Real Time Hand Gesture Recognition System for Android Devices

A Seminar Report Submitted
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for the award of the Degree of
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By
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COMPUTER SCIENCE AND ENGINEERING
Albertian Institute of Science and Technology-AISAT
Kalamassery –Kochi 682022

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CO 2- Review literature to identify gaps and define objectives & formulate engineering Problems.

CO 3- Generate and implement innovative ideas for social benefit, analyses and discuss the result to draw valid conclusion.

CO 4- Develop presentation skills with the ability to communicate to audience and also ethical Writing skills as a part of repot submission.

CO 5 – Hypothesize future scope for their present work and how to modify their work Incorporating future advancement in technology

PO-CO Mapping Matrix

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L				M			H			
CO2	M	M			L	M	L	L	M	M		M
CO3	M	L	M	M	M	M	M	M	M	M		M
CO4								H	H	H		
CO5	H	M	M	M	L	M	M	H	H	H	H	H

H-high (3) **M**-medium (2) **L**-low (1)

UNDERTAKING

I declare that the work presented in this seminar titled "*Real Time Hand Gesture Recognition System for Android Devices*", submitted to the Department of Computer Science and Engineering, Albertian Institute of Science and Technology AISAT, Kalamassery-Kochi for the award of the ***Bachelor of Technology*** degree in ***Computer Science and Engineering***, is my research work. I have not plagiarized or submitted the same work for the award of any other degree. In case this undertaking is found incorrect, I accept that my degree may be unconditionally withdrawn.

Date: 11-01-2022
Place: Kochi   Joel P Joji (AIK18CS024)

CERTIFICATE

Certified that the work contained in the seminar titled "*Real Time Hand Gesture Recognition System for Android Devices*", by Joel P Joji (AIK18CS024), has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

Name & signature of Guide	Name & signature of HoD
Ms. Teenu Jose,	Mr. Justin Jose,
Asst. Professor,	Assoc. Professor,
CSE, AISAT	HOD CSE, AISAT

College/departmental seal

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Place: Kalamassery

Date: 11-01-2022 **Signature of Student**

Abstract

Hand gestures are natural and intuitive communication way for the human being to interact with his environment. They serve to designate or manipulate objects, to enhance speech, or communicate in a noisy place. They can also be a separate language. Gestures can have different meanings according to the language or culture. They can also be a way to interact with machines. The subject of our research concerns the design and development of computer vision methods for recognizing hand gestures by a mobile device. We have proposed a system based on SVM for recognizing various hand gestures. The system consists of four steps: hand segmentation, smoothing, feature extraction and classification. The idea here is to allow the smartphone to perform all necessary steps to recognize gestures without the need to connect to a computer in which a database is located to perform training process. With this system, all steps can be done by the smartphone. In this paper, for image acquisition, frontal camera of the smartphone is used. After that frames are gotten from the video, the color sampling is done which is followed by making binary representation of the hand, and then contours representing the hand were described with convex polygons to get information about fingertips and finally the input gesture was recognized using proper classifier.

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List of Abbreviations

1) Open CV - Open Computer Vision
2) SVM - Support Vector Machine
3) HMM - Hidden Markov Model
4) KNN - K nearest Neighbors
5) Bb – Bounding Box

Chapter 1
Introduction

Hand gesture recognition is a rapidly growing field in various applications, such as sign language, computer vision, natural language processing, biomedical, biometrics, pattern recognition, and much more [15]. Hand Gesture Recognition can be seen as a way for computers to understand the intentions of the human being, creating an interface between machines and humans. With the advent of technologies such as smartphones, Hand Gesture Recognition is expected to add new ways of interacting with mobile devices. Thus, gestures captured by the camera of the mobile can be analyzed to place orders without having to touch the screen.

In our paper, we chose to make our system on an Android smartphone. The choice of the Android operating system is not arbitrary but for several technical and non-technical reasons. Among the non-technical reasons is that Android is the world's most popular operating system for mobile phones and the majority of smartphone users use the android system [1]. And for technical reasons, we have chosen to work with Android platform because it allows to integrate libraries for image processing.

In our case, we have chosen to integrate a free graphics library specializes in real time image processing named Open CV (Open Computer Vision) library [2] to perform image processing. And then we have chosen to integrate the SVM classifier (Support Vector Machine) which can model real-world problems such as image classification, hand-writing recognition, text, bioinformatic and bio sequence analysis.

Our system, unlike systems realized before, is designed to perform all necessary operations in order to recognize hand gestures, by the smartphone and without the need to use another device. Some applications that use gestures as a Human-Machine Interface were first imposed in game consoles (Microsoft Kinect and PlayStation Eye for Sony) and could now be used in other areas such as smart television and smartphone.

CHAPTER 2

LITERATURE SURVEY

2.1 RELATED WORKS

We have studied some previous works done in the field of gesture recognition by different researchers. There are many approaches that were used like vision-based approach and data glove-based approach. The approach we are interested in is vision based. There have been a number of research efforts on vision-based methods in recent years. A straightforward and simple approach that is often utilized is to look for skin colored regions in the image.

Many researchers [3][4][5][6][7] used vision-based approaches for recognizing hand gestures. They used several approaches for image processing such as Gaussian filter, sobel filter, Canny edge detection, color segmentation, skin filtering, palm cropping etc. and they used several classifiers like Artificial Neural Network, Genetic Algorithm, Hidden Markov Model.

Saxena [3] used a smartphone camera to detect frames and then frames are sent via IPWebCam android application to the server and Sobel Edge Detector is performed which is followed by thinning that reduce the noise. The recognition approach used by Saxena is artificial neural network among back propagation algorithm. Accuracy of this system was 77%.

Kapuscinski [4] After finding out the skin colored region from image, used Hit-Miss Transform in the feature extraction step and Hidden Markov Model (HMM) as a proper classifier. Accuracy was 98%.

Rajam [5] used Canny Edge Detection Technique to extract edge of the hand. The main features used are fingertip positions of the fingers and their distance from a reference point at the bottom of the hand. Recognition rate obtained was 98%.

Singha [6] used Canny Edge Detector to detect the contour of the palm and after that the features of hand were extracted using K-L Transform technique and then two classifiers where used and compared; one based on the angle made by the Eigen vector with reference axis and another based on Euclidean distance. Recognizing rate obtained was 96%.

J. L. Raheja and A. Singhal [7] developed a portable android-based hand sign recognition system connected to a server via IPWebCam android application. sobel edge detector was used for image analysis and Principal Component Analysis (PCA) was used after image tokenizer for recognition. Overall accuracy of this system is 77%.

For identifying gesture to interact with a robot, Singh [11] used Hidden Markov Model (HMM). Used Features were optical flow and shape of hand. Extracted features were fed to the HMM.

Fot the Gloved-Based Approach Kumar [9] used KNN classifier algorithm and features position of hand and fingers was given by the gloves. The system was used in applications like image browser and Air writing.

Kim [10] used a Glove with three accelerometer sensors, a Bluetooth and a controller. Glove was used to extract features like joints from hand. For gesture identification Kim used rule-based algorithm.

CHAPTER 3

STATEMENT OF THE PROBLEM

- Currently, mobile devices such as smartphones and tablets are very common with people of all ages. They provide seamless communications through cellular or internet services. These devices can be a big help for people who are unable to communicate on their own. A disabled person who is not able to speak or a person who speak a different language, these devices can be a boon for them as understanding, translating and speaking systems for these people

CHAPTER 4

THEORETICAL BACKGROUND

4.1. Hand Gesture Recognition

Gesture recognition is a computer science field which aims to interpret the gestures of the human being by mathematical algorithms. Hand Gesture Recognition can be seen as a way for computers to understand the intentions of the human being, creating an interface between machines and humans.

The hand gestures are read by an input device like smartphone to detect frames. Hand gestures are then interpreted using algorithm either based on artificial intelligence techniques or statistical analysis. Gesture recognition research aims to convey information through a system which can recognize specific human hand gestures. By identifying the hand gestures of a human being, it can help in controlling machines like robots or smartphones and to communicate with deaf and dumb people.

4.2. Color-based segmentation

Hand segmentation is the first step in applications such as gesture recognition, fingers tracking. Color is a strong tool for image segmentation. Color-based segmentation is better than edge-based and luminance histogram techniques because color is computational inexpensive, and it can give more information than a luminance-only image or an edge-segmented image which need more computational resources, so they make real-time application systems hard to realize [8]. The simplest way to segment hand's palm from an image is the color-based methods. The palm and the background colors should have a significant difference in order to successfully segment palm using color-based methods.

4.3. Smoothing

One of the biggest problems in signal and image processing and computer vision, is to filter the noise while preserving the edges. For many years, many methods of adaptive filtering were developed following multiple approaches. The filtering principle is to modify pixels values of an image in order to improve its appearance.

In practice, it is about creating a new image by using pixels values of the original image. The filter is linear if the value of the new pixel is a linear combination of the values of the neighboring pixels.
Linear combination of the neighboring pixels:

$$New\ value_{x,y} = \sum_{i,j} A_{i,j} * P_{x+i,y+j}$$

with i, j varying from -h to + h, half size of the neighborhood (for 3x3 h=l, for 5x5 h=2 ...) and Ai, j = an integer or real, specific to linear filter. If the filter cannot be expressed by a linear combination, it is called "non-linear". Non-linear filters are more complex to implement than linear filters. However, the results obtained with non-linear filters are frequently better than those obtained by the linear filters.

Many filtering methods for noise removal have been adapted to the processing of binary images. Due to the existence of a total order on the set of gray levels, non-linear filters such as median filter could easily be implemented in 2D or 3D spaces.

4.4. Median filter

The median filter is a nonlinear digital filter, often used for noise reduction. Noise reduction is a step-in image preprocessing to improve the results of future treatments. The median filter technique is widely used in digital image processing because it allows to reduce noise while preserving the contours in the image. The main idea of the median filter is to replace each entry with the median value of its neighborhood. For example, if we consider those new pixels in which there is an aberrant value (111):

4	5	6
5	111	7
6	7	8

Table 4.1. Pixel Values

Median filter will consider the values of the neighborhood by increasing values:

4	5	5	6	**6**	7	7	8	111

Table 4.2. Mean Table

and take the median value, here the median value is 6.

The output of the filter will therefore:

4	5	6
5	**6**	7
6	7	8

Table 4.3. Pixel Values After Median Filter

4.5. Support Vector Machine (SVM)

Support vector machines (SVMs) are a set of supervised learning techniques aimed at solving classification and regression problems.

SVMs are a generalization of linear classifiers. SVMs were developed in the 1990s from theoretical considerations of Vladimir Vapnik on the development of a statistical learning theory: the theory of Vapnik-Chervonenkis. SVMs were quickly adopted for their ability to work with large data, small number of hyper parameters, their theoretical guarantees, and their good results in practice. SVMs can be used to solve problems of classification, such as knowing to which class a sample belongs, or regression, such as predicting the numerical value of a variable. For two classes, the goal of SVM is finding a classifier that will separate the data and maximize the distance between these two classes. With SVM, this classifier is a linear classifier called hyperplane. [13]

The SVM algorithm in its original form is like looking for a Linear boundary between two classes, but this model can greatly be enhanced by projecting in another space to increase the separability of the data. We can then apply the same algorithm in the new space, which results a nonlinear boundary in the initial space. So SVM can perform both linear and nonlinear classification using the kernel trick. The basic idea of the kernel trick is to preprocess initially the data by a non-linear mapping Φ and then to apply the same linear algorithm but in the image space of Φ. (cf. Fig. 1).
We apply the mapping:

$$\Phi : \mathbb{R}^{K} \rightarrow \mathcal{E}, \quad \mathcal{X} \rightarrow \Phi(\mathcal{X})$$

to the $\mathcal{X}_1, \ldots, \mathcal{X}_M \in \mathcal{X}$ data and consider our algorithm $\mathcal{E}$ instead of $\mathcal{X}$,

i.e. The sample is preprocessed as:

$$\{(\Phi(\mathcal{X}_1), y_1), \ldots, (\Phi(\mathcal{X}_M), y_M)\} \subseteq (\mathcal{E} \times y)^M$$

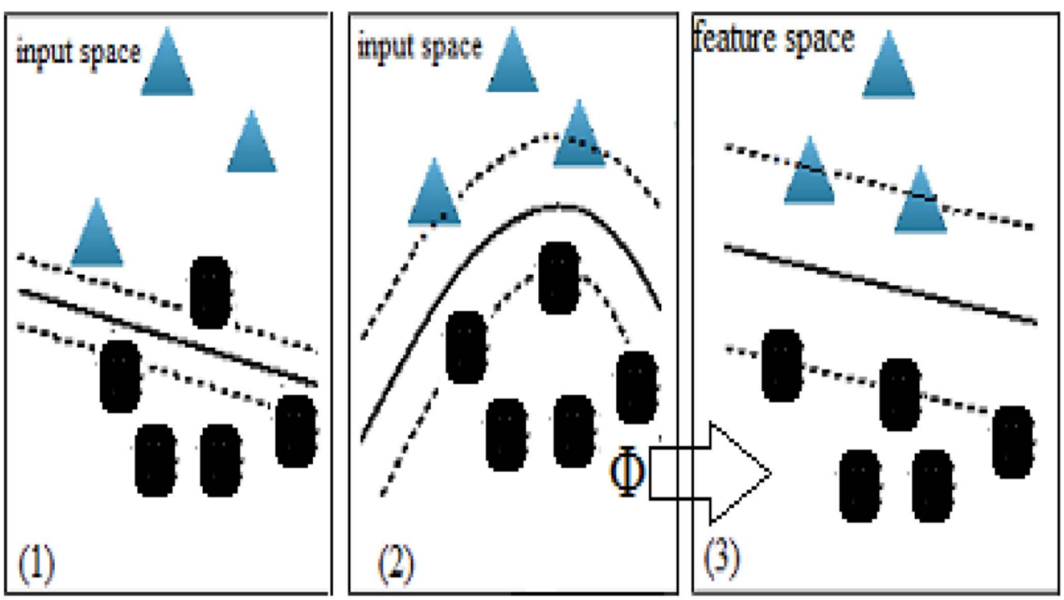

Fig. 4.1. Different 3 views on the same two class discrimination problem

In (1) we show that Linear Separation Generate errors. But in (2) we show that there is a better separation which done by a non-linear surface in that input space. Finally, in (3) we see that this non-linear surface corresponds to a linear surface in a feature space.

Data points are mapped from input space to feature space by on action Φ induced by Kernel function. Non-linear SVM works efficiently when the boundary does not have to be a straight line.

The benefit is that we can capture much more complex relationships between our datapoints without having to perform difficult transformations on our own. The disadvantage is that the training time is much longer as it is much more computationally intensive. [14]

CHAPTER 5

PROPOSED ALGORITHM

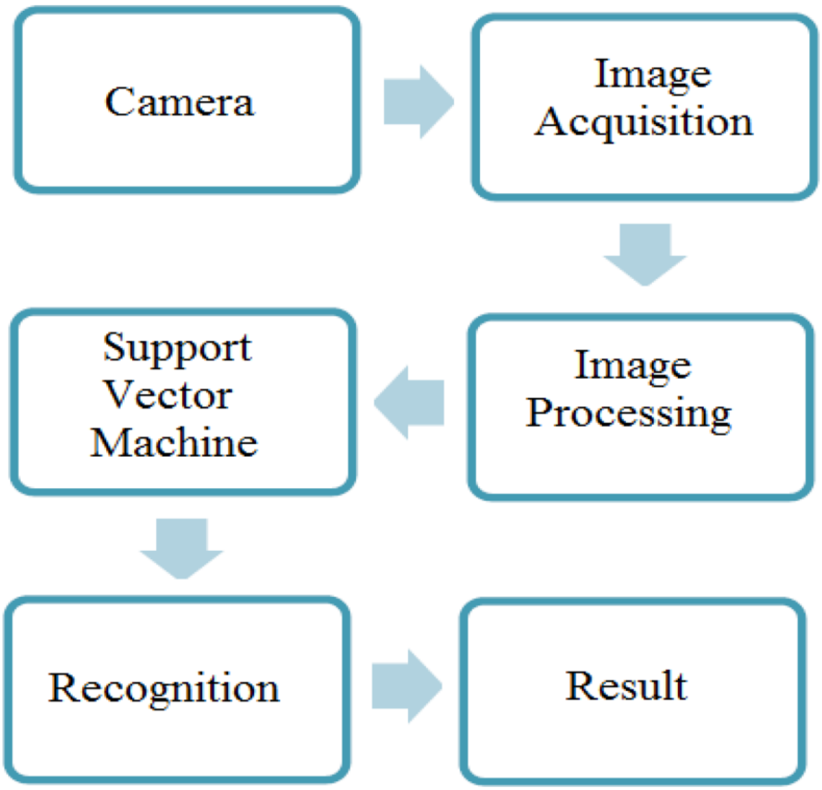

Fig. 5.1. Block diagram of the proposed system

In this chapter, an application for the disable people has been discussed which has been developed on Android device. Android device brings the long-expected technology to interact with graphical interfaces to the masses. Android device captures the user's movements without the need of a controller. The basic block diagram of a hand gesture recognition system is given in Figure. The video sequences captured by an android camera are processed frame by frame to make it suitable for extracting useful information about user.

In this work, a real time object selection and recognition method is proposed for the application for disabled people.

CHAPTER 6

DEVELOPMENT OF WORK

The diagram representing the system is given in Fig. 5.1. Details of each step of the proposed system with explanations and figures are given below.

6.1. Image Acquisition

For any vision system, Image Acquisition is the step only after which we can go forward with image processing.

In our case, this step is done by the application we have developed to make our system. The application uses the frontal camera of the Smartphone for continuous frame capturing and a simultaneous display on the screen.

6.2. Image Processing

In the image-processing step, we aim to sample color at first, then we make a binary representation of the hand, after that we have to get N biggest contours and dismiss contours not representing the hand, then contours are described with convex polygons and [mainly we filter out irrelevant polygon].

6.2.1 Hand Segmentation

In this program Color-Based Segmentation was used to obtain the binary image and segment the hand from the background image. [12] The simplest way to segment hand's palm from an image is the color-based methods.

The palm and the background colors should have a significant difference in order to successfully segment palm using color-based methods. In our system we must first sample the color of the hand. In this mode we have made squares that must be covered by the hand. The goal here is to create a color profile from each square as described in the figure below.

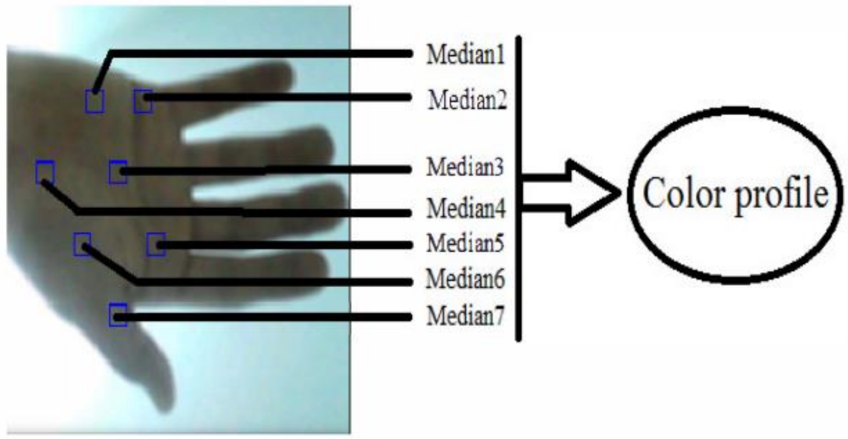

Fig. 6.1. Sampled color profile

Our purpose here is to obtain several binary representations based on each sampled median. Each profile's 'color produces a binary image, which in turn will be summed together to get a binary image.

Figure below explains that.

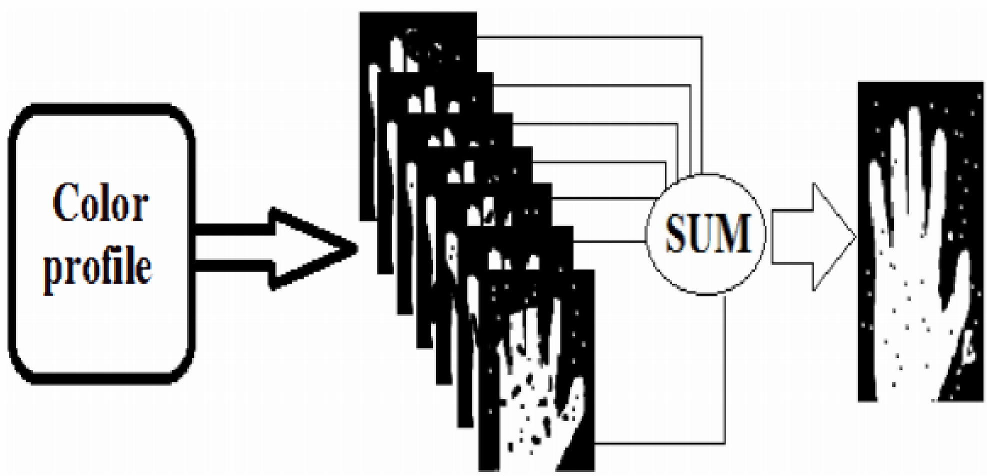

Fig. 6.2. Generating binary image

This binary image here has a segmented hand but it contains noise. Therefore, the smoothing step is necessary to obtain a segmented image with no noise.

6.2.2 Smoothing

Smoothing is a morphological operation that is used to remove noise from binary images. We have chosen to apply a median filter to reduce noise in the binary image.

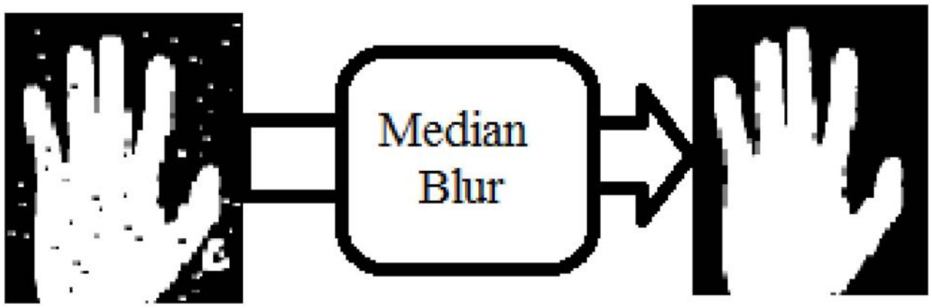

Fig. 6.3. Smoothing binary image

All this process is to detect and generate a binary image of the segmented hand.

Fig. 6.4. Segmented hand

6.3. Feature extraction

detecting hand we can see the extracted features.

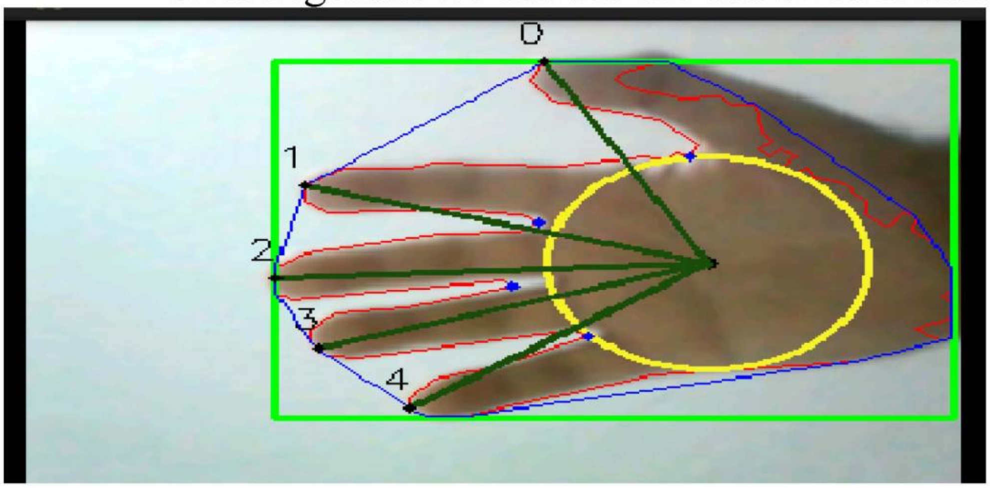

Fig. 6.5. Extracted features

When the binary image is generated, the segmented part, which represents the hand, is processed as follows:

- get convex points in contour
- get point furthest away from each convex vertex (convexity defect)
- Filter out convexity defect not relevant

The properties which determine if a convexity defect must to be rejected or dismissed is the angle between the "lines" that go from the defect to the neighboring convex polygon vertices.

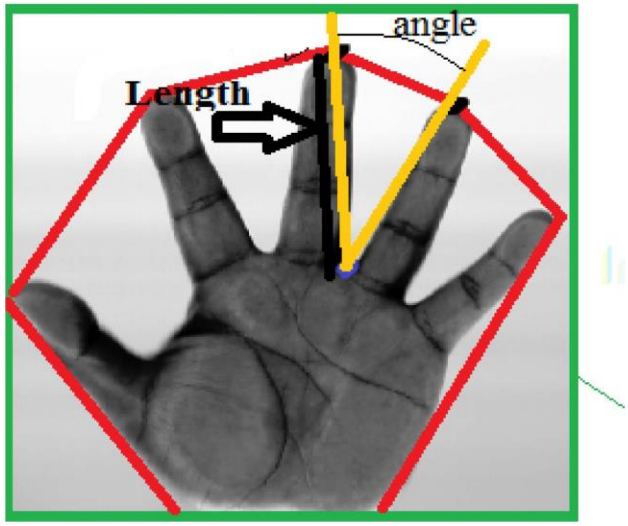

Fig. 6.6. Describes contours

The defect is rejected or dismissed if:

- length<0.41$_{bb}$
- angle>80°

6.4. Classifier

We have used Support Vector Machine (SVM) as a proper classifier. SVM is a binary supervised classification algorithm. It can deal with problems involving large numbers of descriptors, it provides a unique solution (no local minimum problems as with neural networks) and it has provided good results on real problems. 10 gestures have been collected to constitute the initial data base. In our system we tried to classify the gestures from the image of the whole palm. In our system we have create a Dataset, which contains images of different gestures for classification purposes.

6.5. Training Data

The concept of training is important. Training by induction allows reaching conclusions by examining particular examples. It is divided into supervised and unsupervised training. The cases regarding SVM is supervised training. Particular examples are represented by a set of input / output pairs. The goal is to learn a function which corresponds to those seen examples and which predicts the outputs for the entries that have not yet been seen. Entries can be object's descriptions, and outputs the class of given objects as input. In our case, Multi class SVM is used to build the training model and make predictions. For training purpose, the database of images is used. When we want to increase the number of a hand gesture, which is already exist in the training set, we can do it in our application by choosing at first image that represents the gesture. We can then add a gesture to the training set; we must first make a static hand gesture in front of the camera and after that, we can add this gesture to the training set. Gestures in the training set are first processed and then the extracted features are passed to the SVM model for training purpose.

6.6. Recognition

Recognition is the last step in the "life cycle" of the system. To fill inputs of the trained model, the previous features discussed in section 6.2.3 are used. The output is normally specified by the amount of different type of gestures. The nominal mathematical principals of a Support Vector Machine as discussed in section III.E specify all other behavior of the model.

6.7. Testing

To test the application, we have chosen to test different gestures in different lightening condition. In the figure below (Fig.6.7), we can see that when we make a symbol to designate a number from 0 to 9 in front of the camera the application displays result on the screen. In the figure, we have chosen to put frames that represent different hand gestures of two peoples in different lightening condition and background.

We can see the number that corresponds to each symbol on the left top of each screen capture in red color.

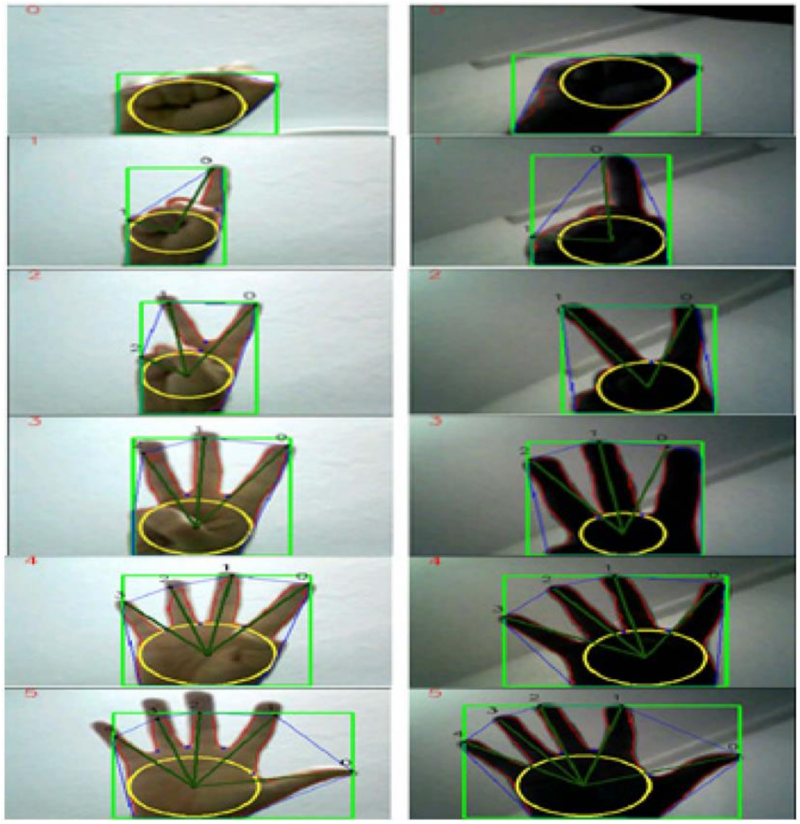

Fig. 6.7. Correct recognition of the gestures in two different scenarios

We tested gestures made by five different people in different lightning condition and different backgrounds.

For each gesture, ten frames were captured in different backgrounds and lightening condition. Indeed, according to observation, recognition result depends on the detection process. In other meaning, if the palm is well detected, the probability that the hand gesture could be classified in the right category is high.

CHAPTER 7

RESULT AND ANALYSIS

TABLE I : RECOGNITION RATE OF 10 GESTURES

Symbol	Number of images	Recognized	Recognition rate
0	10	9	90%
1	10	10	100%
2	10	10	100%
3	10	10	100%
4	10	10	100%
5	10	10	100%
6	10	9	90%
7	10	8	80%
8	10	9	90%
9	10	8	80%
Average			93%

Table 7.1. Result Table

At the end, we can say that the sampling colors step is crucial, thanks to it the system has the ability to well detect the palm and then well recognize gestures in different lighting conditions and backgrounds.

All gestures have recognition rate in between 80-100% which is an acceptable range. Overall accuracy of this system is 93% (approx.).

The performance of the algorithm used for detecting sign gestures can be severely decreased due to varying lighting conditions and noises in the background.

CHAPTER 8

CONCLUSIONS

By using this system, one can control the smartphone without having to touch the device. With this system, we only need to reach towards the camera to perform the desired action. This system could serve deaf people to communicate with others This chapter discuss a hand sign recognition system which would be deployed on an Android device. The system is developed and tested successfully with webcam and an android device.

This system is useful for a deaf and dumb person carrying an android device or a system connected with webcam. All gestures have recognition rate in between 80-100% which is an acceptable range. Overall accuracy of this system is 93% (approx.).

The performance of the algorithm used for detecting sign gestures can be severely decreased due to varying lighting conditions and noises in the background.

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