprehensive solution that integrates information, processes requests, and provides an integrated, consistent view of the information across the enterprise (Nah et al., 2001). ERP systems allow information to flow within and among the business entities (Hilletofth & Lättilä, 2012). An ERP system in a firm allows a company to redesign its business processes, enhance its reporting cycle, and enlarge the possibilities of information access, which ultimately leads to an improvement in the firm's performance (Hong & Kim, 2002).

ERP system is designed to replace obsolete work with a more synchronized application suit for the company. Efficiency is enhanced through standardization and harmonization (Boo, 2007). Moreover, ERP allows the organization to achieve competitive advantage through innovative business strategy while bringing visibility and controlling of operations to work (Boo, 2007). Due to the highest growth rate of ERP in the IT industry, many scholars and industry experts refer the ERPs as one of critical innovations of the last decade (Al-Mashari, 2002).

ERP implementation is a collaborative effort of the ERP consulting team and the customer project team. The physical presence of the ERP consulting team at the customer site for business analysis, requirements gathering, solution mapping, prototypes, user training, data migration, user acceptance test, and go-live is usual during ERP implementation from the beginning to the end of the project. ERP software vendors had to transition from being physically present at the customer location to a remote ERP implementation procedure while preserving social distance and adapting to travel limitations with the Covid-19 pandemic.

In a usual ERP implementation setup, the interactions between the client company and the ERP consulting team are more frequent with the physical presence. To be more specific, the project implementation team, and the system users have frequent meetups, most commonly on the customer site, to identify the business processes of the clients, business requirements, customer expectations which includes training requirements, data setup plans, and data migration. Therefore, there is a mutual understanding regarding the requirements between the project implementation team and the customer project team. However, with the Covid-19 outbreak, physical meetings have been restricted due to the pandemic situation, which compelled in social distancing. Also, Covid-19 circumstances pressurized the companies to have more integrated business operations. Therefore, the companies identified the requirement of getting an ERP implemented, which would streamline integrated

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business operations. However, since the countries underwent lockdowns, to get this requirement fulfilled, the only feasible option was to do the ERP implementations remotely. Several companies undertook this initiative in implementing ERP remotely. However, unlike the usual ERP implementation process, no physical meet ups were conducted between the project team of the ERP vendor company with the customer, nor the project team could physically visit the customer site for user trainings as usual. All the processes of the implementation were done remotely in the virtual setup.

There is a plethora of past literature which discusses the importance and functionality of ERP systems (Ranjan & Jha, 2018; Saade & Nijher, 2016; Hwang, et al., 2015; Saini, et al., 2013).

Although several research has been conducted to identify the critical success factors for ERP implementation, most of the studies have been conducted from the perspective of management. However, the literature's focus on users who are actively working with the established ERP system, rather than just top management and senior ranking executives, appears to be dubious (Saade & Nijher, 2016). Because the ERP implementation will primarily affect the changing nature of employees' tasks, it's necessary to establish the critical success factors for ERP implementation from the user's perspective (Saini, et al., 2013). Several previous studies have emphasized the relevance of assessing actual users' perceptions (Nah, et al., 2007).

As a result of the Covid-19 pandemic, ERP implementation has grown more complex, and ERP software vendors have shifted to remote ERP implementations. While there are several studies on identifying CSFs in ERP implementation, there is a void in the literature on identifying CSFs in remote ERP implementation. According to the existing literature on critical success factors for ERP implementation, the factors vary depending on the circumstance. Based on the available literature, it is identified that from one geographical location to another geographical location, the factors that drive the successful ERP implementation are different. Moreover, from one situation to another situation these factors could be varied. Therefore, it is suggested that for more than 30 years, contingency theory has been the most prominent theory in the information systems literature (Donaldson, 2001). Although past literature has studied about the factors affecting successful ERP implementation in several geographical contexts, until the Covid-19 pandemic situation, almost all ERP implementations have been happening by having the ERP team physically present in the customer site. Therefore, based on the literature, it was found that, limited literature has been focused on remote ERP implementation. The current study tries to bridge these gaps by identifying the critical success factors of remote ERP implementation during Covid-19 by taking Sri Lanka as a case study.

II. Objective

The main objective of the study is to identify critical success factors of remote ERP implementation from system users' perspective.

III. Literature Review

Various benefits have been demonstrated through the implementation of ERP, such as greater efficiency, improved communication and coordination, easier decision-making, better customer service and retention, increased financials, better asset management, and increased ease of use (Shang & Seddon, 2000). During ERP implementation phases, enterprises must focus on external factors (e.g., consultant and vendor commitment) and internal factors (e.g., project management). IT governance also plays a crucial role in enhancing the quality of ERP implementations (Scott & Vessey, 2000). According to the literature, roughly 70% of ERP projects fail to deliver their estimated benefits and three-quarters of ERP projects fail to succeed. In average, these projects run 178% over budget, take 2.5 times longer than originally estimated, and provide less than 30% of the anticipated benefits (Al-Mashari, 2002). Suraj (2013) stated that the estimated failure rate is 93% due to a poor-quality control system, which is abnormally high.

The right ERP system helps to boost the business and integrate the key business functions of a company (Jamie, 2013). Clare (2007), identifies a few controls that should be set up to keep consultants on task to work for the betterment of client organizations. Researchers looked at 18 factors in 10 different parts of the world, where commitment from the top management, and education & training emerged as the most important factors (Ngai et al. 2008).

There are many reasons for customization like resistance to change, low project acceptance, lack of importance given to the implementers' recommendations, and lack of resistance to customization requests (Rothenberger & Srite., 2009). During the implementation of ERP, there are several parallel roll-out activities, so organizations should ascertain the complexity of the project, align the work with the organizational priorities and ensure strong integration with all modules (Ribbers & Schoo, 2002). Also, the role of a consultant is vital. Consultants should have extensive knowledge of the software to execute projects effectively (Ranjan & Jha, 2018). Ideally, the clients and consultants should agree on a single project implementation strategy for success (Chen, et al., 2009). As well as, consultants should analyze the multiple consequences of failure factors on project outcomes and assess the implications if the failure factors are not mitigated (Zare Ravasan & Mansouri, 2016).

A successful ERP implementation involves two distinct phases - successful implementation and system support. There are a few factors that contribute to both domains, nonetheless (Jiwat, Cprkindale, and Wu 2013). According to Hasibuan and Dantes (2012), system success is measured by five indicators, which include system quality, service quality, information quality, strategic impact, and tactical impact. Success is usually viewed from different perspectives by different stakeholders.

Previous research has focused on the Critical Success Factors (CSFs) that a corporation must have to achieve the system's goals. Because the failure of such an ERP implementation would be a substantial financial, time, and effort loss for the firm, it would also jeopardize the organization's ability to gain a competitive advantage (Elmeziane & Elmeziane, 2012). Therefore, the current research focuses on characteristics that would enable a successful remote ERP implementation procedure based on contingency theory.

Any company undergoing a transformation must focus on several elements that could sabotage the transformation's success. As a result, ERP system implementation would necessitate a lot of criteria to be successful. The current study will use contingency theory to investigate the elements that influencing remote ERP implementation. Even though the theory has been tested in the research on CSFs of ERP implementation, there is a void in the literature on applying the contingency theory as a theoretical lens in detecting the CSFs of remote ERP implementation, which is now in vogue with the Covid-19 pandemic limits.

There are many CSFs that determine the success of an ERP implementation. A successful ERP implementation requires several factors that Shaul and Tauber (2013) list as CSFs, including project management, top management support, data management, sufficient training programs, and system users' support. The authors point out that the team of change managers, along with top management have the ability to manage user resistance (Shaul & Tauber, 2013).

According to the systematic literature review recently carried out by Saade and Nijher (2015), after reviewing 37 different cases with the unique eight-step coding system, it was revealed that there are 22 Critical Success Factors (CSFs) for a successful ERP implementation. Top management support and commitment, minimal customization, organization fit to the ERP, legacy system support, detailed cost, quality management, Business Process Re-engineering, data migration plan, measurable KPIs, small team, communication, base point analysis, morale maintenance, contingent plans, documentation of ERP success, results management, user feedback usage, and maximum potential were among the 22 CSFs identified in this study (Saade & Nijher, 2016).

The literature mentions that among all CSFs for ERP implementation, persistent top management involvement and the top management support at each stage of the ERP implementation is critical (Ranjan & Jha, 2018; Saade & Nijher, 2016).

A successful implementation is achievable only if high-degree executives have a sturdy dedication to the assignment (Gargeya & Brady, 2005). For numerous reasons, top management commitment to the project is critical throughout the implementation life cycle (Somers & Nelson, 2004). One benefit of top management prioritizing the project is a reduction in the time it takes to complete, it increased dedication from people in the organization, as well as management's capacity to provide the necessary resources and a sufficient amount of time to complete the task correctly. Senior management must be dedicated to their involvement in the implementation process and willing to devote precious resources to it. Employees should be informed about the organization's shared vision and the function of the new system and structures. It is necessary to establish and approve new organizational structures, roles, and duties. To develop new systems and techniques in the organization, top management should set policies. Managers should intervene between parties in times of disagreement. Finally, senior management support is not only motivating, but it also aligns the ERP project with the entire business strategy (Akkermans & Van Helden, 2002).

Change management refers to the ability to anticipate and manage changes (Mata, et al., 1995; Wade & Hulland, 2004). Change management has been identified as a CSF in ERP implementation (Elmeziane and Elmeziane, 2012; Al-Turki, 2011; Nour and Mouakket, 2011). Guha et al., 1997, emphasizes the importance of change management, and suggests that it is a prerequisite for achieving sustainable competitive performance.

The relevance of change management is highlighted during the project's initial phases and throughout the project's life cycle (Nah, et al., 2007). As a result, change management is unquestionably a CSF in ERP implementation success, as evidenced by a few previous CSFs in ERP implementation success literature. However, the shift must be carefully handled depending on the culture, institutions, and style of ERP deployment, as suggested in the literature (Saade & Nijher, 2016; Shaul & Tauber, 2013; Nah, et al., 2007).

According to the literature, change management is critical to ERP implementation success regarding empowered team management and adapting implementation strategies for identifying, managing, and training ERP project stakeholders (Dezdar & Ainin, 2011). There is a lack of comprehensive coverage of what change management entails from current literature on change management. A change management perspective encompasses not just altering current

business processes and training users, but also changing the overall culture of the organization. The organization, for example, is receptive to new technologies and support systems (Hwang, et al., 2015).

Communication is also important in management when attempting to reduce opposition to change in any organizational situation (Dezdar & Ainin, 2011). Furthermore, efficient company-wide communication is dependent on cross-functional and interdepartmental cooperation, which assures ERP implementation success (Chen, et al., 2009). According to Motwani, et al. (2005), a company that encourages its employees to participate actively in the workplace is more likely to succeed. A corporation that implements open communication is more successful than one that does not. Furthermore, it was emphasized the necessity of open communication when sharing information about ERP system changes and continuing updates (Motwani, et al., 2005). When deploying an ERP system, cross-functional and interdepartmental cooperation is critical, as is having strong company-wide communication (Chen, et al., 2009). It was claimed that communication is a crucial technique for managers to use when attempting to overcome employee resistance to change (Dezdar & Sulaiman, 2009).

Furthermore, according to a slew of studies, a phased strategy is better for implementation because it allows the organization to make changes in the event of unforeseeable circumstances. As a result, it is also argued that the implementation strategy's flexibility has a significant impact on ERP implementation success (Saini, et al., 2013; Scott & Vessey, 2000). According to Mandal and Gunasekaran (2004), this is the most important CSF for a successful ERP implementation from the perspective of a top manager. Several questions must be answered to create a well-functioning implementation strategy: what are the particular information demands at the operational and management levels, how will the ERP system interact with the existing system, and what is the implementation schedule? By answering these questions, a company can develop a plan that will increase its chances of success by 90% when compared to companies which do not have one (Mandal & Gunasekaran, 2003). Many academics support a phased implementation because it allows the organization to make changes to the timeframe if unexpected occurrences occur (Mandal & Gunasekaran, 2003; Scott & Vessey, 2000; Saini, Nigam, & Misra, 2013). Scott and Vessey (2000), use FoxMeyer and their disastrous SAP R/3 implementation as an example. They claim that FoxMeyer would have had a better chance of success if they had been able to change their implementation technique (Scott & Vessey, 2000).

Several authors stress the significance of thorough testing to avoid as many unexpected events as possible. Testing and creating a plan, according to Gargeya and Brady (2005), is an essential part of the implementation process, and Collett (1999) agrees with Mandal and Gunasekaran (2004), that doing so dramatically increases the chances of success.

According to Somers and Nelson (2004), training and education are essential for establishing an ERP system. A lack of user training and a misunderstanding of the corporate applications appear to be the root of many ERP implementation failures. ERP implementations demand a massive amount of data for people to solve problems that may occur inside the system's architecture. If employees don't understand how the system works, they will develop their own processes by removing bits of the system that they can modify, according to Umble et al. (2003). User training should begin far before the implementation process begins to ensure success (Umble et al., 2003). One of the most important items to consider when planning for a new system is user education and training programs, which, along with other criteria, are necessary ingredients for successful implementation (Mabert et al., 2003).

Executives usually misjudge the level of knowledge and training required to establish an ERP system, as well as the associated costs; thus, top management engagement is crucial, as previously indicated (Zabjek et al., 2009; Sarker & Lee, 2003; Nah et al., 2003; Mabert et al., 2003; Umble et al., 2003). Executives must be able to estimate the amount of training and education required to reap the full benefits of the deployed technology (Motwani et al., 2002; Aladwani, 2001). According to Cobert and Finney (2007), training and education can be used to improve user acceptability of the project and develop a positive employee attitude. Nah et al. (2007) expands on this idea, arguing that education should be a priority from the outset of the project, with both money and time spent on various forms of teaching and training.

As a result, the organization aids system users in comprehending the benefits and necessity of the new ERP system, as well as how the system will alter business procedures (Motiwalla & Thompson, 2012; Somers & Nelson, 2004; Nah et al., 2007). Employees are typically expected to be able to efficiently administer and operate the new system based only on their educational background. However, for a substantial part of the learning process, Umble et al. (2003) emphasizes the need of hands-on experience in real-world circumstances.

Furthermore, it has been argued that user training and education is critical to a successful ERP adoption because training and development will allow for a smooth transition (Noudoostbeni, et al., 2010). Apart from training and development, a strong competent core team of qualified implementation team is essential for the ERP implementation to run smoothly.

This is especially important at the start of the project (Cliffe, 1999).

According to Nah et al. (2001), it is identified that the project management is crucial in ERP implementation projects. The project management approach indicates that project planning and control are related to project factors such as project size, technological experience, and project structure (Somers & Nelson, 2004; Holland & Light, 1999). The responsibility for project management success should be delegated to an individual or group of employees (Nah et al., 2001). After the project team has been properly formed, milestones must be established (Holland & Light, 1999). It comprises assessing the project's critical paths, calculating the timeliness of the project, and managing the force of timely decision-making (Nah et al., 2001). As a result, the project scope should be well-specified, well-defined, and limited. ERP projects are often massive and fundamentally challenging due to the comprehensive mix of hardware and software, as well as the various organizational, human, and political concerns (Somers & Nelson, 2004). When a project scope is too broad or ambitious, problems can occur (Somers & Nelson, 2001).

The impact of project management on ERP deployment has been empirically explored in the past literature, and it has been proven to be one of the CSFs in physical ERP implementation success (Ranjan & Jha, 2018). Apart from the aspects in the literature, the relevance of risk and quality management for any system deployment success is stressed in several IS publications (Saade & Nijher, 2016; Shaul & Tauber, 2013). The reason for this is that the system's overall performance is dependent on the team's ability to maintain data accuracy when converting it to the new system. Furthermore, Business Process Re-engineering (BPR) is mentioned in the literature as a CSF in physical ERP deployment during project management. Customization and BPR are essential at different stages of ERP systems, according to Francoise et al., (2009). Furthermore, BPR entails business alignment with the new ERP system, process adoption, adherence to new process standards, flexibility in business process skills, and job redesign (Dezdar & Sulaiman, 2009).

As a result of the literature analysis, it is clear that numerous elements have been identified as CSFs for physical ERP deployment success. Accordingly, a summarized literature review table is generated based on the literature study, which will serve as the foundation for the derived conceptual framework for identifying the elements that influence the success of remote ERP implementation.

Table 1: Supportive Literature for CSFs

Proposed CSFs	Supportive Literature
Top Management Commitment	Persistent top management involvement (Ranjan & Jha, 2018) Top management support and commitment (Saade&Nijher, 2015) Support of top management (Shaul & Tauber, 2013)
Change Management	Cultural change readiness (Saade & Nijher, 2015) Organizational experience of major change (Shaul & Tauber, 2013) Change management programme (Nah, et al., 2007).
Communication	Open and transparent communication (Saade & Nijher, 2015) Enterprise-wide communication and cooperation (Dezdar & Ainin, 2011) Interdepartmental coordination for excellent communication (Chen, et al., 2009)
Implementation Strategy	Contingency plans (Saade & Nijher, 2015) Implementation strategy (Saini, et al., 2013) Implementation strategy and timeframe (Scott & Vessey, 2000) ERP team composition, competence and compensation (Dezdar& Suleiman, 2009) Balanced team (Finney & Corbett, 2007)
User Training & Education	Education and training (Shaul& Tauber, 2013) User training and education (Noudoostbeni, et al., 2010)
Project Management	Project Management (Ranjan & Jha, 2018) Project tracking (Shaul& Tauber, 2013) Project management and evaluation (Dezdar& Suleiman, 2009) Quality management (Saade&Nijher, 2015) System quality (Dezdar& Suleiman, 2009)

	System testing (Finney & Corbett, 2007) Risk management (Saade&Nijher, 2015) Software analysis, testing and troubleshooting (Dezdar& Suleiman, 2009), software maintenance (Shaul& Tauber, 2013)

a) Theoretical and Conceptual Frameworks

Based on the literature review, the following conceptual framework was derived.

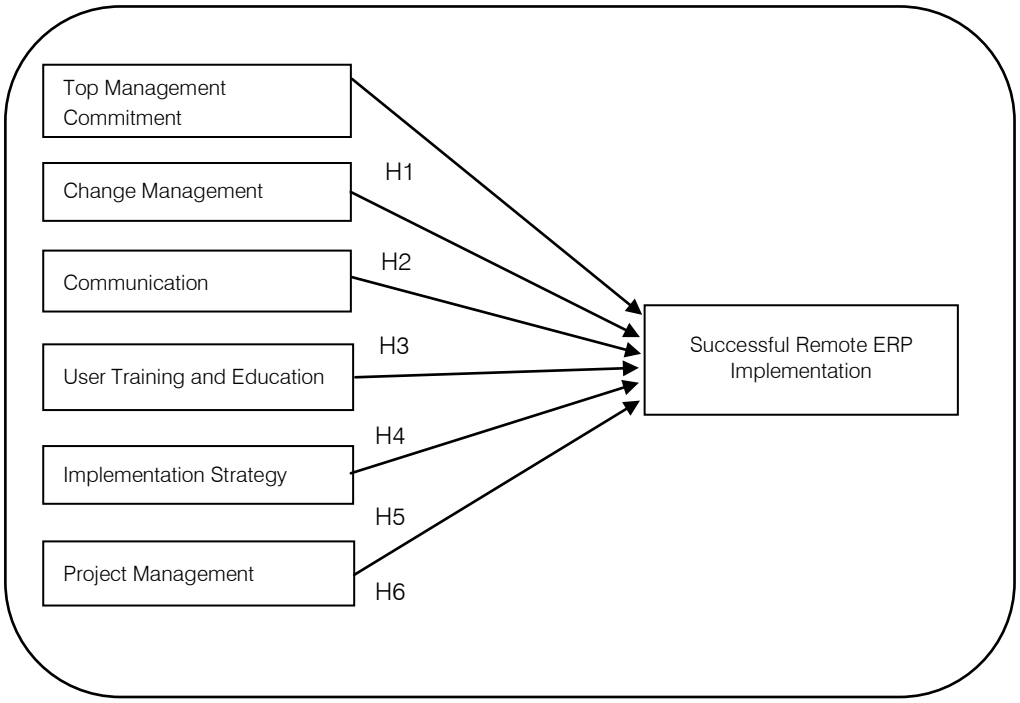


Figure 1: Conceptual Framework

b) Hypotheses

H1: Top Management Commitment is a critical success factor of remote ERP implementation from system users' perspective.

H2: Change Management is a critical success factor of remote ERP implementation from system users' perspective.

H3: Communication is a critical success factor of remote ERP implementation from system users' perspective.

H4: Implementation Strategy is a critical success factor of remote ERP implementation from system users' perspective.

H5: User Training and Education is a critical success factor of remote ERP implementation from system users' perspective.

H6: Project Management is a critical success factor of remote ERP implementation from system users' perspective.

IV. Methodology

The philosophy of research is a system of beliefs and assumptions about how knowledge develops. As discussed by Saunders et al. (2009), a coherent research philosophy is based on well-considered and consistent assumptions. Methodological choices, research questions, data collection techniques, and analysis procedures are based on this. The underlying philosophy of the study needs to be considered when researching since it implies a particular way of viewing the world (Saunders et al., 2009).

Since the purpose of the study was to reveal law like generalizations about phenomena, positivism was the philosophy adopted for this study. Additionally, since the study aimed to examine the Critical Success Factors (CSFs) when implementing an ERP system from a system user perspective, which is a different angle than prior studies, an observational phenomenon was considered as knowledge. During the study, the researchers were detached, neutral, and independent and took an objective stance to yield pure facts and data unaffected by human judgment or opinion.

According to Saunders et al. (2009), the deductive approach usually involves a survey strategy, which was presented in this research study. A deductive approach also emphasizes quantification in the collection and analysis of data (Bryman & Bell, 2011). To

obtain a body of quantitative data connected to two or more variables, as well as their association, survey research entails a cross-sectional design (Bryman & Bell, 2011). With the aid of a survey, the authors were able to categorize and describe the population, and test relationships and assumptions (Jackson, 2015).

Since the primary goal of this study was to establish a correlation between a predictor variable and several response variables, and because it was descriptive and explanatory, data were collected using both a web-based and paper-based questionnaire, which was then used for statistical analysis.

This study adopted a quantitative approach, and in the current research, hypotheses are derived from extensive literature reviews to test the relationships between variables. Users were asked to rate the variables on a Likert scale using a web-based survey. Collected data converted into numerical data, was then further statistically tested using statistical software. As a result of the approach and purpose of this study, a quantitative approach was recommended to answer the research questions and test the hypothesis.

For primary data collection, the survey strategy used in this study included a questionnaire. The current study made use of a self-administered questionnaire for primary data collection. The research used both paper-based responses and online questionnaires to increase the number of responses of system users who are widely dispersed geographically.

As this study makes use of survey research strategies where one needs to draw inferences from a sample of a population to answer the research question, probability sampling was chosen (Saunders et al., 2009).

The current study targeted the system users of ERP systems implemented remotely in Sri Lanka. Since the targeted respondents were a niche group, the chosen respondents were credible since they were the best fit for the intended purpose. The study was aimed the companies in the manufacturing sector where ERP systems have been implemented remotely during the Covid-19 pandemic in Sri Lanka. The population amounted to900 ERP system users of remotely implemented ERP, based on the Krejcie & Morghan (1970), since the population size was 900, the sample size was taken as 269. According to the convenience sampling technique, the sample was selected, and responses were collected both using web-based and paper-based questionnaires. The research extensively made an effort to increase the response rate via e-mails by sending reminders to the respondents and following up the process by reminding them to finish the questionnaire.

To address the initial proposition of the study, the statistical analysis consists of examining, coding, tabulating, or otherwise combining the evidence (Yin, 1989). In this section, we analyze the data collected using questionnaires, using descriptive statistics, Pearson correlation, and multiple linear regression using the statistical package for social scientists (SPSS version 21), and presenting the results as tables and graphs. In terms of the original units of the data, regression analysis measures the average relationship between two or more variables. It shows cause-and-effect relationships between variables. Thus, the current study used multiple regression analysis to determine the type of relationship (positive or negative) that exists between the selected independent variables and the dependent variable - the remote ERP implementation success and whether those independent variables significantly impact on the remote ERP implementation success.

It is necessary to assess the validity and reliability of the measures for the instrument, according to Hair et al. (2003). This study used Cronbach's Alpha to assess the instrument's internal consistency and reliability. Effective research should have a Cronbach's Alpha result of at least 0.7. Thus, while the questionnaire is distributed to 33 first respondents, Cronbach's Alpha result has been checked and found to be above 0.7. This indicates the validity of the research.

Table 2: Cronbach's Alpha Level of Reliability

Cronbach's Alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Source: Based on (Bonett and Wright, 2015)

The scale of reliability of Cronbach's Alpha is shown in Table 2, and there have been various reports of accepted Alpha values above. The most acceptable score Alpha value is above 0.7. Also, a minimal number of questions and poor connections between items or heterogeneous notions could be reasons for a score below 0.7.

Table 3: Reliability Analysis of Variables in Pilot Survey

Variable	Cronbach Alpha	No of Items
Top Management Commitment	.852	3
Change Management	.961	3
Communication	.923	3
User Training and Education	.827	3
Implementation Strategy	.863	3
Project Management	.907	3
ERP Implementation Success	.876	4
Overall Value	.958	22

Source: Author's developed based on SPSS results

When all the questions in the Top Management Commitment variable were added together, Cronbach's Alpha value was .852, in the data set, it is generated as a good score. The Change Management variable has a good Cronbach Alpha rating of .961, it can be an excellent score for that data set. The Communication variable also got a .923 score for all their items. The Cronbach Alpha value for that data set is very high. The User Training and Education variable has a good Cronbach Alpha rating of .827, which means it can be taken as a good score for that data set. The Cronbach's Alpha value was .863 for the Implementation Strategy in the data set, it also generated a good score. The Project Management variable got a .907 score for all items, it means the Cronbach Alpha value for that data set is high. ERP implementation success is the dependent variable in the data set. It achieved a score of .952 among its four items. When identifying overall reliability, the data set achieved a score of .958, it was an excellent Cronbach Alpha value.

Bryman and Bell (2003) define validity as the degree to which any measuring instrument measures what it claims to measure. In this regard, different theories and empirical studies have been analyzed to ensure their validity in the literature survey. According to Stapleton (1997), an approach to discovering the number and nature of the variables which underpin a huge number of variables or metrics is factor analysis. It instructs the researcher on which tests or measurements should be used jointly. When a test user needs to have an implication from the test results to acts that may be categorized under a specific psychological construct, construct validity is investigated. According to Hair et al. (1998), the minimum communality value is 0.4 and the current study has a value of 0.570. The Cronbach's Alpha value of this study in diverse between 0.96 and 0.82. All the independent variables and dependents acquire a Cronbach's Alpha value which is higher than 0.7, as stated by Hair et al. (1998). The Kaiser–Meyer–Olkin measure (KMO = 0.721) confirmed the analysis's sampling adequacy (Field 2009). All individual items' KMO values were more significant than 0.7.

Table 4: KMO Values for Individual Items

Variable	Kaiser-Meyer-Olkin (KMO)
Top Management Commitment	.721
Change Management	.874
Communication	.832
User Training and Education	.756
Implementation Strategy	.811
Project Management	.830
ERP Implementation Success	.743

Source: Author developed based on SPSS results

The validity of the study is established if the research tool evaluates what it claims to quantify (Field, 2009). According to Hair et al. (1998), if the cut-off level of KMO is 0.7, and all the variables exceeded that value, then instrument is valid.

V. Results and Analysis

This section indicates the facts to which extent the identified factors are impacting onremote ERP implementation success and what are the critical factors that has the highest impact on remote ERP implementation success.

a) Demographic Characteristics

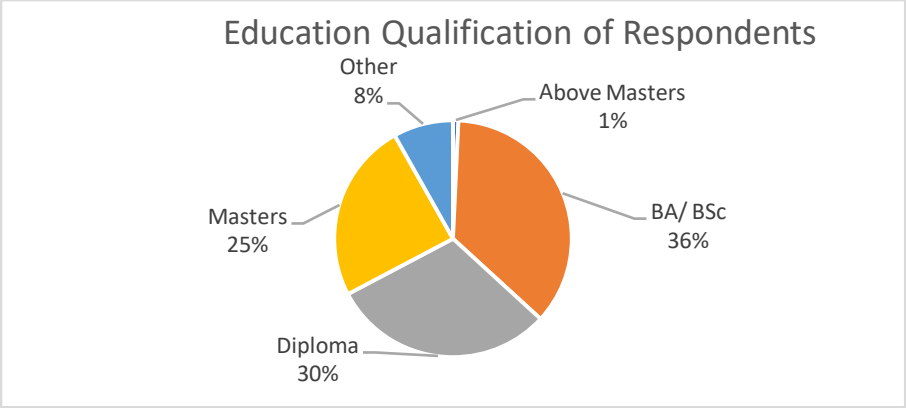


Figure 2: Education Qualifications

As Figure 2 shows most of the sample consisted of system users who had a first degree (BA or BSc) which was a 36% representation of the sample. Only 1% of the sample had the qualification above master's degree, which was the minimum representation of the sample.

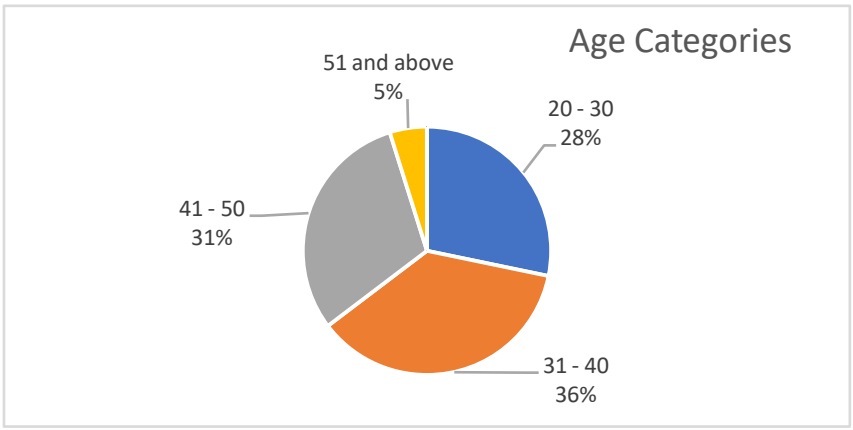


Figure 3: Age Categories

The sample included 36% of the system users in the age range of 31-40 years, which represented the highest representation, while only 5% of the system users were above 51 years. 32% of the respondents had the experience of 5-10 years, and there have been 23% of the respondents who had experience of only 5 years or below.

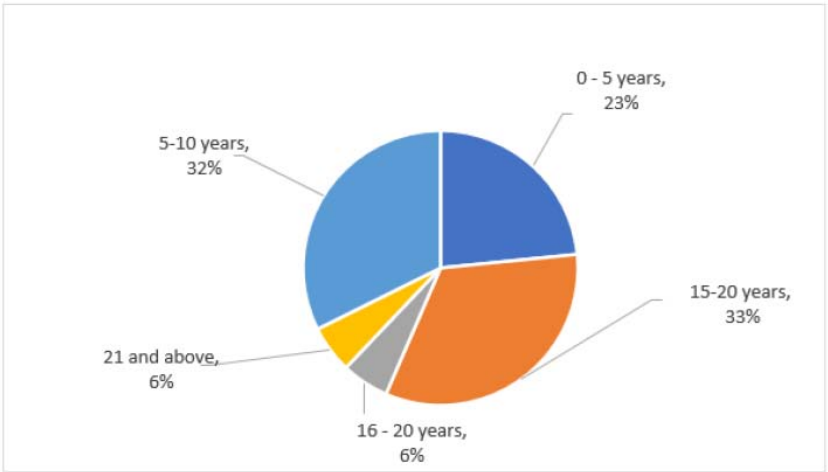


Figure 4: Experience in Years

b) Relationship between each Factor and Remote ERP Implementation Success

The output generated precisely to discuss the relationship between the identified independent variables and remote ERP implementation success, and the impact of each factor on the remote ERP implementation success in the Sri Lankan context. Illustrating it through descriptive statistics, scatter plots were drawn for each control variable (Ursachi et al. 2015) with response variable being remote ERP implementation success (y) to explode on the nature of the relationship that may exist between identified factors and remote ERP implementation success. The scatter plot is one of the most effective tools for data analysis (sometimes also called x y diagrams) as well as the most common method for displaying multidimensional data to identify the direction of the relationship between two attributes and clusters of points (Keim et al., 2010).

Depicting the result obtained using scatter diagrams, the data in all six diagrams of Top Management Commitment, Change Management, Communication, User Training and Education, Implementation Strategy, and Project Management in relation to the remote ERP implementation success showed an upward trend from left to right, demonstrating a positive linear relationship between them and remote ERP implementation success.

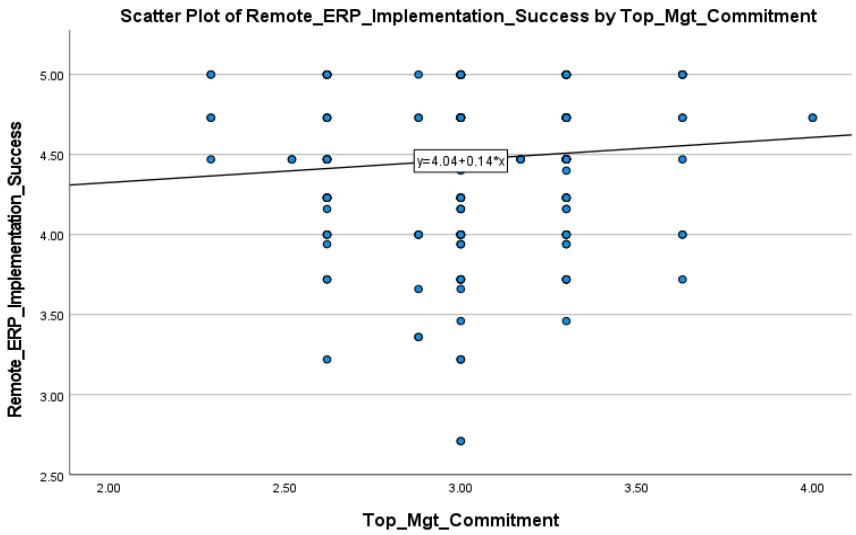


Figure 5: Scatter Plot for Top Management Commitment and Remote ERP Implementation Success

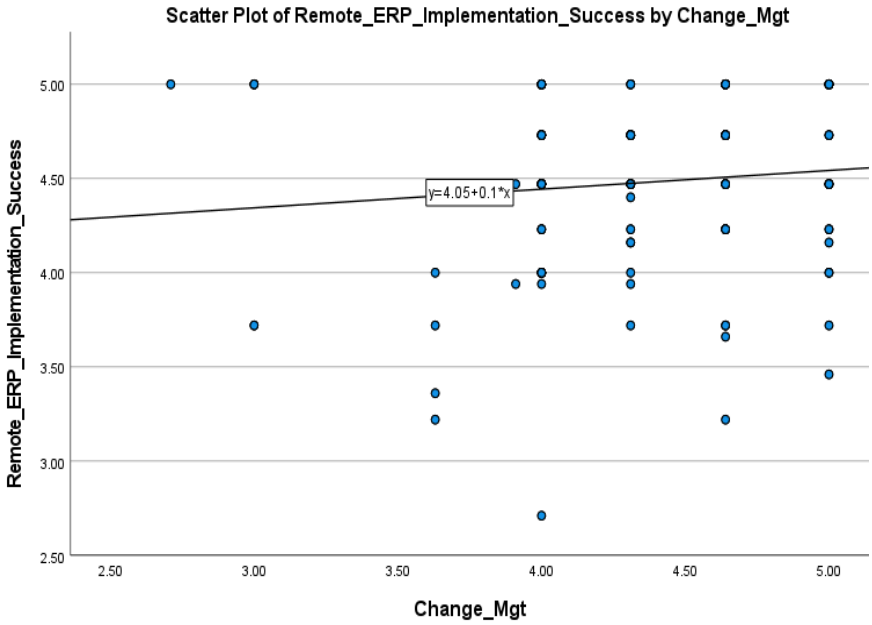


Figure 6: Scatter Plot for Change Management and Remote ERP Implementation Success

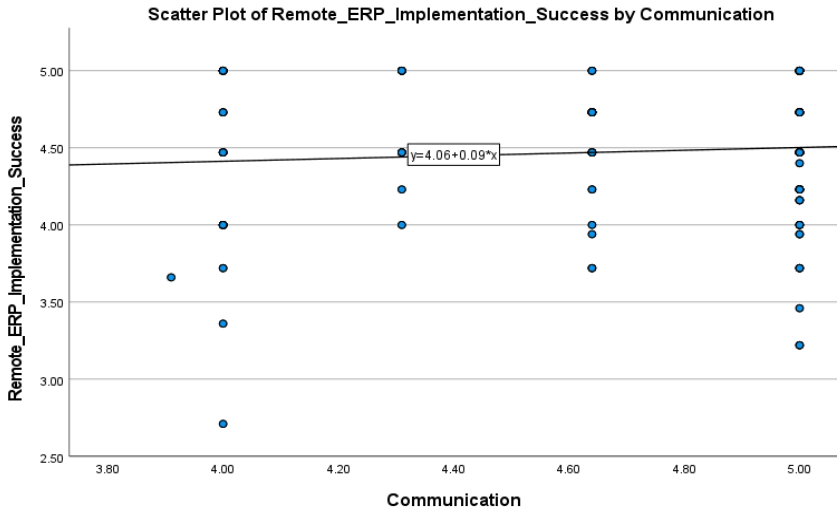


Figure 7: Scatter Plot for Communication and Remote ERP Implementation Success

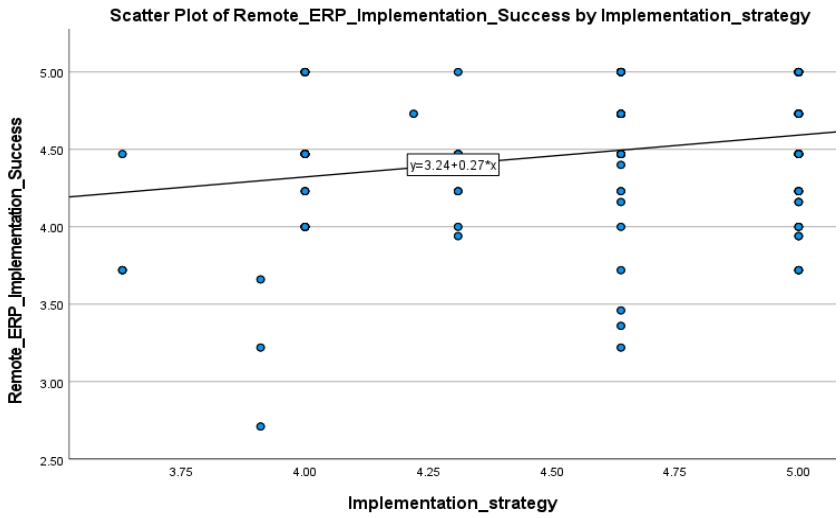


Figure 8: Scatter Plot for Implementation Strategy and Remote ERP Implementation Success

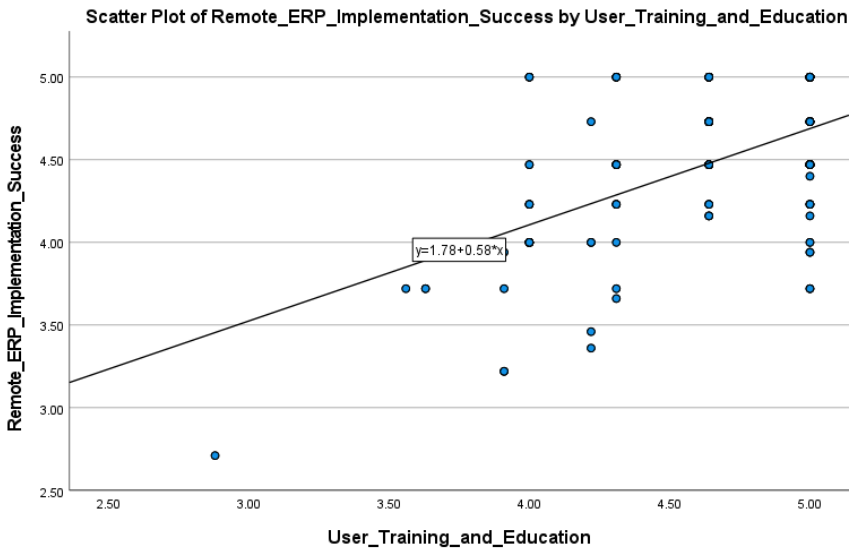


Figure 9: Scatter Plot for User Training and Education and Remote ERP Implementation Success

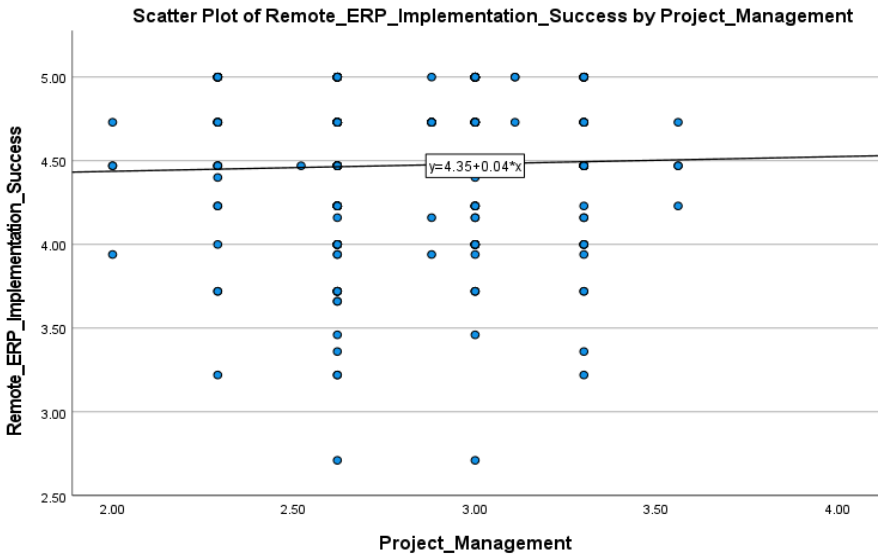


Figure 10: Scatter Plot for Project Management and Remote ERP Implementation Success

To further ascertain on positive relationship visible through scatter diagrams, the study accommodated an inferential statistic tool. Accordingly, the Pearson correlational test was performed using the sample size n = 269 to affirm on positive relationship and further enrich the analysis by indicating the magnitude/strength of the identified relationship between identified factors and remote ERP implementation success.

Pearson correlation coefficients can be positive or negative (direction), and their magnitude might be high or low. Correlation coefficients range from -1 to +1, indicating perfect negative to positive correlation coefficients, and 0 indicating no correlation (zero relationships) (Sedgwick, 2012). Further, correlation coefficients less than 0.30 (negative or positive), between 0.30 – 0.6, and above 0.6 indicate a weak, moderate, and strong relationship between control and response variable (Akoglu, 2018).

Table 5: Pearson Correlation Test Results

		Remote ERP Implementation Success
Remote ERP Implementation Success	Correlation Coefficient Sig. (2-tailed) N	1.000 269
Top Management Commitment	Correlation Coefficient Sig. (2-tailed) N	0.087 .157 269
Change Management	Correlation Coefficient Sig. (2-tailed) N	0.107 .080 269
Communication	Correlation Coefficient Sig. (2-tailed) N	0.542** .000 269
Implementation Strategy	Correlation Coefficient Sig. (2-tailed) N	0.249** .000 269
User Training and Education	Correlation Coefficient Sig. (2-tailed) N	0.878** .000 269
Project Management	Correlation Coefficient Sig. (2-tailed) N	0.031 .607 269

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Authors' Representation Based on SPSS Results

According to the results derived in Table 5 based on the Pearson correlational analysis, it was found that, the User Training and Education, Communication, and Implementation Strategy factors seem to have a statistically significant correlation with the remote ERP implementation success (Sig. (2-tailed) < 0.05). Among these three factors, User Training and Education has the strongest positive correlation (r=0.878) with remote ERP implementation success, while a moderate correlation is witnessed between Communication (r=0.542) and remote ERP implementation success, and a weak positive correlation is witnessed between Implementation Strategy (r = 0.249) and remote ERP implementation success. Although Top Management Commitment, Change Management, and Project Management seem to have positive correlations with remote ERP implementation success, they are not statistically significant, since the Sig. (2-tailed) has been greater than 0.05.

c) Multiple Linear Regression Analysis

According to the previous section, it was identified that a positive relationship exists between all the six independent variables and remote ERP implementation success. This section proceeds with a deeper investigation based on assessing the impact of the identified factors that ensure remote ERP implementation success. For this, the study accommodated the multiple linear regression model.

First, the data were analyzed to check on the convenience for regression analysis. Accordingly, the assumptions of normality, linearity, and absence of collinearity were tested as prerequisites for a multiple regression analysis. With reference to (Pallant, 2001), there are a few main identified assumptions to be tested for a multiple regression which include,

1. The required sample size for a regression test
2. No multicollinearity between independent variables
3. Normality distribution of data set and test for outliers
4. Linearity between independent and dependent variables
5. Homoscedasticity of independent variables

Assumption 01: The Required Sample Size for a Regression Test

As cited in (Pallant, 2001), it is recommended for social research to have at least 15 subjects per predictor for a valid regression test. The ideal sample size for a regression can also be calculated using the following formula: n> 50 + 8m (m = number of independent variables) (Pallant, 2001). Accordingly, the study consists of 6 main independent variables with primary data collected from 269 ERP system users. When outliers are comprised in a data set common, those data points should be removed (Osborne and Overbay, 2004). However, no outliers nor missing values were spotted in the data set, and therefore, 269 responses were used for a regression analysis.

Assumption 02: Multicollinearity Test of Predictor Variables

The collinearity diagnostics confirm whether there is a serious problem with multicollinearity. Condition Index Values greater than 15 indicate a possible problem with collinearity; greater than 30, a serious problem. A tolerance value < 0.10 suggests a concern with (multi) collinearity. VIF is simply the tolerance's reciprocal value. As a result, VIF values > 10 suggest concerns with collinearity. The results of these analyzes are presented in Table 6. It could therefore be seen that the tolerance levels are > .10 and VIF values are < 10 for all independent variables.

Table 6: Multicollinearity Test Based on Tolerance and VIF Value

(Constant)	Tolerance	VIF
Top Management Commitment	0.978	1.023
Change Management	0.859	1.164
Communication	0.672	1.488
User Training and Education	0.700	1.429
Implementation Strategy	0.700	1.429
Project Management	0.978	1.023

Source: Authors' Representation Based on SPSS Results

The study also revealed a safer facet in its Condition Index (CI) values as shown in Table 7. All independent variables had a CI < 15, which thereby indicates that the predictor variables are free from multicollinearity.

Table 7: Multicollinearity Test Based on Condition Index Value

Dimension	Eigen value	Condition Index	Variance Proportions						
			(Constant)	Top_Mgt_Commitment	Change_Mgt	Communication	Implementation_strategy	User training and education	Project_Management
1	6.956	1.000	.00	.00	.00	.00	.00	.00	.00
2	.015	21.406	.00	.04	.13	.01	.03	.01	.49
3	.009	27.210	.00	.18	.59	.02	.01	.03	.22
4	.008	28.751	.00	.47	.17	.08	.01	.11	.11
5	.005	38.219	.00	.02	.06	.00	.78	.38	.03
6	.004	43.304	.01	.00	.00	.77	.15	.45	.02
7	.002	56.772	.98	.29	.05	.12	.02	.01	.14

Source: Authors' Representation Based on SPSS Results

Assumption 03: Normality Distribution of Data Set and Test for Outliers

Reponses for the survey instrument were collected from 269 respondents, which is a relatively large sample, and hence the Central Limit Theorem could be applied, posing no question on normality. Descriptive statistics relevant to normal distribution are shown in Table 8, with values of 4.47, 4.47, and 4.47 indicated as the mean, mode, and median of the dataset respectively.

Table 8: Test of Normality Based on Descriptive Statistics of Dataset

Remote ERP Implementation Success	
Mean	4.474281
Standard Error	0.02771
Median	4.472136
Mode	4.472136
Standard Deviation	0.454478
Sample Variance	0.20655
Kurtosis	1.093872
Skewness	-0.96841
Range	2.289194
Minimum	2.710806
Maximum	5
Sum	1203.582
Count	269

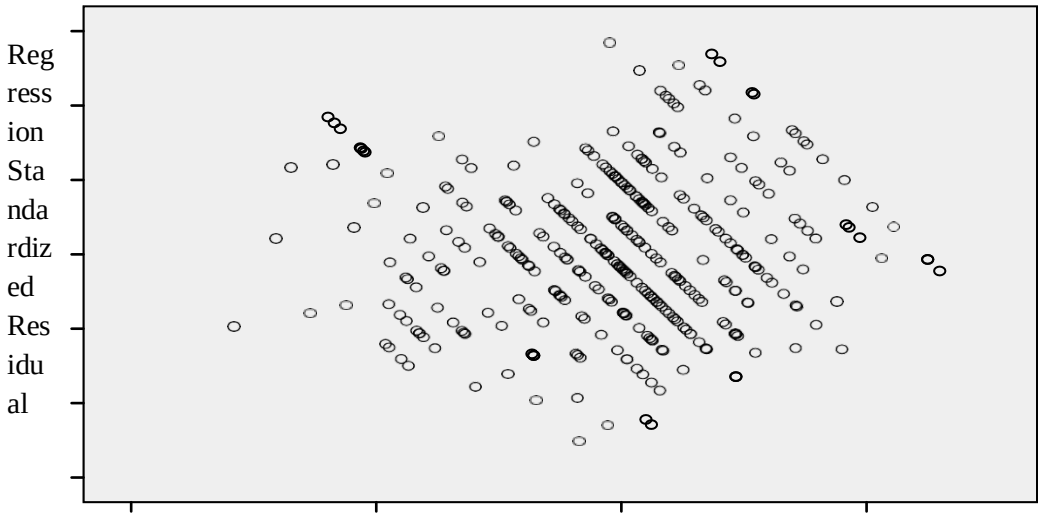
Source: Authors' Representation Based on SPSS Results

Assumption 04: Linearity between Independent and Dependent Variables

The link between dependent and independent variables can only be effectively estimated using standard multiple regression if the relationships are linear (Pallant, 2001). The findings of the regression analysis will underestimate the true relationship if the relationship between the independent factors and the dependent variable is not linear. As tested previously, both descriptively and inferentially using scatter diagrams and Pearson correlation coefficient, it was assured that a linear relationship exists between identified six factors and remote ERP implementation success, which thereby poses no concerns on linearity between variables.

Assumption 05: Homoscedasticity of Independent Variables

The variance of errors is the same across all levels of the independent variables, known as homoscedasticity. A visual study of a plot of the standardized residuals (errors) by the regression standardized projected value can verify this assumption (Jarque and Bera, 1980). In an ideal world, residuals are randomly spread around 0 (the horizontal line), resulting in a relatively uniform distribution that meets the homoscedasticity assumption.



Source: Authors' Representation Based on SPSS Results

Figure 11: Homoscedasticity of Independent and Dependent Variables

Accordingly, with data analyzed to test its viability for regression analysis, all assumptions were successfully cleared, and a multiple linear regression test was done as the next step to explore on the impact of six identified factors towards remote ERP implementation success.

Regression analysis is a mathematical measure that is used to determine the average relationship between two or more than two variables with the use of the data set. The cause-and-effect relationship between independent and dependent variables is indicated through regression analysis. The following Table 9 represents the results received after running multiple linear regression analysis based on the collected data set.

Table 9: Regression Results

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.599[a]	.359	.345	.36840

ANOVA*						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.940	6	3.323	24.487	.001[b]
	Residual	35.558	262	.136		
	Total	55.498	268			

a. Dependent Variable: Remote ERP Implementation Success
b. Predictors: (Constant), Project Mangement, Communication, Top Management Commitment, Change Management, Implementation strategy, User Training and Education

In the process of model estimation, it is common to evaluate the appropriateness of a single descriptive model based on the coefficient determination (R2). R2 serves as a fast and easy way to measure the goodness of fit of an estimated model in empirical studies (Saunders, et al., 2009). Although R2 is a good indicator, it is not absolute. It is simply a measure of explained variance relative to the total variance in the dependent variable (Saunders, et al., 2009). The current study focuses on the system users' perspective on remote ERP implementation success. The results of the regression analysis show that a 34.5% variance of remote ERP implementation success is caused due to the independent variables Top Management Commitment, Change Management, User Training and Education, Project Management, Communication, and Implementation Strategy. However, looking at the ANOVA table based on the derived results, since; $F(6, 262) = 24.487$, $p<0.001$, $R2=34.5\%$, it indicates that the derived regression model is significant to predict the ERP implementation success. However, in the derived regression model,

since R2 = 34.5%, there could be some other factors that significantly impact on remote ERP implementation success apart from the considered six factors Top Management Commitment, Change Management, User Training and Education, Project Management, Communication, and Implementation Strategy.

Table 10: Regression Results

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.995	.442		4.513	**.001**
	Top Management Commitment	.077	.081	.047	.945	.346
	Change Management	.018	.050	-.019	-.358	.721
	Communication	.342	.069	-.298	-4.946	**.001**
	Implementation Strategy	.139	.064	.128	2.163	**.001**
	User Training and Education	.691	.064	.643	10.871	**.001**
	Project Management	.031	.070	.022	.444	.658
a. Dependent Variable: Remote ERP system implementation success						

Table 10 illustrates the impact of each independent variable (Top Management Commitment, Change Management, User Training and Education, Project Management, Communication, and Implementation Strategy) on the dependent variable, which is remote ERP system implementation success. For all the independent variables, beta values derived were positive, which determined that with each of the considered independent variable there has been a positive correlation with the dependent variable remote ERP implementation success. However, looking at the significant values in addition to the constant, the other independent variables that have a significant impact on remote ERP system implementation success have been, User Training and Education (Sig. val = 0.001), Communication (Sig. val = 0.001), and Implementation Strategy (Sig. val = <0.001). Further, the results show that, 1% change in the User Training and Education, Communication, and Implementation Strategy; would increase the remote ERP implementation success by 69.1%, 34.2%, and 13.9% respectively. However, looking at the results, since the significance level of Top Management Commitment, Change Management, and Project Management has been greater than 0.05, although each of these factors have a positive correlation with the dependent variable - remote ERP implementation success, they were not found to be having a significant impact on remote ERP implementation success.

d) Hypotheses Testing

H1: Top Management Commitment is a critical success factor in remote ERP implementation from system users' perspective - Rejected since (B= .077, Sig. = 0.346).

Based on the regression results (refer to table 10), although Top Management Commitment is positively correlated with remote the ERP implementation, Top Management Commitment was found not to be significantly impact on the remote ERP implementation success. Thus, Hypothesis 1 is rejected.

This finding is different from what has been stated in the previous literature where it was mentioned that Top Management Commitment is a critical factor for ERP implementation success in a physical setting. However, since the setting was remote ERP implementation, the finding differed drastically from the previous literature.

Previous literature mentions that in a physical setting, successful ERP implementation is achievable only if high-level executives have a sturdy dedication to the assignment (Gargeya & Brady, 2005). For numerous reasons, top management commitment to the project is critical throughout the implementation life cycle (Somers & Nelson, 2004). According to the literature, among all the CSFs for ERP implementation, senior management engagement and support at each step of the ERP implementation are crucial (Ranjan & Jha, 2018; Saade & Nijher, 2016). Therefore, the rejection of H1 will undoubtedly lead to an argument and would be recommended for future research for further digging deeper to understand the root cause for the result through a qualitative approach.

H2: Change Management is a critical success factor in remote ERP implementation from system users' perspective - Rejected since (B= .018, Sig. = 0.721).

Based on the regression results (refer to table 10), although Change Management is positively correlated with the remote ERP implementation, Change Management was found not to be significantly impacting on the remote ERP implementation success. Thus, Hypothesis 2 is rejected.

The relevance of change management, on the other hand, is highlighted from the project's initial phase and during its whole life cycle (Nah, et al., 2007). Further, the literature mentions change management as a critical factor to ERP implementation success regarding empowered team management and adapting implementation strategies for identifying, managing, and training ERP project stakeholders (Dezdar & Ainin, 2011). Thus, the findings of the current study, questions

whether Change Management is a critical success factor, especially for ERP implementation success in a remote setting since the H2 is rejected statistically.

H3: Communication is a critical success factor in remote ERP implementation from system users' perspective - Accepted since (B= .691, Sig. = 0.001).

Based on the regression results (refer to table 10), Communication is positively correlated with the remote ERP implementation, and Communication was found to be significantly impacting on the remote ERP implementation success. Thus, Hypothesis 3 is accepted.

According to Motwani et al. (2005), a company that encourages its employees to participate actively in the workplace is more likely to succeed. A corporation that implements open communication is more successful than one that does not. The current study findings are on par with the previous literature. The findings suggest that in a remote ERP implementation setting, communication is a critical success factor. Further, the findings exaggerate the statement where it was claimed that communication is a crucial technique for managers to use when attempting to overcome employee resistance to change (Dezdar & Sulaiman, 2009).

H4: Implementation Strategy is a critical success factor in remote ERP implementation from system users' perspective - Accepted since (B= .139, Sig. = 0.001).

Based on the regression results (refer to table 10), Implementation Strategy is positively correlated with the remote ERP implementation, and Implementation Strategy was found to be significantly impacting on the remote ERP implementation success. Thus, Hypothesis 4 is accepted.

According to Mandal and Gunasekaran (2004), implementation strategy is the most important CSF for a successful ERP implementation. Several questions must be answered to create a well-functioning implementation strategy: what is the unique information demands at the operational and management levels, how will the ERP system interact with the existing system, and what is the implementation schedule and methodology? By answering these questions, a business can develop a plan that will increase its chances of success by 90% when compared to businesses who do not have one (Mandal & Gunasekaran, 2003). The current study finding also is on par with this literature and suggests that even in a remote ERP implementation setting, Implementation Strategy remains as a critical factor that would aid in ERP implementation success.

H5: User Training and Education is a critical success factor in remote ERP implementation from system users' perspective - Accepted since (B= .691, Sig. = 0.001).

Based on the regression results, User Training and Education is positively correlated with the remote ERP implementation, and User Training and Education was found to be significantly impacting on the remote ERP implementation success. Thus, Hypothesis 5 is accepted.

According to Somers and Nelson (2004), training and education is critical for deploying an ERP system. Further, in previous literature, it is also mentioned that to ensure that system user training is successful, it should begin well before the implementation process begins (Umble et al., 2003). Moreover, when planning for a new system, one of the most significant aspects to consider is education and training programs, which, along with other factors, are essential ingredients for successful implementation (Mabert et al., 2003). Thus, the findings of the current study are in par with this literature which suggest that may it be an ERP implementation that is done by the project team being physically present on the site or an ERP implementation that is done remotely, for both the situations User Training and Education is a critical success factor.

H6: Project Management is a critical success factor in remote ERP implementation from system users' perspective - Rejected since (B= .031, Sig. = 0.658).

Based on the regression results, although Project Management is positively correlated with the remote ERP implementation, Project Management was found not to be significantly impact the remote ERP implementation success. Thus, Hypothesis 6 is rejected.

However, past literature has empirically examined the impact of project management for ERP implementation in a physical setting and proved to be one CSFs in physical ERP implementation success (Ranjan & Jha, 2018), and according to Nah et al. (2001), good project management is stated to be critical in ERP adoption projects. Although the stated previous literature discusses project management to be a critical success factor, the current study findings do not indicate Project Management to be a CSF in remote ERP implementation. This could be because the current study is conducted focusing on the system users' perspective.

VI. Discussion and Conclusion

The main objective of the current study was to identify critical success factors of remote ERP implementation from system users' perspective. The study adopted a quantitative approach using self-administered questionnaires distributed to system users who have the experience of using remotely implemented ERP systems. The study considered 269 responses collected through web-based and paper-based surveys, and both descriptive and inferential statistics were used to analyze using SPSS version 21 software, and interpretations were done accordingly.

Based on the demographic characteristics, it was found that 35% of responded system users are in

the age range of 31-40 years. This was the highest representation of the sample, while the least representation was from the age category above 51 years which was 5%. Further, the sample consisted of respondents who had a first degree (BA or BSc) which was 36% representation of the sample, while only 1% of the sample had the qualification above master's degree which was the minimum representation of the sample.

The study identified that out of Top Management Commitment, Change Management, Communication, User Training and Education, Implementation Strategy, and Project Management, only User Training and Education, Implementation Strategy, and Communication were found to be the critical success factors for the successful remote ERP implementation. Based on the multiple regression analysis, it was found that, although all the considered independent variables had positive correlations with the dependent variable, which is remote ERP implementation success, it was found that only User Training and Education, Implementation strategy, and Communication were statistically significant with remote ERP implementation success. Majority of the ERP system users believe that User Training and Education is the most important factor which ensure the success in remote ERP implementation setting, where the project is conducted without the physical presence of ERP consultants at the customer site.

Table 11: Findings related to hypotheses

Hypothesis	Regression Coefficient	Significant Value	Result
H1: Top Management Commitment is a critical success factor in remote ERP implementation from system users' perspective	.077	.346	Rejected
H2: Change Management is a critical success factor in remote ERP implementation from system users' perspective	.018	.721	Rejected
H3: Communication is a critical success factor in remote ERP implementation from system users' perspective	.342	.001	Accepted
H4: Implementation Strategy is a critical success factor in remote ERP implementation from system users' perspective	.139	.001	Accepted
H5: User Training and Education is a critical success factor in remote ERP implementation from system users' perspective	.691	.001	Accepted
H6: Project Management is a critical success factor in remote ERP implementation from system users' perspective	.031	.658	Rejected

Although the findings in the previous literature where it was mentioned that Top Management Commitment is a critical factor for ERP implementation success in a physical setting where ERP consultants and ERP system users work together with physical meetups, in the current study, it was found that Top Management Commitment cannot be considered to be a critical success factor in remote ERP implementation from system users' perspective where most of the implementation project activities are conducted in online. However, since the current study was aiming on remote ERP implementation success, the finding was drastically different from the previous literature, which had focused on the dependent variable of ERP implementation success where the project team was physically present in the customer site during the implementation project life cycle.

Previous literature mentions that in a physical setting, successful ERP implementation is achievable only when high-degree executives have a sturdy dedication to the assignment (Gargeya & Brady, 2005). For numerous reasons, top management commitment to the project is critical throughout the implementation life cycle (Somers & Nelson, 2004). The literature mentions that among all the CSFs for ERP implementation, persistent top management involvement and the top management support at each stage of the ERP implementation is critical (Ranjan & Jha, 2018; Saade & Nijher, 2016). Considering remote ERP implementation setup and traditional ERP implementation with the physical presence of the ERP project team, top management involvement is evident as representatives from the ERP software company will be mostly at the customer site for meetings and other activities, then top management of the customer company interact more with ERP consultants and having more formal and informal discussions with them. Also, top management had to play a vital role in resource allocation for project activities and coordinating projects as they are present throughout the exercise. The rejection of H1 will undoubtedly lead to an argument and would be recommended for future research for further digging deeper to understand the root cause for the result through a qualitative approach.

Although, Nah, et al. (2007) highlights the importance of change management during the initiation of the project phase and through its entire life cycle, the current study findings reject hypothesis 2, which states that Change Management is a critical success factor in remote ERP implementation from a system users' perspective. However, the literature mentions change management as a critical factor to ERP implementation success regarding empowered team management and adapting implementation strategies for identifying,

managing, and training ERP project stakeholders (Dezdar & Ainin, 2011). With the Covid-19 new normal and after adapting to work from home and aligning with online work activities, Change Management has been more familiarized with employees. Therefore, Change Management has become a necessity for managing their operational activities. Thus, the findings of the current study, doubts whether Change Management is a critical success factor especially for ERP implementation success in a remote setting, since the H2 is rejected statistically.

According to Motwani et al. (2005), a company that encourages its employees to participate actively in the workplace is more likely to succeed. In par with the study findings, the current study accepts the H3 which indicates that Communication is a critical success factor in remote ERP implementation from system users' perspective. The finding further emphasizes, a corporation that implements open communication is more successful than one that does not. Further, the findings exaggerate the statement where it was claimed that communication is a crucial technique for managers to use when attempting to overcome employee resistance to change (Dezdar & Sulaiman, 2009).

Mandal and Gunasekaran (2004) stated that implementation strategy is the most critical CSF for successful ERP adoption. The current study findings are also on par with Mandal and Gunasekaran (2004), since hypothesis 4 is accepted, which states that the Implementation Strategy is a critical success factor in remote ERP implementation from the system users' perspective. It is identified that having a proper implementation strategy is important to an ERP implementation as it helps to complete the project successfully. Considering the Implementation Strategy, it can be decided how the implementation activities need to be planned, whether the project will be conducted as phase-wise or in a big bang approach, deciding exact project milestones in each phase provides more smooth resource allocation and smooth transitioning into the business process. Also, before moving into project implementation, providing prototypes enhances the reliability and effectiveness of the ERP system.

User training and education, according to Somers and Nelson (2004), are critical for deploying an ERP system. Further, in previous literature, it is also mentioned that to ensure that system user training is successful, it should begin well before the implementation process begins (Umble et al., 2003). Thus, the current study findings are also on par with the stated previous study findings since hypothesis 5 is accepted, which indicates that User Training and Education is a critical success factor in remote ERP implementation from system users' perspective. Moreover, when planning for a new system, one of the most significant aspects to consider is education and training programs, which, along with other factors, are essential ingredients for successful implementation (Mabert et al., 2003). User Training and Education is a critical factor that ensures ERP implementation success, whether ERP implementation is conducted while the project team being physically present at the customer site or ERP implementation that is completely done remotely. After having proper training and education, system users will be more familiarized with the ERP system and will have the capability to continue their business operations through the ERP system effectively with minimum supervision since ERP consultants will not be available at the customer site even after the project Go-Live.

Previous literature has empirically examined the impact of project management on ERP implementation in a physical setting and proved to be one CSF in physical ERP implementation success (Ranjan & Jha, 2018), and according to Nah et al. (2001), good project management is stated to be critical in ERP adoption projects. Although the stated previous literature discusses project management to be a critical success factor, the current study findings reject hypothesis 6, which indicates that Project Management is a CSF in remote ERP implementation. The deviation of the current study findings from the previous literature might be because, system user cannot see the presence of the project team, including the project manager and ERP consultants, in the customer site as usual in a typical ERP implementation setting, which might have been the main reason for the differences in perspectives.

The current study was focused on the Sri Lankan setting due to budgetary and time constraints. Further, the study considered only 269 system users in the sample representing the manufacturing sector. However, increasing the sample size and taking sample from different sectors would have increased the generalization ability of the findings of the current study to the Sri Lankan context. Also, since the current study adopted the positivism philosophy having followed the quantitative approach, the current study could not identify new avenues or drastically new factors which would have impacted the remote ERP implementation success from users' perspective that is not stated in the previous literature which was mainly focusing the ERP implementation success on the physical presence setting.

The current study findings would aid in deploying remote ERP system implementation successfully and would help the companies to reduce the cycle time taken for making the decisions which would increase performance efficiencies. Based on the present study, User Training and Education, Communication, and Implementation Strategy are the critical success factors which contribute significantly to remote ERP implementation success. Finally, although Top Management Commitment, Change Management,

and Project Management are positively correlated with remote ERP implementation success, those factors are not considered to be significantly contributing to remote ERP implementation success based on the system users' perspective.

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Applications of Emerging Smart Technologies in Farming Systems: A Review

By Vipin Kumar Choudhary

Abstract- The future of farming systems depends mainly on adopting innovative, intelligent, and smart technologies. The agricultural sector's growth and progress are more critical to human survival than any other industry. Extensive multidisciplinary research is happening worldwide for adopting intelligent technologies in farming systems. Nevertheless, when it comes to handling realistic challenges in making autonomous decisions and predictive solutions in farming, applications of Information & Communications Technologies (ICT) need to be utilized more. Information derived from data worked best on year-to-year outcomes, disease risk, market patterns, prices, or customer needs and ultimately facilitated farmers in decision-making to increase crop and livestock production. Innovative technologies allow the analysis and correlation of information on seed quality, soil types, infestation agents, weather conditions, etc. This review analysis highlights the concept, methods, and applications of various futuristic cognitive innovative technologies along with their critical roles played in different aspects of farming systems like Artificial Intelligence (AI), IoT, Neural Networks, utilization of unmanned vehicles (UAV), Big data analytics, Blok chain technology etc.

Keywords: *agriculture, artificial intelligence, farming systems, neural networks, smart technologies.*

GJCST-G Classification: *DDC: 630*

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I. Introduction

Crop cultivation is really a challenging task since ancient time. However, some aspects of it require more attention than others. Therefore, farmers have urged intervention of smart technologies since long back to help them address their numerous challenges, such as a lack of quality seeds, affordable fertilizers, manure, a lack of modern Agri-based equipment/machinery, fragmented small land holdings, insufficient irrigation sources, and dominating regional traders.

However, with emerging Information and Communication Technology (ICT) seamlessly integrating advanced technologies into the traditional farming ecosystem, most of these issues can now be resolved efficiently.

ICT (Information and Communication Technology) is a collective term that incorporates many communications equipment or applications, cell phone, drone, sensors, cloud services, IoT, radio broadcasting, television, desktop, internet backbone hardware and software, communications satellites, and so on (Fig.1). Innovative, intelligent technologies and practices are transforming agriculture a profitable industry.

Digitization in the 21st century implies that every contemporary field or industry becomes more dependent on hardware equipment linked through certain media and guided by programming software. Some analysts also call this development "*Agriculture 4.0-The Future of Farming Technology"* a term the World Government Summit used (Dubai United Arab Emirates, 2018). Innovative, intelligent technologies and practices are transforming these industries from the inside out. The farming business has undergone a substantial technological change. These intelligent technologies have pushed the entire agricultural business into the digital age. Agriculture involves big spatial data, sensors, drones, environmental controls, farm management software, micro-farms, intelligent packaging technology, gene manipulation and e-grocer businesses. In addition, artificial intelligence (AI) provides decision support through machine and advanced digital learning processes (*Choudhary VK et al. 2019*).

A farmer needs the intervention of Smart Technology to provide timely Information on various stages of farming. A farmer needs innovative technology to assess the appropriate input requirement, such as seeds, fertilizers, pesticides, timely favorable weather conditions, credit availability, soil testing mechanism, etc. before planting. Innovative technology may assist in adopting good agricultural practices, Pest control, appropriate harvesting technique, and safe, adequate packaging of goods before the harvesting stage. The farmer needs technology help in intelligent storage, grading, and maintenance of international standards, providing supply chain logistic facility and proper post-harvest management. A farmer desperately needs reliable Information on commodity prices in mandis /market, alternative market channels, and consumer behavior.

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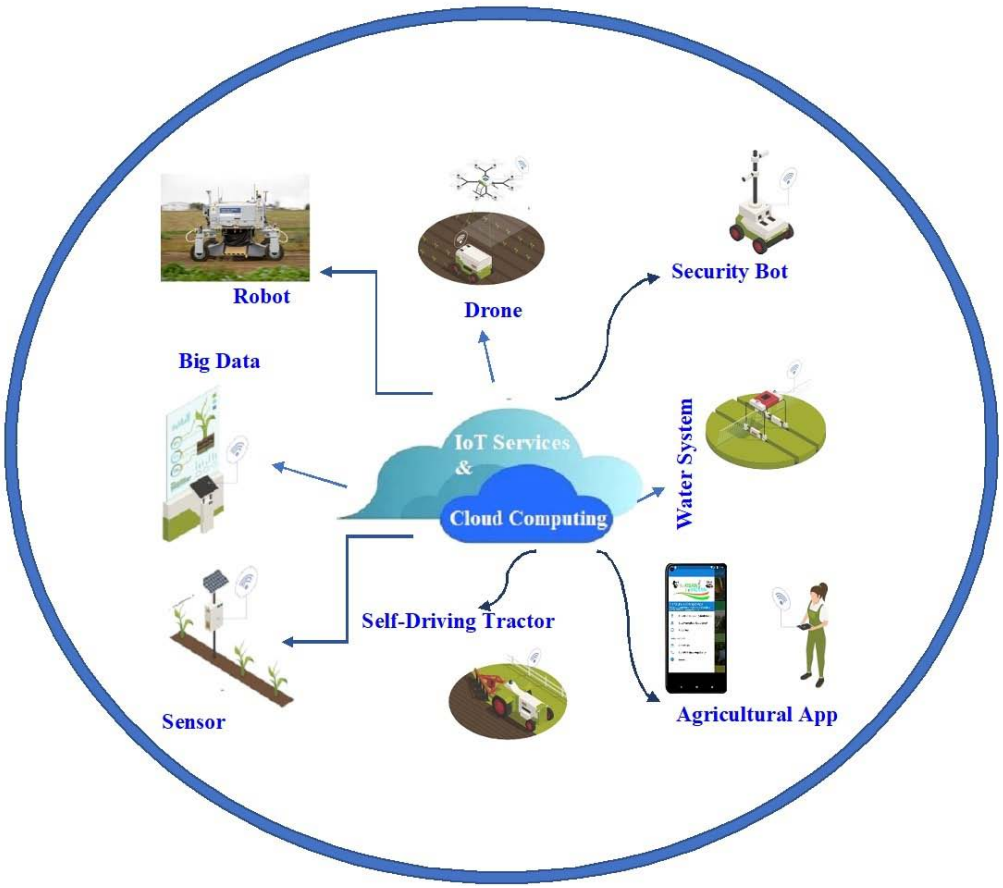

Fig. 1: ICT applications in Farming Systems

Nowadays, the application of Artificial Intelligence (AI), such as Artificial Neural Networks (ANNs), Fuzzy Systems and Genetic Algorithms, Block Chain technology, IoT, etc., has shown greater efficiency in problem-solving like Prediction of crops *(Barriosetal. 2020).* These application areas are essential for economic planning, dry farming growth, crop genetics, pest and pathology effects, weed influence, Quality control, and management during the growing period. These innovative practices and technologies are likely not only limited to the future of agriculture (*Patel and Patel 2013*) but may be the key to human race survival.

II. Technologies

a) The Drones

Applications of Drone in agriculture are a big boon to farmers. Drones are made with sensors and software capable of capturing high-resolution photos of fields to analyze crop health and help provide accurate farming decisions (*Abderahman Rejeb et al. 2022)*. Typically, drones consist of high-quality cameras, GPS, navigation systems, multiple sensors, programmable controllers, and tools for autonomous drones. Unmanned aerial vehicles (UAVs) can get more precise data than satellites. Agri-tech software processes and transforms Data captured by drones into valuable information. In agriculture, drones equipped with sensors and cameras are used to image, map, and survey farms. Drones operate in combination with sensors and GPS. (Fig. 2*)* they can be remotely or automatically controlled using agriculture software-controlled flight plans in their embedded systems.

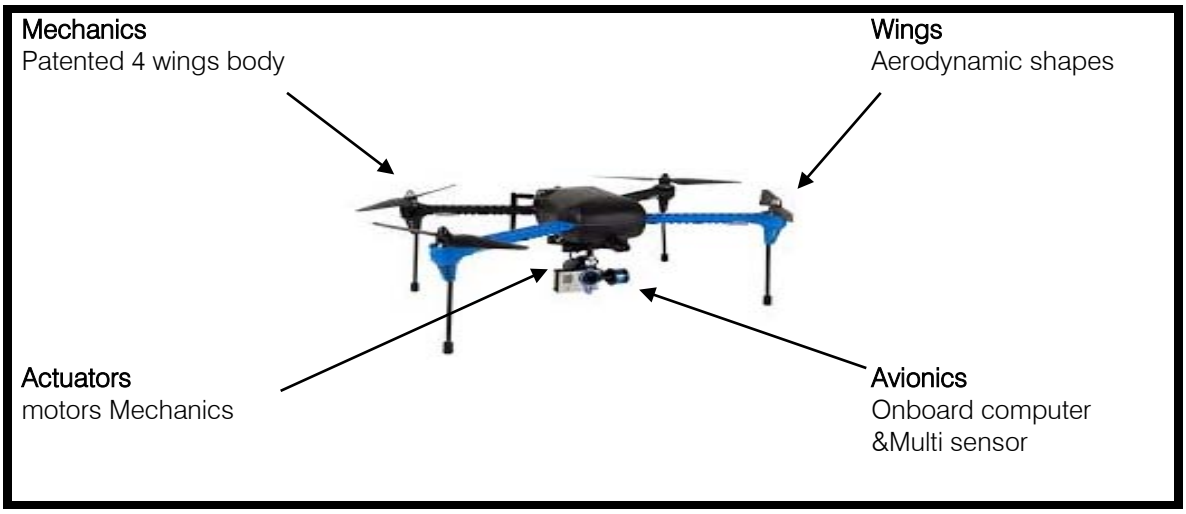

Fig. 2: The Drone

Drones can operate in both satellite and non-satellite modes. The drone works on the propulsion system technology (motors, electronic speed controllers, and propellers), which propels the UAV into the air and allows it to fly in any direction or hover. The motors and propellers on a quadcopter work in pairs, with two motors propellers rotating clockwise. Almost all drones include a Ground Station Controller (GSC) or a smartphone app allowing you to fly the drone and monitor its current telemetry. Telemetry data on the remote controller may include UAV range, height, speed, GNSS strength, battery power remaining, and warnings (*Fintan Corrigan, 2020*). In addition, many UAV drone ground controllers use FPV (First Person View), which transmits the video from the drone to the controller or mobile device.

UAV drones come in a wide variety of sizes-

1. Predator Drone

These are largest in size being mostly used for military combat purposes, having dual Global Navigational Satellite Systems (GNSS) such as GPS and GLONASS.

2. Medium Size Drone

These have fixed wings and require short runways, generally used to cover large sections of land, working in areas such as geographical surveying or to counter wildlife poaching.

3. VTOL Drones (Vertical TakeOff and Landing)

VTOL drones are light sized, generally quadcopters. VTOL drones can take off, fly, hover and land vertically.

An agricultural drone is used to help farmers in increase crop production, optimize agriculture operations and monitor crop growth (Fig. 3). These are high-tech systems equipped with Advance Sensors and digital imaging capabilities that can perform various difficult tasks: monitoring crop health, applying fertilizers and watering the fields, soil health scans, even tracking weather and estimating yields, and then collecting the data and analyzing it.

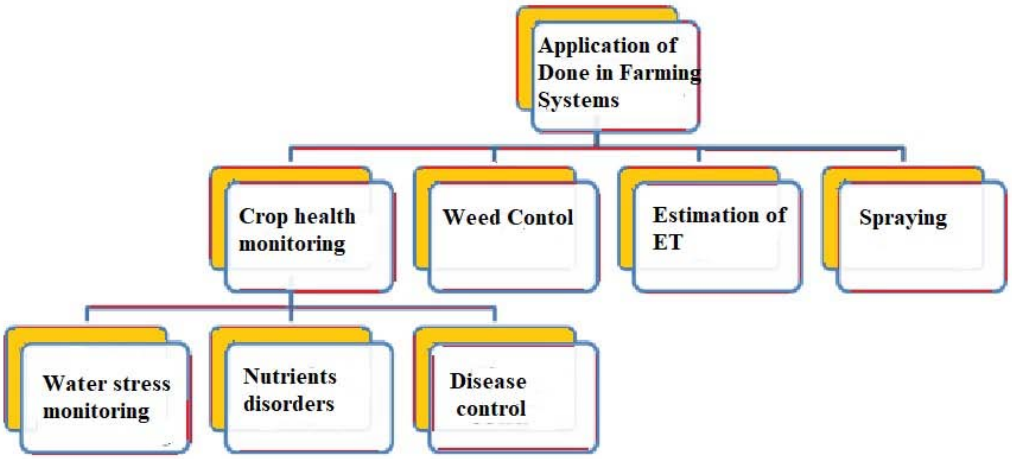

Fig. 3: Major Applications of Drone in Farming Systems

In addition, drones are now being used in projects supplementing the work on pollination that bees have generally perform. Environmental change is a significant issue for humankind. If climate change continues to exacerbate, a crisis of food shortages could occur, resulting in price rise exuberantly even in more developed countries (*Andy Heikkila 2018)* and a public health crisis in the form of global food shortages and hunger. As such, Govt. policymakers should pay attention to the problem. Time magazine reports that more than seven hundred bee species are going extinct. This bee extinction could be catastrophic because bees play an important economic role as pollinators that help to sustain agricultural production.

Having the real time monitoring capabilities, drone can play a vital role in future farming. Drones can mechanize every step of farming, eliminating the costs of human errors and enabling farmers to quick reliable solution. *(Abderahman Rejeb et al. 2022)*

b) Urban/Vertical Smart Farms

The most significant advantage of urban agriculture is the innovative use of space. As a result, urban farms may be as productive as our typical outdoor garden. Nevertheless, on the other hand, they could be as sophisticated, well-regulated, and futuristic as a stack of environmentally controlled pods. We have begun to experience that yields in urban or vertical farming ventures are higher than in traditional Farming. (*Andy Heikkila 2018).* However, "Vertical farming does not promise to change how we farm fundamentally, just make it more effective, competitive and take up less space."

Conventional farmers should come forward to learn vertical farming principles and follow smart design principles in their buildings and construction design to reduce waste and increase production output. Ample space means more energy required for heat and light, resulting in higher costs and more waste of resources. As we keep on overpopulating, we need more space and will need to rely on the effective use of space and growth to continue to feed ourselves.

c) Down on the Robotic-Farm

New generation intelligent innovating machines will radically transform crop cultivation in the future by using expertly selected inputs. Eventually, agricultural robots can work in all farming operations, from weed management driving tractors (automatic weeding), fruit picking, and disease control. The 'adaptable multi-purpose robotic platform' of Bosch's BoniRob (*Fig 4. Trevor Daugherty 2015*) build on an artificial intelligence platform. This agricultural robot uses camera and image recognition technology to detect and remove weeds by driving a bolt into the ground. It learns to discriminate between weeds and crops through picture training on leaf size, shape, and color. BoniRob can roll through a field, removing unwanted plants without destroying anything valuable. *(Trevor Daugherty 2015*). This robot is to cut down the considerable amount of time spent on labor-intensive tasks associated with farming, like planting and picking the seeds. The operating brain of this system can view and distinguish between different plant types based on form, shape, color, and other characteristics. It uses this astute knowledge to correctly classify good and poor plants when working in the field. *(Trevor Daugherty 2015*)

The standout feature of BoniRob is its weed management system. According to Bosch, it can remove weeds by striking them with a metal rod with enough force that the intruder cannot survive. This is a better alternative to chemicals for both humans and the environment. In addition, the system will decide on any item on the ground based on what its trainer has taught.

Source: Trevor Daugherty, 2015

Fig. 4: Bosch-Bonirob

d) Smartphone

With the advent of mobile phone technology, everyone has more access to information. Introducing low-cost mobile phones and data has resulted in the development of new affordable agricultural services and applications. For example, farmers can quickly and timely access weather information, plant health monitoring, market information, education, and other agricultural services on his/her smartphones. In addition, Smartphone holder farmer can manage yield management systems to monitor and make insight-driven decisions about fertilizer, crop yields, weather patterns, water requirements, growing conditions, understanding of Pest Population Dynamics, and disease detection. Voluminous data generated world-wide is used to provide online advisory services for arable farms and other agribusiness organizations. A mobile phone-based remote-control Smart water system helps alleviate leaks and equipment breakdowns by informing farmers timely and allowing them to control water pumps remotely. As a result, farmers can slash travel and water costs/waste by irrigating crops remotely. It is auto-smart, robust & simple, controlled by

a mobile phone for soil/tank sensors. In India, farmers already use a device named Nano Ganesh. (*Ostwal Santosh 2015*).

Mobile Technology using Artificial Intelligence, can help an average Indian farmer to get information regarding forecasting and to predict the weather, crop production, etc., in a timely and precise manner. Scientists at Indian Institute of Farming Systems Research are working on developing an Artificial Neural Network (ANN) -based mobile application (Fig. 5) to help farmers and researchers in the selection of crop variety, planting schedule, disease, pest, weed, weather information, yield forecast, Soil testing labs, and prevailing Govt schemes related to farming, Contact to Kisan Helpline, etc. The application is being developed using the Android Studio platform, Java language, XML, and SQLite database. The neural network *(Back-propagation algorithm)* is being used to create a feature of yield prediction network that can contain three layers of neurons: an input layer, a hidden layer (which is optional), and an output layer. So far, two hidden layers are employed with four neurons in each hidden layer. The final number of hidden layers and number of neurons will be determined by conducting fair numbers of training schedules on data sets

Therefore, resource-poor farmers can be benefitted more from the help of ICT (Information & Communication Technology)/Artificial intelligence.

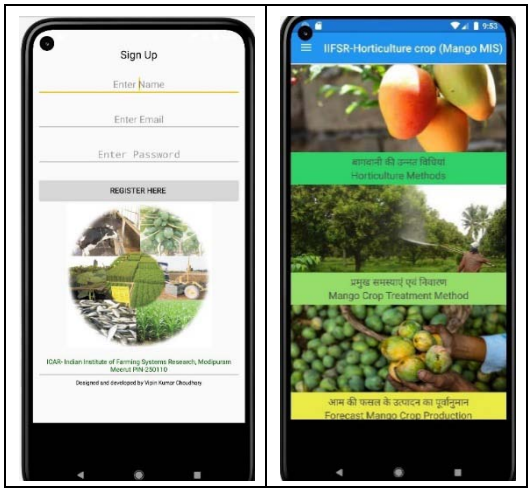

Fig. 5: Smart Phone Application in Mango Crop Management

e) Artificial Intelligence, Internet of Things, and Automation

In AI and IoT-based smart farming, a system is built for monitoring the crop field with the help of sensors like light, humidity, temperature, soil moisture, etc. The agriculture farmers can monitor the field conditions from anywhere. IoT-based farming is highly efficient when compared with the conventional approach.

Most promising AI technologies that transform the agriculture sector, as discussed below.

f) Crop and Soil Monitoring

AI can analyze and interpret data on image perception to track crop health (Fig. 6) and predict production. crop malnutrition may be detected considerably quicker than in humans. In addition, AI models can advise farmers about specific problem regions, allowing them to take prompt action. *(Pradeep N. et al. 2020).* Crop health assessment and early detection of crop infestations are critical in ensuring good agricultural productivity. Climate change, nutrient deficiencies, weed, insect, fungal infestations, and other challenges must be detected early enough to enable farmers to mitigate their effects.

Fig. 6: Crop assessment & Field Spray by Drone

In collaboration with the International Crops Research Institute for Semi-Arid Tropical regions (*ICRISAT*), Microsoft India has developed a sowing application for farmers and a personalized village advisory dashboard for Andhra Pradesh Govt. The sowing app is designed to provide powerful cloud-based predictive analytics to farmers with critical information and insights that will help reduce crop failure and increase yield, reducing stress and generating more income.

Plantixapp a Berlin-based AI agricultural startup (*PEAT GmbH*.) has developed a deep learning application called plantix that identifies potential defects and nutrient deficiencies in soil. The analysis is conducted by software algorithms which correlate foliage patterns with certain soil defects, plant pest and disease. The app uses images to detect plant diseases and other possible defects through images captured by the user's smart phone camera.

Soilsens, a low-cost smart soil monitoring system, has emerged as a potential support to farmers who experience difficult farming decisions. Proximal Soilsens Technologies Pvt. Ltd. developed this technology with the Ministry of Science and Technology (DST) and the Ministry of Electronics and Information Technology. The system includes soil moisture sensors, soil temperature sensors, ambient humidity sensors, and ambient temperature sensors. A mobile app advises farmers on optimal irrigation. The technology has the potential to improve the efficiency of agricultural water use (*Diksha Manaware. 2020*). Furthermore, the intelligent irrigation system based on the Internet of Things (IoT) automate the irrigation process by analyzing soil moisture and weather.

g) Livestock Health Monitoring

Connected wearables make livestock and fisheries management easier, from tracking location to monitoring health conditions. Farmers use these devices also to track pregnant calves, milking frequencies, abnormal behavior, and disease symptoms. There are several M2M livestock solutions, such as the satellite collar-based management system, e.g., FindMySheep (Fig 7. *Source: Globalstar Europe Satellite Services*). This application system makes it possible to find the animal and view a video of its whereabouts around the globe. (*Globalstar Europe Satellite Services, Dublin, Ireland 2014*)). Another system from General Alert adds an extensive list of health and management monitoring for use in pig farms.

Fig. 7: FindMySheep (Source: Globalstar Europe Satellite Services)

Animals are essential to our agricultural systems, requiring slightly more monitoring than plants. CattleEye is an excellent example of an AI application in farming system. Overhead cameras and computer vision algorithms are used to monitor the health and activity of cattle. *(CattleEye.com)*Cattle can be followed and monitored remotely and in real time, allowing farmers to be informed as soon as a problem is detected (*Alberto Rizzoli2022)*. This is not limited to cattle. Computer vision can also count animals, detect disease, identify unusual behavior, and track life-changing events such as pregnancy and birth. Data from cameras and drones (UAVs) are combined with other technologies to inform farmers about animal health and food and water availability. A few countries have recently begun testing a new AI system that screens animal location, health, and well-being using a combination of computer vision, voice recognition, and temperature sensors. (*Gill Sukpal Singh et al. 2017*).

h) Driverless Tractor

Typically, when we imagine the future of driving, we imagine vehicles on the road and passengers not required to keep their hands on the steering wheel because Artificial Intelligence (AI) is handling the driving. Nevertheless, we rarely consider driverless cars on farms. Smart-Ag has announced the working driverless tractor technology as an "AutoCart" (*Smart-Ag.com)* application using Artificial Intelligence. This software program completely automates a grain cart tractor, giving farmers much-needed support during harvest. This cutting-edge technology will enable farmers to automate and maximize the efficiency and capacity of their existing equipment regardless of manufacturer. The AutoCart software is a cloud-based platform, meaning

these automated farming vehicles will join the internet of things (IoT) worldwide. (*Smart-Ag.com)*

i) Electrofishing

Electrofishing is a popular scientific survey method for sampling fish populations to determine abundance, density, and species type. Fishery Management & Surveys of Colorado's Waters stated in their study that correct electrofishing method does not cause permanent harm to fish, which return to their natural state. in just two minutes after being captured. Marine Harvest employs secure video surveillance to track fishery production and assist in fishing management. Fish breeding may be relatively low-tech on the surface, but becoming a world leader requires ongoing data monitoring at each stage of the value chain for seafood.

j) Blockchain Technology

Blockchain technology is mainly known for its application in cryptocurrency finance (BitCoin). However, the agricultural world is beginning to recognize this innovative new technology from a different perspective. Blockchain technology could include producers, retailers, logistics providers, and regulators in any supply chain. Blockchain technology based trading platforms reform agricultural trade by transparently connecting each transacting client to the same dataset (*intellias.com*).Block Chain technology aims to reduce transaction costs and establish financial security. Blockchain technology simplifies and reduces the cost of validation and monitoring in the supply chain, (Fig. 8) which in turn, encourages smaller suppliers in the global food economy. Blockchain technology can transform the supply chain mechanism in the agricultural industry *(intellias.com).*

Blockchain technology in the agricultural supply chain can:

1. Simplifying all phases
2. Track down a product along its entire path from farmland to store shelf
3. Work to improve food safety and removing counterfeit goods
4. Significantly reduce financial risks and encouraging inclusive trade
5. Facilitate toaccess agricultural finance services for farmers and enterprises.
6. Apply data science concepts to generate more intelligent market data for better decision-making.
7. Provide legally valid certifications to relevant authorities.

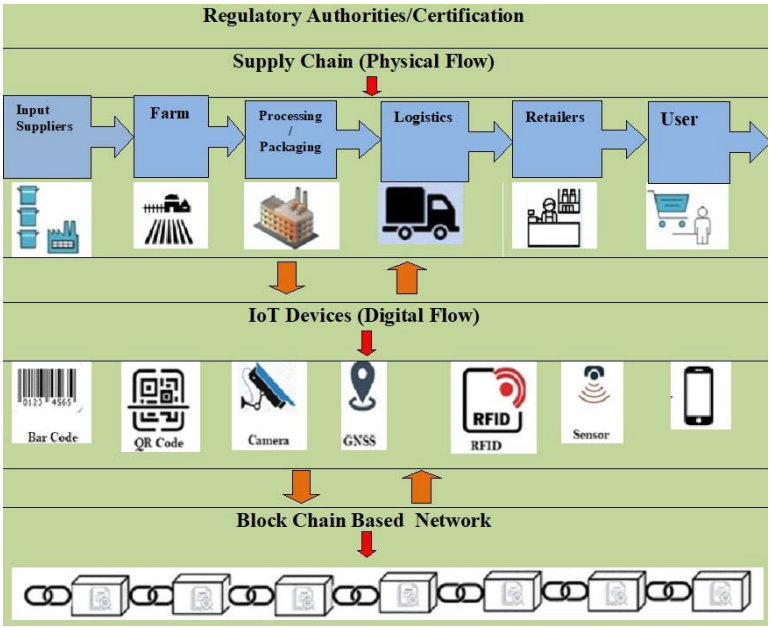

Fig. 8: A simplified Agriculture Supply Chain System.

Commodity traders Louis Dreyfus Co. (LDC), a leading merchant and processor of agricultural goods, completed selling and delivering thousands of tons of soybeans to China in December 2017. This is considered to be the first blockchain-powered agriculture trade. *(ldc.com)*. Many of the initial blockchain applications in agriculture focused on traceability and supply chains, blockchain ledger can record and refresh crop status from planting to harvesting, storage, and delivery. A robust, secure, irreversible ledger that never loses a load is an advantage for large operations. All crops' statuses can be viewed in real-time. Blockchain technology can also be used to manage resources, such as machinery tracking, record-keeping, or monitoring other sensors and equipment.

Jivabhumi is an agri- tech platform connecting farmers directly with Institutional buyers and consumers.

Jivabhumi partners (*https://jivabhumi.com/*) with farmers, and farmers groups, aggregates farm produce and makes it traceable by leveraging a BLOCKCHAIN-enabled platform called FOOTPRINT. Jivabhum is incubated and accelerated by India's leading start-up accelerators, such as YES Scale Accelerator. Jivabhumi enables consumers (B2C) and institutional buyers (B2B) to buy chemical, pesticide-free, and traceable farms directly produced by the producers. It aims to digitalize agriculture to solve supply chain inefficiencies.

k) CRISPR and Genetic Editing

Scientists have recently started using CRISPR/Cas9 (Fig. 9 *Clustered Regularly Interspaced Short Palindromic Repeats, Plec Corrie 2020)*. To achieve precise genetic surgery that allows them to concentrate and modify an organism's genome by ablating or replacing specific parts of the genetic sequence of a DNA strand. Medical News Today states that findings of recent case study of biotechnology company Verve Therapeutics, New Zealand, genetic engineering has been shown to reduce cholesterol through this avenue. (*Plec Corrie2020*).

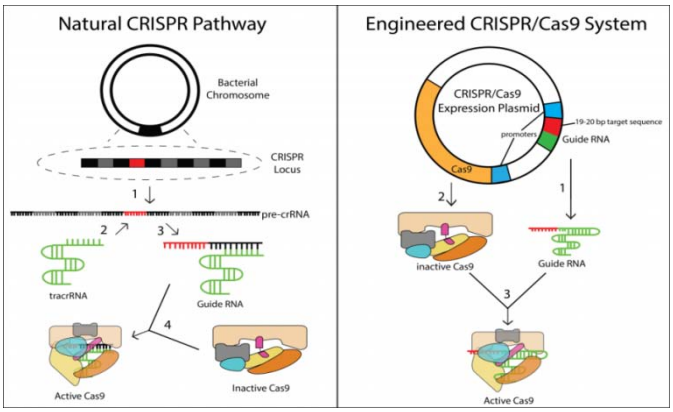

Fig. 9: Natural Vs Engineered CRISPR systems (*Plec, Corrie, 2020*)

CRISPR is now being used to adjust cow's gut microbes in order to reduce the amount of methane produced. Adapting cow microbiomes to produce more meat from fewer foods could boost the meat industry's competitiveness and profitability. Furthermore, methane has approximately twenty-five times more heat-trapping capacity than carbon dioxide. Hence reducing cow methane production could have a significant impact on the environment. Scientists have also begun to develop engineered crops that require less water and produce more food. However, tampering with genetics in any ecosystem or environment may result in unanticipated consequences. So, we must avoid generating more problems to fix a few.

l) Data, the Life of New Agriculture

Agricultural activity does not only generate crops with M2M (Machine to Machine). It also grows another valuable crop, "data." The scientific community is uncovering evidence to support sustainable soil health intensification and soil health maintenance at the field, farm, and enterprise levels. The researchers at IBM anticipate more significant use of extensive data analysis in the agricultural sector *(business.weather.com)*

Farmers and farming companies are trying to discover the advantage of precision farming. "Smart Farming" integrates remote sensing, IoT tools, robotics, extensive data processing, artificial intelligence, and other emerging technologies into an integrated high-crop production system. (*Choudhary VKetal.2016*). *Precision technology* is a farm management concept that uses satellites and GPS tracking systems to measure and respond to crop field variability. Precision farming can double the farming output to feed the 9 billion people predicted to populate the planet by 2050 and shift societal perceptions of the agriculture industry. Precision farming was also the subject of a Goldman Sachs 2016 report, subtitled Cheating Malthus with Digital. According to agricultural researchers, crop yield can be increased by 70% by 2050 through precision planting, fertilizer application, irrigation spraying, and autonomous driving applications, with adoption commencing in existing marine applications. *(Lyndsey Gilpin 2014)*

m) Bio Informatics in Agriculture

Bioinformatics is a multidisciplinary scientific field that uses information technology to process and manage biological data using cutting-edge computer tools. Bioinformatics is a branch of computer science that studies and predicts the structure and function of genomic data, biological sequence data, and macromolecules. Agriculture genomics is a classic example of a bioinformatics application in agriculture in which genomic data is collected, stored, and interpreted.

Bioinformatics tools and methods are used in agriculture in many ways, including increasing plant resistance to biotic and abiotic stressors and improving

nutritional quality in depleted soils. (*CuffariBenedette 2021*) Aside from these priorities, gene discovery using computer software has enabled researchers to develop targeted strategies for improving seed quality, introduce extra micronutrients into plants for improved human health, and engineer plants with phytoremediation capabilities. Some of the most widely used plant/crop bioinformatics online databases include BGI Rice Information System, Gateway of Brassica Genome, Chloroplast DB, The Crop Expressed Sequence Tag (CR-EST_ database, CyanBase, the European Molecular Biology Laboratory (EMBL) nucleotide sequence database, and many more *(biotechgo.org,Bulgaria)*.

Bioinformatics tools play a vital role in providing information about the genes found in the genomes of species. These technologies have also allowed researchers to predict the function of specific genes and the factors that influence them. For example, the information the tools provide about the genes enables scientists to develop drought, herbicide, and pesticide-resistant plant varieties. Similarly, specific genes can be altered to increase meat and milk production. Furthermore, their genes can be altered to make them disease resistant.

Plants' genomes stayed conserved and did not supply much information when evolutionary changes occurred. It is now feasible to extract the needed information from the genome of certain plants thanks to bioinformatics techniques. There are two species of food plants, the genome of which has been entirely mapped, for example, Arabidopsis thaliana and Oryza sativa *(CuffariBenedette 2021)*. These two species of plants have their names in English as watercress and rice, respectively.

Watercress is a tiny plant that grows on rocks. Because of its smaller genomic size, researchers took an interest in its genome and studied plant developmental processes. Its genome consists of 5 chromosomes on which 100 Mbp DNA is distributed. It reproduces in 5 weeks and makes a new generation. Therefore, knowledge of its genes and how they are expressed reveals information about the proteins and expressions of other plants.

By adding the desired genes, many plants have become insect-resistant. For example, Bacillus thuringiensis is a bacterial species that improve soil fertility while protecting plants from pests. When the researchers sequenced its genome, they incorporated its genes into the plant to make it insect-resistant. Corn, cotton, and potatoes, for example, have all been insect-resistant in the past. When insects consume plants with bacterium genes in their genomes, the bacteria enter their circulation and starve them, eventually killing them. Bt corn is a type of food plant that the introduction of bacterial DNA has genetically modified. It works against insects by causing them to acquire resistance. The use of Bt genes in the plant's genome has made agriculturists use insecticides in minimal amounts. As a result, plants' productivity and nutritional value will also increase and benefit human health. When alterations are introduced to a plant's genome, the nutritional value of the plant rises as well. For example, some genes are added to the rice genome to boost the crop's Vitamin A levels.

n) Soft Computing in Agricultural

Soft computing refers to a collection of computational techniques that includes fuzzy logic (FL), artificial neural networks (ANN), and genetic algorithms (GA*). (JacekMZurada et al. 2017*)

Soft computing is advantageous in offering strategies for incorporating human-like ambiguity and real-world uncertainty into traditional computing algorithms. For instance, soft computing-based categorization, modelling, prediction, optimization, and control have been used to tackle problems in soil and water, crop management and post-harvesting, precision agriculture, food processing, food quality and safety, and agricultural vehicle and robotics. (*Lotfi A. Zadeh*).

Agricultural production management is a challenge that includes determining the best sowing season, crop variety selection, land preparation, sowing method, fertilizer, and pest selection based on variety. There is a need for a more versatile fuzzy logic based expert system approach that provides the end user with a diverse range of farming approaches. *(Expert-system-questions, 2018).* Agricultural pest management used the color co-occurrence approach for textural analysis to see if classification algorithms could distinguish between sick and normal citrus leaves.

i. *Fuzzy Logic*

Fuzzy logic is very well-known for its application in developing an image capture/processing system for weed detection (*Dubey Sonal et al. 2013*) and a fuzzy logic decision-making system for deciding where and how much herbicide to spray in a crop field. However, information on the economic thresholds of weed influence on crop productivity is difficult to adapt to a specific region or farm. *(Ogunleye G O et.al 2018)* Therefore, a fuzzy logic approach was used to convert image data into sprayer commands, allowing farmers to use their experience to classify weed status at a given location in the field this research indicated that a fuzzy logic system could understand and facilitates the representation and processing of human knowledge in a computer.

A functional approach to soil characterization is used in the precision agricultural decision support system, which includes water stress, nitrate stress, nitrate leaching, and residual nitrogen content at harvest. First, a fuzzy c-means classifier was used to classify the soil profiles into functional groups. Next, the researcher investigated ways to use the nitrification inhibitor for management zone designation based on

slope and surface texture for a site-specific application. Rather than using expensive grid sampling of soil chemical and physical attributes, fuzzy cluster analysis highlighted the possibility of readily available spatial yield or soil to establish management zones for applying nitrification inhibitors. Finally, in precision agriculture, (*Ortiz et al. 2011*) used fuzzy clustering of elevation and slope of the terrain to delineate root-knot nematode (RKN) risk zones for a comparison test of two nematicide application rates on nematode population density and cotton lint yield.

ii. *Artificial Neural Networks in Agriculture*

Artificial neural network (ANN) has emerged as a new technology that offers a variety of solutions to complicated challenges in agricultural research. Since it can address a wide range of issues that a linear system cannot. Modern agriculture requires a high level of production efficiency as well as a high level of product quality in agricultural and livestock production. (*Russian Federation: Gazprom Neft 2020, Sustainable Development Report*).ANN tools are extensively employed in a variety of classification and prediction tasks. Their applications vary from crop quality classification to disease and pest verification, predicting the impacts on production based on multiple independent parameters and intelligent weed management. ANN techniques improve agricultural decision-making processes, assist in optimizing storage and transportation procedures, and enable the forecasting of expenses. Machine learning methods in the "life cycle of a farm" requires handling large amounts of data collected during the growing season and having the appropriate software to analyze it. The evident growth of digital agriculture and precision farming leads many farms to switch to ANN intelligence-based products. (*AbderahmanRejeb et al. 2022*)

iii. *Genetic Algorithm Applications*

Genetic algorithms are similar to natural systems, created through gene reproduction, cross-over, and mutation to provide better environmental adaptation. It works on the principle of pheromones that are substances which are secreted to the outside by an individual and received by a second individual of the same species. A complex structure could be built using its more fundamental constituents. *(LiuLingxiao 2022*). Genetic algorithms determine the best cropping pattern while considering various constraints and complexities using search and optimization technique. Genetic algorithms have also been used to assist with modelling and Prediction. Genetic algorithm approach can address the issues in Crop management, water management, food quality and safety, food processing, precision agriculture, agricultural biology, agricultural machinery, agricultural facilities, animal behavior, and forecasting agricultural commodity prices.

The standard genetic algorithm's steps can be summarised as follows.

1. The population of individuals is initialized. This can be done by randomly generating a definite number of people represented by fixed-length character strings. The following stages (2–4) are repeated until the halting requirement is reached.
2. Every individual in the population has a chance of experiencing a mutation. In other words, the given individual can be randomly modified
3. In some unexpected way, the (possibly modified) individuals split and interchange these splits in pairs, creating new individuals (cross-over). As a result of Steps 2 and 3, the population modifies.
4. The fitness of each individual in the newly obtained population is assessed. As a result, only a subset of all individuals is advanced to the next stage. (i.e., Step 2) or, if some individuals obtain satisfactory fitness. The procedure is stopped.

In this way, a solution—or an approximate solution—to the problem can be found,

Table-1: Summary of Soft Computing Techniques in Smart Farming

Sl. No.	Soft Computing	Application thrust Area	Technique
1.	Fuzzy Logic	Pest Management	Colour co-occurrence Classification
		Soil Analysis (Mapping & Caracterization)	Fuzzy set grid spacing
		Irrigation and ET calculation (evapotranspiration)	Estimation of daily reference evapotranspiration using FL crop water stress index (CWSI)
		Prediction of sediment and phosphorous movement	Fuzzy c-means clustering for RBF training
		Yield Prediction based on different energy Inputs	Adaptive neuro-fuzzy inference system)ANFIS
2.	Artificial Neural Network (ANN)	Weed Management	classification of images based on color. estimation by multi-linear regression and discriminant analysis for classification of images
		Irrigation, demand and water supply	Feedforward ANN model trained with Back Propagation algorithm
		Soil Analysis	Fuzzy neural network classifier and multilayer ANN trained with GA.
		Prediction of rainfall and crop production	Fuzzy logic k-mean Neuro fuzzy with genetic algorithm
3.		Weed management, vegetation cover	GA based image segmentation algorithm, component analysis technique based on GA uses GPS data and hyperspectral remote sensing data
		Soil Analysis, water	stochastic imaging

	Genetic Algorithm (GA)	capacity (AWC), uncertainty and variability	
		Irrigation , optimal crop water allocations	GA models
4.	Decision Tree (DT)	Weed and Nitrogen Management	Classification of multispectral images
		Precision Agriculture (Distinguishing between chemical fertilizer and manure treatments)	spatial decision support system (SDSS)

o) Data Mining Techniques a Boon for Modern Agriculture Research

Data mining is a highly interdisciplinary field that includes statistics, machine learning, databases, pattern recognition, and other disciplines (*Choudhary V K et al. 2013).*Data mining is the time-consuming process of discovering authentic, relevant, potentially useful, and eventually visual patterns in data. The pattern should be novel and potentially beneficial, resulting in some benefit to the user or activity *(Choudhary VK et al. 2011).* Furthermore, if not instantly, then after some post-processing, the pattern should be understandable.

Data mining is the process of extracting hidden predictive information from large databases. *(Robert P. Schumaker et al. 2010).* Data mining techniques forecast future trends and behaviours, allowing enterprises to make more informed decisions. The automated, prospective analysis provided by data mining goes beyond the retrospective analysis provided by decision support system tools. Agriculture data mining is a relatively new field of research. It entails the application of data mining techniques to agroeco systems. For example, the Naive Bayes data mining technique was developed to categorize soils using massive experimental soil profile datasets. Data miners use the decision tree method and clustering approaches (based on partitioning algorithms and hierarchical algorithms for forecasting soil fertility) to find information on productive agricultural land. (*Hassina Aitlssad et al. 2019*)

p) Application of Data Mining in Smart Farming

i. *Grading Segregation of Fruits and Vegetables*

Fruits and vegetables are frequently classified into different price ranges based on size, color, and water content. These external variables, however, cannot be used to assess the quality of fruits and vegetables properly. Data mining can help us solve this problem by capturing images of fruits and vegetables at the packaging line. These images are then further analyzed to estimate the product's quality accurately. Furthermore, data from various specimens help to develop a more precise prediction of the quality of fruits and vegetables. These images can be fed into a deep layered Convolutional neural network for large-scale image recognition. (*Bagal Yash V et al. 2020)*

ii. *Maximizing Yield Depending on the Quality of the Soil*

Assessing soil quality is necessary to hike the agricultural income from farmers' land. Assessing soil quality analyzes the amounts of minerals and nutrients in the soil, the alkalinity, salinity, moisture content, and other variables that also affect the soil quality. Data

mining is utilized to explore different soil types. (*Bagal Yash V et al. 2020*) Analysts of soil data propose the crop to be planted and harvested based on the soil's fertility to provide the optimum yield. Data mining can also be used to study cross-cultivation (*Bagal Yash V et al. 2020*). Different crops can be grown simultaneously, bringing in more revenue than single-crop cultivation and utilizing resources to the best possible extent without affecting soil fertility. The scope of data mining is enormous, and its scope can be seen in the soil analysis as follows (*Bagal Yash V et al. 2020*).

1. Crops can be grown by sensing and detecting soil capabilities.
2. Previously unknown soil patterns can be discovered.
3. Soil traits and behavior can be predicted based on climate conditions and ingredients.
4. d) Soil fertility testing can be done using statistical methods.

iii. *Optimizing the use of Pesticides*

Agricultural researchers revealed in a recent study that pesticides are overused, which is highly hazardous for the environment. Additionally, overuse of pesticides can result in pest immunity, which makes them less vulnerable to control and ultimately more harmful to crops. Clustering is one of the data mining methods that can cluster the features by providing interesting patterns of farmer practices and thus provide meaningful information highlighting the negative effect of excessive pesticide use. (*Bagal Yash V et al. 2020*). The system employs an image processing mechanism based on aspect ratios, shapes, and surface area. Later, images of the cultivation area are processed to detect weed patches using specific algorithms. Color density in the images is used to represent the density of crop growth in a specific area, whereas a different color represents irregular crop growth. (*Bagal Yash V et al. 2020*).

iv. *D. Prediction of wine Fermentation*

This Prediction can be made using the k-means Data Mining technique (*Han and Kamber, 2006*). This Prediction can warn the chemist to fix any stuck or slow fermentation processes and ensure a good fermentation process.

v. *Weather Forecasts*

A k-nearest neighbor approach can be used to improve weather forecasting, where it is assumed that the climate during a specific year is similar to the one recorded in the past. The same data mining technique can also be used to estimate soil water parameters. Before marketing, apples, and other fruits are thoroughly examined in agriculture. Humans can inspect apples on conveyor belts, and bad apples (those with defects) can be removed. The data mining tasks can perform the same task efficiently. The apple water core is examined using X-ray images in this task. It is based on an artificial neural network that learns how to classify X-ray images from a training set. *(Winter School Notes of ICAR-IASRI2011).*

III. Issues & Challenges

Smart technologies are a boon for the farming community in many ways, but they pose challenges. The main challenges are privacy, reliability, data confidentiality, and security. The Weather Company, an IBM business, held a first-of-its-kind event titled The AgriTech Challenge 2018 in Mumbai on 13 June 2018 to find solutions to transform the lives of over three million Indian farmers. The event was held in association with the Agripreneurs Group, SMART AGRIPOST and Graype.in and discussed the top challenges faced by the whole ecosystem in adopting smart technologies.

a) Cost of Technology

Smart technologies such as machine learning, robotics, IoT, big data analytics, bioinformatics etc., necessitate expensive equipment. However, while sensors are the least expensive, outfitting at farmers' fields would cost more. Moreover, automated machinery is far more expensive than manually operated machinery since it covers the cost of agricultural management solutions software and cloud access to record data. However, Farmers are eager to invest in these techniques to enhance their earnings, but they might need help to raise the initial investment to set up a smart farm.

b) Poor Bandwidth and Internet Connectivity

Adopting digital technologies in rural farmer's fields will be improved by providing better network connectivity and adequate bandwidth speeds. Smart farming agriculture technologies, including satellite mapping systems, soil sensors, and many monitoring tools, rely on cloud services/cloud-based computing for data storage and retrieval. These services might be compromised by inadequate bandwidth. Furthermore, farms with large, dense trees and hilly terrain must receive GPS signals seamlessly, making it much more challenging to use smart farming techniques there. Implementing smart technologies in remote rural areas may be difficult due to limited electricity and network coverage.

c) Lack of Technical Know-how in Farming and Allied Workforce

In general, farmers are typically ignorant and unskilled, and many of them would not prefer to learn about new technologies. On the other hand, policymakers have yet to make enough efforts to create online /offline capacity-building programs for farmers in locally relevant content. Lack of technical expertise in handling smart farming setup and bad implementation, such as installing a sensor in the wrong place or forgetting to switch off the irrigation tank, might harm

farm productivity and efficiency. Farmers need to be adequately familiar with the concept and operation of the tools/devices featured in the system of smart farming technologies. It would ensure the desired outcomes of higher profitability, decreased environmental risk, and better crop output. Lack of knowledge will cost them a waste of time and effort, making it harder to adopt smart farming systems smoothly.

d) Monitor and Manage BIG Data in Agriculture

For many farmers and agribusinesses, data management is a significant concern. Even a tiny farm collects and maintains a plethora of data to guide marketing and associated operations. Monitoring or analyzing these millions of data points daily or weekly throughout the growing season is practically impossible. This problem grows bigger in large farms and multi-crop fields. A novel data processing and management approach is required to overcome this obstacle *(Kumar Prakash et. al 2018)*. In order to accomplish this, farmers need to decide which data points they must track frequently and which ones can be left to be analyzed only during different seasons. *(Andrew Meola 2021)*. Farmers must know when and how to use the information recorded in their agriculture databases. Tech giant IBM estimates that the average farm can generate half a million data points daily, helping farmers improve yields and increase profits. Even though the typical Indian farm is tiny and may generate substantially lesser data points. (*Abhishek Beriya2020*).

e) Privacy and Security Issues

Since the need for explicit norms and regulations around smart technologies, ICT-based innovative technologies pose several legal issues that usually need to be solved. Unfortunately, many farmers are exposed to privacy and security risks like cyber attacks and data leaks. However, the following important factors must be appropriately addressed to adopt these technologies successfully.

1. To make efforts to develop affordable technology,
2. Ease of access and operations,
3. Easy maintenance of systems,
4. Timely grievance redressal
5. Appropriate policy support,
6. To develop good ICT infrastructure,
7. Provide adequate ICT skills,
8. To facilitate excellent and affordable internet connectivity,
9. To provide adequate bandwidth for internet service from a reliable ISP.
10. Availability of ICT Literature in Local Languages

IV. Conclusion

The use of smart technologies like robots, automated devices, and the application of artificial intelligence in farming is still in the infancy stage. Still, developing countries are finding the relevance of these technologies in farming systems activity. Smart technologies have just been in a prototype phase in underdeveloped countries and their visibility and outcome in global agriculture are almost negligible.

Smart technologies can revolutionize the agriculture system, making crop and livestock production more efficient and environmentally friendly and contributing to higher productivity. All farmer outreach programs must overcome three significant challenges: ensuring cost-effective awareness, designing solutions that meet specific needs, and ensuring sustainability. Large segments of the farming community, particularly rural folk, need access to the vast knowledge base amassed by agricultural researchers and extension people. Even though ICTs have the potential to make a difference and accelerate information access for the farming community, most ICT applications are implemented in smaller geographical areas and cover only a few hundred farmers. The outreach sphere of these technologies should be broader.

This review article has discussed the concept, methods, and use of major state-of-the-art smart technologies applications in farming systems with examples. These technologies can potentially increase the sustainable management of natural resources (soil and water) and reduce the use of agricultural inputs, making agricultural areas more productive and reducing their environmental impact. We have also highlighted some issues and challenges facing in adopting smart farming technologies.

The rate of the adoption trend and its amplitude are challenging to anticipate. The full adoption of smart technologies in global agriculture could take a few more decades. Nevertheless, these findings have their origins in the framework of existing agricultural systems and human nature without considering significant transformations of factors such as human metabolism, biology, or energy absorption, scientific achievable, which may provide exciting answers to the challenge.

These are just a few examples of how innovative, intelligent farming practices transform our future and make the planet more livable. Without these breakthroughs, the threat of overpopulation could devastate humanity. So agricultural creativity is not just fascinating — essential to survival.

V. The Future Road Map: The Way Forward

Adopting intelligent digital technology, particularly by small and marginal farmers, can play a transformative role in significantly improving Indian as well as global agriculture scenario. Digitization makes data management faster and simplifies the communication process to obtain loans, assess the status of their

crops, and determine which crops are best suitable for their particular parcel of land. The potential advantages and challenges have been thoroughly explained in this paper. Overall, India's current smart technology application scenario is promising.

To empower farming community meaningfully, further robust research, development, and policy decisions are desperately needed to address the issues preventing the seamless adoption of smart ICT applications in farming systems.

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Data Visualization as a Means of Optimizing Control Systems Model in Project Management

By Amirali Kerimovs

Annotation- The article addresses current issues concerning the utilization of data visualization in project management within the project context. It delves into the characteristics and principles of implementing projects within the project management framework of business entities. The classification of processes within the project management system is outlined. The study examines the significance of data visualization as a prerequisite for decision-making, highlighting the traits of visual project management. The tools employed for crafting visual representations of project data, derived from project implementation outcomes, are investigated. Various types of infographics intended for monitoring the execution of project-related business tasks, encompassing factors such as sequence, resources, and commencement and culmination dates, are identified. The article concludes by presenting the outcomes of generating visualizations using MS Project and MS Power BI within the realm of project management business processes in the project area.

Keywords: software engineering, project management, project data, visualization, project management, project scope, dashboard.

GJCST-G Classification: ACM Code: D.2.8

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I. Introduction

Project management decision-makers rely on their own professionalism, critical thinking skills, experience, and subjective awareness of the generalized presentation of information, particularly concerning project management outcomes, which is facilitated through data visualization.

II. Literature Review

The digitization of various aspects of enterprise operations, particularly in the realm of project management, involves the creation of visualizations based on project data. A project, defined as a temporary endeavor aimed at producing a unique product, service, or outcome, serves as a means to directly or indirectly achieve the organization's strategic objectives [8]. According to the official state portal that registers social and economic development projects in state financed by international project organizations [7], the funding for projects in the design domain constitutes 10.88% (pertaining to design and insurance activities) of the overall volume. These projects focus on enhancing project-related activities within business entities, implementing solutions and technologies in the broader project sphere, encompassing both the general project field and the FinTech sector. Project developments within the design sphere align with the Strategy for the Development of Design Sector until 2025 [2], which outlines five strategic directions: project stability, macroeconomic development, project inclusivity, project market development, and innovative advancement. Under the innovative development direction, the development of the digital economy is emphasized, with metrics encompassing the advancement and utilization of cloud technologies, IT infrastructure development, and the proliferation of paperless technologies.

Project management entails the application of knowledge, skills, tools, and methods to project activities to meet defined requirements, necessitating effective process governance [8]. Modern project management principles [6], shown in Fig. 1, emphasize strategic project management, aligning with the broader strategic business goals. Project management is perceived as a business process, within which responsible individuals make crucial business decisions.

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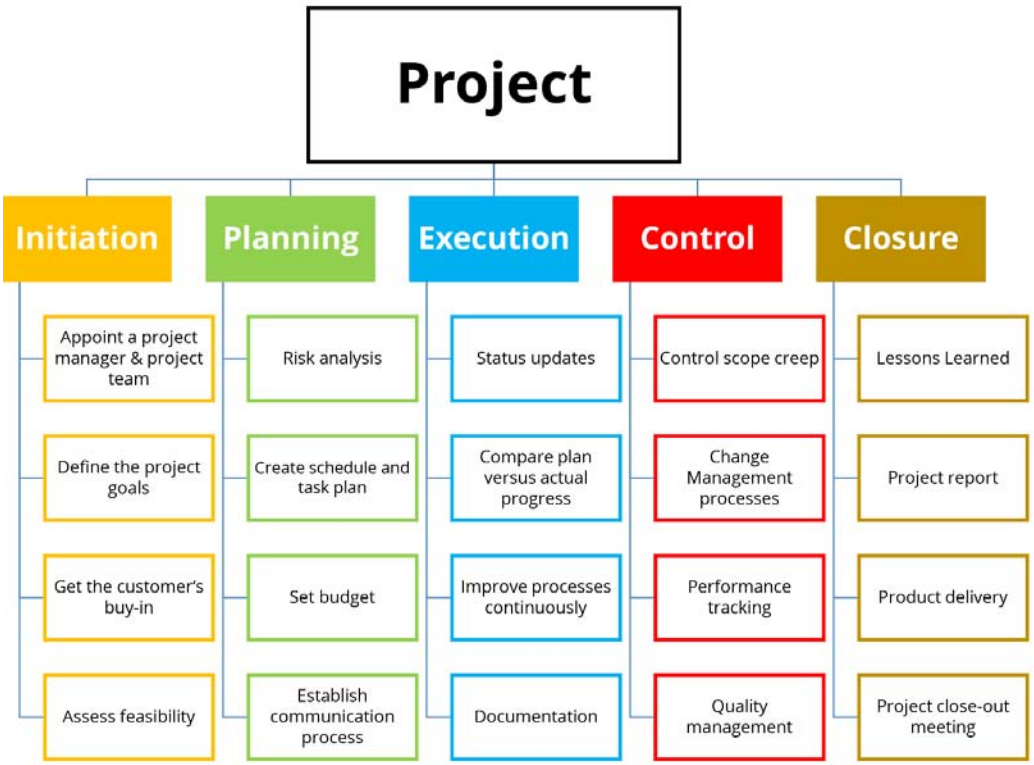

Fig. 1: Principles of Task Implementation in the Project Management System [3]

From an expert perspective, project management enables the creation of desired business advantages and enhances business value. Consequently, priority is given to projects that offer enduring benefits to the economic entity, with their managers executing strategic tasks that drive sustainable competitive advantage and foster growth in project performance indicators. In this context, project management transforms into a strategic competency for decision-makers, integral to their career progression, rather than a standalone milestone.

The execution of projects by business entities within the project domain constitutes a key phase in implementing their development strategies, comprising various business processes of differing durations.

Project progress in the project domain hinges on the effective execution of assigned tasks by project implementers. Among the primary tasks in project management [1] are project integration management, project scope management, project time management, project cost management, project quality management, project resource management, communication management, and project risk management. Project management encompasses methods for budget management, task sequencing, stage breakdown, and more. The project management process necessitates meticulous planning and monitoring, entailing a comprehensive understanding of all participants and the tasks they're responsible for.

The classification of processes within the project management system, according to the British standard Guide to the Project Management Body of Knowledge (PMBOK Guide) [8], is depicted in Fig. 2.

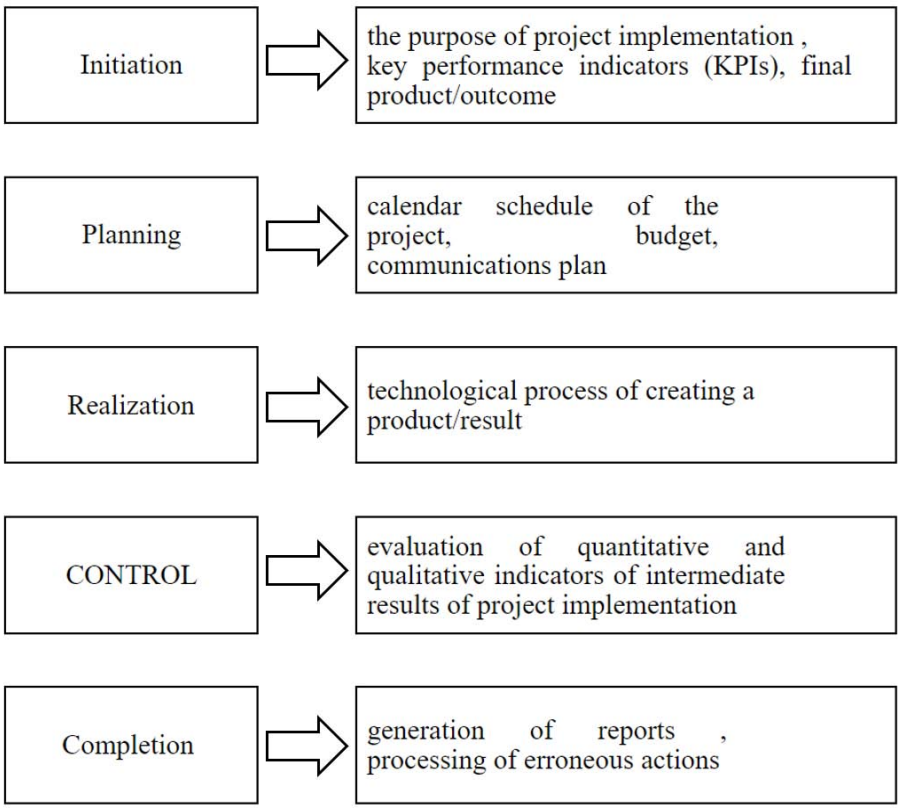

Fig. 2: Project Management Processes [8]

Establishing this interconnected process system underscores the integral role of the project component in each, with project indicators indicating feasibility, effectiveness, initiation, planning, and control of the ultimate outcome. Consequently, financial considerations emerge as a crucial criterion for evaluating the management effectiveness of projects within the project domain and other areas.

Efficiently coordinating the timely execution of numerous project tasks in the project domain demands significant resource allocation. Hence, in the context of the digital economy, employing tools that facilitate effective visualization and subsequent organization of tasks within the project activity sphere of a business entity has become pertinent.

The literature delves into the fundamental context and significance of GABP neural network recognition technology, highlighting its burgeoning research applications in relevant fields [10]. It elucidates both domestic and international trends in research applications, centering on systems like LPR and their real-world development trajectories in related domains. The primary focus of the literature centers on a detection model founded upon the integrated gray-scale GABP neural network model [11]. A comprehensive exploration ensues, encompassing aspects such as edge localization through electronic algorithms within gray-scale contextual images, wavelet transform detection techniques, color image segmentation algorithms, analysis of texture-based gray-scale object images, and modern mathematical image morphology-based edge detection algorithms. Notably, the pivotal experiment-tation in this study employs the Roberts edge detection operator algorithm, directly applied to grayscale image edge detection [12].

Detailed insights into the software experimental environment are provided, encompassing the experimental software platform, processor, installation package, memory specifications, software runner, operating system, and the requisite software platform for the experiment. Through software examples and videos, the paper methodically elucidates the software's specific process and application procedure for the system experiment [9].

Drawing from the operational requisites of local taxation agencies within a specific city, the literature sequentially designs and scrutinizes the business process of the city's local taxation departments, followed by an analysis of business functions within the devised management system that cater to actual demands [5]. Employing both the company's technological assets and national key construction project management expertise as a research foundation, the literature synthesizes business requirements, research outcomes, and analytical findings into a comprehensive system design [2]. The integration of Java, MySQL, and other

technologies facilitate experimentation on the core modules of the entire system. The resulting test outcomes affirm the alignment of the designed national key project management system with current enterprise needs, characterized by its systematic nature, robust performance, intuitive interface, and operational convenience [1].

Data visualization encompasses the graphical representation of information, serving both to interpret and discern data essence, as well as facilitate communication [4]. Visualizations of design data not only allow for an analysis of design indicators but also provide a holistic depiction of the enterprise's design status. This aids in comprehending the situation and guiding further management actions. In essence, visualizations assist in identifying critical junctures within dynamically evolving project tasks within the project domain.

III. The Purpose of the Article

The aim of this article is to empirically implement approaches to project management within the project context using tools for visualizing project data.

VI. Presentation of the Main Material

Visual project management extends beyond the conventional task list, offering an organized approach to project execution and oversight [3]. This methodology leverages visual representation to communicate project progress across various dimensions. Visual project management encompasses showcasing ongoing tasks, target completion dates, pivotal milestones, and other relevant project aspects.

In project management, the planning processes serve to establish the project's overall scope, define objectives, sequence activities, devise a project plan, and generate implementation-related documentation [8]. These documents comprehensively detail content, timelines, resources, and other pertinent facets.

A prominent technique for visualizing project processes is the Gantt chart [3]. This tool visualizes project stages, outlining the scheduled sequence of individual tasks and their respective timeframes. Chronologically breaking down the project facilitates effective allocation by decision-makers, enabling them to discern relationships among all components involved in the management process. The Gantt chart, resembling a visual bar chart, provides insights into task initiation, duration, and completion percentage. Through project data visualization, resource management, budget tracking, error monitoring, quick navigation, and adaptability to project changes are facilitated.

Fig. 3 depicts the visualization of project stages within the project area, targeting the implementation of project leasing operations within a business entity. This visual representation allows for monitoring project tasks concerning involved specialists and their work schedules.

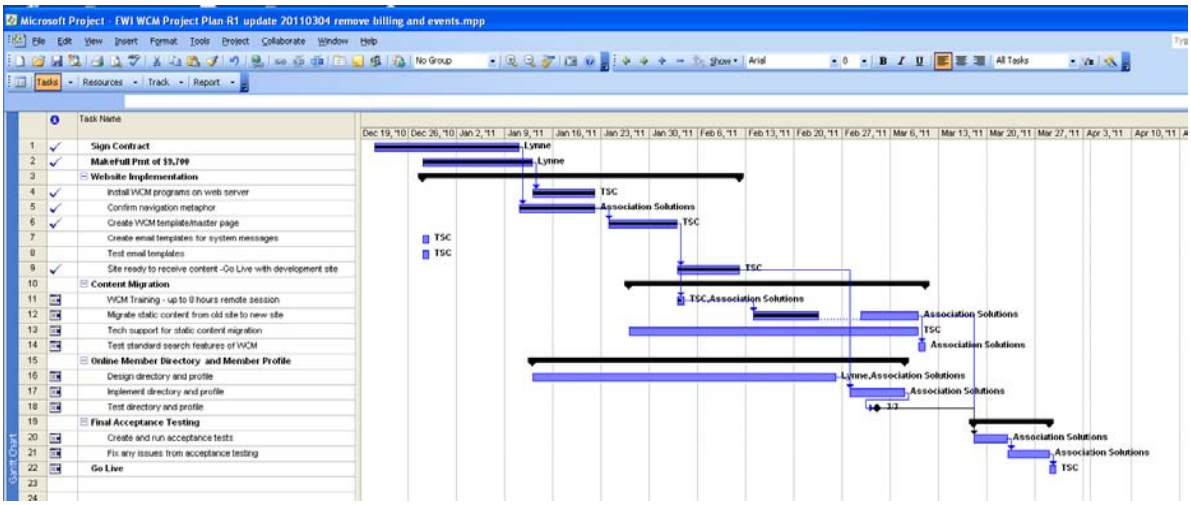

Fig. 3: Visualization of the Work Planning Results for the "Implementation of Project Leasing Operations in the Enterprise" Project in the Microsoft Project Environment (Fragment)

Within the project management framework, the manager conducts an analysis of resource expenditure for project implementation, evaluates the implications of risk exposure, and considers associated costs (such as enhancing working conditions, personnel training related to business processes, etc.).

Tracking the project's progress within the project domain, including the interdependencies among tasks, and their advancement, is facilitated through the use of a visual tool known as the "Gantt Chart" (Fig. 4). This visualization is accompanied by an explanatory table presenting task names, durations, and implementation deadlines.

Phase	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Requirement Gathering								
Decide Deployment (Single / Multi node)								
Install VRA including IaaS								
Gather information about end users, approvers								
Create AD groups (System wide and Tenant Roles)								
System-Wide Roles (System, IaaS and Fabric Administrator) **Tenant Roles** (Tenant Administrator, Service Architect, Business Group Manager, Support User, Business User, Approval Administrator, Approver etc)								
Configure vRA								
Create Tenant, Business groups								
Define Reservation Policy for Business groups								
Create Network profiles								
Create Templates, Blue Prints								
Create Catalog, Catalog Items and Entitlements								
Configure custom fields in intake form								
Configure Approval Workflow								
Configure Monitoring using vROps and vRLoginsight								
Bulk Import								
End user and Cloud management training								

Fig. 4: Fragment of the "Gantt Chart" Visual Histogram for the Project on Implementing Project Leasing Operations in the Company's Activities (Microsoft Project Environment)

The group of monitoring and control processes within the project management system encompasses essential activities for tracking, analysis, and coordination of project progress and execution [8].

The effectiveness of project implementation is gauged by the extent to which set goals are achieved and business tasks are resolved, alongside adherence to established budgets and deadlines.

The outcomes of project implementation yield both internal and external benefits for the business entity. Internally, project indicators such as resource cost levels, professional growth of project participants, and more are evaluated. Externally, benefits are measured in terms of capital investments in the project and the degree to which planned objectives are realized.

An approach for evaluating project performance involves the use of a Balanced Scorecard (BSC), a framework that identifies key indicators influenced by project outcomes. It quantitatively assesses changes in these indicators, establishing checkpoints at various project management stages to evaluate and compare actual values with planned ones. A strategic map provides a graphical representation of the Balanced Scorecard.

Note the tasks in red are along the critical path and tasks in blue are non-critical. Looking closer we see that some activities, such as Grade Site and Set Foundations, are performed in parallel. Others, such as Lay Control Cable and Remove Equipment are in a strict series relationship. We want a better understanding of task relationships, so we can coordinate activities, particularly those performed in parallel. A network diagram will help us focus in on the activity relationships. To display a network diagram of the schedule select the Task tab, View ribbon group, Gantt chart drop down menu, and Network Diagram, Figure 5-7.

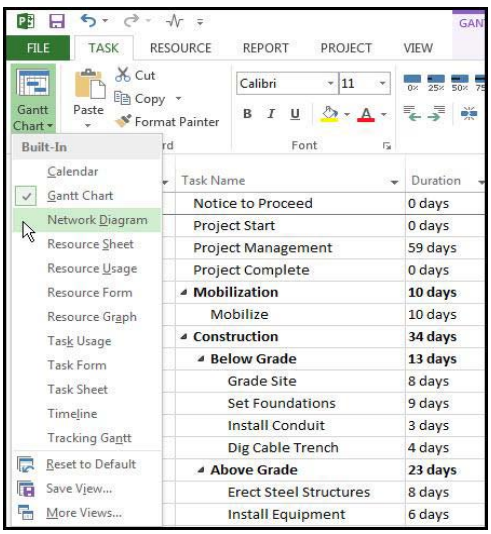

Fig. 5: A Network Diagram of the Schedule Select the Task Tab, View Ribbon Group, Gantt Chart Drop Down Menu, and Network Diagram

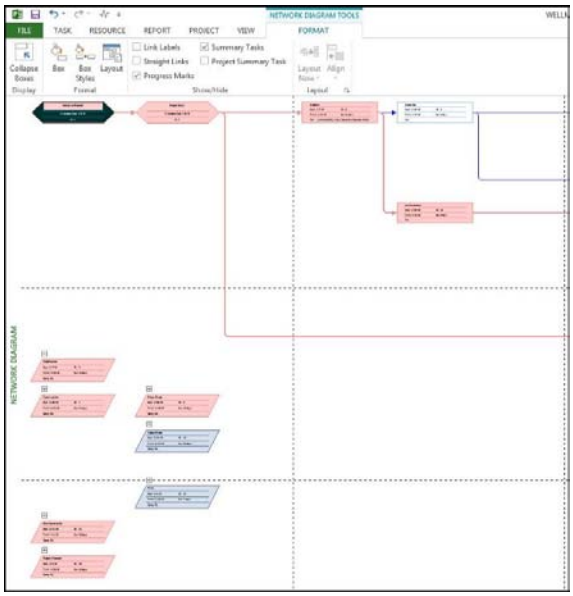

Fig. 6: The Network Diagram for Our Demonstration Project

Note the nodes that are not connected are summary tasks. Because these nodes are not providing any useful information let's remove them from our network diagram. To do this select the Format tab, Format ribbon group, and Layout, Figure 7.

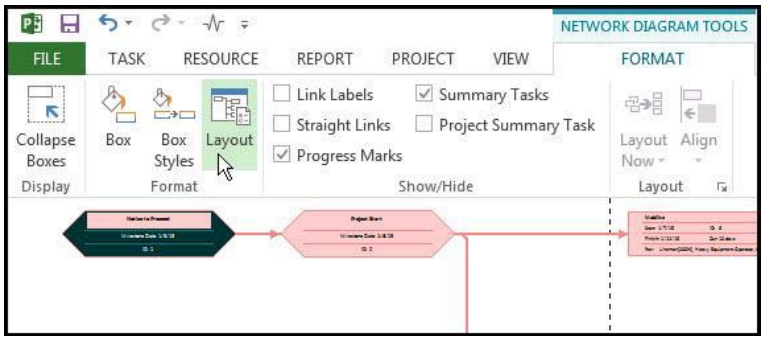

Fig. 7: Format tab

In the resulting Layout diagram toggle off, "Show summary tasks", Figure 8.

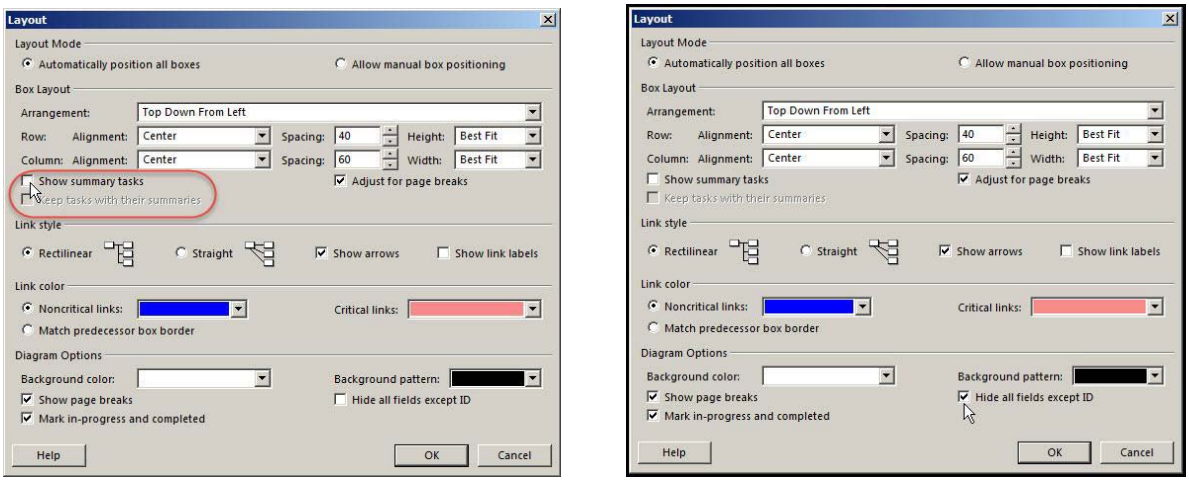

Fig. 9: Layout dialog

Task nodes are rectangular in shape. Critical tasks are in red and non-critical are blue. Each task node provides the task name, start, finish, duration, resources, and ID. This is probably more information than we need and it makes distinguishing any task node information near impossible or difficult to read when the entire schedule network is displayed, as in Figure 8. Let's simplify the node details using the Layout dialog, Figure 9.

In the Layout dialog toggle on 'Hide all fields except ID'. Now we can clearly see the entire schedule network and associated IDs, Figure 10.

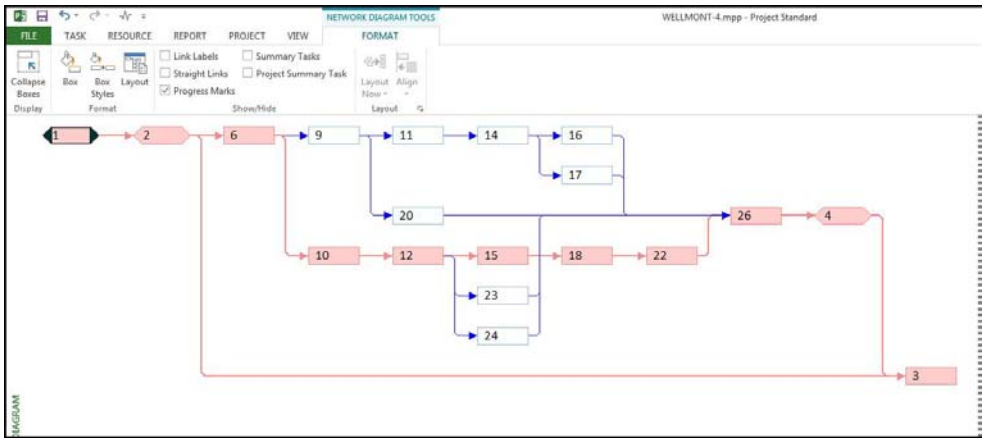

Fig. 10: Hide all fields except ID'

We also know that if we want more information on a network node we simply toggle off 'Hide all fields except ID'. With only the ID displayed as in Figure 10 we can easily see the entire network in a way that provides useful insight. The node (task) predecessor and successor is apparent for each node. The critical path is clearly visible. We can also distinguish the nodes or tasks performed in parallel and/or series. Effective project management necessitates the utilization of business intelligence (BI) to evaluate project metrics. BI is employed to ascertain and validate decisions related to meeting needs and achieving project goals. During project initiation, funding considerations demand significant attention, while upon completion, the focus shifts to evaluating implementation effectiveness.

Project indicators enable the assessment of individual management decisions and the overall project performance. Monitoring key performance indicators (KPIs) for the project is facilitated through a dashboard, an information panel displaying essential indicators through visualizations such as graphs, tables, and diagrams. The neural model comprises an external bias, which, depending on its positivity or negativity, augments or diminishes the network output upon activation of the activation function. Neuron K can be described using two equations, denoted as (1) and (2):

$$u_k = \sum_{j=1}^{m} \quad w_{ki}\, x_j \tag{1}$$

$$y_k = \phi(u_k + b_k) \tag{2}$$

The role of the threshold is to affine the output of the linear combiner within the model:

$$u_k = u_k + b_k \tag{3}$$

Bias represents an external parameter of artificial neuron K. The same relationship can be obtained by combining formula (2) and formula (3) as follows:

$$u_k = \sum_{j=0}^{m} \quad w_{ki}\, x_j \tag{4}$$

$$y_k = \phi(u_k) \tag{5}$$

Where the activation function is represented by.

$$\phi(v) = \begin{cases} 1, & \text{if } v \geq 0 \\ 0, & \text{if } v < 0 \end{cases} \tag{6}$$

This represents the step function. The corresponding output in this scenario is given by:

$$y_k = \begin{cases} 1, & \text{if } v \geq 0 \\ 0, & \text{if } v < 0 \end{cases} \tag{7}$$

Another activation function can be represented as.

$$\phi(v) = \begin{cases} 1, & \text{if } v \geq 1 \\ 1 + v, & \text{if } -1 < v < 1 \\ 0, & \text{if } v \leq -1 \end{cases} \tag{8}$$

Commonly used nonlinear functions are S function and radial basis function as shown in Figure 11.

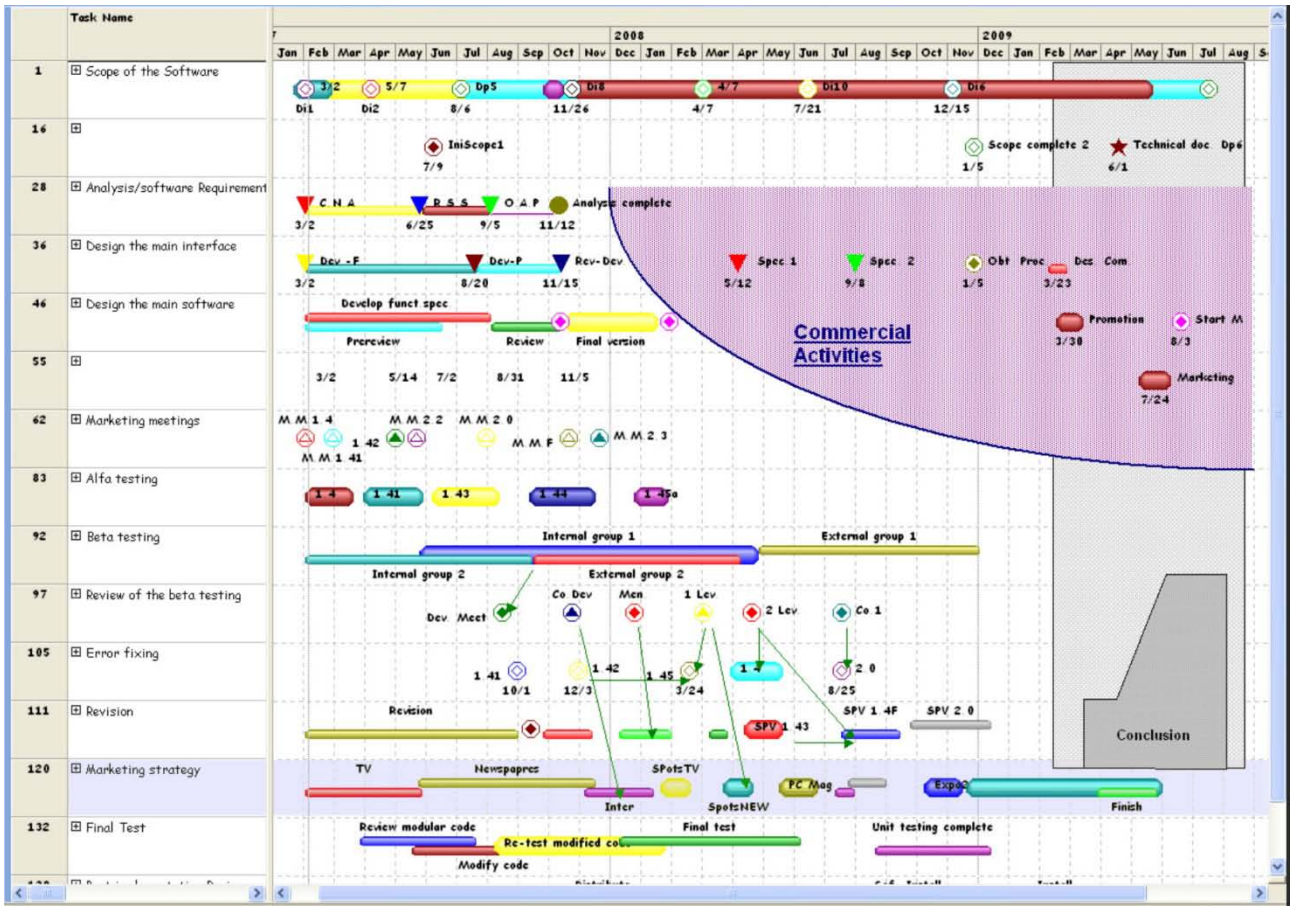

Fig. 11: Visualization of Project Data for Evaluating the Effectiveness of Project Management Decisions (Dashboard Fragment) in the PowerBI Environment

A dashboard, also referred to as an information panel, is a visually organized display of crucial information, grouped by content on a single screen for easy comprehension [5]. Fig. 5 illustrates a portion of project data visualization within a dashboard, achieved using a business analytics tool.

V. Conclusion

The established visual presentation designed for monitoring individual business tasks' execution within the project area can be effectively implemented within the MS Project environment. The visualization of data, in the form of a Gantt chart, enables the assessment of project stages from the perspective of allocated resources, their costs, work schedules, and task deadlines. The success of project implementation is gauged by the performance indicators of the business entity. Hence, the visualization of design data through modern VI tools, which yield operational metrics crucial for decision-making, remains pertinent. The project data analysis dashboard consists of visualizations aligned with a specific set of parameters. The assortment of infographics varies based on the significance of indicators and their relevance to decision-makers. Analytical data are presented through tables, charts, arrow indicators, and other visualization formats, resulting from the grouping and aggregation of raw data. Dashboards facilitate the application of sorting tools and filters at different indicator levels, enabling the creation of calculated fields. In this manner, data visualization in project management within the design domain lays the groundwork for the formulation and adoption of operational management decisions. Future research endeavors will focus on visualizing project metrics derived from the balanced scorecard analysis system of project indicators.

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ASSOCIATE OF COMPUTER SCIENCE RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

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Career | Financial

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Financial

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Organize seminar/conference

Associates are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

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Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

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Associate	Fellow	Research Group	Basic
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Certificate, LoR and Momento **2** discounted publishing/year **Gradation** of Research **10** research contacts/day **1 GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day **5 GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

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2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
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7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

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3. Final approval of the version of the paper to be published.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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