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Content-Based Image Retrieval using SURF and Colour Moments

By K.Velmurugan, Lt.Dr.S. Santhosh Baboo

Abstract- Content-Based Image Retrieval (CBIR) is a challenging task which retrieves the similar images from the large database. Most of the CBIR system uses the low-level features such as colour, texture and shape to extract the features from the images. In Recent years the Interest points are used to extract the most similar images with different view point and different transformations. In this paper the SURF is combined with the colour feature to improve the retrieval accuracy. SURF is fast and robust interest points detector/descriptor which is used in many computer vision applications. To improve the performance of the system the SURF is combined with Colour Moments since SURF works only on gray scale images. The KD-tree with the Best Bin First (BBF) search algorithm is to index and match the similarity etween the features of the images. Finally, Voting Scheme algorithm is used to rank and retrieve the matched images from the database.

Keywords: Content-Based Image Retrieval (CBIR), SURF, Colour Moments, KD tree.

GJCST Classification: I.4.8

CONTENT-BASED IMAGE RETRIEVAL USING SURF AND COLOUR MOMENTS

Strictly as per the compliance and regulations of:

Content-Based Image Retrieval using SURF and Colour Moments

K.Velmurugan[α], Lt.Dr.S. Santhosh Baboo[Ω]

Abstract- Content-Based Image Retrieval (CBIR) is a challenging task which retrieves the similar images from the large database. Most of the CBIR system uses the low-level features such as colour, texture and shape to extract the features from the images. In Recent years the Interest points are used to extract the most similar images with different view point and different transformations. In this paper the SURF is combined with the colour feature to improve the retrieval accuracy. SURF is fast and robust interest points detector/descriptor which is used in many computer vision applications. To improve the performance of the system the SURF is combined with Colour Moments since SURF works only on gray scale images. The KD-tree with the Best Bin First (BBF) search algorithm is to index and match the similarity between the features of the images. Finally, Voting Scheme algorithm is used to rank and retrieve the matched images from the database.

Keywords- Content-Based Image Retrieval (CBIR), SURF, Colour Moments, KD-tree.

I. Introduction

Content-based image retrieval (CBIR) is a system, in which retrieves visual-similar images from large image database based on automatically-derived image features, which has been a very active research area recently. In most of the existing CBIR systems[1], the image content is represented by their low-level features such as colour, texture and shape[2][3]. The drawback of low-level features is losing much detail information of the images, in case of looking for images that contain the same object or same scene with different viewpoints. In recent years, the interest point detectors and descriptors [4] are employed in many CBIR systems to overcome the above drawback.

SURF (Speed Up Robust Feature) is one of the most and popular interest point detector and descriptor which has been published by Bay et al.[5]. It is widely used in most of the computer vision applications. The SURF has been proven to achieve high repeatability and distinctiveness. It uses a Hessian matrix-based measure for the detection of interest points and a distribution of Haar wavelet responses within the interest point neighborhood as descriptor. An image is analyzed at several scales, so interest points can be extracted from both global and local image details. In addition to that, the dominant orientation of each of the interest points is determined to support rotation-invariant matching. SURF is one of the best interest point detectors and descriptors currently available.

The Proposed System

The proposed CBIR system is shown in Figure 1. The feature vectors are extracted from the images in the database and described by multidimensional feature vectors, which form a feature database. To retrieve images, the feature vectors are extracted from the given query image. The similarities between the feature vectors of the query image and the feature vectors of the database images are then calculated. And the retrieval is performed with the aid of an indexing scheme and matching strategy, which provide an efficient way to search the image database. In this work, SURF algorithm is used to extract the features and the first order and second order colour moments is calculated for the SURF key points to provide the maximum distinctiveness for the key points. The KD-tree with the Best Bin First (BBF)[6] algorithm is used to index and match the similarity of the features of the images. In section II, the feature extraction algorithm is proposed; indexing and matching is discussed in section III; the experiments based on COIL-100 object database are discussed in section IV; the paper is concluded in section V.

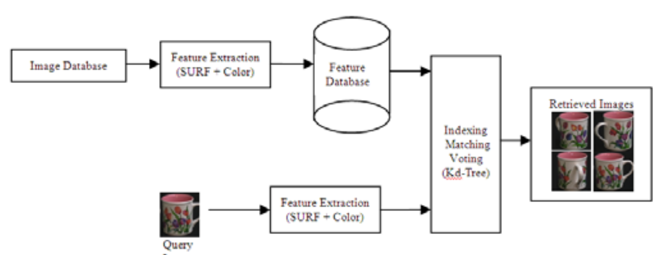

Fig.1. The Proposed CBIR system

II. Feature Extraction

a) *SURF Algorithm*

The Speeded up robust features algorithm is a scale and rotation-invariant interest point detector and descriptor which is computationally very fast. It uses Integral images to improve the speed. The key points are detected by using a Fast-Hessian matrix. The descriptor describes a distribution of Haar-wavelet

About[α]- Associate Professor, Dept. of Computer Applicatios, S N R . Sons College, Coimbatore, Tamil Nadu, India – 641 006. (email:velskvm@gmail.com)
About[Ω]- Reader, PG and Research Dept. of Computer Applications, D G Vaishnav College, Chennai, Tamil Nadu, India-600 106. (email: santhosh2007@sify.com)

responses within the interest point neighborhood. The performance of SURF increased by using an intermediate image representation known as the *Integral Image*. The integral image is computed rapidly from an input image and is used to speed up the calculation of any upright rectangular area. The major computational steps of SURF algorithm is as follows:

Step 1 : Fast Interest Point Detection.
The SURF feature detector is based on the Hessian matrix. The determinant of the Hessian matrix is used to determine the location and scale of the descriptor. The Hessian matrix is defined as H(x, σ) for a given point $\boldsymbol{x} = (x, y)$ in an image as follows:

$$H(x,\sigma) = \begin{bmatrix} L_{xx}(x,\sigma) L_{xy}(x,\sigma) \\ L_{xy}(x,\sigma) L_{yy}(x,\sigma) \end{bmatrix} \quad (1)$$

where L_{xx} (x,σ) is the convolution of the Gaussian second order derivative $\frac{\partial^2}{\partial x^2}$ g(σ)with the image I in point x and similarly for L_{xy} (x,σ) and L_{yy} (x,σ). The SURF approximates second order derivatives of the Gaussian with box filters. Image convolutions with these box filters can be computed rapidly by using integral images.
The determinant of the Hessian matrix is written as:

$$Det\,(H_{approx}) = D_{xx} D_{yy} - (0.9D_{xy})^2 \quad (2)$$

In order to localize interest points in the image and over scales, a non maximum suppression in a 3 × 3 × 3 neighborhood is applied. Finally, the found maxima of the determinant of the Hessian matrix are then interpolated in scale and image space.

Step 2 : Interest Point Descriptor
The SURF descriptor is extracted from an image in two steps : the first step is assigning an orientation based on the information of a circular region around the detected interest points. The orientation is computed using Haar-wavelet responses in both x and y direction. Once the Haar-wavelet responses are computed and they are weighted with a Gaussian with σ = 2.5s centered at the interest points. In a next step the dominant orientation is estimated by summing the horizontal and vertical wavelet responses within a rotating wedge which covering an angle of π/3 in the wavelet response space. The resulting maximum is then chosen to describe the orientation of the interest point descriptor.

In a second step, the region is split up regularly into smaller square sub-regions and a few simple features at regularly spaced sample points are computed for each sub-region. The horizontal and vertical wavelet responses are summed up over each sub-region to form a first set of entries to the feature vector. The responses of the Haar-wavelets are weighted with a Gaussian centered at the interest point in order to increase robustness to geometric deformations and the wavelet responses in horizontal d_x and vertical Directions d_y are summed up over each sub-region. Furthermore, the absolute values $|d_y|$ and $|d_y|$ are summed in order to obtain information about the polarity of the image intensity changes. Therefore each sub-region has a four-dimensional descriptor vector

$$V = (\sum d_x, \sum|d_x|, \sum|d_y|) \quad (3)$$

where dx denotes the horizontal wavelet response and dy the vertical response. The resulting descriptor vector for all 4 by 4 sub-regions is of length 64.

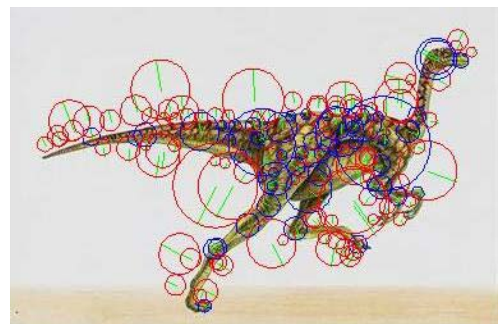

Fig.2. *SURF Interest points of a dinosaur*

b) *Colour Feature*

Surf works only on gray scale images to extract the colour features around the region of each interest points the Colour Moments [7] are used. Colour moments are calculated for a 5x5 region around the SURF interest point for the RGB channel. Since most of the information is concentrated on the low order moments, only the first moment (mean) and the second moments (variance) will be used as the colour features. The value of the i-th colour channel at the j-th image pixel is p_{ij}. The index entries related to this colour channel are calculated by:

$$E_i = \frac{1}{N}\sum_{j=1}^{N} P_{ij} \quad (4)$$

$$\sigma_i = \left[\frac{1}{N}\sum_{j=1}^{N}(P_{ij} - E_i)^2\right]^{\frac{1}{2}} \quad (5)$$

where N is the number of pixels in the image patch. The first order and second order colour information are concatenated to obtain the descriptor vector length as 70.

III. Indexing and Matching

In our CBIR system the KD-tree [8] algorithm is used to match the features of the query image with those of the database images. The KD-tree with the BEST bin First(BBF) search algorithm is used for indexing and matching the SURF features. The KD-tree is a kind of binary tree in which each node chooses a dimension from the space of the features being classified: all features with values less or equal to the node in that particular dimension will be put in the left sub-tree; the other nodes will be put in the right sub-tree and thus recursively. The BBF algorithm uses a priority search order to traverse the KD-tree so that bins in feature space are searched in the order of their closest distance from the query. The k-approximate and reasonable nearest matches can be returned with low cost by cutting off further search after a specific number of the nearest bins have been explored. The Voting scheme algorithm is used to rank and retrieved the matched images.

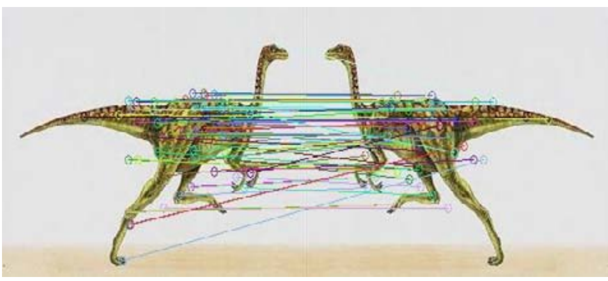

Fig.3. Matching SURF Interest points

IV. Experiment and Results

The image retrieval system based on SURF with colour feature tested on COIL-100 object database[9]. COIL-100 is a popular image database for benchmark which contains 72 views for 100 objects acquired by rotating the object under study about the vertical axis. In figure 4, shows sample views for the each of the objects in the database. Our database consists of total 1080 images of size 128x128. There are 15 different categories consisting of 72 images in each category. To test this system, a single query image is selected from each category. The SURF feature and colour moments are extracted for all images in the database. The feature database consist the features of the database images. The size of the feature vector is 70(64-d SURF + 3 X 2 First order and second order colour moments of RGB channel). The fast and multidimensional KD-tree data structure is used to compare the features of the query image with the data base images. To check the performance of proposed technique the precision and recall is used. The standard definitions of these two measures are given by following equations.

$$Precision = \frac{Number\ \ of\ relevant\ \ images\ \ retrieved}{Total\ \ number\ \ of\ \ image\ s\ retrieved} \qquad (6)$$

$$Recall = \frac{Number\ \ of\ relevant\ \ images\ \ retrieved}{Total\ number\ \ of\ relevant\ \ images\ \ in\ the\ database} \qquad (7)$$

Figure 4 shows a sample database of 15 images by randomly selecting one image from each category. The database has 15 categories, for a total of 1080 images. Figure 5 Shows Results of Paper-Box query image. Note that the database contains total 72 Paper-Box's images. Table 1. Shows the Results of retrieved images by using SURF feature alone. The percentage of Precision/Recall vs Number of Retrieved images for all categories are given in Table 1. The Average Precision obtained is 65.47%. Table-2 Shows the Results of retrieved images using SURF and Colour feature for all 15 categories of images. The Average Precision obtained using the proposed method is 88%.

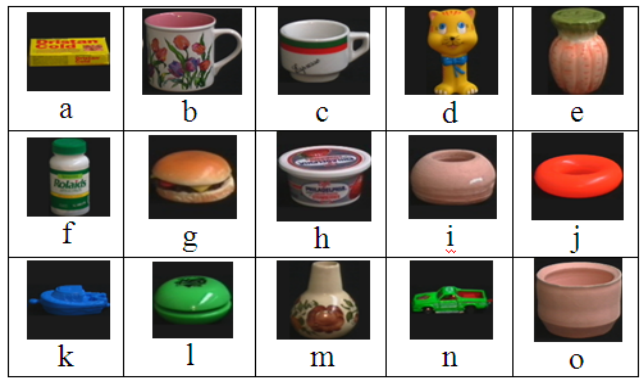

Fig.4. shows a sample database of 15 images by randomly selecting one image from each category. The database has 15 categories, for a total of 1080 images. [Image categories are named as from a to o]

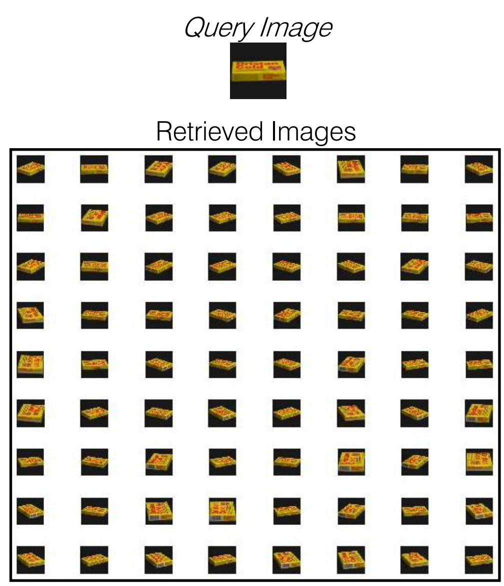

Fig.5. Shows Results of Paper-Box query image. Note that the database contains total 72 Paper-Box's images. For the query image as shown in figure for 72 retrieved images the total relevant images obtained are all 72.

Table 1. *Retrieved images using SURF Features*

Object Category	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	Average Precision / Recall
No. of relevant images retrieved	18	26	70	10	46	71	36	70	59	71	12	72	55	11	71	
Precision/Recall (%)	**25**	**36**	**97**	**13**	**63**	**98**	**50**	**100**	**97**	**98**	**16**	**100**	**76**	**15**	**98**	**65.47**

Table-1 gives number of total relevant images in the set of first 72 retrieved images for all 15 categories. The percentage of Precision/Recall for all categories of the resultant images are shown in Table-1.The Average Precision for all 15 categories is ***65.47%***

Table 2. *Retrieved images using SURF and Colour Moments*

Object Category	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	Average Precision / Recall
No. of relevant images retrieved	72	61	50	56	72	69	64	72	66	60	52	72	71	50	66	
Precision/Recall (%)	**100**	**84**	**70**	**78**	**100**	**96**	**89**	**100**	**92**	**83**	**72**	**100**	**99**	**70**	**92**	**88**

Table-2 gives number of total relevant images in the set of first 72 retrieved images for all 15 categories. The percentage of Precision/Recall for all categories of the resultant images are shown in Table-2.The Average Precision for all 15 categories is 88%.

V. Conclusion

The explosive growth of image data leads to the need of research and development of Image Retrieval. Content-based image retrieval is currently a very important area of research in the area of multimedia databases. Plenty of research works had been undertaken in the past decade to design efficient image retrieval techniques from the image or multimedia databases. More précised retrieval techniques are needed to access the large image archives being generated, for finding relatively similar images. In this work the SURF is combined with colour Moments to improve the retrieval accuracy of the system which improves 23% of Average Precision. The proposed method gets 88% of Average Precision, for 15 categories of 1080 images which outperforms than SURF alone which gives only 65.47% of Average Precision.

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Growth Option Model For Oil Field Valuation

By Ajayi Kehinde, Ogunlade Temitope Olu
University of Science and Technology Ifaki

Abstract- This paper considers the use of Real Option Approach (ROA) to value an oil field project. The Geometric Brownian Motion and the classic Black-Schole's model is used to obtain the value of the fair price (option value F). We show that ROA is an invaluable tool in decision making in situations where investment involves high risk and uncertainty.

Keywords: *Real options, Brownian motion.*

GJCST Classification: *J.2*

GROWTH OPTION MODEL FOR OIL FIELD VALUATION

Growth Option Model For Oil Field Valuation

Ajayi Kehinde, Ogunlade Temitope Olu

Abstract- This paper considers the use of Real Option Approach (ROA) to value an oil field project. The Geometric Brownian Motion and the classic Black-Schole's model is used to obtain the value of the fair price (option value F). We show that ROA is an invaluable tool in decision making in situations where investment involves high risk and uncertainty.

Keywords: Real options, Brownian motion.

I. Introduction

Myers (1984) first used the term "real options" to describe corporate investment opportunities that resemble options. He proposed that the value of a firm could be divided into the value of its assets in place and the value of these "future growth options". Growth options are also frequently referred to as expansion options.

Real options analysis (ROA) can more accurately model the nature of the investment and therefore provide a better basis for the investment decision. For example, ROA is preferred when the investment decision hinges on the outcome of a future event, or when there is enough uncertainty to defer the investment decision. Also companies use real options analysis when future growth is a significant source of the investment's value, when a traditional discounted cash flow (DCF) analysis returns a low or slightly negative net present value, and when the options associated with the investment could change management's decision from "no go" to "go". Essentially, real options analysis is ideal for companies in high-growth industries where there is a great deal of uncertainty and the investments are both large and strategic. High tech, venture capital, pharmaceutical and oil exploration all qualify, and interestingly all are early adopters of real options analysis.

The need to developing valuation models that is capable of capturing such features of investment as irreversibility, uncertainty as well as timing flexibility has resulted in a vast amount of literature on real options and investment under uncertainty. In his seminar paper Myers (1977) draws attention to the optimal exercise strategies of real options as being the significant source of corporate value.

Brennan and Schwartz (1985) are one of the first to adopt the modern option pricing techniques (see Black and Scholes, 1973 and Merton, 1973) to evaluate natural resource investments. The price of the commodity is used as an underlying stochastic variable upon which the value of the investment project is contingent. McDonald and Siegel (1986) derive the optimal exercise rule for a perpetual investment option when both the value of the project and the investment costs follow correlated geometric Brownian motions. The authors show that for realistic values of model parameters, it can be optimal to wait with investing until the present value of the project exceeds the present cost of investment by a factor of 2. This reflects substantial value of waiting in the presence of irreversibility and uncertainty. Majd and Pindyck (1987) contribute to the literature by considering the effect of a time to build on the optimal exercise rule. The optimal choice of the project's capacity is analyzed by Pindyck (1988) and Dangl (1999). Dixit (1989) analyzes the effects of uncertainty on the magnitude of hysteresis in the models with entry and exist. Dixit and Pindyck (1996) present a detailed overview of this early literature and constitute an excellent introduction to the techniques of dynamic programming and contingent claims analysis, which are widely applicable in the area of real options and investment under uncertainty. An introduction to real options, which is closer in the spirit to the financial options theory, is presented by Trigeorgis (1996).

There is the need for a good and reliable option-pricing model that will yield or give the best result. Therefore, the first reliable option-pricing model was derived by Black and Scholes (1973). The Black-Scholes formula can be used to obtain the value of European call options on non-dividend paying assets. The value of the European put with identical parameters can be inferred from the call value. Merton (1973) developed an option pricing formula for dividend-paying assets and made other significant contributions to the development of option pricing theory. Merton and Scholes won the Noble Price in Economics for their contributions to derivative pricing in 1997. Cox, Ross and Rubinstein (1979) built on the insights of Black and Scholes (1973) and others to develop the binomial option-pricing model. The binomial model is simpler to understand and explain than the Black-Scholes model, it is more widely used in practice, and is capable of generating the same results as the Black-Scholes.

Arnold and Crack (2000) extended the binomial model to yield additional probabilistic information about the option that cannot be obtained directly from the Cox, Ross and Rubinstein (1979) model. It must be stressed that the interest here is more on the Black-Scholes model and so, we shall be examining and employing the Black-Scholes model.

About- University of Science and Technology Ifaki, Nigeria
E-mail- topsmatic@yahoo.com

II. BROWNIAN MOTION

For a project value V or the value of the developed reserve that follows a Geometric Brownian Motion, the stochastic equation for its variation with the time t is

$$dV = \alpha V dt + \sigma V dz \qquad (1)$$

where $dz = Wiener\ increament = \epsilon\sqrt{dz}$.
ϵ is the normal standard distribution, α is the drift and σ is the volatility of V. In real options problems, there is a dividend like income stream δ for the holder of the asset. This dividend yield is related to the cash flows generated by the assets in place. For commodities prices, this is called convenience yield or rate of return of shortfall. In all cases, the equilibrium requires that the total expected return μ to be the sum of expected capital gain plus the expected dividend, so that $\mu = \alpha + \delta$ so that equation (1) becomes

$$dV = (\mu - \delta)Vdt + \sigma Vdt$$

Geometric Brownian Motion (GBM) has the great advantage of the simplicity but it is sometimes useful to work with arithmetic Brownian for the logarithm of the project value. If

$$\frac{dV}{V} = \alpha dt + \sigma dz$$

Letting $v = ln\, V$ and using Ito's Lemma, we find that v follows the arithmetic (ordinary) Brownian motion:

$$dv = d(ln\, V) = \left(\alpha - \hat{A}\frac{1}{2}\sigma^2\right) d + \sigma dz$$

So $dv = \alpha' dt + dz$
Although, the volatility term is the same of the geometric Brownian for V, $d(ln\, V)$ is different from dV/V due to drift. In reality, by the Jensen's inequality, $d(ln\, V) < dV/V$ (Ito's effect).

III. REAL OPTIONS IN PETROLEUM

A simple real option method is to exploit the power of the analogy with financial
European call option on a stock paying a continuously compound dividend yield. In the analogy with petroleum, instead of the stock, the underlying asset is the developed reserve value, V (which is a function of petroleum prices). The excise price is the cost of development, D and the time to expiration, T is the relinquishment requirement.

Study has shown that there is high correlation between oil price, P and the market value of the developed reserve V, so it is reasonable to set V as a proportion of P.
Let

F: denote the value per barrel of the undeveloped reserve
V: denote the value per barrel of the developed reserve
π: denote Profit (after-tax) from producing and selling one barrel of oil.
B: denote Remaining Reserve (number of barrels of oil equivalent in a developed
reserve)
R: denote Owners Developed Reserve Return
ω: denote the fraction of the reserve (exponential decline parameter) produced each year
D: Investment cost per barrel (or unit exercise price of the option)
r: Risk-free interest rate (real and after-tax)
σ: Volatility of the developed reserve (standard-deviation from dV/V)
μ: Risk-adjusted expected rate of return from a unit of developed reserve
δ : Dividend yield (or convenience yield or payout rate) from a unit of developed
reserve
dz: Wiener increament

The exponential decline, largely used by industry as the first estimate of the petroleum production profile.

$$dB = -\omega B dt \qquad (2)$$

Developed Reserve Return = Gain from Production [dividends] + Remaining Reserve Valorization [capital gain].

$$Rdt = \omega B\pi dt + d(BV) \qquad (3)$$

But

$$d(BV) = \frac{\partial(BV)}{\partial V}dV + \frac{\partial(BV)}{\partial V}.dB = BdV + V\,dB$$

Using the equation (1) and substituting in the equation (2) we have

$$Rdt = \omega B\pi dt + BdV - \omega VBdt \qquad (4)$$

For a model which the rate of return on the developed reserve follows a
geometric Brownian motion.

$$\frac{Rdt}{BV} = \mu dt + \sigma dz \qquad (5)$$

$$\frac{\omega B\pi dt + BdV - \omega VBdt}{BV} = \mu dt + \sigma dz$$

$$\rightarrow dV = (\mu - \delta)V\,dt + \sigma V dz \qquad (6)$$

This is a very important result of the developed reserve return where the divided
(convenience) yield is:

$$\delta = \frac{\omega(\pi - V)}{V} \qquad (7)$$

Ito's lemma for $F(V,t)$ is

$$dF = F_V\, dV + \frac{1}{2}F_{VV}\,(dV)^2 + F_t dt \qquad (8)$$

Where the subscripts denotes partial derivatives, so that from (6)

$$(dV)^2 = \sigma^2 V^2 dt \qquad (9)$$

so that

$$dF = F_V\, dV + \frac{1}{2}\sigma^2 V^2\, F_{VV}\, dt + F_t dt \qquad (10)$$

The risk free portfolio values

$$\Phi = F - nV = F - F_V V \qquad (11)$$

The quantity of stocks n to build a risk-free portfolio is the derivative of the option
(named delta in financial market), because it makes the random term(dz), of the
return equation equal to zero. The portfolio returns per barrel
$= dF - F_V\,(\omega\pi dt + dV - \omega V dt)$ Equating with eqn (11) and substituting dF in the equation (10)

$$r(F - F_V V) = F_V dV + \frac{1}{2}\sigma^2 F_{VV} dt + F_t dt - F_V\omega\pi dt - F_V dV + F_V \omega V dt$$

Simplifying this we get

$$-F_t = \frac{1}{2}\sigma^2 V^2 F_{VV} + (r-\delta)VF_V - rF \qquad (12)$$

which is the Black-Scholes' equation. Next, we shall solve the equation (6) for the
value of V. From (6) $dV = (\mu - \delta)V\, dt + \sigma V dz.$ It implies that

$$dV\,(t) = \alpha V(t)dt + \sigma V(t)dz(t)$$

Where $\alpha = \mu - \delta$

$$\frac{dV(t)}{V(t)} = \alpha dt + \sigma dz(t) \qquad (13)$$

Hence $d(ln(V\,(t))) = \alpha dt + \sigma dz(t)$. Let $U\big(V\,(t)\big) = ln(V\,(t)).$
Using Ito's formula

$$U\big(t,V(t)\big) = U\big(s,V\,(s)\big) + \int_0^t \frac{\partial U\big(t,V(t)\big)}{\partial t} + \int_0^t \frac{\partial U\big(\tau,V(t)\big)}{\partial V} dV(t) + \frac{1}{2}\int_0^t \frac{\partial^2 U\big(\tau,V(t)\big)}{\partial V^2} d\langle V\rangle t \qquad (14)$$

hence

$$dU\big(t,V(t)\big) = \frac{dV(t)}{V(t)} - \frac{d\langle V\rangle t}{2V(t)^2} \qquad (15)$$

But

$$d\langle V\rangle t = \big(dV(t)\big)(dV_t) = (dV_t)^2 \qquad (16)$$

And

$d\langle V\rangle t =$
$\sigma^2(V(t))^2 dt$ … … … … (16)

putting (16) into (15) we have,

$$dU\big(V(t)\big) + \frac{1}{2}\sigma^2 dt = \frac{dV(t)}{V(t)} \qquad (17)$$

$$dU(V(t)) = \left(\alpha - \frac{1}{2}\sigma^2\right)dt + \sigma dz(t) \qquad (18)$$

Integrating from t_0 to t, we have

$$U\big(V(t) - V(t_0)\big) = \left(\alpha - \frac{1}{2}\sigma^2\right)\Delta t + \sigma N(0,1)\sqrt{\Delta t}$$

Since it follows from a normal distribution, therefore

$$V(t) = V_0 exp\left[\left(\alpha' - \frac{1}{2}\sigma^2\right)\Delta t + \sigma N(0,1)\sqrt{\Delta t}\right] \qquad (19)$$

Hence, we have the equation for real simulation of the developed reserve . But for the risk-neutral simulation which we shall use, we have:

$$V(t) = V_0 exp\left[\left(r - \delta - \frac{1}{2}\sigma^2\right)\Delta t + \sigma N(0,1)\sqrt{\Delta t}\right] \qquad (20)$$

Where $\alpha' = r - \delta$ is the risk-neutral drift.

IV. The Black-Scholes' Formulae

Theorem: Let $C_E(S_0,T,K)$ be the fair price of a European call with strike price K, expiration T and initial asset price S_0. Similarly, write $P_E(S_0,T,K)$ for the fair price of a European put with the same strike price K, expiration T and initial asset price S_0. Then

$$C_E(S_0,T,K) = \mathrm{S_0 N(d_1) - ke^{-rT}} N(d_2)$$
$$P_E(S_0,T,K) = \mathrm{ke^{-rT} N(-d_2) - S_0(-d_1)}$$

Where

$$N(x) = \frac{1}{\sqrt{2\pi}}\int_\infty^x e^{\frac{-y^2}{2}} dy$$

$$d_1 = \frac{1}{\sqrt{\sigma^2 T}}\, In\left[\frac{S_0 e^{\left(r+\frac{1}{2}\sigma^2\right)T}}{K}\right]$$

$$d_2 = \frac{1}{\sqrt{\sigma^2 T}}\, In\left[\frac{S_0 e^{\left(r-\frac{1}{2}\sigma^2\right)T}}{K}\right]$$

$$d_1 = \frac{1}{\sqrt{\sigma^2 T}}\, In\left[\frac{S_0 e^{\left(r+\frac{1}{2}\sigma^2\right)T}}{K}\right]$$

Note that $d_2 = d_1 - \sqrt{\sigma^2 T}$. Since the fair price f of a contingent claim, with this underlying asset (the developed reserve value V) satisfies the B-S equation, that is, equation (12) Then, the corresponding B-S formulae for the European call and European put are given by

$$C_E(V_0, T, K, \delta) = V_0 e^{-\delta T} N(d_1) - k e^{-rT} N(d_2)$$
$$P_E(V_0, T, K, \delta) = k e^{-rT} N(-d_2) - V_0 e^{-\delta T}(-d_1)$$

The Black-Scholes' expression for the fair price F (option value) of a contingent claim depends on; the asset value V_0 at time t = 0, the volatility σ, the time to maturity T, the interest rate r, and the strike price K. The sensitivities of the fair price F with respect to the first four parameters called Greeks are used for hedging.

$$C_E(V_0, T, K, \delta, r, \sigma) = V_0 e^{-\delta T} N\left(\frac{1}{\sqrt{\sigma^2 T}} \mathrm{In}\left[\frac{V_0 e^{\left(r-\delta+\frac{1}{2}\sigma^2\right)T}}{K}\right]\right) - k e^{-rT} N\left(\frac{1}{\sqrt{\sigma^2 T}} In\left[\frac{S_0 e^{(r-\delta-\frac{1}{2}\sigma^2)T}}{K}\right]\right)$$

$$\Delta := \frac{\partial C_E}{\partial V_0} = e^{-\delta T}\left[\frac{1}{\sqrt{\sigma^2 T}} In\left(\frac{S_0 e^{\left(r-\delta+\frac{1}{2}\sigma^2\right)T}}{K}\right)\right] + \frac{V_0 e^{-\delta T} e^{-\frac{x_1^2}{2}}}{V_0\sqrt{2\pi\sigma^2 T}} - \frac{K e^{-rT} e^{-\frac{x_2^2}{2}}}{V_0\sqrt{2\pi\sigma^2 T}}$$

$$\Gamma := \frac{\partial^2 C_E}{\partial V_0^2} = \frac{e^{-\delta T} e^{-\frac{x_1^2}{2}}}{V_0 \sigma \sqrt{2\pi T V_0}} + \frac{K e^{-rT} e^{-\frac{x_2^2}{2}}}{V_0^2 \sigma \sqrt{2\pi T}}$$

$$\Theta := \frac{\partial C_E}{\partial T} = \frac{V_0 e^{-\delta T} e^{-\frac{x_1^2}{2}}}{\sqrt{2\pi\sigma^2}}\left[-\frac{1}{2}T^{-\frac{3}{2}} In\, V_0 + \frac{1}{2}\left(r-\delta-\frac{\sigma^2}{2}\right)T^{-\frac{1}{2}} + \frac{1}{2}T^{-\frac{3}{2}}\, In\, K\right] \delta V_0 e^{-\delta T} N(\frac{1}{\sqrt{(\sigma^2 T)}}\left[In\, V_0 + \left(r-\delta+\frac{\sigma^2}{2}\right)T - In\, K\right])$$

$$+ K r e^{-rT} N(\frac{1}{\sqrt{(\sigma^2 T)}}\left[In\, V_0 + \left(r-\delta+\frac{\sigma^2}{2}\right)T - In\, K\right])$$

$$-\frac{K e^{-rT} e^{-\frac{x_2^2}{2}}}{\sqrt{2\pi\sigma^2}}\left[-\frac{1}{2}T^{-\frac{3}{2}} In\, V_0 + \frac{1}{2}\left(r-\delta-\frac{\sigma^2}{2}\right)T^{-\frac{1}{2}} + \frac{1}{2}T^{-\frac{3}{2}}\, In\, K\right]$$

$$= \frac{1}{2}\frac{V_0 e^{-\delta T} e^{-\frac{x_1^2}{2}}}{\sigma\sqrt{2\pi T}}\left[\left(r-\delta-\frac{\sigma^2}{2}\right) + \frac{In\frac{K}{V_0}}{T}\right] - \delta V_0 e^{-\delta T} N\left(\frac{1}{\sqrt{(\sigma^2 T)}}\left[In\, \frac{V_0}{K} + \left(r-\delta+\frac{\sigma^2}{2}\right)T\right]\right)$$

$$+ K r e^{-rT} N(\frac{1}{\sqrt{(\sigma^2 T)}}\left[In\, \frac{V_0}{K} + \left(r-\delta-\frac{\sigma^2}{2}\right)T\right]) - \frac{K e^{-rT} e^{-\frac{x_2^2}{2}}}{2\sigma\sqrt{2\pi T}}\left[\frac{In\frac{V_0}{K}}{T} + \left(r-\delta-\frac{\sigma^2}{2}\right)\right]$$

Therefore, our F_V, F_{VV} and F_t for the European call is obtained as:

$$\Delta := F_V = e^{-\delta(T-t)} N\left[\frac{1}{\sqrt{\sigma^2(T-t)}} In\left(\frac{S_0 e^{\left(r-\delta+\frac{1}{2}\sigma^2\right)(T-t)}}{K}\right)\right] + \frac{V_0 e^{-\delta(T-t)} e^{-\frac{x_1^2}{2}}}{V_0\sqrt{2\pi\sigma^2(T-t)}} - \frac{K e^{-r(T-t)} e^{-\frac{x_2^2}{2}}}{V_0\sqrt{2\pi\sigma^2(T-t)}}$$

$$\Gamma := F_{VV} = \frac{e^{-\delta(T-t)} e^{-\frac{x_1^2}{2}}}{V_0\sigma\sqrt{2\pi(T-t)}V_0} + \frac{K e^{-r(T-t)} e^{-\frac{x_2^2}{2}}}{V_0^2\sigma\sqrt{2\pi(T-t)}}$$

$$\Theta := F_t = \frac{1}{2}\frac{V_0 e^{-\delta(T-t)} e^{-\frac{x_1^2}{2}}}{\sigma\sqrt{2\pi(T-t)}}\left[\left(r-\delta-\frac{\sigma^2}{2}\right) + \frac{In\frac{K}{V_0}}{(T-t)}\right] - \delta V_0 e^{-\delta(T-t)} N\left(\frac{1}{\sqrt{(\sigma^2(T-t))}}\left[In\frac{V_0}{K} + \left(r-\delta+\frac{\sigma^2}{2}\right)(T-t)\right]\right)$$
$$+ Kre^{-r(T-t)} N\left(\frac{1}{\sqrt{(\sigma^2(T-t))}}\left[In\frac{V_0}{K} + \left(r-\delta-\frac{\sigma^2}{2}\right)(T-t)\right]\right)$$
$$- \frac{K e^{-r(T-t)} e^{-\frac{x_2^2}{2}}}{2\sigma\sqrt{2\pi(T-t)}}\left[\frac{In\frac{V_0}{K}}{(T-t)} + \left(r-\delta-\frac{\sigma^2}{2}\right)\right]$$

V. Numerical Example

In this section, we provide a numerical example of an oil company considering an investment in an oil company, the initial value, $V_0$of the oil field is set at 1billion naira. An investment of 60million naira which could be thought of as the option premium on the option is required immediately for permitting and other preparations. This first stage will take one year. If this stage investment is made, then the firm may any time over the next five years choose to make a second stage investment of 800million naira to develop the reserve. The offshore lease is for 5 years. Set r = 0.03, $\delta = 0.04$ and $\sigma^2 =$ 0.0676. With these settings, we get the value of $V(1) = 898{,}783{,}498.8 naira$, $x_1 = 0.9498$, $x_2 = 0.6898$, $F_V = -0.2571$, $F_{VV} = 2.3799 \times 10^{-9}$, $F_t = 57596310.04$.

With this, the value of F for four years before expiration is $F = 4{,}162932{,}089$ and for one year before expiration is $1{,}247{,}975{,}971\ naira$ which shows that in any case the option is profitable.

VI. Conclusion

In this research work, we considered an investment opportunity of a firm using real options approach. We employed Geometric Brownian Motion to capture the value of the developed reserve and the classic model equation (12) to capture or obtain the value of the undeveloped reserve that is, the option value F. This option value F is also known as the fair price or theoretical value of the option. The value is to guide investors and managers in making rightful decisions rather than running into unnecessary risk. Real options approach is a very useful mathematical instrument. The investment is critically analyzed and we see that the investment is a lucrative one even with the imposition of some tight assumptions made.

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A Three Phase Scheduling for System Energy Minimization of Weakly Hard Real Time Systems

By Smriti Agrawal, Rama Shankar, Ranvijay

Abstract- This paper aims to present a three phase scheduling algorithm that offers lesser energy consumption for weakly hard real time systems modeled with (mm, kk) constraint. The weakly hard real time system consists of a DVS processor (frequency dependent) and peripheral devices (frequency independent) components. The energy minimization is done in three phase taking into account the preemption overhead. The first phase partitions the jobs into mandatory and optional while assigning processor speed ensuring the feasibility of the task set. The second phase proposes a greedy based preemption control technique which reduces the energy consumption due to preemption. While the third phase refines the feasible schedule received from the second phase by two methods, namely speed adjustment and delayed start. The proposed speed adjustment assigns optimal speed to each job whereas fragmented idle slots are accumulated to provide better opportunity to switch the component into sleep state by delayed start strategy as a result leads to energy saving. The simulation results and examples illustrate that our approach can effectively reduce the overall system energy consumption (especially for systems with higher utilizations) while guaranteeing the (mm, kk) at the same time.

Keywords: Dynamic power down, Dynamic voltage scaling, (mm, kk) model, Preemption Control, Scheduling, Weakly hard real time system.

GJCST Classification: J.7

A THREE PHASE SCHEDULING FOR SYSTEM ENERGY MINIMIZATION OF WEAKLY HARD REAL TIME SYSTEMS

Strictly as per the compliance and regulations of:

A Three Phase Scheduling for System Energy Minimization of Weakly Hard Real Time Systems

Smriti Agrawal[α], Rama Shankar[Ω], Ranvijay[β]

Abstract- This paper aims to present a three phase scheduling algorithm that offers lesser energy consumption for weakly hard real time systems modeled with (m,k) constraint. The weakly hard real time system consists of a DVS processor (frequency dependent) and peripheral devices (frequency independent) components. The energy minimization is done in three phase taking into account the preemption overhead. The first phase partitions the jobs into mandatory and optional while assigning processor speed ensuring the feasibility of the task set. The second phase proposes a greedy based preemption control technique which reduces the energy consumption due to preemption. While the third phase refines the feasible schedule received from the second phase by two methods, namely speed adjustment and delayed start. The proposed speed adjustment assigns optimal speed to each job whereas fragmented idle slots are accumulated to provide better opportunity to switch the component into sleep state by delayed start strategy as a result leads to energy saving. The simulation results and examples illustrate that our approach can effectively reduce the overall system energy consumption (especially for systems with higher utilizations) while guaranteeing the (m,k) at the same time.

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I. Introduction

Real time applications are usually composed of set of tasks that interact with each other by exchanging messages. These tasks and their corresponding messages are often invoked repeatedly and are required to complete their services by respective deadlines. Examples of such applications include process control automated manufacturing system and delivery of audio/video frames in multimedia [1]. In process control automated manufacturing system finishing beyond deadline can have a catastrophic effect whereas it may be annoying but acceptable without much loss in case of multimedia applications. An application with catastrophic effect is defined as hard real time whereas degraded performance application is soft real time in nature. Besides these hard and soft deadlines, multimedia application such as video conferencing is being referred to as weakly hard real time where missing of some tasks to complete by deadlines degrade the quality of result however, result is acceptable. For example, in real time transmission of digitized motion video; a source (e.g., a video camera) generates a stream of video frames at a rate of say 30 frame/sec from which at least 24 frames/sec are needed to visualize the movement of the image [17]. When transmitting such frames if sufficient processing power and network bandwidth are available then a high quality video (receiving 30 frames/sec at destination) can be projected whereas degraded but acceptable quality of image is received. In case at least 24 frames/sec reach at the destination within deadline then desired quality is received. For weakly hard real time systems the assurance of minimum acceptable quality result is attained by imprecise concept [17, 18] or by (m,k) model [11]. In imprecise concept a frame has to be received at destination (may be full or portion of it) while a partially received frame is considered as dropped frame in (m,k). That is, all frames are required to be received for imprecise computation whereas certain frames may be dropped to maintain the minimum quality in (m,k) constraints. To ensure a deterministic quality of service (QoS) to such systems, Hamdaoui and Ramanathan [1] used the (m,k) model in which, out of k consecutive task instances any m instances must meet their respective deadlines. The (m,k) model scatters the effect of m deadline misses over a window of k which is different from accepting low miss rate in which a series of frames may be lost in a burst load leading to intolerant behavior in terms of missing a portion. Besides guaranteeing for QoS in terms of (m,k) designer of real time system has to take care of minimization of energy especially for portable devices.

Energy-aware computing has been realized as one of the key area for research in real time systems [20]. Energy-driven scheduling algorithms have been developed to reduce system's energy consumption while satisfying the timing constraints [2, 3, 4, 5, 6, 19, 20, 21, 22, 25] are applicable for system having frequency dependent component (speed of the system varies with variation in its operating frequency) as resource. They will be able to reduce energy for system having frequency dependent components only. Besides frequency dependent component many systems have frequency independent components such as memory where above energy-driven voltage scheduling algorithms are inadequate.

For the systems having frequency dependent component energy consumption decreases with

About[α]- Department of IT, JB Institute of Engineering and Technolo--gy, Hyderabad, India.

About[Ω]- Department of CSE, Motilal Nehru National Institute of Tech--nology, Allahabad India.

About[β]-Department of CSE, Motilal Nehru National Insti--tute of Technology, Allahabad India.

reduction in operating frequency and vice-versa. The energy consumption may increase while frequency is being reduced for the system having both frequency dependent as well as independent components. This is because on reducing the frequency, components which are frequency independent may be forced to be active for longer duration leading to more energy consumption. Authors [7, 8, 9, 10] revealed that the frequency dependent component (processor core) consumes around 30% of total energy while frequency independent (memory and peripherals devices) account for the remaining 70% of energy consumption. Thus, the energy consumption of the frequency independent components plays a crucial role in overall energy consumption of a system. Group of researcher [6, 28, 29, 32] are focused for minimization of system energy (energy required by frequency dependent and independent component) rather than minimization of processor energy only. We use the term frequency dependent component to refer a processor and frequency independent for memory or peripheral devices. The three common techniques used for minimization of system energy are dynamic voltage scaling (DVS), dynamic power down (DPD) and Preemption control (PC) which will be discussed in the following subsection.

Dynamic Voltage Scaling (DVS), is based on adjusting the processor voltage and frequency on-the-fly [12, 13] as energy requirement depends on operating frequency as well as voltage. The DVS attempts to reduce the processor speed to the extent it is possible, to obtain reduction in energy consumption. The speed of a frequency dependent component is said to be reduced if it is either operating at lower voltage or frequency. The task execution time increases with the reduction in processor speed leading to the following consequences:

- a release may miss its deadline while it is feasible at higher speed.
- the longer execution time will be able to decrease the energy consumption of the processor whereas the system energy may be increased
- frequency independent components remain active for longer time and increase the energy consumption.
- longer execution time implies more losses in energy due to leakage current [44].

However, the task execution times do not always scale linearly with the processor speed [13, 14, 15, 16, 23, 26] because system may have some components (memory and peripheral devices) which do not scale with the operating frequency. Thus, DVS may not be efficient (further reduction in the speed would increase the energy consumption) when the system energy is considered. To solve this problem, authors [27, 29, 30, 31] suggested a lower bound (critical speed which balanced the energy consumption between the processor and peripheral devices to minimize the system energy) on the processor speed to avoid the negative impact of the DVS. Niu and Quan [11] used a combined static/dynamic partitioning strategy for $(\mathbb{m},\mathbb{k})$ model to reduce the processor energy and are not efficient for system energy. Beside the DVS energy minimization approach authors [35, 36] suggested to switch off the system (power down) rather than scale down the speed to reduce the energy requirement which is discussed briefly in next subsection.

Dynamic Power Down (DPD) is switching to sleep mode (least power mode) of the unused components since the workload is not constant at all times. Although leaving a component (frequency dependent or independent) in idle/active state consumes power but switching to sleep mode too often may also be counter productive due to heavy context switching overheads. Thus, the DPD technique strives to balance the active and the sleeping time of the components.

Authors [32, 34, 35] used DPD to switch the processor and the peripheral devices into sleep mode based on threshold (minimum time for which the component may sleep for positive energy saving) value to save energy for both hard and soft real time systems. The Niu and Quan [36] proposed a DPD based scheduling method to reduce the system energy consumption for weakly hard real-time systems with $(\mathbb{m},\mathbb{k})$ constraints. The reduction in energy consumption achieved by the DPD technique would increase with the enlargement of the idle slot length. The increment in the length of the idle slot can be achieved by the preemption control technique which is discussed in the following sub-section.

Preemption Control (PC) is allowing a lower priority job to continue execution even when a higher priority job is ready such that none miss their deadline. When a job starts execution on the processor then the associated devices are switched to active state in which they remain till it completes. Thus, if a lower priority job is preempted by the higher priority job then the associated components remain active and consume energy for the time for which the job is preempted. This extra consumption in the energy can be reduced by delaying the higher priority job if possible and completing the lower priority job in the meanwhile (laxity of the higher one). Moreover, each time a job is preempted the context of the job needs to be saved and to be restored when it resumes. This context saving and retrieval would incur an overhead both in terms of time and energy. Thus, reducing number of preemptions reduces the response time of the job and undue energy dissipations due to preemption overhead, longer response time. Agrawal et. al. [29] proposed a preemption control technique where the lower priority job is forced to execute at higher speed levels and complete before the arrival of a higher priority one. The authors themselves say that such a policy may not always lead to energy saving performance.

It is observed if only DPD is applied on a system then based on the threshold the components would be allowed to switch into sleep state and gain the energy reduction. Although, increasing the length or accumulating the idle slots further reduces the energy by DPD; DPD technique itself does not suggest any method to do so. While DVS would lower the assigned speed to each job and increase its execution time which in turn increases its response time. An increment in response time of a job not only increases the energy consumption by the associated components which remain active for longer time but also due to additional preemption which may occur. On the other hand, preemption control at the assigned speed may not be able to reduce the response time and/or number of preemptions. To address the shortcoming of each (DVS, DPD and PC) and to enhance the overall reduction in system energy consumption we suggest a judicious combination of all the above techniques.

Table 1: Symbol Table

$\mathbb{e}_{p,i}$	Computation required by the frequency dependent components of task τ_i
$\mathbb{e}_{d,i}$	Computation required by the frequency independent components of task τ_i
rel_i^j	Release time of a job τ_i^j, i.e., $rel_i^j = j * p_i$
D_i^j	Absolute deadline of a job τ_i^j, i.e., $D_i^j = j * p_i + d_i$
ft_i^j	Finish time of a job τ_i^j
s_{ci}	Critical speed of the processor for the task τ_i
s_{ai}	Speed of the processor assigned to the task τ_i
s_{ai}^j	Speed of the processor assigned to the job τ_i^j
a_i^j	Frequency independent component a_i is associated with task τ_j
$E_{dslp,i}^j$	Energy consumed per unit time by the device a_i associated with task τ_j in sleep state
$E_{dact,i}^j$	Energy consumed per unit time by the device a_i associated with task τ_j in active state
thd_i	DPD threshold of the device a_i
E_{pidle}	Energy consumed per unit time by the processor in the idle state
E_{pslp}	Energy consumed per unit time by the processor in the sleep state
E_{pi}	Energy consumed per unit time by the processor when running at a speed s_i ($E_{pi} = Cs_i^3$ where C is constant)
thp	DPD threshold of the processor
L	MK_hyperperiod
$\mathfrak{K}$	Preemption Overhead is context switching time required when a higher priority preempts a lower priority task
$E_{\mathfrak{K}}$	Energy consumed during each preemption

The length of the idle slot can be enhanced by selecting better speed level for DVS (suggested in third phase) or reducing the response time by PC (suggested in second phase) or delaying the execution of a job (suggested in third phase). The priorities are assigned based on the earliest deadline first (EDF) policy in which the job whose absolute deadline is lower has higher priority. The number of preemptions for different jobs of a task may vary as the earliest deadline first scheduling is dynamic at task level and arrival of mandatory jobs depends on the partitioning strategy. Thus, a job level DVS view would increase its efficiency (suggested in third phase). On the other hand, increasing the speed of few jobs (selected based on the greedy technique suggested in phase-2) could reduce energy consumbed by lower priority job with longer execution as well as preemption overhead. Recently, two groups of researcher Agrawal et. al. [29] and Niu and Quan [37] have used a two phase approach for system energy minimization for weakly hard real time system with $(\mathbb{m},\mathbb{k})$ constraints. The authors have suggested a combination of DVS, DPD and PC techniques however, neither have they taken into the account the preemption overhead nor do they balance the effects of the three techniques.

In this paper we aim to minimize the system energy consumption for weakly hard real time system modeled with $(\mathbb{m},\mathbb{k})$ constraints using a fine balance of DVS, DPD and PC. The reduction in energy consumption is achieved at both, task as well as job level for which we adopt a three phase approach. In the first phase the task level view of the system is taken. The feasibility to each task in the set is ensured keeping in account the preemption overhead. While the second and third phase adopts job level view. A greedy based preemption control technique is proposed at the job level in the second phase. It is further refined in the third phase by adjusting the speed assigned to a job and accumulation of idle slots by delayed start to effectively balance the three approaches.

The rest of the paper is organized as follows; the next section provides a system model followed by section III which presents our new approach along with algorithm. The simulation results are enlisted in section IV whereas section V concludes the work.

II. System Model

This paper aims to minimize the system energy consumption for a system having independent periodic task set $T = \{\tau_1, \tau_2, \tau_3 \ldots \tau_n\}$ that assures minimum QoS defined by $(\mathbb{m},\mathbb{k})$. The priority of a job is assigned based on the earliest deadline first policy. The system consists of two types of components namely, frequency dependent (processor) and frequency independent (memory and peripheral devices). The following considerations are made:

1. The frequency independent components are represented by set $A = \{a_1, a_2, a_3 \ldots a_N\}$ where a_i represents a memory or peripheral device. The power management policies reported in [29, 37, 39] used only two states (active and sleeping) for a frequency independent component and there is no

May 2011
13
Global Journal of Computer Science and Technology Volume XI Issue X Version I

recourse conflicts. Same consideration is taken in this work.

2. The frequency dependent components (DVS processor) can operate at $\mathcal{N}+1$ discrete voltage levels, i.e., $V = \{v_{slp},\ v_1,\ v_2,\ v_3 \ldots v_{\mathcal{N}}\}$ where each voltage level is associated with a corresponding speed from the set $S = \{s_{slp},\ s_1,\ s_2,\ s_3 \ldots s_{\mathcal{N}}\}$.The speed s_1 is the lowest operating speed level measure at voltage v_1 whereas maximum speed $s_{\mathcal{N}}$ at the voltage level $v_{\mathcal{N}}$. A processor can lie in one of the three possible states namely active, idle and sleep. In the active state the processor can run at any of the speed levels between s_1 to $s_{\mathcal{N}}$, while in the idle state and sleep state it will function at speed s_1 and s_{slp} repectively.

3. Each task $\tau_i \in T$ has attributes $< e_i(s_j),\ p_i,\ d_i,\ \mathbb{m}_i, \mathbb{k}_i >$ where $e_i(s_j)$, p_i and d_i are the computation time at the speed s_j, period and relative deadline respectively. We assume that the task relative deadline is conservative [38] i.e. $d_i \le p_i$ which is same as considered in [29, 37]. Beside these temporal characteristics minimum QoS requirement is represented by a pair of integers $(\mathbb{m}_i, \mathbb{k}_i)$, such that out of $\mathbb{k}_i$ consecutive release of τ_i at least $\mathbb{m}_i$ releases must meet their deadline.

The symbols used in this paper are summarized in the table1 while the terms used are discussed in the next subsection.

a) *Terms Used*

MK_hyperperiod $(\boldsymbol{L})$: It can be defined as the point after which all the task in the set are in phase and $(\mathbb{m}, \mathbb{k})$ pattern for each task is restarted i.e. the situation at time $t = 0$ is restored, mathematically,$L = LCM((\mathbb{k}_i * p_i)\ where\ i = 1, 2 \ldots n)$ where LCM stands for least common multiple.

Response time $\left(\boldsymbol{R_i^j}(s)\right)$ of a job $\boldsymbol{\tau_i^j}$: It is the sum of the time requirement of the job τ_i^j and higher priority preempting jobs. Mathematically, $R_i^j(s) = e_i(s) + \sum_{\forall \tau_h^x \in H_{(i,j)}} (e_h(s_{ah}^x) + \mathfrak{K})$where $H_{(i,j)}$ is the set of mandatory jobs preempting τ_i^j during the time $\left(rel_i^j, rel_i^j + R_i^{j,\gamma-1}(s_k)\right)$. The equation $R_i^j(s)$ is an iterative equation which can be solved using different iterations represented by $\gamma = 0, 1, 2 \ldots \infty$. For the first iteration $R_i^{j,0}(s) = e_i(s)$. The iterative equation $R_i^{j,\gamma}(s)$ terminates when either of the two conditions is satisfied: a) value of the two consecutive iteration is same i.e., $R_i^{j,\gamma-1}(s) = R_i^{j,\gamma}(s)$ or b) value exceeds its relative deadline i.e., $R_i^{j,\gamma}(s) > d_i$.

DPD Threshold $(\boldsymbol{th})$: In DPD policy a component is switched to a sleep state on the occurrence of idle slot to save energy. For such a switching the system has to save the state of the task at the beginning and restore the saved status at the end of sleep state (switching from sleep state to active state). These two activities incur an overhead called the DPD overhead. To have a positive energy saving the component should not be switched to sleep state for duration (t) less than the DPD threshold th which can be estimated as follows:

Energy consumed by a component when it remains idle during idle slot t is $E_{idle}\, t$ (1)

Energy consumed in sleep state during t

Energy consumed by the component to go into sleep state is $E_{save} * t_{save}$ and to awake is $E_{wake} * t_{wake}$ where E_{save} is the energy per unit time to save the context, E_{wake} is the energy per unit time to retrieve the context and t_{save}, t_{wake} are the time the component needs to save and wake during context switch respectively. Thus, the component can sleep for time $(t - t_{save} - t_{wake})$ and consume energy at a rate E_{slp}. Hence, the energy consumed for sleep state of duration t would be

$$E_{save}\, t_{save} + E_{wake}\, t_{wake} + E_{slp}\, (t - t_{save} - t_{wake}) \quad (2)$$

To attain a positive energy gain the energy consumed by switching to sleep state (as measured in equation (2)) should be less than that consumed in the idle mode (as measure in equation (1)), i.e., (2)<(1)

$$\Rightarrow E_{save}\, t_{save} + E_{wake}\, t_{wake} + E_{slp}\, (t - t_{save} - t_{wake}) < E_{idle}\, t$$

In worst case when no energy gain is measured (equation (1)=(2)) then the threshold th can be estimated

$$th = (E_{save}\, t_{save} + E_{wake}\, t_{wake} - E_{slp}\, (t_{save} + t_{wake}))/(E_{idle} - E_{slp}) \quad (3)$$

The threshold of each component can be estimated by equation (3).

Substituting the value of $E_{save}\, t_{save} + E_{wake}\, t_{wake}$ in terms of th in the equation (2) we get,

$$th(E_{idle} - E_{slp}) + E_{slp}\, (t_{save} + t_{wake}) + E_{slp}\, (t - t_{save} - t_{wake}) \quad (3a)$$

Energy saved by switching to sleep state would be the difference between equations (1) and (3a).

$$\begin{aligned} diff &= E_{idle}\, t - th\left(E_{idle} - E_{slp}\right) + E_{slp} \\ &= (t - th)\left(E_{idle} - E_{slp}\right) \end{aligned}$$

If $(t > th)$then the energy gain $(diff)$ would be positive hence, energy consumed in switching to sleep state and remain in it for t units of time would reduce energy consumption and hence, is advisable to switch to sleep state.

For $(t = th)$the energy consumed to remain idle or sleep are same.

When $(t < th)$then it is recommended to remain in the idle state rather than to switch to sleep state in which it would consume more energy.
Thus, the energy consumed by a component for an idle slot of (t)would be:

$$\varepsilon(t) = \begin{cases} E_{idle}\, t & 0 \le t \le th \\ E_{idle}\, th + E_{slp}\,(t - th) & t > th \end{cases} \quad (4)$$

Critical speed of the task (s_{ci}): The DVS technique advocates that reduction in the speed of the frequency dependent component would reduce the energy consumption. This may not be true when the system is having both frequency dependent and independent components because lower speed leads to longer execution time for which the frequency independent components would remain active and consume energy. That is, on reduction in speed, the system energy consumption first decreases then it starts increasing incase speed is further reduced. The speed at which system energy requirement is least for a task is called the critical speed. Each task in the system has its own critical speed because its computation demand and set of associated components may differ. It can be determined as follows:

Consider a task τ_i with computation time $e_i(s) = e_p/s + e_d$ where e_p and e_d are the computation requirement for frequency dependent component at the speed s and independent component respectively. Then the energy consumed by the task τ_i at speed s would be

$$E_i(s) = e_i(s) * \left(E_{p\omega} + \sum^{k\in A} E^i_{dact\,,k}\right)$$

where ω is the speed index of s, i.e., $s_\omega = s$. Thus, $E_{p\omega}$ is the rate of energy consumption of the processor at speed $s (or\ s_\omega)$, $\sum^{k\in A} E^i_{dact\,,k}$ is the total energy consumption rate of all the frequency independent devices associated with task τ_i.

In [11, 13] authors have used energy model where energy consumed by the processor is directly proportional to the cube of the operating speed i.e., $E_p \propto s^3$ hence, $E_p = Cs^3$ where $s \in S$ and C is the proportionality constant.

As the task energy consumption function, $E_i(s)$ is a strictly convex function over speed s it can have a single speed at which energy consumption could be minimum, this can be estimated by setting its first derivative to zero followed by the second derivative to be positive.
Thus, taking the first derivative of $E_i(s)$ with respect to s as

$$\frac{\partial E(s)}{\partial s} = \left(-(e_p/s^2)\left(Cs^3 + \sum^{k\in A} E^i_{dact\,,k}\right)\right) + \left((e_p/s + e_d)(3Cs^2)\right) = 0$$

$$\frac{\partial E(s)}{\partial s} = 3Ce_d s^4 + 2Cs^3 e_p - e_p \sum^{k\in A} E^i_{dact\,,k} = 0 \quad (5)$$

By Descartes' Rule of Signs [43], there is only one positive root of the equation since the sign between two consecutive terms changes only once. This root is referred to as the critical speed of the task τ_i represented as s_{ci}.

In the following subsection we discuss the various methods for partitioning the jobs into mandatory and optional. The partitioning problem is NP-hard [40] hence, various heuristic techniques (Red_Pattern, Even_Pattern, Rev_Pattern, Hyd_Pattern, Mix_Pattern) can be used which are discussed below:

Deeply Red-Pattern (Red_Pattern): This pattern was proposed by Koren & Shasha [41]. Mathematically, this can be described as

$$\pi_i^j = \begin{cases} 1, & 0 \le j \bmod \mathbb{k}_i < \mathbb{m}_i \\ 0, & otherwise \end{cases} \quad j = 0, 1, \ldots . \mathbb{k}_i - 1$$

When π_i^j is 1, release τ_i^j is mandatory while it is optional in case 0 is assigned to π_i^j. We refer this pattern as Red_Pattern. Advantage of applying this pattern to a task set for energy minimization is that it aligns the optional jobs together so that a component has a better opportunity to switch into sleep state to save energy. For a task whose critical speed is higher than or equal to the highest possible speed $(s_{\mathcal{N}})$ the operating speed should never be scaled down. Assigning Red_Pattern to such a task helps to extend the idle interval for switching to sleep state. However, for a task whose critical speed is lower than $s_{\mathcal{N}}$ Red_Pattern overloads the system leading to large size busy intervals and need more energy to be feasible.

Evenly Distributed Pattern (Even_Pattern): Ramanathan [42] used evenly distributed pattern in which the first release is always mandatory and the distribution of mandatory and optional is evenly i.e., alternating. Mathematically, this can be described as

$$\pi_i^j = \begin{cases} 1, & if\ j = \left\lfloor \left\lceil \frac{j * \mathbb{m}_i}{\mathbb{k}_i} \right\rceil * \frac{\mathbb{k}_i}{\mathbb{m}_i} \right\rfloor \\ 0, & otherwise \end{cases} \quad for\ \ j = 0, 1, \ldots \mathbb{k}_i - 1$$

We refer it to as Even_Pattern.

Reverse Evenly Distributed Pattern (Rev_Pattern): This pattern is a reverse of the Even_Pattern, hence the first release is always optional and the distribution of mandatory and optional is alternating. Mathematically:

$$\pi_i^j = \begin{cases} 0, & if\ j = \left\lfloor \left\lceil \frac{j * (\mathbb{k}_i - \mathbb{m}_i)}{\mathbb{k}_i} \right\rceil * \frac{\mathbb{k}_i}{(\mathbb{k}_i - \mathbb{m}_i)} \right\rfloor \\ 1, & otherwise \end{cases} \quad j = 0, 1, \ldots \mathbb{k}_i - 1$$

This pattern was first proposed by Niu & Quan [11] and we refer it as Rev_Pattern.

Hybrid Pattern (Hyd_Pattern): This pattern was proposed by [11] in which instead of assigning same pattern to all the tasks in the task set, they assigned different type of patterns (Red_Pattern or Even_Pattern) to each task. For example, task τ_1 is partitioned into mandatory and optional according to Red_Pattern while τ_2 and τ_3 could be assigned Red_Pattern or Even_Pattern. Thus, yielding 2^n possible combination of pattern assignment where n is the number of the tasks in the task set.

May 2011
15
Volume XI Issue X Version I
Global Journal of Computer Science and Technology

Mixed Pattern (Mix_Pattern): The hybrid pattern allows a task in the task set to be scheduled by Red_Pattern or Even_Pattern. In both cases at least the first release of each task is mandatory (if not more e.g. $(\mathbb{m},\mathbb{k}) = \{(3,5),\ (4,7)\}$ first two releases of both the task are mandatory with the Hyd_Pattern) and are in phase hence, will overload the system, forcing it to be feasible with high energy requirement. Therefore, to improve the performance of Hyd_Pattern authors [29] suggested a mixed pattern (Mix_Pattern) which combines the Hyd_Pattern with the Rev_Pattern yielding 3^n possible combination of pattern assignment. By including the Rev_Pattern the Mix_Pattern would give a task fairer chance to execute at lower speed assignment (the second release of both the task in the above example would be mandatory while the first may or may not be so. Since the second release of a task would usually be out of phase with the other releases and will not overload the system as hybrid pattern does). Thus, Mix_Pattern is the superset of all the above suggested patterns. In this paper we would use Mix_Pattern.

In the following section we propose the energy minimization technique for the weakly hard real time system which was modeled in this section.

III. Three-Phase Energy Minimization Technique

This work is refinement of the two phase approach suggested by Agrawal et. al. [29]. In the first phase authors estimate the critical speed for each task and use a static partitioning strategy called Mix_Pattern. Based on the critical speed and the mandatory job distribution authors assigned the speed to each task such that the task set is feasible. While in phase two the authors suggested a preemption control strategy. They suggested increasing the speed of the lower priority job so that it can complete before preemption. However, the reduction in energy due to preemption control may be less than the energy consumed to fit the lower priority job in the slack of the higher priority job, i.e., the technique may be counter productive. In such cases they suggest to execute at the assigned speed as was done by Niu and Quan [37].

In this paper we suggest a three phase technique for system energy minimization. In the first phase we generate a feasible schedule which assigns the speed closest to the critical speed to all the tasks partitioned by Mix_Pattern. In the second phase, we refine the preemption control technique suggested by Agrawal et. al. [29], Niu and Quan [37] after locating their pitfalls. Further, in the third phase we measure the idle slots available on either side of a job execution window. Based on which we adjust the speed of the job or delay the starting of a job so as to combine the two slot. In the following subsection we illustrate the three phases.

Phase-1: Task Level Feasibility and Speed Assignment

In this phase we first estimate the critical speed of each task according to the equation (5). Further, the jobs of each task are marked mandatory/optional according to Mix_Pattern and speed closest to the critical speed on which the task set is feasible is assigned. The algorithm for speed_fitting as suggested by [29] can be stated below.

// Greedy approach based speed fitting algorithm

Algorithm speed_fitting(task set $\boldsymbol{T}$)

Begin

1. For all the task $\tau_i \in T$

   Do

   a. Compute the critical speed for each task s_{ci}

   b. Initialize ω_i with the speed index of s_{ci}

   c. Assign $s_{ai} = s_{\omega_i}$ (which is same as s_{ci})

   Repeat

2. While (not feasible)

   Do

   a. For all task $\tau_i \in T$

   Do

   i. If $(\omega_i < N)$

      1. Compute

$$\nabla_i = \left(\left(\left(E_{p\omega_i+1} e_i(s_{\omega_i+1})\right) - \left(E_{p\omega_i} e_i(s_{\omega_i})\right)\right) m_i\right)/p_i k_i$$

      Else

      1. $\nabla_i = \infty$

   Repeat

   b. Select a task τ_i with smallest ∇_i

   c. If $(\omega_i < N)$

   i. $\omega_i = \omega_i + 1$

   ii. $s_{ai} = s_{\omega_i}$

   iii. Goto step 2

   Else

   i. Goto step 2b. to select next smallest ∇_i

   Repeat

End

In the following subsection we describe the job level second phase.

Phase-2: Modified Preemption Control Technique

The feasible schedule generated after speed_fitting for the task set T in the first phase may not be optimal in terms of energy consumption. To further reduce the energy consumption in this phase we suggest a greedy based preemption control followed by speed adjustment and delayed start in third phase.

When a job is scheduled on the processor then the associated devices are switched to active state in which they remain till it completes. Thus, if a lower priority job is preempted by the higher priority job then the associated device remain active and consume energy for the time for which the job is preempted. This extra consumption in the energy can be reduced by delaying the higher priority job if possible and completing the execution of the lower priority job in the meanwhile (laxity).

The higher priority preempting job can be delayed up to its laxity available so that it does not miss its deadline. This laxity can be estimated as follows: $laxity_h^x = D_h^x - R_h^x(s_{ah}^x)\ \forall \tau_h^x \in H_{(i,j)}$ where $H_{(i,j)}$ is the set of mandatory jobs which preempts τ_i^j such that $rel_h^x > rel_i^j$. Hence, the time available for execution non-preemptively by the lower job would be

$$Ta_i^j = min\Big(min_{\forall \tau_h^x \in H_{(i,j)}:(rel_h^x + laxity_h^x) < t_{curr}} (rel_h^x - tcurr + laxityhx, Dij - tcurr \qquad (6)$$

where t_{curr} is the current time when no higher job is available then $rel_h^x = \infty$. If the time available is sufficient to complete the job τ_i^j non-preemptively as suggested by [37] then we do so. However, when more than one higher priority jobs preempt a single lower priority job then approach suggested in [37] may fail to finish the lower priority job earlier. This is due to the fact that once a higher job finishes and another higher priority job is available in the ready queue then it would be scheduled as it has priority higher than the incomplete preempted job. This can be observed from the example 1.

Example1: Consider a task set $T = \{\langle e_i(s_{ai}),\ p_i,\ d_i\rangle : \langle 15, 25, 25\rangle, \langle 25, 100, 100\rangle\}$. When scheduled without preemption control then the response time of the lower priority job τ_2^1 after being preempted by τ_1^2 and τ_1^3 would be 70 refer figure 1a. However, as illustrated by figure 1b (obtained by utilizing the concept of preemption control used in [37]) the response time of job τ_2^1 remains 70 whereas the number of preemptions is reduced from 2 to 1. This is because τ_2^1 is unable to complete in slack of τ_1^2 which completes at time 50 after which the scheduler schedules the higher priority job τ_1^3 since; no job is being preempted so no preemption control is applied.

Thus, we refine the preemption control approach suggested in [37] without varying the speed as *modified preemption control at assigned speed (MPCAS)*. Here a lower priority job may be allowed to restart even when higher priority job is ready, provided feasibility of the higher priority is assured. The effectiveness of this approach is seen in figure 1(c) where the response time of the job τ_2^1 is reduced to 55 from 70. The proposed MPCAS approach is given as below:

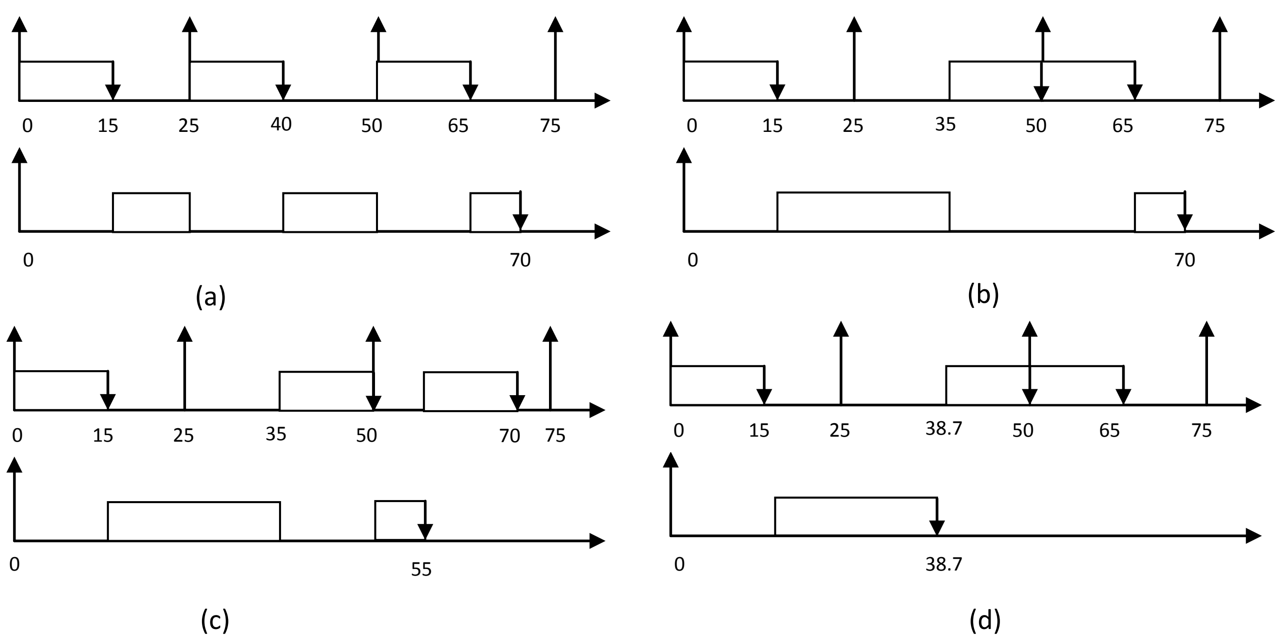


Figure 1: Schedule for task set T of example 1: (a) Uncontrolled Preemption (b) Preemption Control as suggested by [37], (c) Preemption Control by proposed MPCAS algorithm (d) Preemption Control by the

higher priority is assured. The effectiveness of this approach is seen in figure 1(c) where the response time of the job τ_2^1 is reduced to 55 from 70. The proposed MPCAS approach is given as below:

// Preemption control at the assigned speed

//Algorithm MPCAS (task set $\boldsymbol{T}$*)*

Begin

1. Set the $t_{curr} = 0$ // the current time
2. For all jobs in one MK_hyperperiod

Do

a. if(incomplete_queue is empty)
   i. if(ready_queue is empty)
      1. wait for a job to arrive in it
      2. Update t_{curr}
   ii. Let τ_i^j be read from the ready_queue
   iii. Estimate the time available Ta_i^j
   iv. If $\left(Ta_i^j \geq e_i(s_i^j)\right)$
      1. Execute τ_i^j non-preemptively for $e_i(s_i^j)$
      2. Update $t_{curr} = t_{curr} + e_i(s_i^j)$
      3. $e_i(s_i^j) = 0$
      4. Goto step 2a.
   v. Else
      1. Execute τ_i^j non-preemptively for Ta_i^j
      2. $e_i(s_i^j) = e_i(s_i^j) - Ta_i^j + \mathfrak{K}$
      3. Insert τ_i^j into incomplete_queue based on its priority
      4. Update $t_{curr} = t_{curr} + Ta_i^j$
      5. Goto step 2a.
b. Else
   i. Let τ_i^j be read from the incomplete_queue
   ii. Estimate the time available Ta_i^j
   iii. If $\left(Ta_i^j \geq e_i(s_i^j)\right)$
      1. Execute τ_i^j non-preemptively for $e_i(s_i^j)$
      2. Update $t_{curr} = t_{curr} + e_i(s_i^j)$
      3. $e_i(s_i^j) = 0$
      4. Goto step 2a.

      Else
      1. Insert τ_i^j into incomplete_queue based on its priority
      2. Goto step 2.a.i.

Repeat

End

The MPCAS algorithm would reduce the response time of the lower priority job (τ_2^1 would finish at time 55 for the example) so the associated devices have better opportunity to switch to sleep state and save energy according to DPD. However, when component's DPD threshold is large than this reduction in response time may not be sufficient to allow the associated components to sleep and save energy. Agrawal et. al. [29] increase the speed of the lower priority job and hence, reduce its execution time so that it can fit in the slack available before it could be preempted (speed of the job τ_2^1 would be increased such that it would finish by 35 in the example). The authors themselves state that this may be counter productive. That is, increment in energy consumption by executing the lower priority job at higher speed is more than the energy reduction gained due to early switching to sleep state for some components. To overcome this drawback we suggest a speed refinement for the preempted lower priority job as well as preempting higher priority jobs. This speed combination is predicted by greedy based preemption control (GBPC) which utilizes right and left idle slot (refer figure 2 and definition 1, 2, 3, 4) of the processor and the devices.

Definition 1: The device left idle slot of a job τ_i^j *it is the time when the previous job of the same task* (τ_i^{j-1}) *finishes and relinquishes the resource* ${\alpha_{ld}}_i^j$ *to the time* ${\beta_{ld}}_i^j$ *when this job* τ_i^j *is scheduled for the first time.*

Definition 2: The device right idle slot of a job τ_i^j *is the time when this job* (τ_i^j) *finishes and relinquishes the resource* ${\alpha_{rd}}_i^j$ *to the time* ${\beta_{rd}}_i^j$ *when the next job of the same task* (τ_i^{j+1}) *is scheduled for the first time.*

Definition 3: The processor left idle slot of a job τ_i^j *starts when all the jobs in the ready queue finishes* ${\alpha_{lp}}_i^j$ *to the time job* τ_i^j *to its released* $\left({\beta_{lp}}_i^j\right)$ *to the empty queue. Mathematically,* ${\delta_{lp}}_i^j = max\left(0, \left({\beta_{lp}}_i^j - {\alpha_{lp}}_i^j\right)\right)$

Definition 4: The processor right idle slot of a job τ_i^j *is the time when it finishes and relinquishes the processor* ${\alpha_{rp}}_i^j$ *to the time any other job is scheduled on it* ${\beta_{rp}}_i^j$.

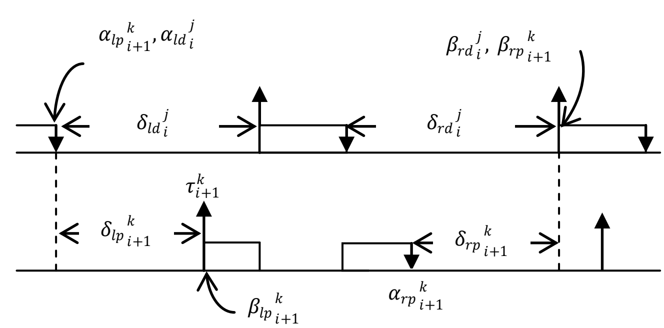


Figure 2: Left and right idle

Thus, the left idle time for the device and the processor are ${\delta_{ld}}_i^j = \left({\beta_{ld}}_i^j - {\alpha_{ld}}_i^j\right)$ and ${\delta_{lp}}_i^j = \left({\beta_{lp}}_i^j - {\alpha_{lp}}_i^j\right)$ respectively whereas ${\delta_{rd}}_i^j = \left({\beta_{rd}}_i^j - {\alpha_{rd}}_i^j\right)$, ${\delta_{rp}}_i^j = \left({\beta_{rp}}_i^j - {\alpha_{rp}}_i^j\right)$ are the right idle slots. As there is no resource conflict for frequency independent component so whenever a task is started first time all the associated resources are activated and remain to be so till the job completes. Thus, the left as well as the right idle time for any two frequency independent component associated with the same task are always same. In the following subsection we estimate the energy consumption required during the idle slots by the device and the processor:

Energy estimation of device a_k^i during the idle slots: Consider an idle slot $\left(\left(idle = \delta_{ld}{}_i^j\right) or \left(idle = \delta_{rd}{}_i^j\right)\right)$ for a device a_k^i associated with a job τ_i^j. If idle time is greater than its threshold thd_k then the device would switch into sleep state otherwise it would remain active. Thus, the energy consumed $\left(\varepsilon_{dk}^i(idle)\right)$ by the device as can be derived from the equation (4) as

$$\varepsilon_{dk}^i(idle) = \begin{cases} E_{dact,k}^i idle & 0 \le idle \le thd_k \\ E_{dact,k}^i thd_k + E_{dslp,k}^i (idle - thd_k) & idle > thd_k \end{cases} \quad (6)$$

Energy estimation for processor during the idle slots: For a processor idle slot $\left(\left(idle = \delta_{lp}{}_i^j\right) or \left(idle = \delta_{rp}{}_i^j\right)\right)$, if this idle time is greater than threshold of the processor thp then the processor would switch to sleep state otherwise remain in idle state. Thus, the energy consumption rate for the processor can be estimated from the equation (4) is

$$\varepsilon_{pi}^j(idle) = \begin{cases} E_{pidle}\, idle & 0 \le idle \le thp \\ E_{pidle}\, thp + E_{pslp}\, (idle - thp) & idle > thp \end{cases} \quad (7)$$

In the next subsection we estimate the energy consumed by the frequency dependent and independent components during job execution.

Energy estimation for response time $\left(R_i^j(s_i^j)\right)$ of a job τ_i^j: When a job τ_i^j starts execution then all the associated frequency independent devices are switched to active state in which they remain till it completes. The frequency dependent components work at the assigned frequency for this task as well as other jobs preempting it. Thus, the total energy consumed by a job τ_i^j during its response time

$$E_i^j(s_i^j) = R_i^j(s_i^j) \sum^{k \in A} E_{dact,k}^i + E_{p\omega_i} e_i(s_i^j) + \sum_{\forall \tau_h^x \in H_{(i,j)}^x} \left(e_h(s_{ah}) E_{p\omega_h} + E_{\mathfrak{K}}\right) \quad (8)$$

where ω_i, ω_h are the speed index of s_i^j, s_{ah}^x and $H_{(i,j)}$ is the set of mandatory jobs preempting job τ_i^j.

The energy consumed by the frequency independent component during $R_i^j(s_i^j)$ would be $R_i^j(s_i^j) * \sum^{k \in A} E_{dact,k}^i$. Whereas, $\left(E_{p\omega_i} * e_i(s_i^j)\right)$ will be the processor energy consumed by the job τ_i^j alone. Further, job τ_i^j would be preempted by $\forall \tau_h^x \in H_{(i,j)}$ during its execution window $\left(rel_i^j, rel_i^j + R_i^j(s_i^j)\right)$. A preempting mandatory job τ_h^x would execute at its assigned speed of s_{ah}^x, therefore it will consume energy $e_h(s_{ah}^x) * E_{p\omega_h}$. However, each time a job preempts τ_i^j it would incur energy overhead $E_{\mathfrak{K}}$ for accessing the memory which is frequency independent [24]. Thus, total energy consumed during response time of job τ_i^j is given in equation (8). Further, energy is also consumed during the idle slots.

Total energy consumption during the left idle, response time and right idle slots

Thus, the energy consumed by the device during the left (and right) idle slot of a job τ_i^j would be $\varepsilon_{di}^j(\delta_{ld}{}_i^j)$ (and $\varepsilon_{di}^j(\delta_{rd}{}_i^j)$) (refer equation (6)) while the energy consumption by the processor during the left (and right) idle slot would be $\varepsilon_{pi}^j\left(\delta_{lp}{}_i^j\right)$ (and $\varepsilon_{pi}^j\left(\delta_{rp}{}_i^j\right)$) (refer equation (7)). The energy consumed during the execution of the job would be $E_i^j(s_i^j)$ as estimated in the equation (8). Thus, the energy consumption of the job τ_i^j along with its left and the right idle slots is

$$\varepsilon_i^j(s_i^j) = \varepsilon_{di}^j(\delta_{ld}{}_i^j) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j\right) + E_i^j(s_i^j) + \varepsilon_{di}^j(\delta_{rd}{}_i^j) + \varepsilon_{pi}^j\left(\delta_{rp}{}_i^j\right) \quad (9)$$

After estimating the energy we now discuss the technique for greedy based preemption control. If the lower priority job is preempted then the preemption control at the assigned speed is done (using PCAS algorithm) and the energy is estimated for the preempting higher priority jobs and the preempted lower priority job. If the lower priority job is still preempted by one or more, higher priority jobs then the response time of the lower priority can be further reduced. The reduction in the response time of the lower priority job can be achieved by increasing the speed of either the higher priority bottleneck job τ_h^x (such that $Ta_i^j = \left((rel_h^x - t_{curr}) + slack_i^j\right)$) or the preempted lower priority job. The choice between the two is made based on the minimum increment in energy, i.e., $min\left(\Delta E_h^x(s_h^x), \Delta E_i^j(s_i^j)\right)$ where

$$\Delta E_h^x(s_h^x) = e_h(s_{\omega_h+1})\left(E_{p\omega_h+1} + \sum^{k \in A} E_{dact,k}^h\right) - e_h(s_{\omega_h+1})\left(E_{p\omega_h} + \sum^{k \in A} E_{dact,k}^h\right)$$

(ω_h is the speed index of s_h^x) similarly, estimate $\Delta E_i^j(s_i^j)$. The speed of the chosen job is incremented and the energy is estimated. The process of further reduction in response time of the lower priority job is repeated and the energy for different combinations is estimated till either a) the lower priority job is no longer preempted; b) all the jobs are assigned maximum available speed level. The speed combination which requires minimum energy is assigned and the schedule is updated.

Further, energy minimization is achieved by improving the schedule obtained in phase-2.

Phase-3: Speed Adjustment and Delay Start (SADS)

After assigning speeds to each task in the phase-1 ensuring feasibility followed by the reduction in

May 2011
Global Journal of Computer Science and Technology Volume XI Issue X Version I

energy consumption by preemption control in the second phase. This phase will adjust the speed assigned (increase or decrease) and accumulate the idle slot (delay start a job if possible) to reduce the energy consumption. In this phase detail analysis of the preemption controlled schedule is done where right and left idle slot (refer figure 1 and definition 1, 2, 3, 4) of the processor and the device are re-estimated. After estimating the energy we now propose the new technique for improvement namely, speed adjustment and delay start which we finally combine to provide overall reduction in energy. The next subsection discusses the speed adjustment.

Speed adjustment

In the phase-1 the feasibility of the task set was to be ensured by assigning the speed at the task level, while the phase-2 increases the speed of some jobs to decrease loss in energy due to preemption. In this phase the speed is adjusted by considering each job separately to reduce the energy consumption based on the left and right idle slots. The philosophy for this approach is that speed fitting was done at the task level to make all the jobs feasible. Executing job at higher speed may favor switching to sleep state by more components (sleeping for more time) in some cases while executing at lower speed may favor the idea of DVS. Thus, depending on the left and the right idle slots we estimate the optimal speed for each job which may be different from that of the task. In the next subsection we measure the energy consumption at the job level after adjusting the speed.

Energy estimation of a job after adjusting the speed

i. Energy estimation at speed s^j_{ai}: The energy consumed by the device during the left (or right) idle slot would $\varepsilon^j_{di}(\delta_{ld}{}^j_i)$ (or $\varepsilon^j_{di}(\delta_{rd}{}^j_i)$) (refer equation (6)) while the energy consumption by the processor during the left(or right) idle slot would be $\varepsilon^j_{pi}\left(\delta_{lp}{}^j_i\right)$ (or $\varepsilon^j_{pi}\left(\delta_{rp}{}^j_i\right)$) (refer equation (7)). The energy consumed during the execution of the job would be $E^j_i(s^j_{ai})$ as estimated in the equation (8). Thus, the energy consumption of the job τ^j_i along with its left and the right idle slots is

$$\varepsilon^j_i(s^j_{ai}) = \varepsilon^j_{di}(\delta_{ld}{}^j_i) + \varepsilon^j_{pi}\left(\delta_{lp}{}^j_i\right) + E^j_i(s^j_{ai}) + \varepsilon^j_{di}(\delta_{rd}{}^j_i) + \varepsilon^j_{pi}\left(\delta_{rp}{}^j_i\right)$$

ii. Energy estimation at speed $s_x < s^j_{ai}$: In a scenario where some of the components may not be able to switch to the sleep state (depending on their thresholds) then executing the job at a lower speed (s_x) than the assigned speed (s^j_{ai}) may save the processor energy. But this execution is subject to the availability of the right idle slot since this reduction in speed will force longer response time. This extra time can be measured as $\Delta^j_i(s_x) = R^j_i(s_x) - R^j_i(s^j_{ai})$ for completion which will reduce the right idle slot by the same amount.

In case the value of $\Delta^j_i(s_x) > \delta_{rp}{}^j_i$ indicating that the right idle slot is not long enough, hence, the lower speed (s_x) cannot be assigned. Otherwise energy consumption will be

$$\varepsilon^j_i(s_x) = \varepsilon^j_{di}(\delta_{ld}{}^j_i) + \varepsilon^j_{pi}\left(\delta_{lp}{}^j_i\right) + E^j_i(s_x) + \varepsilon^j_{di}\left(\delta_{rd}{}^j_i - \Delta^j_i(s_x)\right) + \varepsilon^j_{pi}\left(\delta_{rp}{}^j_i - \Delta^j_i(s_x)\right)$$

iii. Energy estimation at speed $s_y > s^j_{ai}$: When some components are unable to switch to sleep state then if a job executes at a higher speed then it will complete earlier. This would improve the possibility to switch the components into sleep state and increase the sleeping time of the already sleeping components. The time thus saved is $\Delta^j_i(s_y) = R^j_i(s_y) - R^j_i(s^j_{ai})$ which will increase length of the right idle slot. Hence, the total energy consumption will be

$$\varepsilon^j_i(s_y) = \varepsilon^j_{di}(\delta_{ld}{}^j_i) + \varepsilon^j_{pi}\left(\delta_{lp}{}^j_i\right) + E^j_i(s_y) + \varepsilon^j_{di}\left(\delta_{rd}{}^j_i - \Delta^j_i(s_y)\right) + \varepsilon^j_{pi}\left(\delta_{rp}{}^j_i - \Delta^j_i(s_y)\right).$$

Thus, in general the energy estimated at any speed s can be stated as:

$$\varepsilon^j_i(s) = \varepsilon^j_{di}(\delta_{ld}{}^j_i) + \varepsilon^j_{pi}\left(\delta_{lp}{}^j_i\right) + E^j_i(s) + \varepsilon^j_{di}\left(\delta_{rd}{}^j_i - \right.$$
$$\Delta ijs + \varepsilon pij\delta rpij - \Delta ijs \qquad (10)$$

Where $\Delta^j_i(s) = R^j_i(s) - R^j_i(s^j_{ai})$

In the next subsection we discuss the technique for accumulation of idle slots by delaying the task execution window.

Delay Start Technique

In this part of the third phase we aim to assemble the idle slots fragmented on the two sides of a job by delaying its execution if the schedule permits i.e. shift the job execution towards its deadline. This may enable the associated components to sleep or sleep for longer time to save energy. A job may delay its execution up to its deadline so as to be feasible. But extending the job up to its deadline may force the up coming job to miss their deadlines. Thus, a job would be allowed to consume only the processor right idle slot so that it may not push the upcoming jobs. Thus, a job τ^j_i may shift up to $min\left(D^j_i, \beta_{rp}{}^j_i\right)$, without missing its own deadline or modifying the schedule of the subsequent jobs. Hence, a delay will move the task execution by an amount $\theta^j_i(s) = min\left(D^j_i, \beta_{rp}{}^j_i\right) - R^j_i(s)$. In the next subsection we measure the energy consumption at the job level after delaying its execution and adjusting its speed.

Energy estimation of a job with delayed start

i. **Energy estimation due to delayed start at assigned speed s_{ai}^{j}:** Delaying a job τ_i^j would shift it towards right will elongate the left idle slot of the components hence provide better opportunity to the components to switch to sleep state. Thus, when execution of a job is shifted then its left idle slot will increase by $\theta_i^j(s_{ai}^j)$ while the right idle slot will decrease by the same. The energy consumption of the job τ_i^j along with its left and the right idle slots is

$$\varepsilon_i^j(s_{ai}^j) = \varepsilon_{di}^j\left(\delta_{ld}{}_i^j + \theta_i^j(s_{ai}^j)\right) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j + \theta_i^j(s_{ai}^j)\right) + E_i^j(s_{ai}^j) + \varepsilon_{di}^j\left(\delta_{rd}{}_i^j - \theta_i^j(s_{ai}^j)\right) + \varepsilon_{pi}^j\left(\delta_{rp}{}_i^j - \theta_i^j(s_{ai}^j)\right).$$

ii. **Energy estimation due to delayed start at speed $s_x < s_{ai}^j$:** In a scenario where some of the components may not be able to switch to the sleep state (depending on their thresholds) then executing the job at a lower speed (s_x) than the assigned speed (s_{ai}^j) may save energy and reduce length of the right idle slot. Further, delaying the job would add the remaining right idle slot to the left idle slot, hence save energy. The energy consumption will be

$$\varepsilon_i^j(s_x) = \varepsilon_{di}^j\left(\delta_{ld}{}_i^j + \theta_i^j(s_x)\right) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j + \theta_i^j(s_x)\right) + E_i(s_x) + \varepsilon_{di}^j\left(\delta_{rd}{}_i^j - \theta_i^j(s_x)\right) + \varepsilon_{pi}^j\left(\delta_{rp}{}_i^j - \theta_i^j(s_x)\right).$$

iii. **Energy estimation due to delayed start at speed $s_y > s_{ai}^j$:** When some components are unable to sleep in the left idle slot generated after accumulation with speed s_{ai}^j then increasing the speed would reduce the response time. Thus, a combination of higher speed and shift would elongate the left idle slot to provide room for switching into the sleep state. Hence, the energy consumption will be

$$\varepsilon_i^j(s_y) = \varepsilon_{di}^j\left(\delta_{ld}{}_i^j + \theta_i^j(s_y)\right) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j + \theta_i^j(s_y)\right) + E_i^j(s_y) + \varepsilon_{di}^j\left(\delta_{rd}{}_i^j - \theta_i^j(s_y)\right) + \varepsilon_{pi}^j\left(\delta_{rp}{}_i^j - \theta_i^j(s_y)\right).$$

Thus, in general the energy estimated at any speed s and shifting can be stated as

$$\varepsilon_i^j(s) = \varepsilon_{di}^j\left(\delta_{ld}{}_i^j + \theta_i^j(s)\right) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j + \theta_i^j(s)\right) + E_i(s) + \varepsilon_{di}^j\left(\delta_{rd}{}_i^j - \theta_i^j(s)\right) + \varepsilon_{pi}^j\left(\delta_{rd}{}_i^j - \theta_i^j(s)\right) \quad (11)$$

Combining adjusting the speed and delayed start concept

Finally, combining the two concepts the speed adjustment (equation (10)) and delayed (equation (11)) for considering each job for improvement individually we get

$$\varepsilon_i^j(s,\mathscr{s}) = \varepsilon_{di}^j\left(\delta_{ld}{}_i^j + \mathscr{s}\theta_i^j(s)\right) + \varepsilon_{pi}^j\left(\delta_{lp}{}_i^j + \mathscr{s}\theta_i^j(s)\right) + E_i^j(s) + \varepsilon_{di}^j\left(\delta_{rd}{}_i^j - \mathscr{s}\theta_i^j(s) - \mathscr{s}'\Delta_i^j(s)\right) + \varepsilon_{pi}^j\left(\delta_{rd}{}_i^j - \mathscr{s}\theta_i^j(s) - \mathscr{s}'\Delta_i^j(s)\right) \quad (12)$$

Where s ∈ S set of speed levels available, $\mathscr{s}$ is a binary number which has a value 1 if a shift operation is made and $\mathscr{s}'$ is its complement.

Thus, for minimum energy consumption of a job τ_i^j must be assigned a speed s and delayed start operation $\mathscr{s}$ such that $\varepsilon_i^j(s,\mathscr{s})$ is minimum. Since, the left idle slot of job is same as the right idle slot of the previous job. Adjusting the speed/delay starting one job will affect the previous job's idle slots. Hence, by iterating the third phase further reduction in energy is achieved. The proposed Speed Adjustment and Delay Start can be stated as SADS algorithm.

The effectiveness of proposed three phase algorithm can be seen from the example 2 and table 2.

Example 2: Consider a task set $T = \{\langle e_i = (\mathbb{e}_{p,i}, \mathbb{e}_{d,i}), p_i,\ d_i\rangle : \langle(250,5),25,25\rangle, \langle(210,18),100,100\rangle\}$ to be scheduled on a DVS processor which can operate at speed $S = \{10, 25, 30, 35, 37, 40, 105\}$ where its threshold $thp = 10$. The device pool $A = \{a_1,\ a_2\}$ consists of two devices such that device a_1 is associated with task τ_1 and a_2 with τ_2 have attributes as $< a_k^i, thd_i, E_{dact,k}^i,\ E_{dslp,k}^i >: < a_1^1,\ 10,\ 54687,\ 0.0 >, < a_2^2,\ 30,\ 262285,\ 0.0 >$. The preemption overhead is $\mathfrak{K} = 5$ and energy it consumes for preemption is $E_{\mathfrak{K}} = 8568937$.

The critical speed (s_{c1}, s_{c2}) as estimated from equation (5) would be 25 and 30 respectively. The MK_hyperperiod will be 100.

// Speed adjustment and delay start based third phase algorithm

//Algorithm SADS(task set T)

//input is the feasible schedule generated after speed fitting and GBPC after phase-2

Begin

1. While (no further reduction in energy)

 Do

 a. For each job $\tau_i^j \in \mathbb{M}$ where $\mathbb{M}$ is the set of mandatory jobs in the task set T arriving during any MK_hyperperiod (L)

 Do

 i. Estimate the left and the right idle time for device $(\delta_{ld}{}_i^j, \delta_{rd}{}_i^j)$ and the processor $\left(\delta_{lp}{}_i^j, \delta_{rp}{}_i^j\right)$ according to definitions 1, 2, 3 and 4.

 ii. Assign speed to job τ_i^j as $s_{ai}^j = s_{ai}$ and shifting as $\mathscr{s}_i^j = 0$

 iii. Assign $min = \varepsilon_i^j(s_{ai}^j, \mathscr{s}_i^j)$ according to the equation (12)

 iv. For every speed $s \in S$

 Do

May 2011 21 Global Journal of Computer Science and Technology Volume XI Issue X Version I

1. Estimate $\varepsilon_i^j(s,0)$ according to the equation (12)
2. If $\left(min > \varepsilon_i^j(s,0)\right)$
   a. Update $min = \varepsilon_i^j(s,0)$
   b. Update $s_{ai}^j = s$ and shifting as $\mathcal{s}_i^j = 0$
   End if
3. Estimate $\varepsilon_i^j(s,1)$ according to the equation (12)
4. If $\left(min > \varepsilon_i^j(s,1)\right)$
   a. Update $min = \varepsilon_i^j(s,1)$
   b. Update $s_{ai}^j = s$ and shifting as $\mathcal{s}_i^j = 1$
   End if

End for

End for

2. Estimate the total energy for a MK_hyperperiod (L)

End while

End

In the following section we present the results obtained by implementation of the approach discussed in this section.

IV. Simulation Results

This section compares the performance of our proposed three phase scheduling algorithm (in which we apply greedy based preemption control, speed adjustment and delayed start) referred to as GBSADS with the higher speed preemption control (HSPC) approach suggested by [29]. All simulation results are computed on a DVS processor with operating speed level set as $S = \{0,\ s_1,\ s_2,\ s_3 \dots s_{10}\}$ where s_i is a uniform random number generated in the interval $[10, 200]$. We consider ten types of devices with multiple instances forming a pool of devices. For a task, devices are randomly selected from this pool. Rate of energy consumption for a device is computed based on the energy required by the processor at the maximum speed, i.e., $E_{dact,i} = \text{Þ}E_{p10}$ where Þ is a uniform random number in the range [0.1, 20]. The task set $T = \{\tau_1,\ \tau_2,\ \tau_3 \dots \tau_n\}$ with $(\mathbb{m}, \mathbb{k})$ utilization $\mathbb{U}$ (i.e. $\sum \mathbb{m}_i e_i / p_i \mathbb{k}_i$ a uniform random number in the range (0, 1]). The preemption overhead and energy required during preemption are uniform random number in the range (0, 1] and (0, 100] respectively. Similar type of considerations where taken in [29]. The other parameters are summarized in the table 3.

The key parameter, measured for simulation is energy consumed during one MK_hyperperiod. The result reported is the average value of results obtained for hundred task sets. The following section deals with the variation in energy with component threshold, task set utilization and device to processor energy proportionality constant.

Table 2: Energy estimation for a MK_Hyperperiod of the task set T for the example 2

s_{a1}^2	s_{a1}^2	s_{a1}^3	s_{a1}^4	s_{a2}^1	ft_1^2	Energy	Remark
25	25	25	25	30	100	56393661	Uncontrolled Preemption technique with DVS and DPD
25	25	25	25	30	75	33473217	Preemption control as suggested by [37]. Reduction in energy consumption is 40.6%.
25	25	25	25	105	35	36900380	Preemption control by increasing the speed of the lower priority job as suggested by [29].
Phase 2: GBPC							
25	25	25	25	30	60	29538942	Performing preemption control at the assigned speed (ASPC). This incapable of preventing preemption but reduces the response time. Reduction in energy from [37] 11.7% and 47.6% from uncontrolled preemption technique.
25	30	25	25	30	58.3	29126514	Increasing the speed of τ_1^2 based on the $\Delta E_1^2(s_1^2) = 31757.1,\ \Delta E_2^1(s_2^1) = 91715$. Preemption could not be prevented but the energy consumption is decreased.
25	30	25	25	35	57.3	29219229	$\Delta \mathrm{E}_1^2(\mathrm{s}_1^2) = 94063.1,\ \Delta \mathrm{E}_2^1(\mathrm{s}_2^1) = 91715$. Increasing the speed of τ_2^1
25	30	25	25	37	57	29312320	$\Delta \mathrm{E}_1^2(\mathrm{s}_1^2) = 94063.1,\ \Delta \mathrm{E}_2^1(\mathrm{s}_2^1) = 92790$. Increasing the speed of τ_2^1
25	35	25	25	37	55.8	29092841	$\Delta \mathrm{E}_1^2(\mathrm{s}_1^2) = 94063.1,\ \Delta \mathrm{E}_2^1(\mathrm{s}_2^1) = 185809$. Increasing the speed of τ_1^2
25	37	25	25	37	55.5	29076167	$\Delta \mathrm{E}_1^2(\mathrm{s}_1^2) = 62511, \Delta \mathrm{E}_2^1(\mathrm{s}_2^1) = 185809$. Increasing the speed of τ_1^2
25	40	25	25	37	38.7	16205293	$\Delta \mathrm{E}_1^2(\mathrm{s}_1^2) = 98151,\ \mathrm{E}_2^1(\mathrm{s}_2^1) = 185809$. Increasing the speed of τ_1^2. Preemption is avoided. Reduction in energy consumption by 51.59% from [29, 37] and 71.3% from uncontrolled preemption is received.
Phase -3: SADS							
Delaying job τ_1^4 for 10 units						15648423	Reduction of 53.3% from [29, 37] and 72.3% from uncontrolled preemption is received.

Effect of component threshold on Energy consumption: The value of the threshold of a component indicates the length of the idle slot for which the component will consume same energy in active state as it would do so in sleep state. Thus, as the threshold increases the requirement for long idle slots increases in absence of which energy consumption increases. However, increment in threshold will affect the energy requirement up to a certain value (length of the longest idle slot) beyond which no component would switch to sleep state, so any further increment in the threshold will not increase the energy consumption of the system. The effect of the increment in threshold for frequency independent and dependent components can be seen in the figure 3 and figure 4 for which the value of $U = [0.5, 0.6]$ and $\text{Þ} = 10$.

Table 3: *Simulation Parameters*

Parameter	Condition	Range
UTh Utilization Threshold	Is assigned	0.01
u_i Utilization	If $U-\sum u_{i-1} \geq UTh$ the select a uniform random number	$(0, U-\sum u_{i-1}]$
	If $U-\sum u_{i-1} < UTh$ then assign	$u_i = U-\sum u_{i-1}$
e_i worst case execution time	select a uniform random number	(0,100]
p_i period	select a uniform random number	(0,1000]
d_i deadline	select a uniform random number	$[e_i, p_i]$
k_i	Is a random integer selected uniformly	[1,10]
m_i is the number of mandatory jobs in k_i	Assigned a value	$\lfloor u_i p_i k_i / e_i$
thp processor threshold	select a uniform random number	[0, 200]

The effect of the variation of the device threshold is shown in the figure 3. When the device threshold is lower (0-80) it can be observed that the energy consumption by GBSADS approach is almost 23% lower than that of the HSPC approach, while this reduction in the energy consumption is more prominent (approximately 32%) at higher values of the threshold range (90-140). Beyond 130 it is constant due to the fact that at lower threshold value both GBSADS and HSPC control preemption around the assigned speed. But as this threshold increases the shorter idle slots become inadequate to switch the device into sleep state, the greedy based preemption control in second phase and delay start done in the third phase of the GBSADS approach assembles these idle slots efficiently and hence, provide better opportunity to switch the device into sleep state. Similar trends are seen for the variation in the processor threshold (refer figure 4) in which we get an overall gain of approximately 30%.

Effect of rate of processor to device energy (Þ) on Energy consumption: The rate of energy consumption by a frequency independent component is a constant. This constant could be less than the rate of the energy consumption in the processor (for processor dominant system $Þ \leq 1$) while for device dominant systems this would be greater than one. This variation in the ratio (0.1-10) for both processor and device dominant systems is observed in the figure 5 for which task sets of utilization U=[0.5, 0.6]. For lower value of the ratio (0.1-1) processor dominated system the GBSADS approach saves approximately 20% of the energy and this saving increase up to 26% for device dominant systems. A sudden rise in the energy consumption is observed for a value of $Þ = 2$ which indicates the dominance of the devices energy consumption and as more devices are added to such a system this rise is even more prominent. At lower level the DVS approach is more prominent due to the fact the processor energy consumption is dominant, the HSPC approach applies DVS and high speed preemption control which would be inadequate. On the other hand, GBSADS approach applies the concept of DVS

Figure 3: Energy consumption Vs. Device threshold

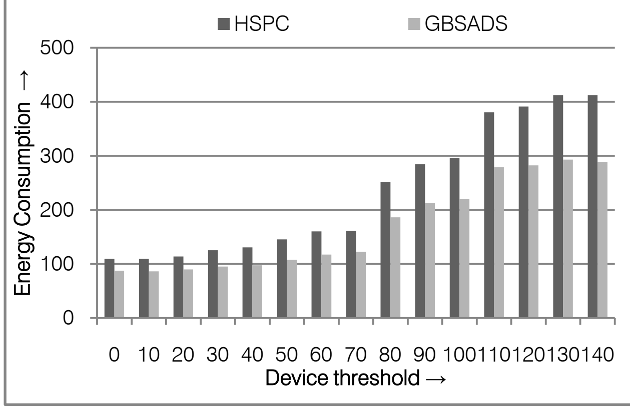


Figure 4: Energy consumption Vs. Processor threshold

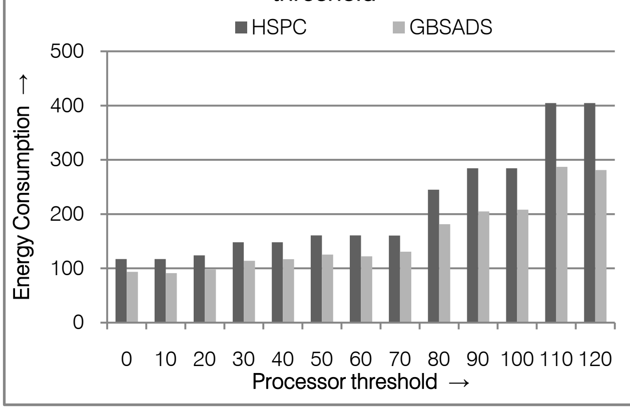
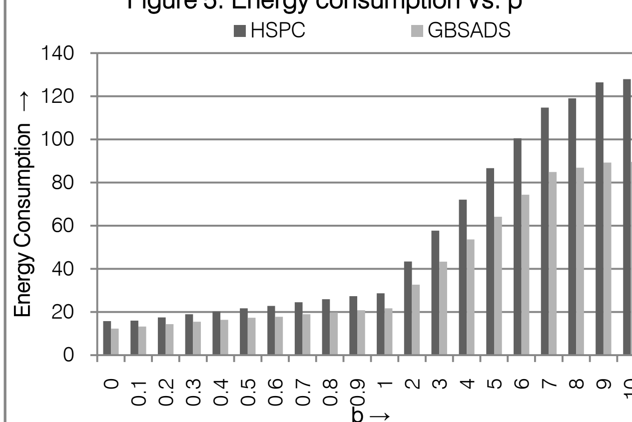


Figure 5: Energy consumption Vs. Þ

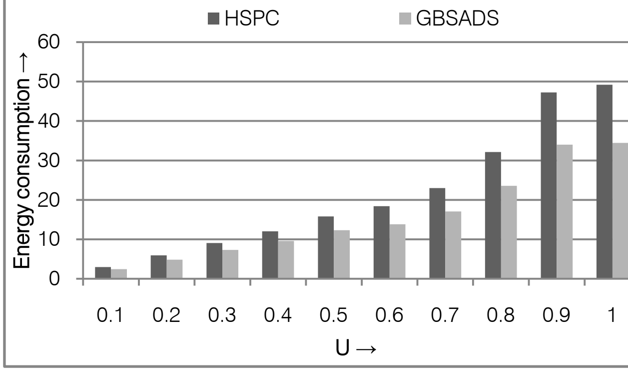


at three levels (speed assignment, greedy based preemption control and speed adjustment) thus, a gain of 20% is received. However, at the higher ratio the device energy consumption is dominant and hence DVS is less effective compared to the DPD technique. The GBSADS approach is able to accumulate the idle slots efficiently as it does delayed start along with speed adjustment while controlling the preemption based on greedy approach whereas HSPC only controlled preemption.

Effect of system utilization on the energy consumption: The energy consumption is measured as the system utilization increases for different values of Þ. The value of Þ indicates the dominance of the device energy consumption on the overall energy consumption of the system (higher its value more the system is device dominated). It can be observed from all the following figures (6, 7 and 8) that when the utilization is high (0.8-1) then the reduction in the energy consumption is substantial. This is because for such utilizations the system is overloaded hence, the speed assignment for the feasibility in the first phase is at higher speeds. The HSPC approach does not slow the once assigned speed while GBSADS approach may reduce the speed assigned to the out of phase jobs substantially leading to reduction in the energy consumption. Besides speed adjustment it also delays the start and controls the preemption of lower priority jobs to accumulate the idle slots favoring the sleeping off the components.

Effect of only processor energy consumption (when no devices are attached Þ=0): When no frequency independent components are associated with the system then the effect of the utilization on the system energy consumption can be seen in the figure 6. For lower utilization (0.1-0.3) the GBSADS approach consumes around 18% less energy while this reduction improves up to around 24% for medium utilizations (0.4-0.7) and still further up to approximately 30% for higher utilizations. For lower utilizations the speed assigned by both approaches in first phase is close to the critical speed and hence, energy saving by GBSADS is only due to the delayed start in the third phase which accumulates the fragmented idle slots and favor the processor to switch into the sleep mode (or sleep for longer time). For task sets with higher utilization, the speed assigned to a task in the first phase are generally higher than its critical speed due to overloading of the system by both the approaches. For reducing the energy consumption the HSPC approach the execution of the preempted jobs at either higher or at the same assigned speed. Executing preempted jobs at higher

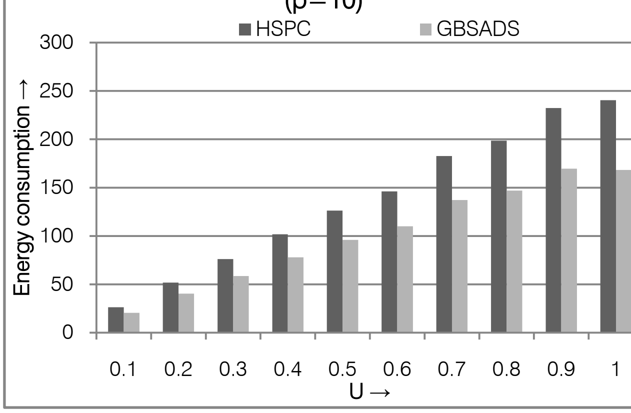
Figure 6: Energy consumption Vs. Utilization (þ=0)



speed of such systems having no devices attached would be counter productive while execution at the assigned speed would not incur any reduction in energy. On the other hand, GBSADS would adjust the speed (may reduce the assigned speed) taking into the account the thresholds and the idle slots in the second and the third phase so as to balance the impact of DVS, DPD and PC techniques.

When the device to processor rate of energy consumption is comparable Þ=1: The effect of the utilization on the overall energy consumption can be seen from the figure 7. The trend of the energy consumption is similar to that observed in the figure 6. But for higher utilizations the reduction in the energy

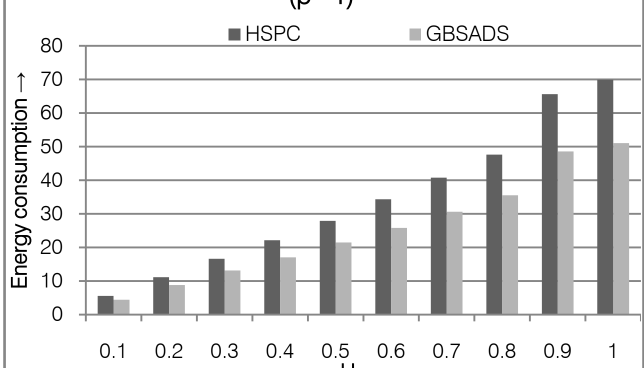
Figure 8: Energy consumption Vs. Utilization (þ=10)



consumption is less (approximately 26%) as compared to 30% in figure 6. This is due to the fact; when higher speeds are assigned in the phase-1 reducing the speed by the GBSADS approach increases the response time of a job which would in turn force the devices to remain active for longer period and consume energy hence, lower gain is observed when compared to system comprising of frequency dependent components only.

When the device to processor rate of energy consumption is ten times (device dominated) Þ=10: The effect of utilizations on the energy consumption of a device

Figure 7: Energy consumption Vs. Utilization (þ=1)



dominated system can be observed in the figure 8 which is similar to the trend seen in figure 6 and 7 in which at higher utilizations GBSADS approach performs better than HSPC approach.

V. Conclusion

In this paper we presented a three phase scheduling algorithm which minimizes the system energy consumption for weakly hard real-time system while maintaining the (m,k) guarantee. The system consists of a DVS processor (capable of operating at various frequencies) and frequency independent peripheral devices. We proposed a three phase scheduling algorithm where in the first phase a mixed pattern based partitioning is used to determine the mandatory and optional jobs of a task and assign speed levels to ensure the feasibility of the task set.

However, the major contribution of the work lays in the second and third phase which analyses and refines the first phase schedule at job level. In the second phase we formulated a greedy based preemption control technique which adjusted the speed of the preempted/preempting jobs based on the laxity to further reduce the energy consumption. The third phase focused on accumulation of the idle slots through utilizing the concept of delay start and speed adjustment. The speed adjustment is a method of assigning an optimal speed to individual job based on the availability of idle slot on the either side of the execution window of a job and the threshold of the components. While delayed start technique delays the execution of a job up to its available slack time to assimilate the idle slots fragmented on the either side of a job's execution window. The effectiveness of the proposed algorithm has been discussed through examples and extensive simulation results.

The proposed three phase scheduling algorithm is compared with [29] where the authors have adopted similar scenario. The simulation results indicate that the three phase scheduling algorithm consumes approximately 30% less energy for task set at higher utilizations (0.8-1) while it is 24% better for lower utilization systems (0.1-0.7). The reduction in the energy consumption is 30% for higher values of the threshold of a component while lesser improvement is observed approximately 23% for lower threshold value. The proposed algorithm was targeted for device dominant systems for which it performed 26% better. However, the simulations indicate that the approach is valid for processor dominant systems as well for which an improvement of about 20% is received. Thus, the proposed algorithm is capable of performing better in the system/process energy constrained systems when the system is overloaded (utilization is high) or the threshold of the components are high.

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Face Recognition in compressed domain based on wavelet transform and kd-tree matching

By Menila James, Dr.S.Arockiasamy
University of Nizwa

Abstract- This paper presents a novel idea for implementing face recognition system in compressed domain. A major advantage of the proposed approach is the fact that face recognition systems can directly work with JPEG and JPEG2000 compressed images, i.e. it uses directly the entropy points provided by the compression standards as input without any necessity of completely decompressing the image before recognition. The Kd-tree technique is used in the proposed approach for the matching of the images. This algorithm shows improvement in reducing the computational time of the overall approach. This proposed method significantly improves the recognition rates while greatly reducing computational time and storage requirements.

Keywords: Face recognition, compressed domain, wavelet transform, entropy points, kd-tree, Normalized Recognition Rate.

GJCST Classification: I.5.4, I.4.6

FACE RECOGNITION IN COMPRESSED DOMAIN BASED ON WAVELET TRANSFORM AND KD-TREE MATCHING

Strictly as per the compliance and regulations of:

Face Recognition in compressed domain based on wavelet transform and kd-tree matching

Menila James[α], Dr.S.Arockiasamy[Ω]

Abstract - This paper presents a novel idea for implementing face recognition system in compressed domain. A major advantage of the proposed approach is the fact that face recognition systems can directly work with JPEG and JPEG2000 compressed images, i.e. it uses directly the entropy points provided by the compression standards as input without any necessity of completely decompressing the image before recognition. The Kd-tree technique is used in the proposed approach for the matching of the images. This algorithm shows improvement in reducing the computational time of the overall approach. This proposed method significantly improves the recognition rates while greatly reducing computational time and storage requirements.

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I. Introduction

Face recognition [1][2][3] is playing a key role in the research areas of pattern recognition and computer vision due to its capable applications such as personal identification, bankcard verification, automated surveillance etc. So far, various face recognition systems have been proposed but still research is going on in the field of face recognition as it has various inherent complexity associated with environmental changes and subject actions (facial expressions and head pose variations), etc. The performance of face recognition systems mainly varies corresponding to the environment where face images are taken. These Face recognition approaches normally use visible spectrum images for recognition because they provide clear representation of facial features and face texture to differentiate between two individuals.

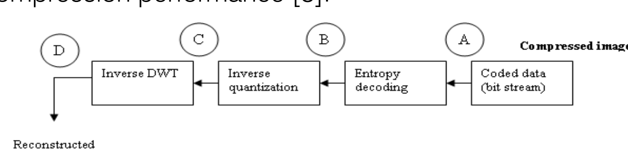
With the growth of internet and multimedia, compression techniques have become the popular research area in the field of Image processing. But, there are very few researchers have concentrated on to investigate the effect of compression on face recognition, even though the images are mainly stored and/or transported in a compressed format. Image Compression is an area of face recognition which needs more attention since the adoption of face recognition as part of the e-passports which use face images as one of the three identifiers along with fingerprints and iris scans being the other two. Mainly, the compression of images are essential in face recognition due to the advantages such as ability to store compressed images on smart cards and low-capacity chips, easy to transmit image to a distant server for verification and improved computational speed [4]. Moreover, image acquisition equipment also often delivers the compressed images as its output. So, to work directly in existing compressed domain has its valid reasons as well. For the stored (or derived) image of the unknown individual to be identified it has to be compared to one or more images of known individuals. Decompressing all those images (including the unknown one) is very computationally intensive. Thus, avoiding full decompression process could be very advantageous when compared to the existing techniques [5].

II. Background

Image Compression Technique Using Wavelets

The most widely used standard image compression techniques are JPEG [6] and JPEG2000 [7]. These image compression standards have been employed in face recognition systems in past few years. Usually, compression is vital for any reasonable implementation where a large quantity of images need to be stored. All modern image coders are considered to be transform coders. The Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are examples of those transforms methods. Both JPEG and JPEG2000 have been using the general transform coding scheme as shown in Figure 1.

The input signal is first encoded as bit stream using an invertible transform, and then quantized and entropy coding has been done. The rate distortion unit controls the quantization to minimize the distortion within the available bit rate. These stages have an impact on the image quality achieved in terms of compression ratio. A better transform will provide improved compression performance [8].



About[α]- Senior Lecturer, Department of Computing, Muscat College, Sultanate of Oman.
menilajames@muscatcollege.edu.om
About[Ω]- Head, Department of Information Systems, University of Nizwa, Sultanate of Oman.
arockia99@gmail.com

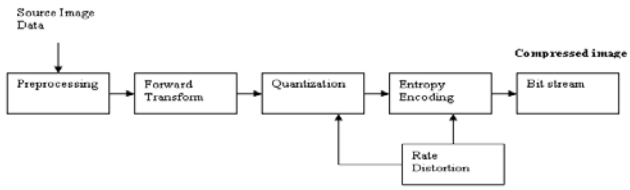


Figure 1: Block diagram of compression /decompression in transform coding

In decompression process, the data must be entropy decoded first, inverse quantized and then inverse transformed in order to reconstruct an original image. This resultant image may be with a poor quality due to information discarded during compression. In figure 1, point D represents image pixels and point A represents fully compressed domain. The resulting reconstructed images will have a checker-board or the smear effect.

As the transform coefficients that represent higher frequencies are more and more discarded (or are rounded to lower precision) with higher compression rates, the images become more and more low-pass filtered. This is clearly observed in the JPEG2000. For example at 0.2 bpp, the finer details of the face (like wrinkles) were eliminated in the reconstructed image. Thus it is observed that, low-pass filtering can greatly affect the recognition results [9].

The magnitude of compression is mainly calculated by *compression ratio*, expressed in the form of *bits per pixel* (bpp). The performance of the compression technique can be effectively measured by Peak Signal to Noise Ratio (PSNR), and calculated as:

$$PSNR = 20 log \left(\frac{2^n - 1}{RMS} \right) \quad \text{[dB]}$$

where n is the number of bits per pixel in the original image and RMS is the Root Mean Square Error defined as:

$$RMS = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (I_i - I_i')^2}$$

where Ii is pixel value in the original image, $I'i$ is corresponding pixel value in the reconstructed image and N is the total number of pixels in the image.

The basic image compression technique usually takes high computational time for stored image of the unknown individual and it can be recognized if it is compared to one or more images of known individuals. Moreover, decompressing all those images will be very difficult; this leads to a novel idea of image compression technique which will avoid the difficult position in the decompression domain.

III. Related Work

In Ekenel, H.K. et al. [10], the face recognition system that can be deployed for real-life smart interaction applications have been described. This system is capable of developing a fast and robust fully automatic face recognition system. The algorithm is mainly based on the appearances of local facial regions that are represented with the coefficients of discrete cosine transform. There are three fully automatic face recognition systems have been formulated based on this algorithm. The first device is the “Door monitoring system” which is formulated based on this algorithm that records everything which is entering into the room and identifies the subjects. The second device is “portable face recognition system” which recognizes the user of a machine. The third system “3D face recognition system” which operates fully automatic face recognition on 3D range data.

Rabab M. Ramadan et al. [11] have presented Face recognition comprises of many applications which are ranging from security access to video indexing by content. Here they described about the VQ-based automatic face recognition system and which analyze the feature selection effects, codebook size and feature dimensionality on recognition performance in the VQ-based framework. In specific, the DCT-based feature vectors are examined in such a system. Directly the recognition can be performed on the bit stream of the DCT based compressed images. The system comprises of three parts: a preprocessing step which is accomplished to segment the face, then the feature selection process and finally the classification. A database which comprises of 500 images could be recognized with high accuracy.

In a study conducted by Delac in 2007 [12], the feasibility of implementing face recognition algorithms directly into JPEG2000 compressed domain was examined and CDF 9/7 wavelet was used in the study. The Standard face recognition algorithms PCA, ICA and LDA were fed with CDF 9/7 wavelet and also FERET database was used. It was proved that no significant drops were observed and the authors claimed that face recognition algorithms can be directly implemented in JPEG2000 compressed domain. The authors also recommended further research for finding a way to intelligently extract feature vectors within compression scheme or finding another mechanism for image matching in order to improve recognition performance. This proposed method continues the study reported in this paper.

IV. Proposed Methodology

The proposed methodology uses the entropy points as the input to the face recognition system as in PCA. The original image is transformed using the DWT and quantization and entropy coding is done on the coefficients. The proposed approach eliminates major part of the decompression phase.

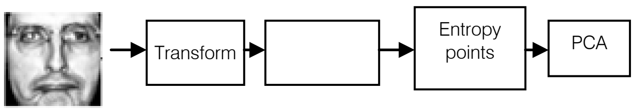


Figure 3: *Face Recognition in Compressed Domain*

It is very vital to define the compressed domain as it plays a key role in this research. The Compressed domain is any point in the compression / decompression procedure after transform and before inverse transform.

The clear approach to transport face recognition into the compressed domain is to stop the decompression process before the inverse transformation and to utilize coefficients as input to face recognition approaches. The inverse quantization as well as the inverse transformation is removed.

There is no change in the performance when using the inversely transformed coefficients. When the inverse quantization is eliminated some additional computation time was saved. For the experimental observation, all the coefficients available after the entropy decoding were used. In case of the normalized 128 x 128 sized images, all 1195 coefficients per image were used as input to PCA [13].

Improved Matching by Kd tree

The K-dimensional tree (kd-tree) is a space-partitioning data structure for organizing points in a k-dimensional space. This method is a widely used data structure in various applications like exploration which involves multidimensional search key (e.g. range searches and nearest neighbor searches). The kd-tree methods are considered as a special case of BSP trees. In this proposed approach, kd tree is used for improved matching of the face recognition algorithms.

Kd-tree Algorithm: Given a list of n points, the following algorithm will construct a balanced kd-tree containing those points.

Algorithm Build Kd tree (P, depth)
Input: A set of points P and the current depth.
Output: The root of a kd-tree storing P.

1. If P contains only one point
2. then return a leaf storing this point
3. Else if *depth* is even
4. then Spilt P into two subsets with a vertical line l through the median x coordinate of the points in P. Let P_1 be the set of points to the left of l or on l, and let P_2 be the set of points to the right of l.
5. Else Spilt P into two subsets with a horizontal line l through the median y-coordinate of the points in P. Let P_1 be the set of points below l or on l, and let P_2 be the set of points above l.
6. V_{left} - BUILDKDTREE(P_1, *depth*+1)
7. V_{right} - BUILDKDTREE(P_2, *depth*+1)
8. Create a node V storing l, making V_{left} the left child of V, and make V_{right} the right child of V.
9. Return V

Complexity

- Constructing a static kd-tree from n points takes O (n log ^{2} n) time if an O (n log n) sort is used to calculate the median at each level. The complexity is O (n log n) if a linear median-finding approach.
- Inserting a new point into a balanced kd-tree takes O (log n) time.
- Removing a point from a balanced kd-tree takes O (log n) time.
- Querying an axis-parallel range in a balanced kd-tree takes O ($n^{1-1/k}$ +m) time, where m is the number of the reported points, and k the dimension of the kd-tree.

Thus from the complexity information, it is found that compared to Euclidean distance which was used in earlier studies for recognition purpose, the proposed kd-tree matching technique takes less time.

V. Experimental Setups And Results

Database and protocol

To implement the proposed idea, a Standard FERET data [13] set is utilized in this paper for evaluating the proposed technique which includes the data partitions for recognition tests, as represented in [14]. This dataset contains 1,196 images and also four sets of query images that are matched to the dataset images in identification phase. The fb probe set consists of 1,195 images of subjects obtained at the same time as dataset images with the only dissimilarity being that the subjects were told to suppose a various facial expression.

The fc probe set consists of 194 images of subjects with various illumination cases. The dup1 (duplicate I) set consists of 722 images taken somewhere between one minute and 1,031 days after the dataset image was obtained, and dup2 (duplicate II) set is nothing but a subset of dup1 which consists of 234 images obtained at minimum18 months after the dataset image was obtained. Every image in the data set is of size 384 × 256 pixels and represented in grayscale.

Preprocessing

There are several well known appearance-based subspace face recognition algorithms like Principal Component Analysis (PCA) [15], Linear Discriminant Analysis (LDA) [16] and Independent Component Analysis (ICA) [17].

The Original FERET images are initially transformed spatially to obtain the eyes at the fixed points depending on a ground truth file of the eye coordinates provided with the original FERET data. Each and every image is then cropped to size of 128 × 128 pixels and an elliptical mask was utilized to mostly to remove the background. At last, image pixel values were histogram equalized to the sort of values between 0 and 255. These preprocessing processes are performed on each image earlier to carry out the experiments even before compression.

In training the PCA algorithm, a subset of classes that there are three images per class was utilized. It is identified that there are 255 such classes which represent 255 various persons, thus the training set contain total of 675 images with 3 images per person (M = 675, c = 225).

The outcome of this process is that this percentage of overlie has on the performance of this algorithm requires additional examination. The result of PCA algorithm according to the theory is (M - 1 = 674) meaningful eigenvectors. The FERET suggestion is assumed and reserved the top 40% of those, consequence in 270-dimensional PCA subspace W (40% of 674 = 270). It was obtained that 97.85% of energy was preserved in those 270 eigenvectors.

The performance of the proposed approach compared to the existing image compression algorithms were evaluated by the performance measure called the Normalized Recognition Rate (NRR).

In Figure 3, it shows the graphical representation of the NRR of the proposed method compared to the existing method. It is clearly observed from the graph that the proposed approach shows the improvement in the NRR compared to the existing recognition technique.

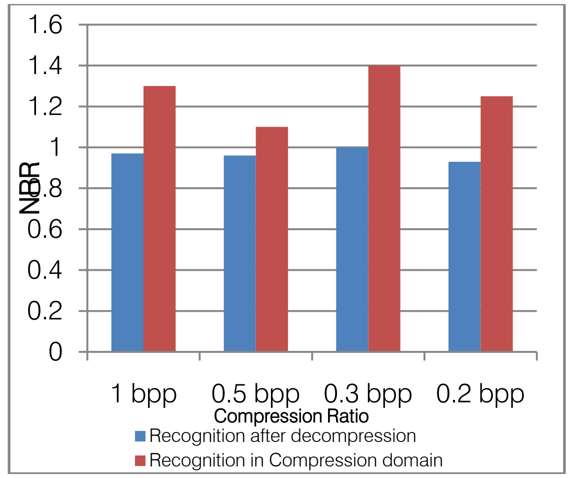


Figure 3: NRR evaluation of the proposed approach

The computational time of the proposed approach using the kd tree method is compared with the existing techniques in figure 4. The kd-tree takes very less computation time when compared to the recognition rate of the existing approach.

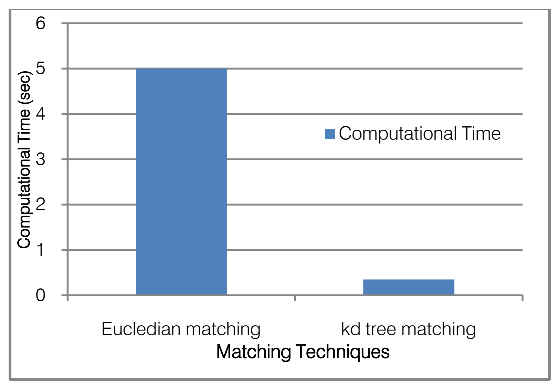


Figure 4: Comparison of the Computational Time

VI. Conclusion

This paper presents systematic approach of implementing face recognition methods directly in compressed domain. All the aspects that can occur in such circumstances, ranging from the effects of compression on recognition rate to technical implementation issues like computational time and storage requirements savings were analyzed.

The experimental results proved that implementing the standard recognition method such as PCA directly in compressed domain will not deteriorate recognition results. All the experimentation results in compressed domain illustrated in this paper were compared to the results in pixel domain i.e. using either uncompressed or fully decompressed images.

Moreover, the proposed approach uses the kd-tree method for the face recognition comparison. This algorithm effectively reduces the computational time to a very great extent. Thus the proposed approach provides significantly improved performance in terms of both computational time and NRR.

The scope for further improvement of this work will consist of analyzing the influence of proposed methodology on the result of performance for known face recognition algorithms using Linear Discriminant Analysis (LDA) and Independent Component Analysis (ICA). This could be implemented by testing on various images from different databases for generalization.

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Usefulness and Usability of a Multilingual Electronic Meeting System

By William Pepper, Milam Aiken Ph.D., Bart Garner Ph.D.
University of Mississippi

Abstract- Communication in multilingual meetings is difficult, and interpersonal barriers increase with the number of languages used in the discussion. In this paper, we show how participants in pseudo-oral and electronic, multilingual meetings were able to comprehend previously prepared comments in up to five languages, but the electronic meetings took much less time. In addition, there were no significant differences between the two types of meetings in terms of ease of use or usefulness, which leads us to the conclusion that for certain sets of languages and topics, an electronic meeting with machine translation is a viable alternative to the more traditional, oral setting.

Keywords: Electronic meetings, group support systems, machine translation

GJCST Classification: JEL Code: O33

USEFULNESS AND USABILITY OF A MULTILINGUAL ELECTRONIC MEETING SYSTEM

Strictly as per the compliance and regulations of:

Usefulness and Usability of a Multilingual Electronic Meeting System

William Pepper[α], Milam Aiken Ph.D.[Ω], Bart Garner Ph.D.[β]

Abstract- Communication in multilingual meetings is difficult, and interpersonal barriers increase with the number of languages used in the discussion. In this paper, we show how participants in pseudo-oral and electronic, multilingual meetings were able to comprehend previously prepared comments in up to five languages, but the electronic meetings took much less time. In addition, there were no significant differences between the two types of meetings in terms of ease of use or usefulness, which leads us to the conclusion that for certain sets of languages and topics, an electronic meeting with machine translation is a viable alternative to the more traditional, oral setting.

Keywords: Electronic meetings, group support systems, machine translation

I. Introduction

About one quarter of Americans can hold a conversation in a second language, and the incidence of multilingualism is even higher in some parts of the world, such as Europe (McComb, 2001). Yet, there is a growing need for meeting interpretation as international communication continu--es to increase (House & Rehbein, 2004). For example, the Directorate General for Interpretation at the United Nations provides interpreters for about 50-60 meetings per day, and meetings with up to 23 langua--ges can be held with the aid of 69 interpreters(Fügen, et al., 2007). Interpreters and translators in the Unit-ed States held about 31,000 jobs in 2004, and the demand has increased faster than the average for all occupations (Collegegrad, 2010).

In the past decade, technology has made the work of interpreters and translators easier (Sert & Açıkgöz, 2006). Now, people are using free, Web-based machine translation (MT) such as Google Translate and Yahoo!Babelfish to quickly obtain the gist of Web pages and email, and several multilingual Internet communities have arisen in which each participantcommunicates in his or her own native language (Yamashita & Ishida, 2006). In addition, groups are now engaging in face-to-face, multilingual discussions through electronic meeting systems hat automatically translate among all the participants' languages (Aiken, 2008).

However, much is unknown about how multilingual groups behave and how electronic meeting participants perceive machine translation. In particular, there has been no direct comparison of a traditional, human-interpreted, oral meeting with an equivalent, electronic discussion integrating MT. In this paper, we provide a background of oral and electronic multilingual meetings and then describe an experiment in which groups in simulated oral meetings are compared with groups in electronic discussions to determine the relative efficiency and effectiveness of each technique. The paper concludes with limitations and directions for future research.

II. Background

There are at least 11 million business meetings in the United States every day, and about 37% of the average employee's time is spent in these sessions (Infocom, 2010). However, traditional, oral meetings have long been perceived as unproductive and unpleasant. For example, in one study (Wainhouse Research, 2010), 92% of attendees reported valuing meetings as providing opportunities to contribute, but 91% admitted to daydreaming during the discussions, and 39% have actually slept.

Electronic meeting systems have been developed to increase the productivity of group work. Using this technique, group members often can exchange typed comments simultaneously and anonymously while all text is automatically recorded in a transcript, and numerous studies with this technology have demonstrated that people can generate more ideas in less time, participate more, and are more satisfied with it (Nunamaker, et al., 1991). However, the vast majority of research with electronic meetings has taken place using a single language, typically English, and multilingual groups have been relatively ignored in comparison (Aiken, et al., 2002; Briggs, et al., 1998).

Traditional, oral, multilingual meetings have been supported by human interpreters who listen in one language and utter the equivalent in another, neither simultaneously or consecutively after the main speaker has verbalized a group of words or sentences. However, human interpretation can be expensive and fees have ranged from US $20 per hour (Ku & Flores, 2005), up to 300 to 400 Euros (US $423 to $564) per hour (Fügen, et

About[α]- School of Business Administration, University of Mississippi, PO Box 1848, University, MS 38677, USA
E-mail: wpepper@bus.olemiss.edu
About[Ω]- School of Business Administration, University of Mississippi, PO Box 1848, University, MS 38677, USA
E-mail: maiken@bus.olemiss.edu
About[β]- School of Business Administration, University of Mississippi,PO Box 1848, University, MS 38677, USA
E-mail: bgarner@bus.olemiss.edu

al., 2007). In addition, scheduling an interpreter for a particular language pair (e.g., Vietnamese to German) at a specific time and location could be difficult.

In addition, human interpreters are not perfect, and errors rise steadily as time goes on (Al-Khanji, et al., 2000; Moser-Mercer, et al., 1998). For example, interpreter accuracy usually holds level for about 30 minutes, and then falls 10% for every 5 minutes afterward due to fatigue (Fügen, et al., 2007). As a result of these limitations, some researchers have investigated how electronic meetings can be used to assist groups that do not share a common language.

Although multilingual, electronic meeting systems were first developed in the early 1990s (Aiken, et al., 1994), only recently has there been a burst of growth in this field of research as MT quality has increased dramatically. Translation comprehension in these electronic discussions often suffers in comparison with that of oral meetings (Aiken & Ghosh, 2009), but the majority of MT users understand its limitations and are in general, impressed by the translation quality achieved (Yang & Lange, 2003). As a consequence, groups of up to 40 people at once using 40 different languages have used the technology successfully (Aiken, et al., 2010).

III. Theoretical Model

Many variables have been proposed over the years to measure an information system's quality, including data currency, response time, turnaround time, data accuracy, reliability, completeness, system flexibility, and ease of use (Legris, 2003). However, no theoretical model has been specifically designed for evaluating a multilingual information system's usefulness.

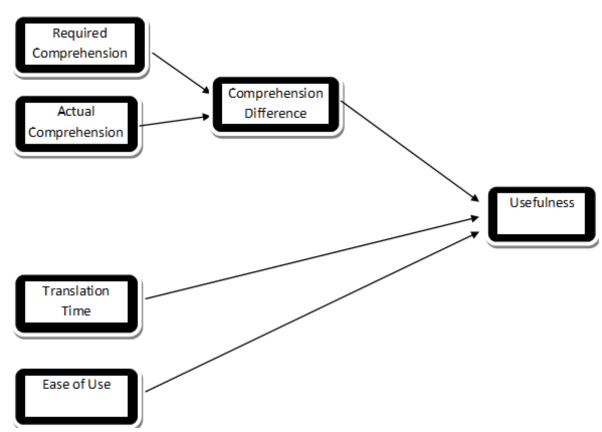
Prior studies of multilingual meetings have focused primarily on how well the group members comprehended the translations of comments, but few if any have compared this with the group's required understanding (Aiken, 2008). That is, a measure of text comprehension is relatively worthless without some criteria for success, and required comprehension can vary based upon the importance, complexity, and urgency of the information (Aiken, et al., 2011). Thus, it is this relative comprehension success (or failure) which could influence a user's perceptions of the meeting technique's usefulness.

The time taken to translate or interpret meeting comments also affects the productivity and satisfaction of group members (Korth & Silberschatz, 1997). Even though machine translation of comments in an electronic meeting might be relatively worse than human interpretation in an oral meeting, the reduction in translation and comment submission time might offset the limitation of poor quality (O'Hagan & Ashworth, 2002). For example, because of the stress and time demands on human linguists in a meeting, some have suggested that an acceptable accuracy for interpretation is only 80%, while text translation needs to be at least 99% accurate (Fügen, et al., 2007). If translations are fast and accurate in a multilingual, electronic meeting, group members might be more likely to think the system is useful (Chuan-Chuan & Lu, 2000; Wixom & Todd, 2005).

A system's ease of use is another factor that can influence its perceived usefulness (Segars & Grover, 1993). Oral meetings are natural and people are comfortable with speaking, but they might find the burden of taking turns and waiting for comments to be written on a board to be frustrating. On the other hand, in an electronic meeting, group members must learn how to use the software, and typing is less natural than speaking. But, if the meeting takes less time with acceptable translation quality, the technique might be perceived as easy to use and useful.

Based upon this prior research, we develop the theoretical model shown in Figure 1. Here, a comprehension difference is derived based upon group members' required and actual comprehension, which in turn, influences the meeting technique's perceived usefulness. Two other factors (translation time and ease of use) also affect this perception.

Figure 1: Multilingual meeting theoretical model



Thus, comprehension and translation time as well as perceptions of ease of use and useful can vary between oral and electronic, multilingual meetings, and including more languages within the discussion could exacerbate these differences. The translation quality in some additional language pairs could be much worse (e.g., Hungarian to Vietnamese), but oral meetings with a large number of languages might take much longer as interpretations must be made between each language combination.

IV. Experiment

An experiment was conducted with small groups averaging about eight people, a size large enough for the full benefits of an electronic meeting to be achieved (Aiken & Wong, 2003; Dennis, & Williams, 2005). Eighty-five undergraduate, business students (52% male) at a large university in the Southern United States participated in the study. The students had very little or no prior experience with electronic meetings.

In order to keep the comprehension comparison between the two meeting types fair, the same set of comments were used by all groups. That is, simulated, oral meetings were used in which the group facilitator simply wrote comments and translations on a board at the front of the room, as if they were spoken and then translated. Although these groups were only simulated, they are designated 'oral' meetings throughout the remainder of this paper. In theelectronic meetings, group members copied and pasted non-English comments from a MS Word file into the Polyglot user interface.

Seven random comments written in English from a previous electronic meeting focused on ways to solve the parking problem on campus were used:

1. Parking lots are too far from the business school.
2. Due to the parking problem, I was late to my morning class.
3. Doctoral students should get preferred parking.
4. I wish the school could secure some space only for PhD students.
5. The solution to the entire issue is to make everyone ride bicycles.
6. We should prevent freshmen from parking on campus.
7. Just assign me a parking place, and forget everyone else.

These comments were translated, and groups exchanged these comments in either three languages (English, German, and Spanish) or five (English, German, Italian, Spanish, and Swedish). The students were randomly assigned to four electronic meetings (sizes: 8, 7, 7, and 9), or six oral meetings (sizes: 9, 9, 8, 9, 9 and 10). In each electronic meeting, one group member was assigned one comment to contribute (translated to a foreign language). Because a few groups had more than 7 participants, some were idle.

A total of five minutes was allocated for each of the electronic meetings because a previous study (Aiken, 2002) indicated that this time was more than adequate for a person to contribute a comment with this technique. After they submitted the comments, the group members switched the language setting to English and evaluated the automatic translations. In each 3- language, oral meeting, the facilitator took about 11 minutes to write the 21 sentences on the board and about 18 minutes to write the 35 sentences in the 5 language meetings. After meeting, the students completed a questionnaire to express their feelin--gs about the meetings.

V. Results

Cronbach's alpha values were calculated to test the reliability of the two categorical variables, and ease of use (0.911) and usefulness (0.935) each met the minimum criterion of 0.7 (Cronbach, 1970; Nunnally, 1978).

Some of the means and standard deviations (Mean/Std Dev) in the 3-language experiment varied greatly between Electronic (E) and Oral (O). Examples of this include: Actual comprehension - E (86.57/11.93) vs. O (60.81/12.48); Required Comprehension – E (80.28/5.52) vs. O (57.58/3.97); Compreh diff1 – E (6.29/6.41) vs. O (3.23/8.51); Req. Comp(No Translation) – E (60.28/32.58) vs. O (31.32/31.19); Req. Comp (5 mins late) – E (85.22/17.74) vs. O (52.14 vs. 31.44).

Some of the 3-language experiments were very similar in means between sessions. Examples include: Ease of Use – E (4.87/1.06) vs. O (4.11/0.33); Usefulness - E (4.75/1.06) vs. O (4.51/0.70); Time preference – E (4.71/1.01) vs. O (4.57/0.28).
Similar results exist in the 5-language meetings for the same measures.

There was a significant difference between the electronic and oral meetings in regards to required comprehension in the 3- language treatment. In addition, there was a significant difference between the electronic and oral meetings using three and five languages in actual comprehension. Those in the oral meetings indicated that they understood substantially less; perhaps because they were confused by the text written in so many different languages on the board.

Using three and five languages, the electronic group comprehension was higher than the required comprehension overall, required comprehension when the alternative was no translation, and comprehension when the alternative was information five minutes late. However, the oral group members' comprehension using three languages was only slightly higher than the three required comprehension criteria. Using five languages, the oral groups' comprehension was lower than two of the required comprehension benchmarks.

Oral groups took significantly more time than the electronic. Both types of groups wanted translations quickly. In addition, there were no significant differences between the oral and electronic groups or between the 3- and 5- language groups in terms of ease of use, and there were no significant differences between the oral and electronic groups or between the 3- and 5- language groups in terms of usefulness.

In addition to comparisons between the meeting types, we conducted a correlation analysis to investigate the relationships among the variables. Those who comprehended the discussion more felt the meeting technique was easy to use and useful, but

May 2011

Global Journal of Computer Science and Technology Volume XI Issue X Version I

surprisingly, they also required less comprehension in the discussion.

Students in the longer, oral meetings comprehended the discussions less, and required less understanding. Further, they thought the meeting technique was less easy to use and useful. As we expected, those who thought the meeting technique was easy to use also thought it was useful. Finally, students who expected translations quickly thought the technique was not easy to use or useful. This might be due to strong feelings among oral group members who were less satisfied with their technique.

VI. Conclusion

This research investigated simulated oral and electronic meetings using three or five languages. Results show that participants in the electronic groups were able to understand the foreign comments translated to English better than those in the simulated-oral groups, and better than that required. Oral group comprehension was lower than that required in some cases.

With five languages, the oral meeting technique was not perceived to be easy to use, but the electronic technique was easy to use and useful in all cases. Finally, the electronic meetings took significantly less time. Therefore, we conclude that for these groups, languages, and topic, electronic, multilingual meetings can be used effectively and efficiently.

The first limitation of this study is the fact that only a small subset of European languages was used (English, German, Italian, Spanish, and Swedish), and students evaluated only the translations to English. Comprehension of translations between other languages (e.g., Croatian to Chinese) could be different.

Second, group members in the pseudo oral meetings did not actually say anything because the text needed to be identical between the treatments and participants might have behaved differently in this simulated environment.

Fourth, some results could have been affected by members' dissatisfaction with the overall process. For example, oral-group members' reported comprehension was lower than expected, perhaps because of their frustration with the long meeting time.

Finally, only one facilitator was used to write comments on the board in the simulated oral meetings. More facilitators writing simultaneously in different languages could reduce the amount of time needed in these meetings, but there also could be more confusion.

Future research should focus on a comparison of electronic groups with actual, oral groups using a variety of languages and topics to determine in which cases the technology is most beneficial.

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A Survey On Image Segmentation Using Decision Fusion Method

By M.Janani, Ms.D.Kavithadevi

Abstract- Neonatal brain MRI segmentation is challenging due to the poor image quality. Existing population atlases used for guiding segmentation are usually constructed by averaging all images in a population with no preference. However, such approaches diminish the important local inter-subject structural variability. Tissue segmentation of neonatal brain MR images remains challenging because of the insufficient image quality due to the properties of developing tissues. Among various brain tissue segmentation algorithms, atlas-based brain image segmentation can potentially achieve good segmentation results on neonatal brain images. Atlas-based segmentation approaches have been widely used for guiding brain tissue segmentation. Existing brain atlases are usually constructed by equally averaging pre-segmented images in a population. However, such approaches diminish local inter-subject structural variability and thus lead to lower segmentation guidance capability. To deal with this problem, we propose a multi-region-multi-reference framework for atlas-based neonatal brain segmentation.

GJCST Classification: I.4.6

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A Survey On Image Segmentation Using Decision Fusion Method

M.Janani[α], Ms.D.Kavithadevi[Ω]

Abstract- Neonatal brain MRI segmentation is challenging due to the poor image quality. Existing population atlases used for guiding segmentation are usually constructed by averaging all images in a population with no preference. However, such approaches diminish the important local inter-subject structural variability. Tissue segmentation of neonatal brain MR images remains challenging because of the insufficient image quality due to the properties of developing tissues. Among various brain tissue segmentation algorithms, atlas-based brain image segmentation can potentially achieve good segmentation results on neonatal brain images. Atlas-based segmentation approaches have been widely used for guiding brain tissue segmentation. Existing brain atlases are usually constructed by equally averaging pre-segmented images in a population. However, such approaches diminish local inter-subject structural variability and thus lead to lower segmentation guidance capability. To deal with this problem, we propose a multi-region-multi-reference framework for atlas-based neonatal brain segmentation.

I. Introduction

In Neonatal Brain MRI Segmentation By Building Multi –Region-Multi –Reference Atlases, Brain tissue segmentation, which classifies brain tissues into meaningful structure such as gray matter (GM), white matter (WM), and then cerebrospinal fluid (CSF).The segmentation is performed in this structure is difficult in neonatal brain image due to low spatial resolution ,insufficient tissue contrast ,and ambiguous tissue intensity distribution.

Due to these problem difficulties image intensity is insufficient for effective neonatal brain MRI segmentation. The knowledge-based algorithm is seems to be effective. The atlas is build with multiple individual atlases with decision fusion strategies. The strategy implies that individual atlas-based segmentation fuse the segmentation into final result. Prastawa constructed an atlas by averaging 3 semi-automatic segmented neonatal image are alignment using affined transformation. Weisenfeld obtained an unbiased atlas by averaging the probability maps of 20 newborn subjects. Which are non-rigidly aligned with a simultaneous group-wise registration .a multi-region –multi-reference approach, which estimates multiple atlases for different anatomical regions. Subject specific atlas is constructed for more effective neonatal segmentation.

There are two issues, taking brain as a single entity assign weight globally to all vowels so that a local shape patterns in the brain will be desired. The parcellation is performed to separate the brain into multiple sub regions. So that atlas can be build for each region separately. A cluster technique called affinity propagation is used to cluster the images.

In Neonatal Brain Image Segmentation In Longitudinal MRI Studies, It is difficult for the experts to visually distinguish between different neonatal brain tissues (nishida et al., 2006;song et al., 2005). The image acquired at late time point is easier than the image acquired at neonatal stage. Knowledge based algorithm has been developed to segment neonatal brain image. The atlas built on multiple images can appear from blurry to sharp depending on different setting of registration regularization in atlas construction process.

In atlas based image segmentation algorithms, the segmentation performance is affected by the registration procedure. The image acquired at late time brain image such as two-years old can achieve high accuracy using the existing segmentation method like fuzzy clustering. The proposed method is to use late-time point image in conjunction with its segmentation result as subject-specific tissue probabilistic atlas to guide tissue segmentation of neonatal image. The subject-specific atlas can be used within a joint-registration-segmentation.

In Construction of Multi-Region-Multi-Reference Atlases For Neonatal Brain MRI Segmentation, Atlas can be grouped into two categories1) average –shape atlas method (prastawa et.,2005;song et al.,2007;xue et., 2007)2)multi-classifier decision fusion methods, multi subjects in a population are selected as individual atlases to independently guide segmentation.

Single atlas may not sufficiently characterize shape variation in a population; the atlas-based segmentation approach has the drawbacks. The brain is taken as a single entity, different brain images regions have different anatomical pattern as region-wise comparison approach may be more appropriate. A single average shape atlas is generating from a population, it is better to construct multiple atlases. To

About[α]- M.phil Scholar, P.S.G.R. Krishnammal College for Women, Coimbatore.
Email id: janumphil@gmail.com
About[Ω]- Assistant Professor BSc Dept., P.S.G.R. Krishnammal College for Women, Coimbatore.
Email: kavisha58@gmail.com

overcome these 2 issues a method for each query image a subject specification is accommodated to the structural shapes of the query image. First the average-shape atlas of a population images is divided into multiple regions. Each sub- population is represented an exemplar and each its regions is represented by multiple exemplars. Collection of regional exemplar is called multi-region-multi-reference atlas. A query image, one best match exemplars is selected for each region and the selected exemplars for all regions are combined to form the final subject-specific atlas. A joint-registration–segmentation strategy is finally used to segment the query image. Experiment result indicates that, in significant segmentation accuracy improvement can be achieved.

II. Decision Fusion Method

Detecting edges in each image separately and then fusing the results is called decision fusion method.

a) *Process of Decision Fusion*

In neonatal brain MRI segmentation by building multi –region-multi –reference atlases, To build the atlas as prior knowledge and to aid segmentation three strategies are commonly used 1) single individual atlas 2) average-shape atlas 3) multiple individual atlases with decision fusion. The category 3 implies that the individual-atlas-based segmentation multiple times with different atlas subject and then fuse the multiple image segmentation into a final result with majority voting rule. It is to be noted that computation cost is quite high due to multiple segmentation.

In neonatal brain image segmentation in longitudinal MRI studies, The decision fusion is widely used to combine multiple segmentation into final decision with compensation for errors in single segmentation (Heckerman et al., 2006;Warfield et al., 2004). Decision fusion technique could be used to achieve better neonatal segmentation. The concept of decision fusion is used to fuse the multiple image segmentation into a single segmentation, with the single segmentation the neonatal brain MRI can be segmented easily. The need of decision fusion is to fuse multiple image segmentation and to get the final result.

In Construction of multi-region-multi-reference atlases for neonatal brain MRI segmentation, Atlas construction methods can be roughly grouped into two categories1) average-shape atlas methods 2) multi-classifiers decision fusion methods. In multi-classifier decision fusion methods, multiple subjects in a population are selected as individual atlases to independently guide segmentation. All segmentation results from different atlases can then fused by a majority-voting rule.

III. Methodology

In Neonatal Brain MRI Segmentation By Building Multi –Region-Multi –Reference Atlases, The multi-region-multi-reference framework for neonatal segmentation is carried out using neonatal images of 10 neonatal subjects (6 males & 4females) with age ranging from 26 to 60 days. For evaluation process 2 sagittal, 3covonal, &3 transverse slices of images are manually segmented by expert. The proposed method was compared with manual segmentation .The Dice ratio (DR) is used to measure tissue overlap rate for manual segmentation and automatic segmentation. The approach was evaluated with 2 other atlases. The first method (population A) was created 76 infants with ages ranging from 9 to 15 months. The second method (population B) uses the population atlas. To compare population A&B the joint registration –segmentation strategy is used to segment the brain images. It is to be said proposed method yield a good result. Decision fusion is used with multiple atlas because single atlas does not give a good result. Multiple atlases are carried out independently.

A multi-region-multi-reference framework for neonatal brain image segmentation is proposed in this paper. For representing the local shape variation, multiple atlases are selected. Experimental results demonstrate that our method yield the highest agreement with manual segmentation and brings out two population-atlas based segmentation methods.

In Neonatal Brain Image Segmentation in Longitudinal MRI Studies, MRI images of neonates were performed with more than 180 subjects. MRI scanning was performed using a 3T siemens scanner .In 10 subjects (4 females and 6 males) their neonatal images have been manually segmented.manual image segmentation was mainly focused on 2 sagittal slices,3 coronal slices and 3 axial slices. Segmentation was based on intensity based clustering method and then manually edited with ITK-SNAP software (yushkevich et al., 2006). In 10 subjects with both one-year-old and two-year-old images. We use both of them to guide neonatal image segmentation separately. To measure the overlap rate between two segmentation we use dice ratio (DR).The decision fusion technique could be potentially used to achieve better neonatal segmentation performance, by combining the segmentation results from multiple subject-specific atlases.

A framework is presented by using subject-specific tissue probabilistic atlas. The experimental results demonstrate that subject-specific atlas has superior performance compared to the population-based atlases, and the proposed algorithm achieves comparable performance manual raters in neonatal brain image segmentation. The average total computation time is around 28 min for segmentation of a $256 \times 256 \times 198$ image with $1 \times 1 \times 1$ spatial resolution on a pc with 2.5 GHZ Pentium 4 processor.3 min is used for segmentation of a late time point image for generating a subject-specific atlas,14 min is used for atlas-to subject registration ,and 11 min are used for atlas based neonatal image segmentation. It is to be concluded that proposed segmentation framework is able to achieve satisfactory segmentation results with reasonable computational time.

In Construction Of Multi-Region-Multi-Reference Atlases For Neonatal Brain MRI Segmentation, The proposed multi-region-multi-reference neonatal segmentation framework was applied to 10 subjects.10 image were manually segmented by expert rater using ITK-SNAP (yushkevich et al., 2006). Central brain region was not segmented due to extremely low tissue contrast. The proposed segmentation algorithm was compared with that of manual segmentation. The tissue overlap rate is compared with dice ratio (DR). The decision fusion is used to fuse the multiple image segmentation into single segmentation and the fused images are been used for manual segmentation and the result yields a good result. Our method yields the highest agreement with manual segmentation and outperforms the two average-shape atlas-based segmentation method .If the given population includes subject with a broad range of ages, the constructed multiple atlases in each region will learn all the shapes from different ages. It is to be concluded that multi-region-multi-reference atlas makes it adaptable to a large range of datasets. The methods such as brain parcellation, similarity measurement and image clustering can be future refined and optimized.

From this survey on image segmentation using decision fusion gives good result on neonatal images and brain tissues. This method can be further used to get the better performance for even very small images. The manual segmentation are done for 10 subjects in Neonatal brain image segmentation in longitudinal MRI studies, it is to be said that manual segmentation can be evaluated for more subjects when decision fusion technique is used. In Construction of Multi-Region-Multi-Reference Atlases for Neonatal Brain MRI Segmentation, large range of data set is adaptable for manual segmentation when decision fusion technique is used to fuse the multiple image segmentation into a single segmentation to bring a final decision. The neonatal brain image when done with manual segmentation gives good result but additionally when decision fusion technique is used it yield a better result. It is to be concluded that manual segmentation with decision fusion yields a good result. All these work can be proceeded to get better result.

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Construction Of Hadamard Matrices From Certain Frobenius Groups

By M.K. Singh, P.K. Manjhi
Ranchi University

Abstract- Hadamard matrices have many application in computer science and communication technology. It is shown that two classical methods of constructing Hadamard matrices viz., those of Paley's and Williamson's can be unified and Paley's and Williamson's Hadamard matrices can be constructed by a uniform method i.e. producing an association scheme or coherent configuration by Frobenius group action and then producing Hadamard matrices by taking suitable (1-1) – linear combinations of adjacency matrices of the coherent configuration.

Keywords: *Hadamard matrix, Coherent Configuration. Association Scheme and Frobenius group.*

GJCST Classification: *F.2.1, G.1.3*

CONSTRUCTION OF HADAMARD MATRICES FROM CERTAIN FROBENIUS GROUPS

Strictly as per the compliance and regulations of:

Construction Of Hadamard Matrices From Certain Frobenius Groups

M.K. Singh[α], P.K. Manjhi[Ω]

Abstract : Hadamard matrices have many application in computer science and communication technology. It is shown that two classical methods of constructing Hadamard matrices viz., those of Paley's and Williamson's can be unified and Paley's and Williamson's Hadamard matrices can be constructed by a uniform method i.e. producing an association scheme or coherent configuration by Frobenius group action and then producing Hadamard matrices by taking suitable (1-1) – linear combinations of adjacency matrices of the coherent configuration.

Keywords – Hadamard matrix, Coherent Configuration. Association Scheme and Frobenius group.

I. Introduction

We begin with following definitions.

a) *Hadamard matrix (H-matrix)*

A Hadamard Matrix H of order m is an m x m matrix of +1's and -1's such that

$$HH^T = mI_m \qquad [1]$$

b) *Coherent configuration (CC)Let X = {1,2,3,....n}, and R = {$R_1, R_2 \ldots, R_r$} be a collection of binary relations on X such that.*

(cc1) $R_i \cap R_j = \phi$ for $1 \le i < j \le r$;

(cc2) $\bigcup_{i=1}^{r} R_i = X^2 = X \times X$

(cc3) For all $i \in \{1,2,3\ldots,r\}$ there exists $i' \in \{1,2,3\ldots,r\}$ such that $R_i^{-1} = R_{i'}$

(cc4) There exists $I \subseteq \{1,2,3\ldots,r\}$ such that $\bigcup_{i \in I} R_i = \Delta$,

Where $\Delta = \{(x,x) \mid (x \in X\}$;

c) *Adjacency matrix of a relation*

Let R be a relation defined on a non-empty finite set X = {1,2,3…,n}.Then adjacency matrix of R = (aij) is defined as

$$a_{ij} = \begin{cases} 1, \text{ iff } (i,j) \in R, \\ 0, \text{ otherwise} \end{cases}$$

d) *Association Scheme (AS)*

Let X = {1,2,3…,n}.The set R = {$R_1, R_2 \ldots, R_r$} of r relations R_i (i=0,1,2,…r) is called an AS with r classes if

(As1) $R_0 = \{(x,x) \mid x \in X\}$; (Called a diagonal relation)

(As2) $R_i^{-1} = R_i$, for $i \in \{0,1,2,\ldots,r\}$;

(As3) For all $i,j,k \in \{0,1,2,\ldots,r\}$, for all $(x,y) \in R_k$

$|\{z \in X \mid (x,z) \in R_i \text{ and } (z,y) \in R_j\}| = P_{ij}^k$ [2] and [9]

AS is also defined by the adjacency matrices of the relations

R_i (i = 0, 1,2,…,r)

e) *Coherent configuration from group action*

If G is a group of permutations on a non-empty finite set X, then we say that G act on X. Now define action of G on X x X by $g(x,y) = (g(x),g(y))$ $g \in G$ and $(x,y) \in X \times X$. Then different orbits of G on X x X define a coherent configuration. [9]

f) *Frobenius group*

A group, G is called a Frobenius group. If it has a proper subgroup H such that $(xHx^{-1}) \cap H = \{e\}$ for all $x \in G - H$. The subgroup H is called a Frobenius complement.

Frobenius groups are precisely those which have representations as transitive permutation groups which are not regular – meaning there is at least one non identity element with a fixed point and for which only the identity has more than one fixed point. In that case, the stabilizer of any point may be taken as a Frobenius complement. On the other hand, starting with an abstract Frobenius group with complement H the group of G acts on the collection of left cosets G/H via left multiplication.This gives a faithful permutational represention of G with the desired properties. The Frobenius complement H is unique up to conjugation,

About[α]- Dept. Of Mathematics, Ranchi University, Ranchi – 834008 India
E-mail- mithleshkumarsingh@gmail.com
About[Ω]- Dept. Of Mathematics, Vinoba Bhave University, Hazaribag – 825301
E-mail- 19pankaj81@gmail.com

hence the corresponding permutation is unique up to isomorphism.

A theorem of Frobenius says that if G is a finite Frobenius group given as a permutation group, as above, the set consisting of the identity of G and those elements with no fixed point forms a normal subgroup N. The group N is called the Frobenius kernel. We have G = NH with $N \cap H=\{e\}$ where H is Frobenius complement.[1], [3] and [10].

g) *Paley's construction of Hadamard matrix*

If p^{α} =q is prime power and q+1=0(mod 4).Then a Hadamard matrix of order q+1 can be construction as follows.

Suppose the members of the field GF(q) are labeled $a_0,a_1,a_2\ldots$, in some order. A matrix Q of order q is defined as follows. The (i,j) entry of Q equals $\chi(a_i-a_j)$, where χ is the quadratic character on GF(q) defined by, $\chi(0)=0$

$$\chi(b)=\begin{cases} 1, \text{if b is a non zero quadratic element (perfect square in GF (q))} \\ -1 \text{ if b is not a quadratic element in GF(q)} \end{cases}$$

Set $S = \begin{bmatrix} 0 & 1' \\ -1 & Q \end{bmatrix}$, $H = I_{q+1}+S$

where 1 = q x 1 matrix with each entry 1. H is Hadamard matrix. [11] and [7]

h) *Williamson's Method*

Williamsons takes the array

$$H = \begin{bmatrix} A & B & C & D \\ -B & A & -D & C \\ -C & D & A & -B \\ -D & -C & B & A \end{bmatrix}$$

where A,B,C and D are circulant matrices of order n. Williamson constructed these matrices as appropriate (1,-1)-linear combination of (U+Un-1), (U2+Un-2). $\left(U^{\frac{n-1}{2}}, U^{\frac{n+1}{2}}\right)$ and Un = In where U = circ (0,1,0…,0)

The coefficients 1, -1 in the linear combination are obtained through computer search. Such that $A^2+B^2+C^2+D^2=4nI_{4n}$ [4], [13] and [7]

Hadamard matrices are used in communication system, digital image processing and orthogonal spreading sequence for direct sequence spread spectrum code division multiple access. They have direct application in constructing error control codes. They have also application in the constructing supersaturated screening design and optimal weighing design.. [9]

II. Construction of Hadamard Matrix From Frobenius Group

Singh, etal [12] forwarded a method of constructing H-matrices from certain AS. Here we forward a method which constructs suitable AS or CC by the action of Frobenius group and then H-matrix is obtained as suitable (1,-1)- linear combinations of adjacency matrices of AS or CC.

a) *Construction of Frobenius group (G) of order $\frac{p(p-1)}{2}$, p is an odd prime of the from 4t-1.*

Let ρ = (123…p) be a cycle in Z_p.
and $\sigma = (x^2x^4\ldots x^{p-1})(x^3x^5\ldots x^{p-2})$ (p) be a permutation on Z_p.
Where x is primitive root of multiplicative cyclic group of Z_p.
Let K = the cyclic group generated by ρ.
and H = the cyclic group generated by σ.
Let G = KH, We claim that G is Frobenius group. Elements of K, except identity element e, fixes no point and each element of H fixes exactly one point. Next we show that elements in KH-(KUH) fixes exactly one point, take

$\rho^i\sigma^j(0<i<p,\ 0<j<\frac{(p-1)}{2}) \in$KH-(KUH)

Note that if $\rho^i\sigma^j(y) = y$

$\Rightarrow$ yx2j+i=y

$\Rightarrow$ $y=i(1-x^{2j})^{-2}$ we get unique y .[$\because$ inverse element is unique in a group]

Hence every element in $G-(H\cup K)$ fixes exactly one point. So G = KH is Frobenius group of order $\frac{p(p-1)}{2}$

b) *Orbits of G on X x X. Where X = {1,2…,p}*

Orbit of (p,1) under the action of G

$= \{g(p,1)\ |g\in G\}$

$= \{\rho i\sigma j(p,1)\,|\,1\le i\le p,\ 1\le j\le \frac{p-1}{2}\}$

$= \{(i,x2j+i)\ |1\le i\le p, 1\le j\le \frac{p-1}{2}\}$=R1(say)

This set clearly contains $\frac{p(p-1)}{2}$ distinct elements and difference b-a of each pair (a,b) $\in$ R, is a quadratic residue modulo p.

Orbit of (1,p) under the action of G

$= \{x2j+I,i)\,|\,1\le i\le p \text{ and } 1\le j\le \frac{p-1}{2}\}$=R2 (say)

This set contains $\frac{p(p-1)}{2}$ distinct elements and difference of each pair is an non quadratic residue modulo p. Since G is transitive,

Orbit of (1,1) = {(1,1), (2,2),(3,3), …(p,p)}
= R0 (Say)

We can be easily verified that {R0,R1,R2} defines a CC.
Now we extend the action of G on the set X={1,2…,p,p+1} such that G fixes (p+1).

Then different orbits of G on X x X are as follows.

$R'_{01} = \{(1,1),(2,2)\ldots,(p,p)\}$;
$R'_{02}=\{(p+1,p+1)\}$;
$R'_1=R_1$;
$R'_2=R_2$;
$R'_3=\{(1,p+1), (2,p+1), (3,p+1)\ldots,(p,p+1)\}$;
$R'_4 = \{(p+1,1), (p+1,2)\ldots, (p+1,p)$

Let, $M_{01},M_{02},M_1,M_2,M_3$ and M_4 be adjacency matrices of the relations $R_{01},R_{02},R_1,R_2,R_3$ and R_4 respectively. Clearly $M_{01}+M_{02} = I_{p+1}$

Let $Q = M_1\text{-}M_2$
and $S = Q + M_3 - M_4$
and $H_{p+1} = I_{p+1}+S$

Then H_{p+1} is a Hadamard matrix equivalent to Hardamard matrix of Paley's form.

Remark : The above construction can be easily extended to GF(p^{α}) to have an H-matrix of order $p^{\alpha}+1$. Construction of Hadamard matrix from Dihedral group D_{2n} (n is odd) We describe below the construction for H matrix from D_{2n} (n is odd) which is also a Frobenius group. The permutation representation of dihedral group.

D_{2n} is $\{\rho, \rho^2, \rho^3,\ldots \rho^n = e, \rho\sigma, \rho^2\sigma \ldots \rho^n\sigma\}$
where $\rho(x) = x+1 \pmod n$
and $\sigma(x) = n\text{-}x+2 \pmod n$.
Consider the action of D_{2n} on X x X when $X = \{1,2,\ldots,n)$
The orbit of $(1,2) = \{(\rho^i(1), \rho^i(2)) : i=0,1,2,\ldots,n-1\}$
$\cup\{(\rho^i\sigma(1), \rho^i\sigma(2) : i = 0,1,2\ldots,n-1\}$
$= \{(1+i,2+i): i = 0,1,2\ldots,n-1\}$
$\cup\{(1+i,i) : i = 0,1,2,\ldots,n-1\}$
$= R_1\cup R_2$ (Say).

Let U = Circ (0,1,0,0…,0) (Circulant matrix with 1st row (0,1,0,0…,0))

$$= \begin{bmatrix} 0 & 1 & 0 & 0\ldots\ldots\ldots0 \\ 0 & 0 & 1 & 0\ldots\ldots\ldots0 \\ 0 & 0 & 0 & 1\ldots\ldots\ldots0 \\ \ldots\ldots & & & \\ 0 & 0 & 0 & 0\ldots\ldots\ldots0 \\ 1 & 0 & 0 & 0\ldots\ldots\ldots0 \end{bmatrix}_{nxn}, \text{ Clearly } U^n = I_n$$

Then Adjacency matrix of $R_1 = U$
We have the following matrix representation of the orbits

Orbit of (1,2) $\rightarrow U + U^{n-1}$
Similarly orbit of (1,3) $\rightarrow U^2 + U^{n-2}$
Orbit of (1,4) $\rightarrow U^3+ U^{n-3}$

Orbit of $1,\frac{(n+1)}{2}$ $\rightarrow U^{\frac{n-1}{2}}+U^{\frac{n-1}{2}}$

An orbit of (1,1) $\rightarrow I_n$

$U^i+U^{n-i},(i=1,2\ldots\frac{(n-1)}{2}))$ and I_n are the adjacency matrices of an AS.

Note that these circulant matrices are used in construction of Williamson's matrices A, B, C and D that Williamson used in his construction of Hadamard matrices.

III. Illustrations

a) *Construction of Hadmard Matrix of Order 7+1=8*
Consider the permutations on X = {1,2,3,4,5,6,7}

Given by
$\rho = (1234567)$
$\sigma = (3^2 3^4 3^6)\ (3^1 3^3 3^4)\ (7) = (241)\ (365)\ (7)$
Then $G = \{\rho^i\sigma^j : 1\le i\le 7, 1\le j\le 3\}$ is Frobenius Group of order 21.
Orbits of G on X x X where X = (1,2,3,4,5,6,7} are obtained as follows.
Orbit of (7,1) =
{(1,2),(1,3),(1,5),(2,3),(2,4),(2,6),(3,4),(3,5),
(3,7),(4,1),(4,5),(4,6),(5,2),(5,6),(5,7),(6,1),
(6,3),(6,7),(7,1),(7,2),(7,4)=R(say).

Orbit of (1,7)-
{((1,4),(1,6),(1,7),(2,1),(2,5),(2,7),(3,1), (3,2),
(3,6),(4,2),(4,3),(4,7),(5,1),(5,3),(5,4),(6,2),
(6,4),(6,5),(7,3),(7,5),(7,6)} = R_2 (say)
Orbit of (1,1)=
{(1,1),(2,2),(3,3),(4,4),(5,5),(6,6),(7,7)}=R_0 (say)

Note that R_0,R_1,R_2 defines a CC on X = {1,2,3,4,5,6,7}
Now we extend the action of G on the set X=(1,2,3,4,5,6,7,8) such that different orbits of G on X x X are.

$R'_{01} = R_0$;
$R'_{02} = \{8,8)\}$;
$R'_1 = R_1$;
$R'_2 = R_2$;
$R'_3 = \{(1,8), (2,8), (3,8), (4,8), 95,80, (6,8), (7,8)\}$;
$R'_4 = \{(8,1), (8,2), (8,3), (8,4), (8,5), (8,6), (8,7)\}$

M_{01}, M_{02}, M_1, M_2, M_3, and M_4 are adjacency matrices of the relations R_{01}, R_{02}, R_1, R_2, R_3 and R_4 respectively and are given by

$$M_{01} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \qquad M_{02} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$M_1 = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \qquad M_2 = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$M_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \qquad M_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$Q = M_1 \quad M_2 \quad -$

$S = Q + M_3 - M_4 = M_1 - M_2 + M_3 - M_4$

We take, $H = I_8 + S = M_{01} + M_{02} + M_1 - M_2 + M_3 - M_4$

$$= \begin{bmatrix} 1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & 1 & -1 & 1 & -1 & 1 \\ -1 & -1 & 1 & 1 & 1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & 1 & 1 & -1 & 1 \\ -1 & 1 & -1 & -1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & -1 & 1 & 1 & 1 \\ 1 & 1 & -1 & 1 & -1 & -1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 \end{bmatrix}$$

b) *Construction of H-matrix from dihedral group D_6.*
The permutational representation of dihedral group D_6.

is $\{\rho, \rho^2, \rho^3 = e, \rho\sigma, \rho^2\sigma, \rho^3\sigma = \sigma\}$

where $\rho(x) = x + 1 \pmod 3$

$\sigma(x) = 3\text{-}x+2 \pmod 3)$

i.e. $\sigma = (123)$, $\sigma = (2,3)$

consider the action of D_6 on X x X where X {1,23}
the orbit of (1,1) = {(1,1), (2,2), (3,3)} = R_0 (say)
orbit of (1,2)={(2,3), (3,1),(1,2)}∪{(2,1),(3,2),(1,3)}=$R_1 \cup R_2$ (say)
then adjacency matrix of R_1 = U
and adjacency matrix of $R_2 = U^{3-1} = U^2$
matrix representation of orbit of (1,2) is $U+U^2$ =

$$\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

matrix representation of orbit of (1,1)= $U_3=I_3$=

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

then A, B, C and D are given by A =

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} = U^3 + (U + U^2)$$

$$B = C = D = -(U+U^2) + U^3 = \begin{bmatrix} 1 & -1 & -1 \\ -1 & 1 & -1 \\ -1 & -1 & 1 \end{bmatrix}$$

Now we have the following H-matrix of order 12.

$$H_{12} = \begin{bmatrix} A & B & C & D \\ -B & A & -D & C \\ -C & D & A & -B \\ -D & -C & B & A \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 1 & 1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 \\ 1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 \\ 1 & 1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & 1 & 1 & 1 & -1 & 1 & 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & 1 & 1 & 1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & 1 \\ -1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & 1 & -1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 \\ 1 & 1 & -1 & 1 & 1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

IV. Future Prospects

At present no single method of construction can settle Hadamard conjecture which states that there exists an H-matrix of order 4t for all positive integer. By Computer search Djokovic [5] shows that there is no Williamson matrix of order t = 35 and so H-matrix of order 35x4=140 can be constructed by Williamson method. However since 139 is a prime of the form 4t-1, an H-matrix of order 140 can be constructed by the above method. We conjecture that by our general method H-matrix of any order can be constructed from suitable group.

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An approach for exposing legacy applications for integration in modern enterprise business processes

By Manish Verma, Prof. Vijay Shah

Abstract- Organizations have legacy software applications and systems, which are valuable assets and still critical to their current business operations. One of the key challenges for today's enterprises is how to effectively and efficiently integrate these legacy assets with other. internal and external applications and business processes. Modernizing legacy systems using SOA may help an organization to meet the increasing demands of the business processes integration while maintaining its large investment in legacy systems. SOA bridges the gap between business processes and technology resulting in improved reuse of existing applications and interoperability of desperate applications. Sometimes it is required to integrate legacy system with other application in a short span of time. As per the business requirements although SOA may address the solution, but it is very difficult to integrate due to several issues in service identification and mapping in legacy application and business processes.

In this paper an approach is proposed for participation and alignment of legacy applications in the enterprise business processes in a short span of time with the help of business process modeling and SOA, incorporating both Top down and bottom up approach together. As a case study, the paper describes the exposure of a prototype legacy banking application for participation in a service-oriented architecture.

The paper also proposes a novel way of determining the key business logic and resources embedded in a legacy C/C++ application with a reverse engineering approach so that the SOA mapping is automated and the constraints like memory and processing can be analyzed.

Keywords: Legacy Applications, Web services, Integration, Service oriented architecture, business process modeling.

GJCST Classification: H.2.4, H.3.4, C.2.1

AN APPROACH FOR EXPOSING LEGACY APPLICATIONS FOR INTEGRATION IN MODERN ENTERPRISE BUSINESS PROCESSES

An approach for exposing legacy applications for integration in modern enterprise business processes

Manish Verma[α], Prof. Vijay Shah[Ω]

Abstract - Organizations have legacy software applications still critical to their current business operations. One of the key challenges for today's enterprises is how to effectively and efficiently integrate these legacy assets with other Internal and external applications and business processes to address the changing business needs. Modernizing legacy systems using SOA may help an organization to meet the increasing demands of the business processes integration while maintaining its large investment in legacy systems. Sometimes it is required to integrate legacy system with other application in a short span of time. As per the business requirements although SOA may address the solution, but it is very difficult to integrate due to several issues in service identification and mapping in legacy application and business processes.

In this paper an approach is proposed for participation and alignment of legacy applications in the enterprise business processes in a short span of time with the help of business process modeling and SOA, incorporating both Top down and bottom up approach together. As a case study, the paper describes the exposure of a prototype legacy banking application for participation in a service-oriented architecture. The paper also proposes a novel way of determining the key business logic and resources embedded in a legacy C/C++ application with a reverse engineering approach so that the SOA mapping is automated and the constraints like memory and processing can be analyzed.

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I. Introduction

Business organizations have a large investment in software written in legacy programming languages and architecture. Today, most of the organizations run systems that have been developed a long time ago and are still adapted and maintained to meet current needs [1]. Approaches used in legacy systems sometimes differ considerably from today's modern paradigms. Adapting legacy software systems to new requirements also requires their migration and integration with new technologies and applications.

About[α] - Research Scholar, Samrat Ashok Technological Institute Vidisha, India.
E-mail- Manish.rc.verma@gmail.com
About[Ω] - Reader, Department of Computer Science Samrat Ashok Technological Institute Vidisha, India.
E-mail- vijayvidisha@gmail.com

A Legacy Information System can be defined as "any information system that significantly resists modification and evolution" [1]. These Information Systems pose considerable problems including brittleness, inflexibility, isolation, non-extensibility, lack of openness on the enterprise IT infrastructure. They significantly resist further modification and evolution. Legacy systems were designed for internal, enterprise wide usage while today's enterprise demands for inter enterprise communications and support for agile business processes.

There are various methods proposed including supplementing or replacing restrictive legacy applications and technology with newer, open standards-based applications and technologies, but still retaining existing business functions [2]. Legacy renovation is an expensive task. As the requests for modifications, new development and integration accumulate, it is very difficult to keep pace and enable a more agile enterprise. So it is advantageous to integrate legacy application with new applications while retaining the business logic intact.

SOA models the enterprise business workflow as a collection of business services, these services can be easily Reused and integrated in the organization to address the application requirements [3] [4]. Rather than developing from the ground up every time a change is needed, new assets can be created easily from existing services, saving time and money [5]. The most important advantage of SOA is to provide a data bridge between incompatible and desperate technologies [6].

BPM is a set of technologies and standards for the design, execution, and administration and monitoring of complex, automated business processes BPM provides the facility to monitor, analyze, control and improve the execution of these processes in real time [7]. Existing Web Services can be integrated as the counterparts of steps in business processes. Examples are credit verification in an on-line order process [8].

Several approaches for Legacy application integration and migration towards Service oriented architecture have been proposed in the past but they include difficulties in identifying candidate services from legacy application and their alignment with the organizational business processes requirements. Wrapping functions of legacy systems for exposing as web services may be a fast way for migration towards SOA, However the services provided are technology-oriented and do not fully address business goal or scenario, which might lead to the services not being fully utilized as per the business goals. *The top-down* approaches analyze existing business processes in order to identify adequate services but services are business oriented and may failed to get the needed functionality in legacy applications.

Our proposed method uses BPM and SOA together in order to make legacy participation in the enterprise business processes by means of exposing and orchestrating services. We used both top- down BPM driven and bottom up SOA driven service identification mechanism along with automated discovery of business logic in legacy codes to better align legacy application with business needs.

The reminder of the paper is organized as follows: Section 2 provides background information needed to understand the paper, Section 3 presents the proposed approach for legacy service exposure and participation in enterprise business processes with a case scenario, section 4 describes Discussion of result and historical approaches for legacy system migration and integration. We conclude with summary and future directions in section 5.

II. Background Information

An organization has a collection of interrelated business processes, which consist of a series of activities, jointly represent a business goal. For instance an order process in a B2B environment includes several activities networked with each other to complete the order process business goal. These business processes may have their span in several desperate applications in the enterprise and beyond.

The ''service'' is an application logic or underlying computing resource with an abstraction of the underlying implementation [3], that is exposed through an interface and which can be invoked over a network with standard protocols [9]. The most important application of SOA is to align the services to the business requirements and to facilitate reusability of existing services connecting the various operational systems that automate an enterprise's business processes [10].

Bottom-up approaches examine legacy systems and standard software for the identification of services. The bottom-up approach analyses the existing application for all available functions that can be exposed as a web service. With a bottom-up approach the definition of services originates in the domain of the application [11]. This approach results in a large number of available functions which can be exposed as services but does not tell anything about their usability. In bottom-up approach Services are discovered, rather than defined as requirements, therefore it tends to lead to poor business services as it preserves the current solution instead of addressing business needs.

The top-down approaches analyze existing business processes in order to identify adequate services. This approach looks at the processes in the business domain, decomposes them into sub process/tasks/functions until 'logical units of work' are defined, which we call services. The decomposition of the process in itself is not enough to discover services, because we will have to convert the 'candidate-service' into a real-world executable and discoverable service. This means we have to compare the functionality of the service with the available infrastructure but it does not reach deep into the architecture and implementation domain.

By combining these two approaches together we may get the best of both eliminating the shortcomings of each one and integration with the current application infrastructure and readiness for the business needs we are looking for. Therefore, a hybrid approach combining both methods is applied in order to minimize the problems associated with these approaches [12][13].The hybrid meet-in-the middle approach combines top-down and bottom-up techniques in order to identify services that better correspond to both the business requirements and the existing systems [14]. It provides a compromise between the top-down and bottom-up techniques that eliminates the most significant disadvantages. We proposed a meet in the middle approach with automatic discovery of prospective services in the legacy application for integration in business processes.

III. Proposed Approach

The proposed approach is a combined meet in the middle approach consists of BPM and SOA along with the reverse engineering of legacy application in order to identify the candidate services and their participation in the enterprise business processes. It eliminates the disadvantages of failure in getting the needed functionality in legacy applications and lengthy time of top down approach and non-business orientation of bottom up approach. Basically, we are proposing consolidated approach that provides guidance on the derivation of both business services and supporting software services to achieve a close business and IT alignment. The proposed method is influenced by meet in the middle approach by Inaganti and Behera with some improvements by minimizing the problem in finding of candidate service in legacy application [15].

This approach requires a comprehensive analysis of the legacy application and not just the mapping .In this paper we also presented a reverse engineering approach to extract the information of the legacy application through resource extraction from the application along to generate and publish the service.

The proposed technique can be summarized as a methodology for mapping legacy application resources to modern enterprise environment by BPM and SOA with the help of Reverse Engineering to facilitate the identification and extraction of the key business logic from Legacy application and alignment with business requirements. Figure 1 shows the block diagram of proposed method.

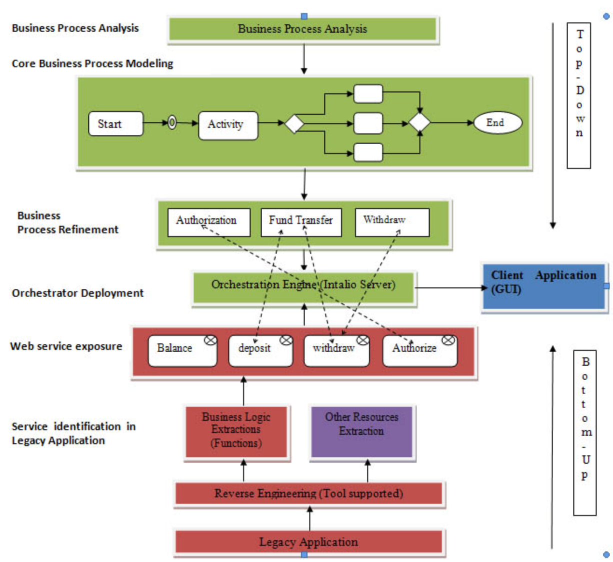

Fig. 1 Block diagram of proposed method

a) Problem Scenario

As an example scenario, here we introduced a prototype legacy banking application developed in C++. The Application is a monolithic standalone C++ application with no external interface for communication with other applications. The application stores the data in flat file system and provides various inbuilt functionalities like opening an account, deposit money, withdraw money, get balance, viewing of transactions and various reports. One can interact with it only through application GUI which is inbuilt in the code.

We assume that there are certain situations arises due to business needs, in which above application is required to be integrate with some other modern applications and business processes. As stated earlier in the paper, it is not viable to replace or rewrite the legacy application with new code. As the legacy application is standalone and the logic is embedded deep in the form of functions, it is very difficult to handle this situation. Our approach resolves the problem without rewriting the legacy code and without interrupting the operation or maintenance of the legacy system.

We presented a business process of ATM here. The ATM process resembles the new business requirement and we have to address it by using core business logic of legacy application. The ATM application will be a thin client with only GUI. The ATM GUI will provide only the user interface and the orchestrator takes care of proper sequencing of operations and calling of web services from legacy application. Various new business conditions and constraints, which are not present in legacy application may be addressed with the orchestrator, for example prohibiting withdraw operation in case of insufficient balance or not allowing a certain transaction if the number of transaction exceeds, without rewriting of the core component of the legacy application. The methodology is mentioned in following steps.

b) Top down Business process Analysis and identification of services in the Business domain

i. *Analyze the Core Business process.*

In the first step, it is necessary to analyze functional domain of business process and understand the business requirements. During the initial analysis phase, basic decisions regarding identifying the most important functions of the domain and showing their interrelationships is identified. The business structure and the functions of the business process are specified [16]. A business process reveals how an individual process activity is linked with another in order to achieve a business objective. We have to identify the start and end events of a particular business activity, human interactions with the process, automated activities and links with the other applications and organization's processes. This step results in a core coarse grained business process. This analysis results in the development of the "to-be" process model that an SOA solution is intended to implement [8].

In the context of our scenario we analyzes how a user will interact with ATM, how the business process will progress with the user interaction. This step results in the use case of ATM process, actors, activities and the flow of business.

ii. *Model the core business processes*

In this step we design the core business process found in previous step into a graphical model using a BPM modeler, as in our case Intalio [7]. At first, the business process is modeled at a high level where activities in the Business Process Diagram usually aggregate sub processes, which are graphically evaluated in another sub process BPM diagram. A [+] sign inside an activity denotes a process that can be decomposed into sub-processes [17]. We marked each task which requests an external service as service task. One of the purposes of the process model is to define process execution and to create the BPMN notation for this purpose.

The BPMN defines both the graphical notation and the semantics of a Business Process Diagram, We model the diagram with core elements of a BPD which comprises Flow Activities, Tasks represented by a rounded-corner rectangle which is a generic term for work that has to be performed, *Events* which are diagrammed as a circle, *Gateway Objects* represented by a *diamond* symbol which are used to control the divergence and convergence of a sequential flow. By means of these basic Flow Objects. The core process contains at least one *POOL* which is executable and can be deployed on orchestration Engine.

The core business process acts as an orchestrator which will direct and invokes the various Web services from legacy and other third party applications to form and execute a complete business activity [18].

iii. *Business Process refinement*

In this step we perform decomposition or refinement of sub processes of core BPM Diagram into elementary or atomic business functions. Business process refinement identifies service tasks, message activities, and events and actions in the sub process [11]. When the business process is subdivided into sub-processes or decomposed into granular activities the lowest level tasks will consist of small, cohesive "logical units of work", that are supported by the functionality offered by distinct services. It results in discovery of elementary business functions which can be addressed by web services in the application domain [19]. Delegating functionality into sub business processes prevents business processes from becoming overly large, complex and difficult to maintain. The refinement can be seen in authorization process diagram.

After refinement of sub processes the next step is to find out the Service Tasks which provide some sort of service which could be calling a Web service or an automated application. We will find the task which will call the legacy and other web services process. This service tasks will call atomic (single) web service interfaces of legacy application. In the case of authorization sub process the <u>*call authorize*</u> task invokes the authorize function of legacy application as shown in yellow color in figure 2.

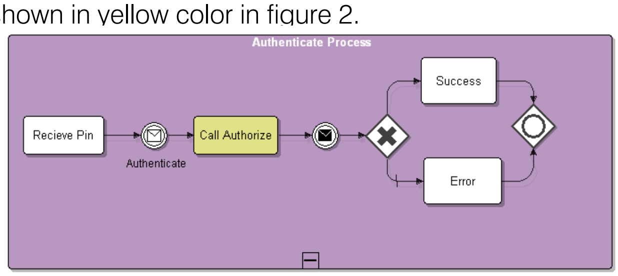

Fig. 2 Authorization sub process

c) *Existing asset analysis and Service identification in Legacy Application*

The purpose of this step is to identify assets in the legacy application i.e. business logic and legacy functionality which are capable of supporting the realization of services that meet business needs. The focus is on existing assets that play a role in business processes 14]. We initially perform a coarse-grained mapping of business processes and process activities to the portfolio of existing applications and application interfaces. Later in the specification, we perform a more fine-grained mapping, including message specification. We also identify various system resources so that the performance can be measured.

i. *Component identification in legacy application*

Service identification On the one hand, it is to determine what business functionalities should be provided by the target service in the application domain. On the other hand, the business functionalities embedded in the legacy system should be identified in order to be reused in the target service [20]. In this step the legacy application will be reverse engineered and we will find the various resources and embedded business logic to be exposed as web services by adopting bottom up approach. The analysis reveals the reuse potential of existing legacy components. The results of this step include information on system architecture, system components, infrastructure details and interfaces.

The proposed work identifies that this is a tedious process and the complexity grows with the line of code that reflects the business logic. Therefore a summary of the business logic present in the code is of extreme important. Here it is performed by a automatic reverse engineering tool. The working description of the tool is as given below.

First the tool Scans the program and tokenizes the program. Thereafter it removes the comments and blank sections. It Extracts the function definitions and other resources using following logic:-

1. Check if there is a "(" token in the line or not If so, extract the previous token (which can be function name or a predefined function or key words like if, for and so on)
2. Check if the token is a key word or not. If not, scan till the end and look for a ";" if it is not there, scan for another token appeared before the current token with space separation.
3. If the previous token is a key word (which reflects the return type) then marks the current line as the function definition. Extract the arguments and return types.

May 2011 54 Global Journal of Computer Science and Technology Volume XI Issue X Version I

4. Generate a summary of the function definition such that it can be used for header file to generate GSOAP web service interface.
5. Extract the variables like arrays, pointers, loops to understand the resources used by the application. The output is expressed in figure 3 below.

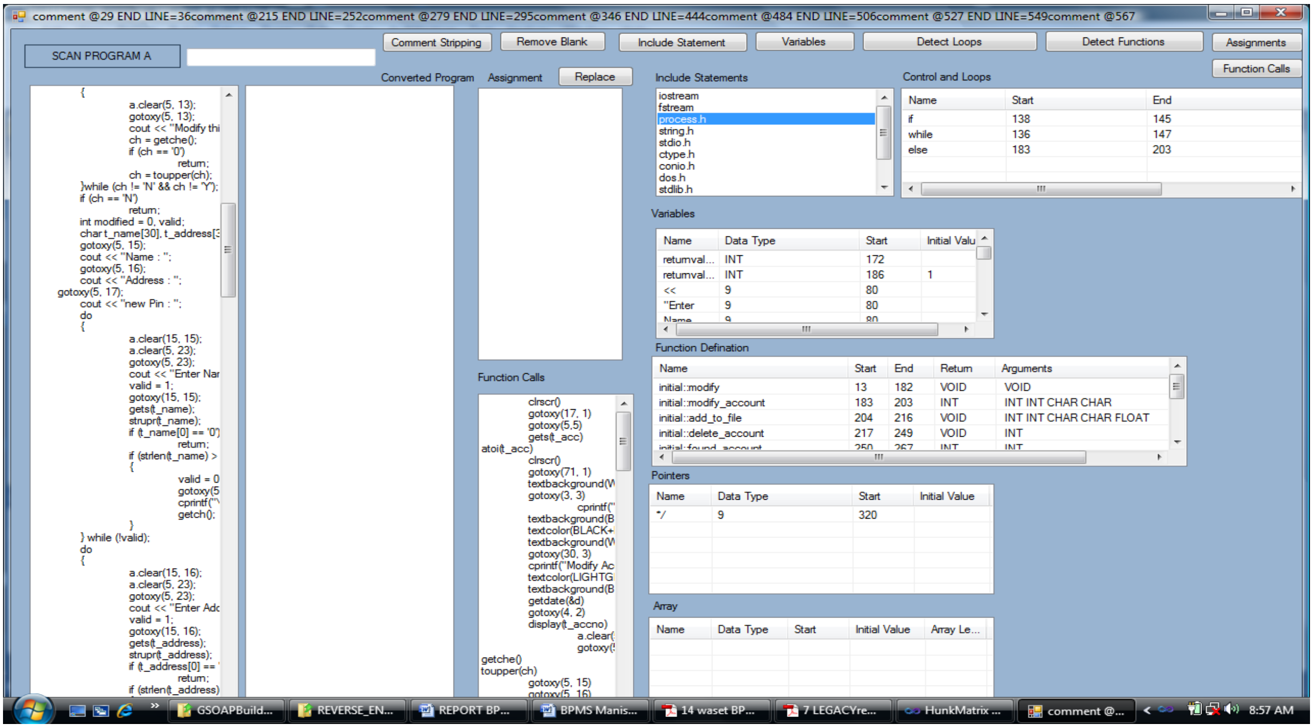

Fig. 3 Reverse Engineering Tool

ii. *Identify the point of functionality in legacy application*

In the previous step we found the information about application resources and various functions present in the Legacy application through reverse engineering. Now we identify the points of functionality of the legacy application that may be useful to implement the needed web services to interact with service task in the Orchestrator [15]. In the output of automated tool we find the independent functions calls so that it can be used to designate or make as a point of functionality, it means, among several functions we found the one that contains the functionality of interest for service tasks found in top down approach. For example *found_account function* may be used to make authorize function wrapper that can be used as point of functionality and can be exposed as web service and mapped with service task.

iii. *Exposure of identified functions as web service.*

The functions identified in previous step as the point of functionality are now exposed as web services [19]. The Service interface defines the types of messages and the message exchange patterns that are involved in interacting with the service, together with any conditions implied by those message.. The definition of functions which has to be called by service task has been written in a single header file *test.h*. The header file guides the GSOAP tool to generate stubs for needed web services. Now we write the web service module by using identified functions of previous step and with the help of GSOAP supporting files. All the exposed web services can be called through the WSDL Interface and the Service end point URL [20]. WSDL describes the operations that a service can support, and the parameters each operation accepts and returns. End point URL serves as a service provider. The application web service will provide the response to service task upon calling with appropriate parameters. Figure 4 describes the wsdl portion for input and output parameter for Authorize operation.

```
<!-- operation request element -->
  <element name="authorize">
    <complexType>
      <sequence>
        <element name="acc-no" type="xsd:int" minOccurs="1" maxOccurs="1"/>
        <element name="acc-pin" type="xsd:int" minOccurs="1" maxOccurs="1"/>
      </sequence>
    </complexType>
  </element>
  <!-- operation response element -->
  <element name="authorizeResponse">
    <complexType>
      <sequence>
        <element name="result" type="xsd:int" minOccurs="0" maxOccurs="1"
nillable="true"/>
      </sequence>
    </complexType>
  </element>
  <!-- operation request element -->
```

Fig. 4 part of a wsdl for legacy application web service interface *d) Service matching and mapping*

The service matching activity maps the service task to corresponding atomic web service in the application layer. Each atomic service task exactly maps single web service [15]. There may be some situation in which a service task will be divided in more than one service task and it may comprised of more than one point of functionality. We will map the service accordingly, for example the fund transfer service task will be associated to two services i.e. deposit and withdraw. Several service task may be associated to same service, for example a withdraw service may be associated to both withdraw and fund transfer service tasks. These concepts can be seen in Fig 1 and Fig 6.

At the end of this step we complete the matching and mapping of all the service task and corresponding web services with each other.

e) Service realization and orchestration

All the web services exposed from legacy system were atomic and asynchronous, that means there is no such execution or sequence order is set by default. In a business process there are several operating conditions upon which a business activity relies. For example a withdraw service can only be happened after authentication service, it must not happened before. Assembling services in order to accomplish business logic and business processes is called orchestration. [3] Explains orchestration as "the implementation of a business related workflow owned by a single entity through the combination of business relevant services". The orchestrator is deployed as a BPEL program in the Orchestration director engine.

In this step we define orchestration logic as the business logic that sequences, coordinates and manages conversations among Web services. This entire thing is expressed in BPEL. To execute a BPEL process a BPEL engine is needed which parses the BPEL code and executes the contained instructions. The Core Web services that are used by the BPEL program have to be deployed in advance. The whole orchestrator is deployed on Intalio BPMS server which acts as an Orchestration director engine. The orchestrator may be called in presentation mechanism through its WSDL and endpoint URL. In the ATM application a Java GUI reforms the presentation task which uses the orchestrator.

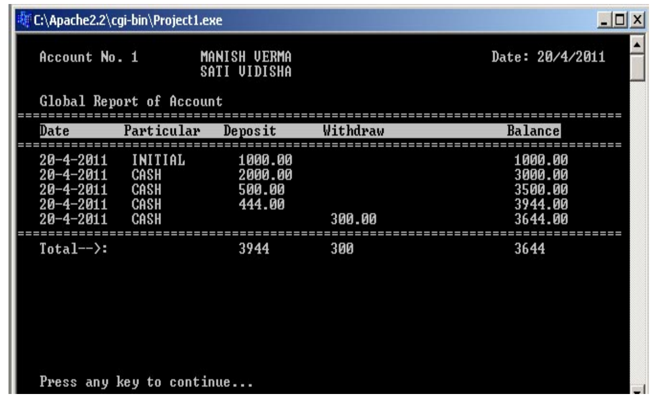

Fig. 5 Legacy application account statement

IV. Discussions and Related Work

The implementation and results of the proposed method may be understood by following demonstration of the case scenario. In figure 5 an account summary page is displayed. We can understand that all the logic is embedded deep in the code of legacy application.

In figure 6 the composite fund transfer service task in the orchestrator is elaborated. New business process requires a fund transfer mechanism, which needs to be achieved from the existing code. This is done in the modeler by calling and sequencing two web services from legacy application thus making a composite process.

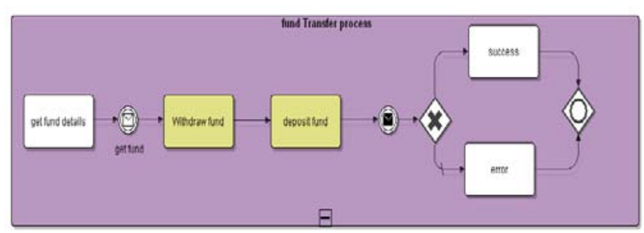

Fig.6 Composite service for fund transfer

In the sample banking application no individual authentication is required as the software interacts only through its GUI and it is accessed by bank authorities. But as per the requirement of ATM business process as the application is exposed to an external world then it is very important to put an authentication mechanism. This is incorporated in the orchestrator as shown in figure 7.

The results demonstrate the process proposed in this work with a sample banking application as elaborated in the case description. The system can map legacy application at par with the requirement of business using exposure of functionality through web services and the usability by orchestration of BPM process. Further the released services can be used by any language or application like Java and C# through the service description. This also proves that by adopting the proposed technique one would be able to integrate new logics with the existing business logic or would be able to seamlessly upgrade the existing services without having to make any changes in the coding in the legacy application. Therefore the architecture minimizes the maintenance cost by maintaining the business logic in the middle layer independent of the implementation.

In the past several methods for legacy system modernization have been proposed and discussed. [21] elaborated the white-box modernization and black-box modernization approaches comparisons.

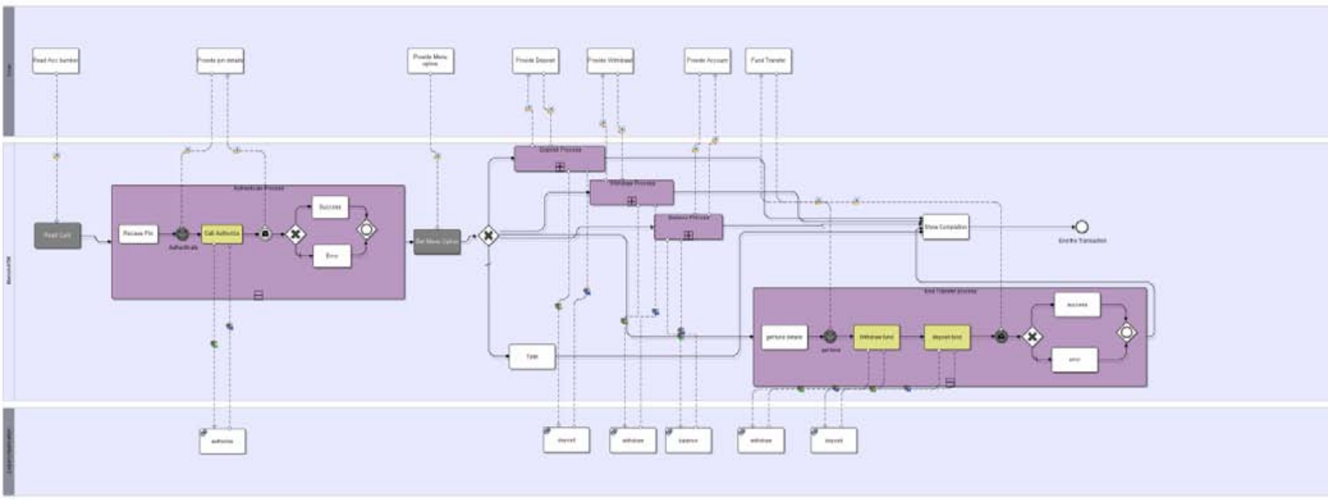

Fig. 7 Intalio ATM orchestrator process with interfaces

[22] Proposed a method to address the issues on migrating legacy systems into a Web enabled environment by using CORBA. [23] Used reverse engineering techniques to encapsulate the logic with JNI wrapper. [24] Proposed a method to make interactive legacy systems accessible by wrapping interactive functionalities. [25] Proposed a tool based approach to wrap the legacy codes. All of the methods were focused on the application modernization only rather than addressing the business domain. In our approach we emphasized on a close business and IT alignment.

V. Conclusion

In this work a legacy application mapping technique by combining top-down approach with bottom-up approach is proposed using SOA and BPM. The method defines how a legacy application should be exposed as services and how these services can be used to fulfill business goals. The solutions principles are demonstrated through the results. Instead of using the manual functionality discovery in the legacy service identification stage, a tool is developed to automatically identifying the services. The interoperability of the entire solution is shown in the result section. The prime criteria and objective of the work has been to prove the proposed design of legacy application mapping and integration to participate in enterprise business processes. As the services are exposed to be used on network, performance calibration and tuning is another aspect and the speed and processing capabilities of the environments used must be taken into consideration. The proposed approach performance and speed issues are some of the work that can be associated with the future direction of research for this work.

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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

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

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

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. 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 to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After 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 to 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 in 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 criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of 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 the 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 evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

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

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing 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 approach 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. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than 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 maintain the initial two items to no more than one ruling each.

- Reason of the study - 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 quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness 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 to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled 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 with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose 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 sound written Procedures segment allows a capable scientist to replacement 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 for the least amount of information that would permit another capable scientist to spare 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 object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text 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:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not 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 - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in 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 a 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. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise 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 in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to 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 part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a 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 implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly 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 with prospect, and let it drop at that.

- Make a decision if each premise is supported, 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 the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One 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 available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
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

INDEX

N

O

P

R

S

T

V

W

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