

Towards Developing an Effective Hand Gesture Recognition System for Human Computer Interaction: A Literature Survey

Santosh Choudhary¹

¹ College of Technology and Engineering,MPUAT,Udaipur

Received: 8 December 2015 Accepted: 2 January 2016 Published: 15 January 2016

Abstract

Gesture recognition is a mathematical analysis of movement of body parts (hand / face) done with the help of computing device. It helps computers to understand human body language and build a more powerful link between humans and machines. Many research works are developed in the field of hand gesture recognition. Each works have achieved different recognition accuracies with different hand gesture datasets, however most of the firms are having insufficient insight to develop necessary achievements to meet their development in real time datasets. Under such circumstances, it is very essential to have a complete knowledge of recognition methods of hand gesture recognition, its strength and weakness and the development criteria as well. Lots of reports declare its work to be better but a complete relative analysis is lacking in these works. In this paper, we provide a study of representative techniques for hand gesture recognition, recognition methods and also presented a brief introduction about hand gesture recognition. The main objective of this work is to highlight the position of various recognition techniques which can indirectly help in developing new techniques for solving the issues in the hand gesture recognition systems. Moreover we present a concise description about the hand gesture recognition systems recognition methods and the instructions for future research.

Index terms— hand gesture recognition, neural network (NN), hidden markov model (HMM), support vector machine (SVM), principle component analysis (PCA).

Abstract-Gesture recognition is a mathematical analysis of movement of body parts (hand / face) done with the help of computing device. It helps computers to understand human body language and build a more powerful link between humans and machines. Many research works are developed in the field of hand gesture recognition. Each works have achieved different recognition accuracies with different hand gesture datasets, however most of the firms are having insufficient insight to develop necessary achievements to meet their development in real time datasets. Under such circumstances, it is very essential to have a complete knowledge of recognition methods of hand gesture recognition, its strength and weakness and the development criteria as well. Lots of reports declare its work to be better but a complete relative analysis is lacking in these works.

1 I. Introduction

functionality [9].

Gestures recognition system increasingly becomes a significant part of human-computer interaction. Movement of humans creates the gestures. Face and/or hands are the sources of gestures. The movement of the body reflects the information/feeling through gestures. Gesture can be "saying hello" but typing something on keyboard is not considered gesture. It is because the movement of fingers typing on the keyboard is not noticeable.

Gestures are of two types: Static and Dynamic. The shape of poses of hands depicts Static Gesture whereas their movement is Dynamic Gesture [7]. Gestures have different versions based on culture/ region of different people which creates diversity and uncertainty [8].

Hand gesture is defined as the combination of all kinds of gestures and movements which produced by hand and arm [8]. Hand gesture is the most animated, mobile, communicative and the most often used, among a range of gestures. Gestures have been utilized as a form to communicate or interact with computers in an effortless and simple way. This type of human-machine interfaces will permit a user to manage and control an ample range of devices through hand gestures recognition. Using hands as a tool can support people interact with PC in a much intuitive way. When they communicate with other people their movements of hand plays an essential role and the data they convey is rich in several ways. They use their hands for denoting an object or person conveying data about shape, temporal and space features. They steadily use their hands to communicate with objects, change them, transform them and move them. In similar unconscious way they gesticulate while interacting to notions. Hand gesture recognition can be mainly divided into two types such as Data Glove-based and Vision based glove to acquire a motion. In this approach it is possible to analyze 3D space hand motion with perceived data. As it is tedious and incurs high cost, it is not convenient for the user. The users have limitations in using the Vision based methods. Vision based methods have come up as a research area for improving Human Computer interaction without use of keyboard, mouse etc. [3].

Vision-based hand gesture recognition has pinched considerable attention from researchers in recent years. An automatic hand gesture recognition system will discover many applications in Human-Computer Interaction area. Hand gesture detection is a fundamental step in the practical application process of this system. It requires the ability to accurately segment the hand from the background. Due to the difficulty of this task, early systems usually require markers or colored gloves to make the detection easier. However, these methods often bring much in convenience for the Human-Computer Interaction process. Moreover, the current research is mainly focused on detecting the bare hand and recognizing hand gestures without any markers and gloves [5].

These days gesture recognition technique is used in a broad range like in Virtual reality, video games, sign language recognition etc. Gesture recognition is done by tools based on various methods like statistical modeling, signal and image processing, pattern recognition and computer vision etc. Statistical modeling been one of the most widely used methods in resolving problems such as HMMs, Kalman filtering, PCA and Finite State Machine (FSM) [6][12] [13].

2 II. Review of Recent Researches on

Hand Gesture Recognition System

Hand gesture recognition methods use different research approaches and these approaches are grouped together based on their techniques which they are using in the process of hand gesture recognition. By exploiting different recognition methods, the hand gesture recognition process is examined. Different types of recognition methods utilized by the researchers are such as HMM, NN and SVM, these methods plays vital role in hand recognition method. Most of the earlier researches were based on HMMs, NN and SVM. a) Literature survey on HMM Based Recognition Methods in Hand Gesture Recognition System Model based hand recognition system which consists of three phases; feature extraction, training and recognition. In feature extraction phase, spatial and temporal information of each frame is combined by the hybrid technique to extract the feature images. In training phase, spatial shape variation is characterized by principal component analysis (PCA) and temporal shape variations are described through Hidden Markov Models (HMMs). Generation of observation patterns from the input sequences is done with pre-trained PCA and HMMs in the recognition phase. After this Viterbi algorithm is applied for gesture identification [14].

HMM has been proposed for various types of hand gesture recognition. Hand localization, hand tracking and gesture spotting are the three different procedures in the pre-processing stage of this approach. In hand location detection procedure, hand region is detected on the basis of motion and color of skin. A hand trajectory is produced by joining the centroids of moving hand region. The centroid of the moving hand regions is detected through hand tracking algorithm. There after the gesture spotting algorithm separates the trajectory into real and meaningless sectors. A feature database is constructed using angle and velocity feature codes, combined and weighted location uses a k-means clustering algorithm for Hidden Markov Models code book.

Similarly different authors in their papers [16][17] [18][19] and [20] have proposed different models or methods or techniques for a hand gesture recognition system.

But hand gesture recognition system is described in "Wearable Sensor-Based Hand Gesture and Daily Activity Recognition for Robot-Assisted Living", here gesture spotting is done by neural network and for contact-based recognition it used hierarchical HMM. The motion data collected from foot and waist of a human subject is processed by a multi-sensor fusion developed for daily activity recognition.

Use of two sensors, three axis accelerometer (ACC) and multichannel electromyography (EMG) sensors, is done for hand gesture recognition [22]. The intensity of EMG signals automatically detects the start and end points of significant gesture segments. The final result is obtained by utilizing a decision tree and multi-stream HMMs as decision level fusion.

3 b) Literature survey on NN Based Recognition

Methods in Hand Gesture Recognition System Based on motion trajectories, an algorithm classifies and extracts of two-dimensional motion in an image sequence. A homogenous region is generated in each frame by multi-scale segmentation. Two view correspondences are obtained by matching region between two consecutive frames. In order to define pixel match, a fine transformation is calculated from each pair of the corresponding regions.

Pixel-level motion trajectories are obtained by concatenating the pixel matches over consecutive images across the image sequence. Time delay neural network is used to learn about the motion patterns from the extracted trajectories. Forty hand gestures of American Sign Language are recognized in the proposed method.

Similarly different authors in their papers [24][25] [26][27] [28][29] [30] and [31] have proposed different models or methods or techniques or ideas for a hand gesture recognition system.

A method of Hand gesture recognition in Indian Sign Language is proposed [32]. In this the Histograms of Oriented Gradients (HOG) features are used for recognizing alphabets (A-Z) and numerals (0-9) with a purpose to implement the algorithm of extracting HOG features. The Histograms of Oriented Gradients (HOG) features are used for passing in neural network training for the gesture recognition purpose.

Using neural network a vision based sign gesture recognition system is proposed [33]. In the first step the images of static gestures of American Sign Language were converted into Lab Color space by the system. Parameter L denotes lightness & (a,b) are the dimensions of color-opponent. With color-opponent dimensions skin region segmentation is done using threshold technique. For feature extraction, hand (skin region) is cropped and converted into binary image. After this other dimensions (like height, area, centroid, centroid-distance from the origin) of the image are used as features. In order to train a feed forward back propagation network, we use feature vectors of each set.

4 c) Literature survey on SVM Based Recognition

Methods in Hand Gesture Recognition System Daehwankim et al have proposed a forward spotting scheme with sliding window and accumulative HMMs. Recognition and segmentation of gesture is executed simultaneously and it is applied to identify upper body gestures for controlling the lights and curtains in a smart home environment [34].

A user independent framework is proposed for demonstrating and identifying hand postures that are used in sign language [35]. A hand posture feature, an Eigen space Size Function are proposed, which is robust to classify hand postures independent of the performer. On analysis of the properties of the proposed Eigen space size function, a significant improvement in performance is seen w.r.t original unmodified size function.

In [36] they have used twin support vector machine for gesture classification based on EMG, and shows that this technique is extremely suited to such applications.

Similarly different authors in their papers [37] [38][39] [40] have proposed different models or methods or ideas for a hand gesture recognition system.

A Gesture Recognition system for Alphabetical Hand Gestures was proposed to simplify the process of interaction of humans with computer [41]. Design of the system is done with the use of Support Vector Machine (SVM) classifier. SVM classifiers are widely used in classification and regression testing. A model is built by SVM training algorithm which predicts if a new example falls into one category or the other.

5 d) Literature survey on other Methods in Hand Gesture

Recognition System

An approach based on fuzzy rule to spatiotemporal hand gesture recognition system is proposed in [42]. For selecting templates, it uses a method based on hyper rectangular composite neural networks (HRCNNs). If-THEN rules, represents the templates for each hand shape, If-THEN rules are obtained from values of synaptic weights of the corresponding trained hyper rectangular composite neural networks (HRCNNs) A special membership function is employed to fuzzify each crisp IF-THEN so that the pattern has similarity to the corresponding predecessor part. For the classification of any unknown gesture, each fuzzy rule tests each sample of the unknown gesture. The collected similarity of all the input samples is computed for each hand gesture in the vocabulary, and then the gesture can be classified as gesture yielding the highest accumulative similarity. A small sized dynamic hand gesture can be implemented based on the method used.

Similarly different authors in their papers [43] [53] and [54] have proposed different models or methods or ideas for a hand gesture recognition system.

For gesture recognition, an algorithm framework was proposed which processed acceleration and surface electromyography (SEMG) signals [55]. This algorithm includes a score-based sensor fusion scheme, a segmentation scheme and two new features. An improved dynamic time-warping algorithm and bays linear classifier are used in the framework. In addition to that a prototype system is developed to realize gesturebased real-time interaction. The prototype system includes an application program with the proposed algorithmic framework for a mobile phone and a wearable gesture sensing device (embedded with a three-axis accelerometer and four SEMG sensors).

Along with Kinect depth camera a super pixel hand gesture recognition technique based on a novel super pixel earth mover's distance metric was presented [56]. Marker less hand extraction is produced by effectively utilizing the depth and skeleton information from Kinect. The super pixels were represented by the hand shapes,

corresponding depths and textures. Overall shapes and color of the gestures, to be recognized, is effectively retained. The dissimilarity between the hand gestures is proposed to be measured by super pixel Earth mover's distance (SP-EMD) and a novel distance metric.

6 III. Performance Review of Hand

Gesture Recognition System Based on the same protocol as Triesch and von der Malsburg, the first evaluation was performed (2002). The data extracted from 3 of the 24 signer was used in the training of the SVMs on each of the 10 hand signs. Testing of the system is done on all the hand signs from remaining 21 subjects. In second evaluation, 8 of the 24 signers are used for training a validation and for testing the rest of the 16 used. The result of the experiments shows that the system is robust and recognition of hand gestures is independent of the person performing them. Similarly different authors analyze with different input data and got different outputs which are given in the above table. Sign Language) and using the real-time implementation (Tele-Gest) compared the performance. In the comparison of user-dependent and user-independent systems 13 gestures dataset was made. Accuracies of 98.9% and 98.2% of the system were found for userdependent and independent systems respectively on testing with their own trainer. The Gripsee system achieved 93.75% of recognition accuracy.

On an artificial dataset formed by 30 gestures, validation of the proposed architecture was performed by George Caridaki set al. 10-fold cross validation strategy was used in this experiment. An average recognition rate of 93 % was achieved.

Similarly different authors analyze with different input data and got different outputs which are given in the above table.

7 IV. Direction for The Future Research

In our review work, hand gesture recognition system is analyzed by using different recognition techniques. Here all the proposed methods are worked efficiently but these methods give high performance on the particular datasets. The datasets contains background images and face images datasets have the small recognition accuracy value than the other datasets. Hence there is a need to develop new techniques in the datasets with background and face images. So the proper analysis is to be needed. As a result this review paper will be supportive for the researchers to improve the hand gesture recognition system in real time datasets. We believe that in future various works will arise using our review work.

8 V. Conclusion

In this paper, an extensive survey has been performed about different recognition techniques used in the system of hand gesture recognition. While all the methods proposed are fairly accurate. Our goal of hand gesture recognition process needs to further perfect those approaches or develop some more efficient methods. Here the researches are categorized based on recognition techniques that are exploited in hand gesture recognition process and also an introduction about hand gesture recognition is presented. From this review, the researchers can able to know about several recognition techniques and their performance existing in hand gesture recognition system.

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Figure 1: F

Figure 2:

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Author's Name	Database	Recognition (%)	Accuracy
Chung-Lin Huang and Sheng-Hung Jeng [14]	18 different gestures from 20 people	Simple gesture 92%	
Ho-Sub Yoon et al. [15]	4800 alphabetical gestures of 20 persons	Hybrid gesture 87%	
Feng-Sheng Chen et al. [16]	20 different gestures	Cartesian system 96.10%	
Agnes Just et al. [20]	Interact Play database	polar systems 96.04%	
Chun Zhu et al. [21]	Two Hand Manip database	>90%	
Xu Zhang et al.[22]	Five gesture data	75% and 63%	
	8640 CSL word samples	99% and 97%	
	800 sentence samples	82% and 91%	
		93.1%	
		72.5%	

Figure 3: Table 1 :

2

Author's Name	Database	Recognition Accuracy (%)
Ming-Hsuan Yang et al. [23]	40 hand gestures	96.21%
Chia-Feng Juanget al. [24]	100 temporal gestures	92%
S.S. Geet al. [25]	280 gesture samples	91.9%
Stergiopoulou et al. [26]	180 test hand images	90.45%
Heung-Il Suk et al. [27]	10 isolated gestures	99.59%
JawadNagiet al. [28]	2400 gesture images	96%
Wensheng Li et al.[29]	200 samples	94.7%
Trong-Nguyen Nguyen et al. [30]	445 samples	98%
Ao Tang et al. [31]	36 hand postures	98.12%
Parul Chaudhary et al. [33]	-	85%
As mention in above table-2 in performance of NN based hand gesture recognition methods we analyze second NN based hand gesture recognition methods with following data. Ming-		

Figure 4: Table 2 :

3

Author's Name	Database	Recognition Accu- racy (%)
Daehwan Kim et al. [34]	480 test gesture sequences	95.42%
Daniel Kelly et al. [35]	ISL	97.3%
Ganesh R. Naik et al. [36]	Triesch	93%
Nasser H. Dardas et al. [38]	49 sets of data	86%
	Sebastien Mar- cel database	96.23%
Daniel Kelly et al. [39]	962 signs	82.3%
Nasser H. Dardas et al. [40]	Four gestures with 1000 frames	97.6%
Aseema Sultana et al. [41]	5 alphabetical dynamic hand gestures	80%

As mention in above table-3 in performance of SVM based hand gesture recognition methods we analyze third SVM based hand gesture recognition methods with following data. Daehwan Kim et al. have used 480 test gesture sequences and results show that the proposed method has a good recognition rate of 95.42% for continuously changing gestures.

Figure 5: Table 3 :

4

Author's Name	Database	Recognition Accuracy (%)
Mu-Chun Su [42]	90 spatio-temporal hand gestures	94.1% and 91.2%
Juan P. Wachs et al. [43]	Gripsee	93.75%
George Caridakiset al. [45]	30 gestures	93%
Deng-Yuan Huang et al. [46]	-	96.1%
Ruize Xu et al. [47]	628 gestures	95.6%
Luigi Lamberti et al. [48]	907 hand gestures	98.46%
Zhou Ren et al. [50]	-	93.2%
Yuan Yao et al. [51]	SQLite database	51.87%
Kui Liu et al.[53]	Microsoft MSR dataset	93%
Eshed Ohn-Bar et al. [54]	19 hand gestures	98.4%, 99.7% and 92.8%
Zhiyuan Lu et al. [55]	19 predefined gestures	95.0% and 89.6%
Chong Wang et al. [56]	Own dataset	97.2% and
	NTU hand digit dataset	99.1%
	ASL finger spelling dataset	99.6% and 75.8%

As mention in above table-4 in performance of other methods in hand gesture recognition we analyze other methods in hand gesture recognition with following data. Mu-Chun Su used two data bases, for verifying its performance, comprised of 90 spatio-temporal hand gestures.. In first and second database he achieved 94.1% and 91.2% recognition results.

[Note: But Juan P. Wach s et al. have taken three types of gesture dataset (Gripsee, BGU and American)]

Figure 6: Table 4 :

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