“A HIGHLY ROBUST AND EFFICIENT HAND GESTURE RECOGNITION SYSTEM USING DIFFERENT TECHNIQUES FOR HCI APPLICATIONS”

A

Dissertation

Submitted

in partialfulfillment

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Master of Technology

in Department ofComputer Science & Engineering

(With Specialization in Software Engineering)

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Certificate

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Candidate's Declaration

I hereby declare that the work, which is being presented in the dissertation, entitled "**A Highly Robust And Efficient Hand Gesture Recognition System using Different Techniques for HCI Applications**" in partial fulfillment for the award of Degree of "Master of Technology" in Department of Computer Science & Engineering with Specialization in Software Engineering, and submitted to the Department of Computer Science & Engineering, Suresh GyanVihar University is a record of my own investigations carried under the Guidance of Mr. Sandeep Bhargava, Suresh GyanVihar University, Jaipur.

I have not submitted the matter presented in this Dissertation anywhere for the award of any other Degree**.**

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ABSTRACT

Hand gesture recognition system is based on recognizing messages while showing hand gestures. It make use of compactness and radial distance. Area and perimeter of hand are also considered. The proposed algorithm takes real time gesture input through high definition camera and then calculates three features of the image, two based on compactness, and one based on radial distance. On the basis of variables estimated for compactness and radial distances, a final parameters is estimated which in comparison to defined compactness threshold generates interpretations. The oldest one technique is wired technology in which wire is needed by users to tied up themselves to establish the interface or connection with the computing device. In wired technology users are connected with the computer by using wire so the users cannot move freely in the room or the area where they are sitting because the wire is of limited length. Instrumented gloves are also known as electronics gloves or data gloves. Electronics gloves build up of using sensors and these sensors are used to provide information related to finger point orientation, hand location, hand positions etc. These instrumented gloves produce good results but to utilize this method widely in common applications is very expensive and not support according to economically. After that data gloves method is replaced by optical markers. These techniques uses Infra-red light for projection and Infra-red light is projected on the computer screen and wherever the markers are wear at hand it will provide the information about fingers tips or location of hand, then the respective portions will be display onto the screen. These data gloves systems provide the good result but it require very complex system configuration. After that some advanced techniques have developed like image based technologies which completely based on processing of image features such as skin tones, textures etc. If we go with these image based features of the image for hand gesture recognition the outcome may varies and may be different as texture, color and skin tones varies very quickly from person to person. And also under different illumination condition, color texture gets modified which leads to changes in observed results. For utilizing various hand gestures to promote real time application we choose vision based handGesture recognition system that works on shape based features for hand gesture recognition.

Chapter-1

INTRODUCTION

1.1 Introduction

Communication in daily life is performed via the help of vocal sounds and body language. However vocal sounds are the main tool for interaction, body language and facial expressions have a serious support in the meanwhile. Even in some cases, interacting with the physical world by using those expressive movements instead of speaking is much easier. Body language has wide range of activities namely eye expressions, slight change in skin color, variation of the vibrations in vocal sounds etc. But the most important body language expressions are performed using hands. Hand gestures would be ideal for exchanging information in recent cases such as pointing out an object, representing a number, expressing a feeling etc and also hand gestures are the primary interaction tools for sign language and gesture based computer control. With the help of serious improvements in the image acquisition and processing technology, hand gestures become a significant and popular tool in human machine interaction (HCI) systems.

Recently, human machine interfaces are based on and limited to use keyboards and mice with some additional tools such as special pens and touch screens. Although those electro-mechanical devices are well designed for interacting with machines and very ordinary in daily life they are not perfect for natural quality of human communication. Hand gestures and other body language expressions are thought to replace keyboard and mouse for HCI systems in the near future. Many of the significant information technologies companies have been working on such systems. Main application areas of hand gesture recognition in human machine interface systems are keyboard-mouse simulations, special game play without joysticks, sign language recognition, 3D animation, motion and performance capture systems, special HCI for disabled users etc. Especially special game play and motion and performance capture systems based on hand gesture recognition are being designed and used in industry today. Also in daily life people usually do not want to touch buttons or touch screens in public areas like screens in planes or

buttons in automatic teller machines (ATM) because of hygienic considerations. Hand gestures would be an ideal replacement in that manner.

Hand gesture recognition system are very useful to provide a communication medium between human and computer using hand posture. Hand gesture is important element of body languages. Hand gesture or hand posture play an important role in our daily life. So if use hand gesture system as a communication medium between computing devices and human then we will get the natural and easy interfacing betweencomputing devices and human being. Vision based hand gesture techniques do not require any extra hardware except high definition camera for more accurate results, so these techniques are very attractive and such kind of systems and methods are very suitable for omnipresent computing and developing applications. One of the main problems in vision based gesture analysis is capture different hand postures or hand gestures and many researchers concentrate and try to solve problem of differentiate various hand positions and shapes, i.e. hand posture or static hand gesture recognition. However, hand posture recognition is still an unresolved problem. Hand is an articulated object with variable configurations, shapes and structures. In addition, it's difficult to describe the texture in hand area. Researchers are trying to use local features of hand like rectangular features for a good and clear representation of hand areas and local texture histograms to represent the hand. Besides, rule based and semi-supervised classification strategies are designed to differentiate various hand postures. The two types of hand gestures e.g. first is gesture made from different arm positions and second is hand gesture made by different shapes from hand. Both of these gestures have many different applications in real world. The project has implemented both of these, hand gesture recognition in real time with video processing. Second hand gesture i.e. gesture from different shapes of hand is implemented with an application of Sign language.

Now, when the application detected an object to process, it can analyze it trying to recognize a hands gesture. The idea of the hands gesture recognition algorithm used is 100% based on histograms and statistics. This makes the proposed algorithm quite easy in implementation and fast for real time implementation. Analysis of two types of object's histograms :- Vertical and Horizontal histograms is the core idea of this method and this method is based on these object histograms.

Here gestures formed with different hand shapes are recognized and after implementing this in real time we used this for sign language implementation. A camera is used to take images

and MATLAB is used as programming toolbox. In this project it is first detect a hand in a frame of video and generate a radial histogram for that detected hand.

1.2 Problem Definition

For utilizing various hand gestures to promote real time application we choose vision based handGesture recognition system that works on shape based features for hand gesture recognition. This is universal truth that every person poses almost same hand shape with one thumb and four fingers under normal condition. The efficient functioning and success for hand gesture recognition based on shape features is highly influenced by some constraints like hand should be straight for orientation detection in image, if it will not be followed then result could be unexpected or wrong and also we fix the new parameter to detect the presence of thumb. An optimal approach of hand gesture recognition can be carried out by using shape parameters, for that a scheme can be developed by calculating three combined features of hand shapes which are area, compactness and radial distance. Compactness is formulated as ratio of squared perimeter to area of the hand shape. Two hand shapes would be classified as same, if the compactness are same of two hand shapes, for this reason this approach limits the number of posture patterns that will be classified by using three hand shape based descriptors and only 10 different hand patterns have been recognized. On the other hand performing real time video or frame synchronized data inputs the system can be made more universal for real time HCI implementation and device development. A synchronized image segmentation, parametric calculation, threshold comparison and decision set generation can be accomplished for an efficient hand gesture based HCI development. This research has been developed with the similar functional paradigm.

1.3 Research Objective

There are some specific objectives of the mentioned project work. Few of them are given below:

- To develop a highly robust and efficient algorithm for natural hand gesture extraction system in real time application scenario
- To develop an Image Processing approach for process the real time video, consisting hand and then extracting the gestures being formed by user
- To develop a robust shape based hand gesture recognition system, without using any static images data for classification training etc.

- To develop a region, area, compactness, and radial distance based robust system architecture for extracting the gesture

1.4 Existing System

From last many years Gesture or posture Recognition becomes a burning term. There were several hand gesture recognition techniques has developed for recognition and tracking of various hand postures. Each and every techniques has their advantage and disadvantage. The oldest one technique is wired technology in which wire is needed by users to tied up themselves to establish the interface or connection with the computing device. In wired technology users are connected with the computer by using wire so the users cannot move freely in the room or the area where they are sitting because the wire is of limited length. Instrumented gloves are the example of wired technology, and instrumented gloves are also known as electronics gloves or data gloves. Electronics gloves build up of using sensors and these sensors are used to provide information related to finger point orientation, hand location, hand positions etc. These instrumented gloves produce good results but to utilize this method widely in common applications is very expensive and not support according to economically. After that data gloves method is replaced by optical markers. These techniques uses Infra-red light for projection and Infra-red light is projected on the computer screen and wherever the markers are wear at hand it will provide the information about fingers tips or location of hand, then the respective portions will be display onto the screen. These data gloves systems provide the good result but it require very complex system configuration. After that some advanced techniques have developed like image based technologies which completely based on processing of image features such as skin tones, textures etc. If we go with these image based features of the image for hand gesture recognition the outcome may varies and may be different as texture,color and skin tones varies very quickly from person to person. And also under different illumination condition, color texture gets modified which leads to changes in observed results. For utilizing various hand gestures to promote real time application we choose vision based handGesture recognition system that works on shape based features for hand gesture recognition. In numerous other applications, certain hand gesture recognition approaches has been developed but unfortunately, most of them are based on static images based trained system that could not be universal for varied applications.

1.5 Motivation

As the prevalence of ubiquitous computing, traditional user interaction approaches with mouse, keyboard and touch pen are not convenient enough for user. In addition, many emerging applications such as augmented reality and interactive entertainments require natural and intuitive interface.It is inconvenient to use traditional mobile phones or hand held devices because it has limited input space with tiny touch screen or keyboard.In this study, a hand gesture recognition system was developed to capture the hand gesture being performed by the user and to control a computer system by that incoming information. Many of such systems in literature have strict constraints like wearing special gloves, having uniform background, long-sleeved user arm, being in certain lightning conditions, using specified camera parameters etc. Such limitations ruin the naturalness of a hand gesture recognition system and also correct detection rates and the performances of those systems are not well enough to work on a real time HCI system. This research or project work aims to design a vision based hand gesture recognition system with a high correct detection rate along with a high performance criterion, which can work in a real time HCI system without having any of the mentioned strict limitations (gloves, uniform background etc) on the user environment. Both academic and commercial world lack such an assertive system and this presented research work intends to fill this gap.

1.6 Proposed System

Considering the requirement of a highly robust and efficient gesture recognition system for real time HCI development for varied gesture based applications, in this research work or project work a real time and effective operating hand gesture or hand posture recognition system will be developed and uses three hand shape based features for identification of what posture it is supporting. The overall algorithm has been divided in three main steps: segmentation, calculating features and last is classification. The proposed algorithm takes real time gesture input through high definition camera and then calculates three features of the image, two based on compactness, and one based on radial distance. On the basis of variables estimated for compactness and radial distances, a final parameters is estimated which in comparison to defined compactness threshold generates interpretations. The generated counts can be employed for gesture recognition based Human computer/machine Interface developments. A tentative flow of the proposed system has been given as follows:

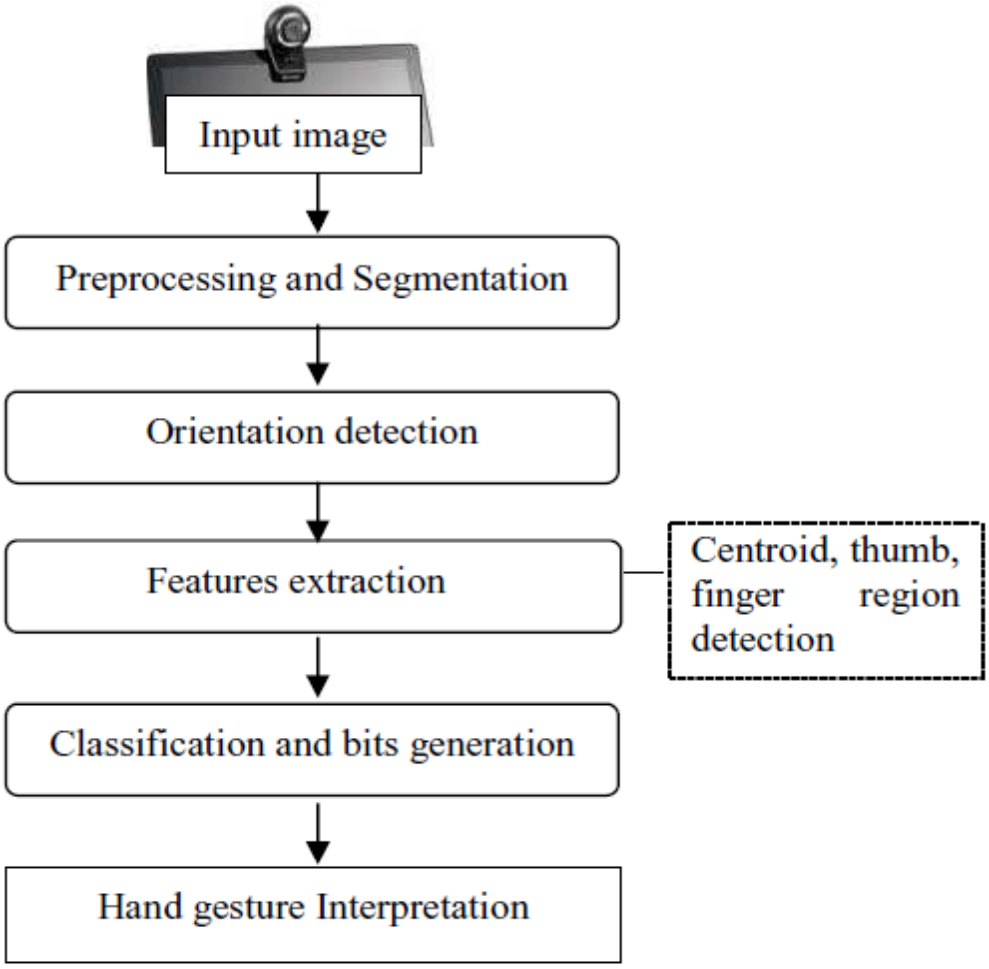


Figure 1.1 A proposed system model for shape based hand gesture recognition system

1.7 Application

In present day automation and human traits or gesture based computing system development, hand gesture and gesture pattern based HCIU has huge development potential. Hand gesture based system can be employed for various human machine interfaces in real time navigation and monitoring system. Gesture based applications, such as domestic device control systems as well as industrial critical navigation and security application can be potentially enhanced. In future gesture recognition system would be immense utility for varied applications. Since, the proposed system doesn't employ any static image patterns for system training and it is capable of functioning in real time scenario, therefore this could be playing vital roles for future generation device and control and navigation system development.

1.8 Thesis Organization

The presentation of a thesis and its significant contents plays the vital role in knowledge transfer and optimal object discussion with better understanding and knowledge flow. Taking into consideration of this requirement here in this thesis the overall thesis has been classified into nine chapters where each chapter discusses its individual objectives. The outline is as follows:

Chapter-1 Introduction

This chapter provides introduction of the research work and in this section of presented manuscript, the key components such as research background, research objectives, motivations, proposed system, problem formulation and research significances for the developed hand gesture detection scheme have been discussed. The prime objective of this chapter is to facilitate an introductory of the proposed research.

Chapter-2 Literature Survey

In this chapter a brief of survey conducted for hand gesture detection using varied techniques and approaches has been presented. A literature conducted for reviewing research done for gesture detection, recognition, and varied enhancements schemes for classification schemes have been presented in this manuscript.

Chapter-3 Proposed System: A Shape based Highly robust Hand Gesture Recognition system

In this chapter the system proposed in this research has been provided with every comprised detail. This chapter mainly focuses on hand gesture recognition process and steps involved in accomplishing gesture recognition. The overall system development and gesture recognition can be understood from this chapter and knowledge transfer.

Chapter-4 Software Requirement Specification

In this chapter the software requirement specifications and associated hardware configuration has been discussed. This chapter also discusses a brief of Matlab software and its significance for image processing**.**

Chapter-5 Implementation

In this chapter the developed system implementation and realization of research model has been presented. The associated Pseudo codes developed hand gesture recognition and HCI oriented command generation have been discussed in this chapter.

Chapter-7 System Testing

Considering the significance of system testing for any system development and its robustness validation, in this chapter the testing of developed system model has been provided. Testing accomplished for various levels such as unit model test, integrated test and complete model test etc have been discussed in this section.

Chapter-8 Results and Analysis

In this chapter the results obtained for proposed research "A highly robust and efficient Hand Gesture recognition and HCI oriented command generation has been given. The system implementation and its results realization for varied gesture patterns data has been presented in this part of manuscript. The system analysis for its robustness with respect to varied gesture position, orientation and sign language have been obtained and discussed in this chapter. The robustness and effectiveness of the proposed system can be obtained from this chapter.

Chapter-9 Conclusion

In this section the conclusion derived for whole research accomplished has been provided. The research and its outcomes with probable enhancement have beenmentioned in this chapter. This chapter has been followed by References used in this research work.

Chapter-2

LITERATURE SURVEY

An objective oriented subject study and existing systems analysis plays a significant role for rooting foundation of any research and system optimization schemes. Thus taking into consideration of a hand gesture recognition oriented literature review we have conducted a review that discusses various existing systems available and various algorithms proposed. The review also facilitates strengths as well as weaknesses of existing approaches. In this chapter the literature survey conducted has been presented.

1. Shiravandi, S. et al proposed a method for hand gesture recognition using dynamic Bayesian networks. Their study includes two main subdivisions namely: hand posture recognition and dynamic hand gesturerecognition (without hand posture recognition). In the first session, after hand segmentation using a method based on histogram of direction and fuzzy SVM classifier, they trained the posture recognitionsystem. In the second session, after skin detection and face and hands segmentation, their tracing were carried out by means of Kalman filter. Then, by tracing the obtained data, the positions of handwas achieved. For combining the achieved data and output of hand posture recognition unit they utilize Bayesian dynamic network. For recognition of 12 hand gestures in their study, 12 Bayesian dynamic networks with two distinct designs were used. The difference between these two models was in the utilizing features and their relations with each other. Therefore, one of these models was used based on each gesture feature.

2. Pham etalintroduced a hand gesture recognition system to recognize real time gestures in Vietnamese sign language system. In their system, there are three modules: real time hand tracking, training gesture and gesture recognition using pseudo two dimension hidden Markov models (P2-DHMMs). In the hand tracking module, they introduce a new robust algorithm to obtain hand region, called Tower method, and use skin color for hand gesture tracking and recognition. Next, a gesture recognitionsystem has been developed, which can reliably recognize single hand gesture on a standard camera. A new feature type is

developed in this proposal with the use of new feature in hand Gesture Recognition System will improve accuracy of the whole system. IN this experiment vocabulary of 29 gestures are used and system have been tested against this gestures in Vietnamese sign language system (VSL) and also represent the effectiveness of tower method and system.

3. Gaus, Y.F.A. etalproposed a new hand gesture recognition system in which the insulated Malaysian sign language (MSL) is recognized. This new proposed system involves four different phases: Collection of input images, Extraction of features, Training of Hidden Markov Model (HMM) and Gesture or Posture Recognition. First of all to detect the skin region the skin segmentation procedure is applied all over the input frames. Then, they proceededfor feature extraction process consisting of centroids, hand distance and hand orientation collecting.Kalman Filter was used to identify the overlapping hand-head or hand-hand region. After having extracted the feature vector, the hand gesture trajectory is represented by gesture path in order to reduce system complexity. The authors applied Hidden Markov Model (HMM) to recognize the input gesture. The gesture to be recognized is separately scored against different states of HMMs. The model with the highest score indicates the corresponding gesture.

4. Chenglong Yu etalpresented a feature extraction method for hand gesture based on multi-layer perceptron. The feature of hand skin color in the YCbCr color space was used to detect hand gesture. The hand silhouette and features can be accurately extracted in means of binarizing the hand image and enhancing the contrast. In this research the median and smoothing filters were integrated to remove the noise. Combinational parameters of Hu invariant moment, hand gesture region, and Fourier descriptor were created to form a new feature vector which can recognize hand gesture. To confirm the robustness of this proposed method, a dataset including 3500 images was built.

5. Doe-Hyung Lee etaldeveloped a real time hand posture recognition system that is based in difference image entropy with the help of stereo camera. Existing systems use hand detection primarily with some type of marker. Their system, however, takes into consideration of a real-time hand image recognition system.In the detection step, a depth map is implemented by using addition of absolute differences and it is based on acquired right left image with use of stereo camera. Their proposed system detected a foreground object and perceives it as a hand. The difference image entropy of the average image and the input image is used in this new developed hand gesture recognition system. To evaluate the performance of the proposed technology, the authors implement a recognitionexperiment using the hand gesture 240 database.

Luo, R.C. et al [10] in their research proposed a integrated system of emotion recognition and hand posture recognition and this integrated system has the capability to track the number of

people at the same time, to distinguish both social atmosphere and facial expressions. Therefore robots shall easily understand, recognize and identify the facial expressions and hand postures of dissimilar persons with variation in emotions and robots can also respond properly. Two different algorithms are used for collectively for gesture recognition. The process known as Combinatorial approach recognizer (CAR) is used to determine the hand gesture with use of collectively two recognizers. The feature vectors based approach is employed for recognition of facial expressions and These two recognizers collectively determine the hand's gesturevia a process called combinatorial approach recognizer (CAR) equation. As for the facial expressionrecognition scheme, the authors fuse feature vectors based approach (FVA) and differential-active appearance model features based approach (DAFA) is employed to determine not even positions of feature points but also detects information about texture and appearance.

Huang, Yu et al [11]proposed a hybrid method forhand gesture recognition, which extends their previous work on a gesture recognition method based on concept learning by the addition of an association learning process. The authors used association learning to reveal the frequent patterns in gesture sequences, and then use such patterns to help recognize incomplete gesture sequences. Experiments also exhibited that the hybrid method is comparable to two state of the art methods (HMMs and DTW) for hand gesture recognition, but outperforms them in the larger datasets.

Caridakis, G.et al [15]developed a recognition system completely based on the trajectory of the hand, the verification is performed for original system architecture for this recognition system. We uses both spatial and temporal information of hand gestures. The spatial information is carried out by self organizing feature maps and temporal information is extracted with the help of Markov models within the trajectory of hand. According to experimental results it ensures the robustness and set of models are used for production of classification tools that are validated.

Kim, J.-S.et al [17]developed a real time hand gesture recognition system that have control over motion of human hand and it is grounded on dynamic hand gesture that are predefined in a virtually created environment. First of all there is needed to note down the dissimilarity in between the starting and ending of hand motionand huge amount of time is spent over in learning of conventional recognition system. To overcome this problem we introduce a recognition method that uses intelligent techniques. So we can also represent a path that is free of restriction for assurance of easily navigation of the human avatar.

Chapter-3

PROPOSED SYSTEM DEVELOPMENT PROCESS

3.1 Introduction

Design is one of the most important phases of product development. The design is a creative process in which a system organization is established that will satisfy the functional and non-functional system requirements. Large systems are putrefied into the subsystems and each subsystem provides some correlated set of services. The outcome of the design phase is a complete report of the software architecture.In the proposed system, the objective is to design such of efficient system in which the human gesture will be used as the command and as per the gesture movement the car or the device will be operated. Here the problem lies in the fact that how to create a system by which only the hand gesture will be extracted and the every hand gesture will be provided a particular command and that command will be interacting with the device.

3.2 Design Considerations

In this research work a new vision based techniques are presented, which permits the users to communicate with computing devices through hand gestures or hand postures, different background and light conditions are adaptable by the system. It is as much efficient as suitable for the real-time applications. The present suggestion emphases on the various stages involved in the hand gesture recognition, starts from original image capturing to image's final classification. Video sequences are divided into frames, these frames are processed and analyzed to eliminate noise, label each object pixel and determine skin tones. Once the hand gesture is captured and then it has been segmented it is defined as a hand gesture otherwise rejected if it does not belong to the stored visual memory. The recognition problem is came out through the matching process in which segmented hand is compared with the all hand gestures i.e. stored in system's memory. All recognizable postures, their edge map, morphologic information and distance transform information are stored in visual memory of system. In this faster and very tough comparison is performed, classifying gestures or postures properly even those which are more likely same, saving time needed for real time applications. The gestures which are stored in visual memory may be initialized by human user, gestures are trained or learned from previous tracking of hand

motion or during the recognition process they can be generated.

Once the gesture has been extracted then it's fed up to the microcontroller and then it is communicated to the Real time system like Car or other mobile devices which have to be controlled by the hand gesture.

Here we have used the RF transmitter and receiver for the purpose of the communication between the data extraction unit and the Execution unit.

3.3 Development Methods

This project would follow Iterative Development Methodology. This would enable the product to be built in increments. Rational Unified Process (RUP) would be the approach to manage the development process of the project. The Rational Unified Process is itself not a single tangible prescriptive process, rather than is a adaptable process framework. It comprises a large number of several activities, it is also be proposed to be tailored, it has the sense of selecting the development processes and methods suitable for a particular development organization or software project. It is determined as applicable to larger software development teams working on large and complex projects.

The benefits of the iterative process model are:-

- It is easier to accommodate the changes in requirement at alter stage.
- It is easier to control the risk. The higher risk areas are addressed in the beginning of the project.
- Incorporation of the feedback of iteration into subsequent iterations will make the quality of the product better.

The best follows of Rational Unified process are:-

- Develop software iteratively
- Visually model software
- Manage requirements
- Use component based architecture
- Software quality verification
- Control to software changes.

3.4 Gesture Extraction and digitization

The goal of the algorithm design is to extract the gesture and then convert it to the real time command so as to interface it with the computer or the real time system.In the first step of the algorithm development or the gesture extraction, preparation of input image for further processing is done by using several standard image processing techniques. After image processing the feature calculation is second step and performed by proposed algorithm and algorithm extract three features of images are 1) compactness of the complete image, 2) compactness of left half of hand and 3) by using radial distance calculating number of fingers. The algorithm is classified into following parts:

3.4.1 Segmentation:

The proposed system uses traditional methods of segmentation but it is implementing the Otsu's method rather than using a defined threshold values for segmentation of the input image. In this way it calculates the space between upper and lower edges of the arm and arm is exactly cut from the wrist, where the space between upper and lower corners increases promptly. This procedure reports for variation in hand and arm sizes by using proportional changes in area between upper edge and lower edge of the arm, rather than a fixed distance changes.

3.4.2 Feature Calculations

After segmentation feature extraction is next phase and in this features are extracted that are shape based and used in combination. The core idea of this paper is to recognize ten hand patterns using shape-based features. The hand can assume different shapes and gestures, so shape based features have not been extensively used in hand gesture recognition algorithm. To overthrown this obstacle, uses the combination of three hand shape based features. These features are explained below:

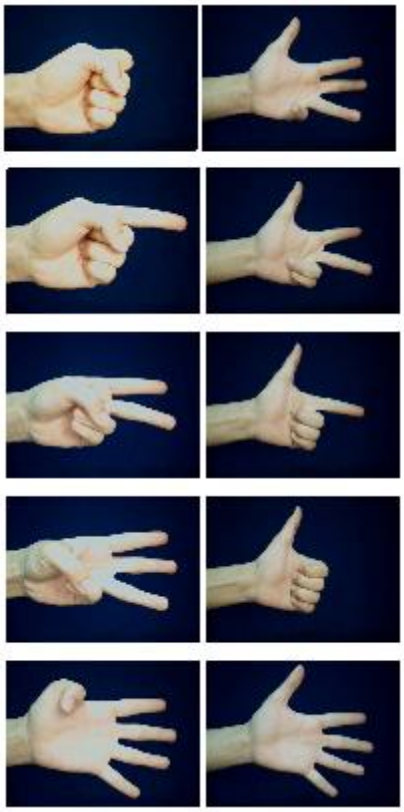


Fig.3.1A sample set of hand gesture patterns used. From top left going counter-clockwise, pattern Zero to pattern nine

3.4.3 Compactness I (CA)

The feature of the image to be extracted is compactness and it's a hand shape based descriptor. The following equation is used for calculating compactness of hand shape:

$$Compactness = \frac{Perimeter^2}{4\pi \times Area}$$

According to above mentioned equation it is clear that compactness of the entire image is calculated by the ratio of the square of the perimeter of the hand shape to the shape area. It is vibrant that the compactness value of the entire image will be same if the two hand patterns have most likely same squared perimeter to area ratio, but sometime the compactness values becomes overlapped due to same hand patterns. So the next feature is useful to overcome this failure.

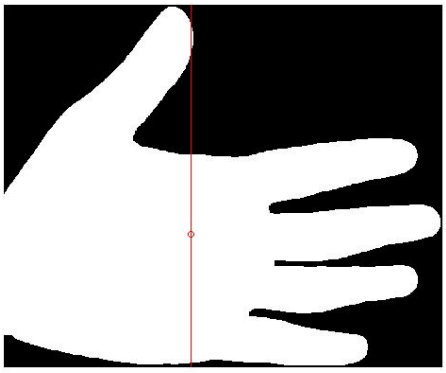


Fig 3.2: Hand partitioning. The circle represents the centroid and the image is partitioned along the vertical line

3.4.4 Compactness II (CL)

The algorithm for second hand feature extraction is focused on the thumb. In another hand posture recognition algorithm, the hand portion is treated like a one complete area by algorithms. But in our employed algorithm we treat the image and the hand as subsisting of two halves:- the first half that consisting the thumb is referred to as first half, and the remaining half that consisting of four fingers is referred to as right half. The user's hand is divided into two halves at its centroid or geometric center, through a vertical line projected parallel to the edge of the image. The image moment is calculated by using the following formula for deriving the centroid of the digital image of the user

$$M_{ij} = \sum_{x} \sum_{y} x^i y^j I(x, y),$$

Where (x; y) is the intensity at coordinate $(xi; yi)$. the coordinate of the centroid $(\bar{x}; \bar{y})$ is found by using

$$\bar{x} = \frac{M_{10}}{M_{00}},$$

$$\bar{y} = \frac{M_{01}}{M_{00}}.$$

The geometric center of a hand lies within the hand and accordingly convenient for separating the thumb and the fingers from the hand. The above figure shows an example of hand partitioning. To examine the presence of the thumb from the left half of the image we used compactness. The thumb has peninsula like shape due to that the thumb shape somewhat

increases the compactness value. If the hand patterns have the thumb i.e. pointing away from the palm surely will have a eye catching compactness value higher in the left half then the hand patterns that do not include thumb. Compactness is RST invariant (rotation, scaling and translation invariant), but it is massively shape dependent. The human hand inherently varies, hence it may be possible for one hand pattern to produce fluctuating compactness values. To upgrade this compactness recognition it is required to use another feature that give results in discrete values.The next feature establishes this purpose.

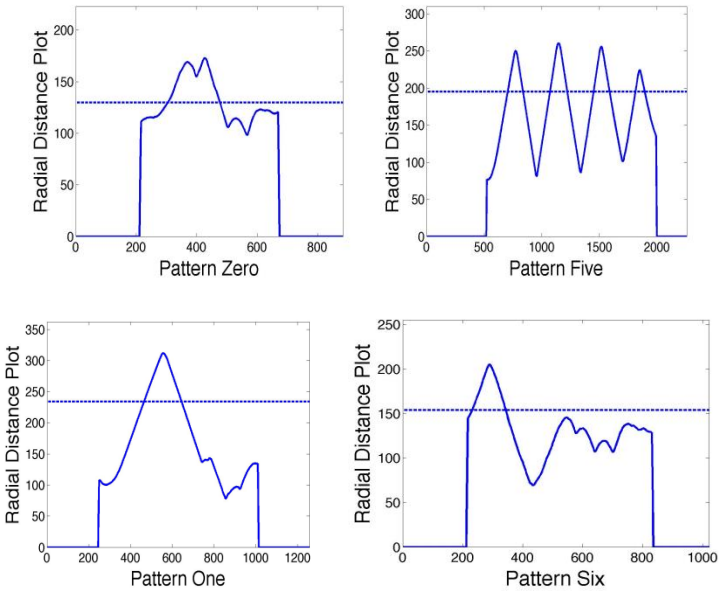
3.4.5 Radial Distance

Radial distance of a hand gesture will be determined by using the Euclidean distance. This distance is applied between all the boundary points of the input hand and a reference point within the same hand.

The following equation is used to calculate Euclidean distance:

$$ED(p,q) = \sqrt{(x_p - x_q)^2 + (y_p - y_q)^2},$$

Where p indicates all the boundary points of the hand and q indicates a reference point within the hand. In previous version the reference point was calculated from the center of the wrist. In the new version, the reference point is calculated from the centroid, and any other boundary point that are left of the hand centroid are not considered in this version.



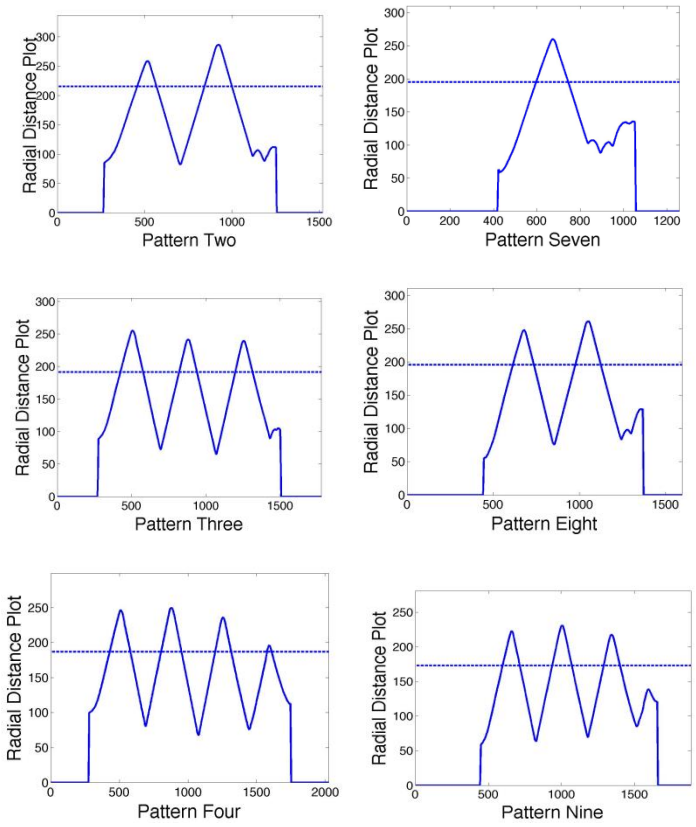


Fig 3.3: Sample radial distance plot for one set of patterns

Proposed Extraction and digital conversion mechanism

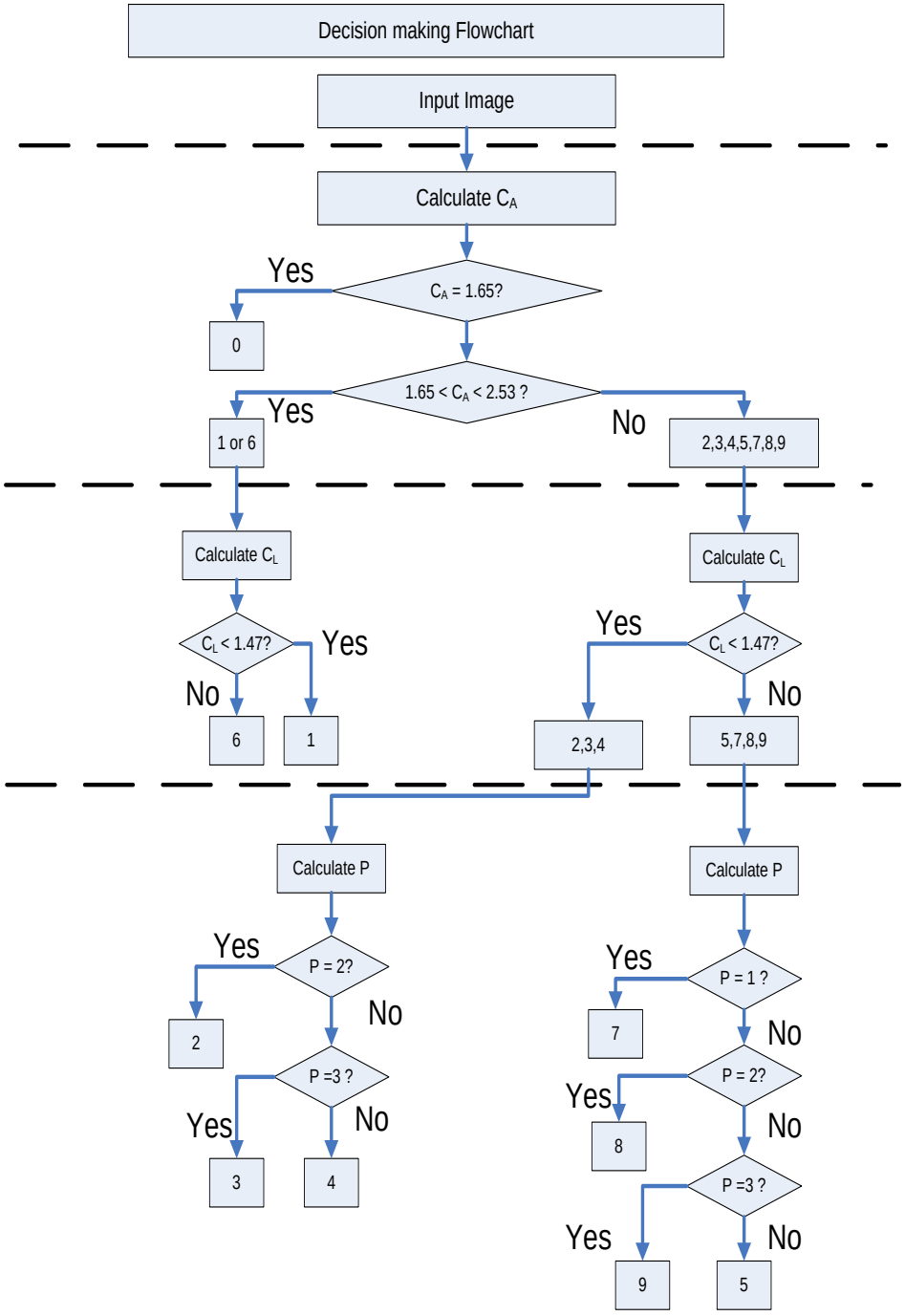


Fig 3.4: The decision flowchart with threshold values obtained from system implementation

3.4 Data Flow Diagrams for Gesture Extraction

A data flow diagram (DFDs) represents the flow of data of any system by using graphical representation over an information system. In each system sequence of sequence of processing steps followed by data and this data flow represented by data flow diagrams. The data is converted into one form to another before moving to one stage to next stage. Every

transformation or processing steps of data are functions of program when data flow models are used to document a software design.

The Data Flow Diagram (DFD) for the proposed system can be decomposed into three levels such as level 0, level 1 and level 2.

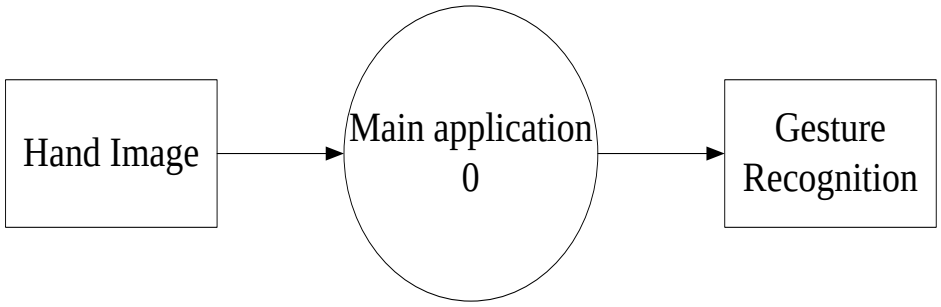


Fig 3.5.1: Level Zero Data Flow Diagram

The above figure represents level zero data flow diagram where the main application {0} s shown to take an input from hand image and then using algorithms, it gives the output as gesture recognition.

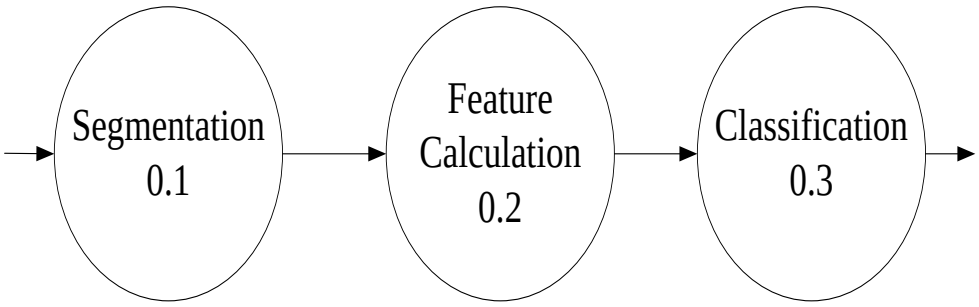


Fig 3.5.2: Level One Data Flow Diagram

The above diagram represents level one data flow diagram where the main process {0} is shown to divided into three sub-process e.g. segmentation {0.1}, Feature Calculation {0.2}, and Classification {0.3}.

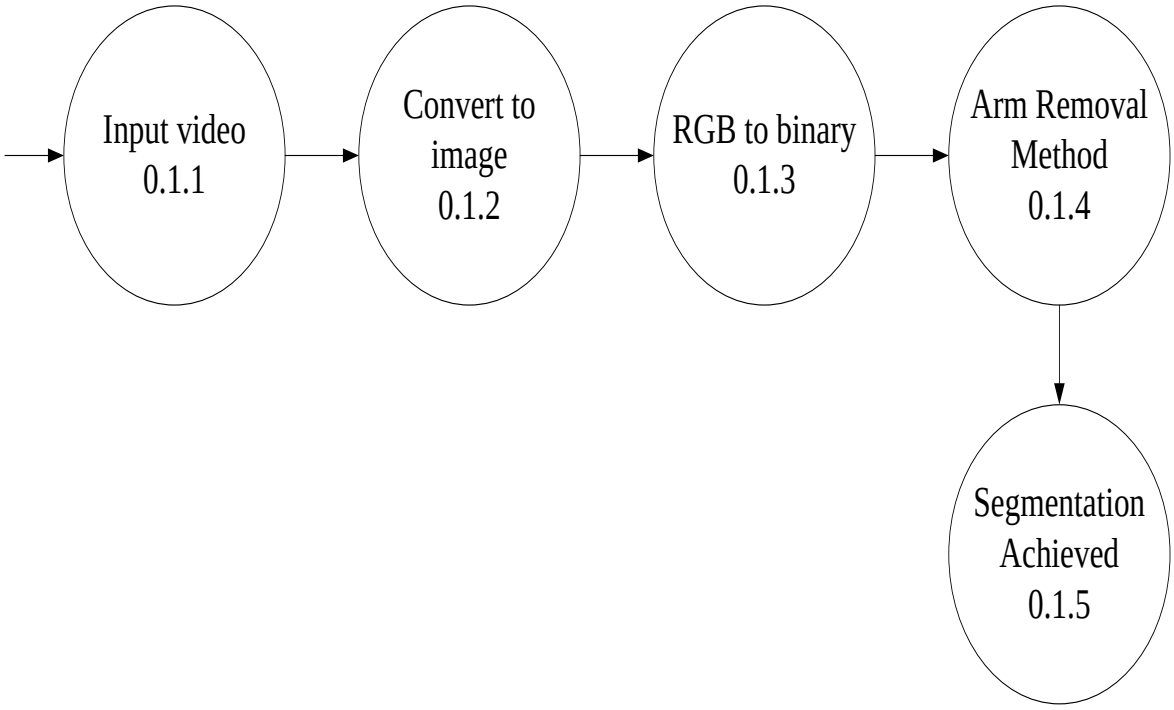


Fig 3.5.3: Level Two Data Flow Diagram

The above figure represents level two data flow diagram, where the sub-process {0.1} is shown as per their respective flows. There are two steps included in image preparation stage: RGB to binary conversion of image and second one is morphological operations.in the segmentation process color information is not used. This permits this method to be color-invariant, more important is to make this algorithm much more to varying conditions of light. Removal of arm is carried out. This scheme cut the arm specifically from the wrist, where the space or distance betwixt the two edges rapidly increases and determine the distance between upper and lower corner of the arm. This process reports for changeable arm and hand sizes with the help of proportional changes in distances between the uppermost and lowermost corner of the arm, rather than fixed changes in distances. The identical method underscore the importance of manipulate the hand area only not in the remaining part of images. We will use only low cost web camera for capturing all input images to imitate practical setting of applications.

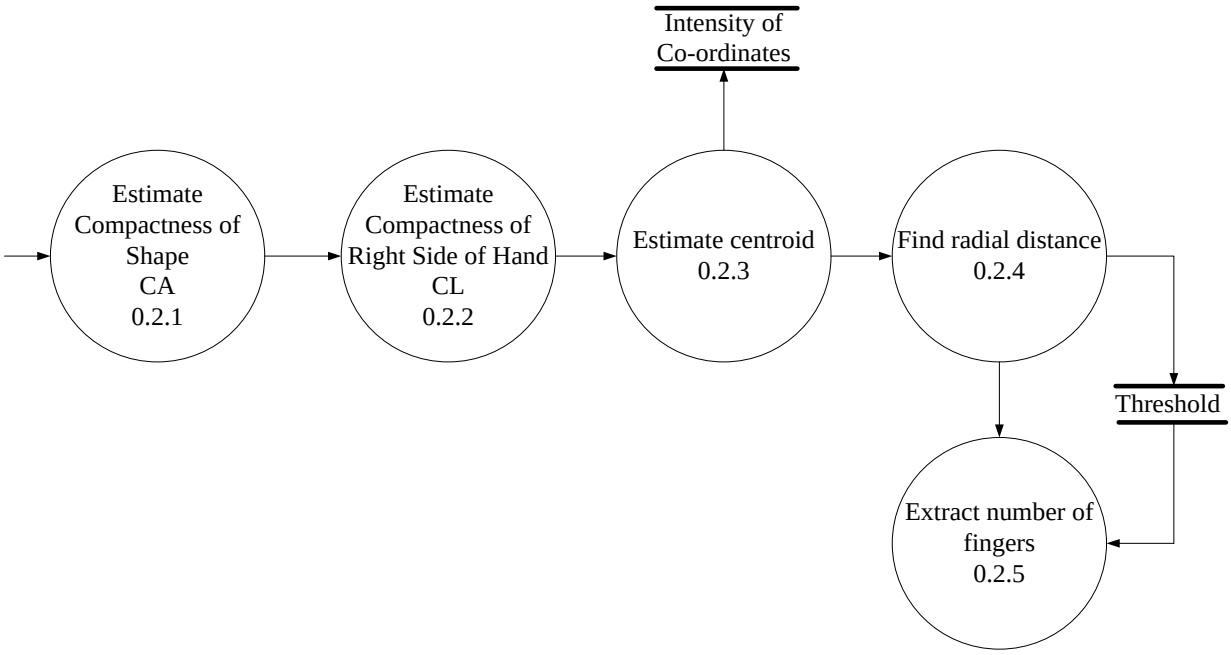


Fig3.5.4: Level Two Data Flow Diagram

The complete target of this paper is to recognize ten different hand patterns with the help of shape based features and techniques. Many shapes can be assumed by hand of user, for this reason shape based features and techniques not used very widely in hand gesture recognition algorithms. To resolve this problem, combined three shape based features and the combination is used for hand gesture recognition. compactness is the first feature of theimage that have to be computed and it is shape based descriptor. After that then we have field of interest in thumb i.e. second feature that to be computed.in this new algorithm we behave with image and hand as subsisting of two half parts:- the first one only contains the thumb that is known as left half and the remaining half that contains the fingers of the hand that is known as right half, except other hand gesture recognition algorithm that treat the user's hand as single complete area. The hand division is performed by dividing the hand into two halves at its centroid or geometric center by a vertical line plotted paralleled to the image corner. It is suitable to make the isolation between thumb and four fingers because the geometric center of the input hand included within the hand. Compactness feature of hand is densely dependent on the hand shake. It is RST invariant (rotation, scaling and translation). The human hands constitutionally varies, so it might be possible for one hand pattern to results in varying compactness values. There is need to improve the existing recognition technique, so we require to use a feature in which it produces discrete values.

3.5 Use case Diagram

The complete target of this paper is to recognize 10 different hand patterns with the help of shape-based features and techniques. Many shapes can be assumed by hand of user for this reason shape based features and techniques will not use very widely in hand gesture recognition algorithm. To resolve this problem combined three shape based features and the combination is used for hand gesture recognition. Compactness is the first feature of the image that have to be computed and it is shape based descriptor.

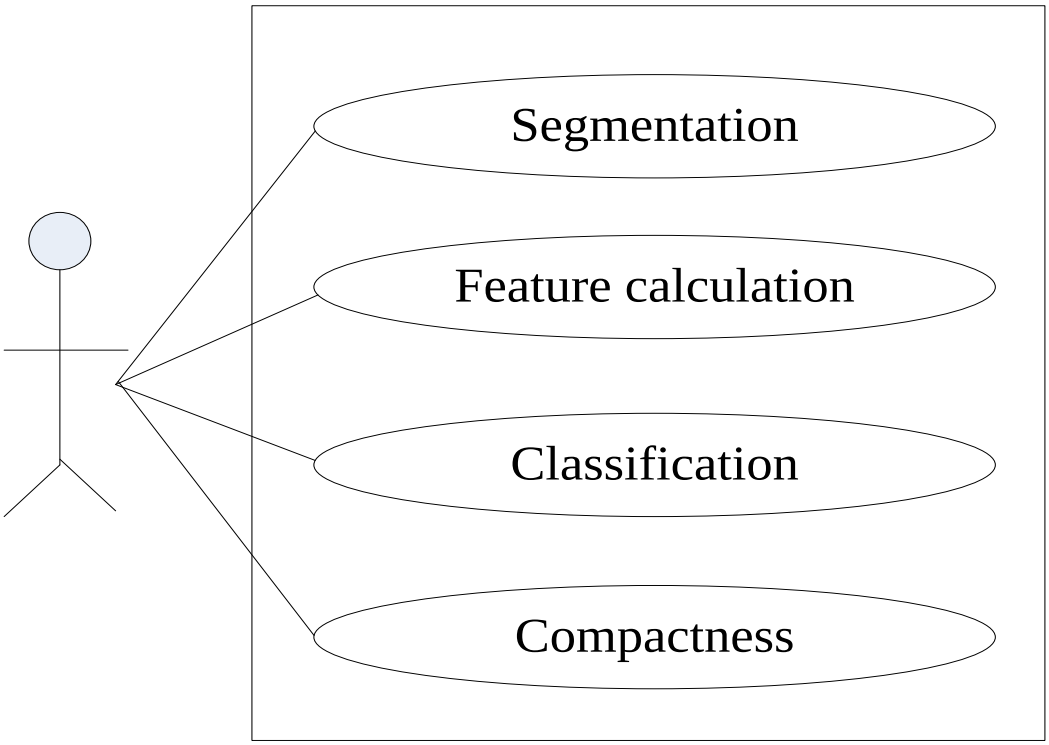


Fig 3.6: Use case Diagram for proposed system

Chapter-4

SOFTWARE REQUIRMENT SPECIFICATION

4.1 Purpose

The software requirement specification for the proposed research work “A highly robust and automatic scheme for texture detection and inpainting in Image or Video data”describes what our software will be delivered and the technical specifications and user requirements. This system requirement specification states a basic document that constitutes the foundation of the system development process. SRS represents the needs of certain model development process. The software requirement specifications represent the organizations perceptive of a customer or prospective client’s system needs dependencies at a certain time or instant previous to any kind of factual development procedure. On the other hand, software requirement specification also functions as an outline for accomplishing certain objective of a project with minimum cost expenditure. It is also significant to consider that the software requirement specification (SRS) comprises functional and non functional requirements only; it doesn’t offer any design recommendations, probable results and paradigms for problem solving, or business issues or any other kind of information except the development team recognizes the requirements of customer’s system.

4.2 General Description

In this section of the presented thesis the introduction of software product under consideration has been presented. It presents the basic characteristics and factors influencing the software product or system model and its requirements.

4.2.1 Product Perspective

In this project or research work, we have proposed a shape based highly robust and efficient hand gesture detection system and gesture recognition based application command generation scheme. The proposed system has been emphasized on developing an efficient scheme that can accomplish hand gesture recognition without introducing any training related overheads. The proposed system has to take into consideration of geometrical shape of human hand and on the

basis of defined thresholds and real time parametric variation, the segmentation for human shape is accomplished. On the basis of retrieved specific shape, certain application oriented commands have to be generated. The predominant uniqueness of the proposed scheme is that it doesn't employ any kind of prior training and it is functional in real time without having any databases or training datasets. Unlike tradition approaches of images datasets based recognition system; this approach achieves hand gesture recognition in real time, and responds correspondingly. This developed mechanism neither introduce any computational complexity nor it causes any user interferences to achieve tracing of human gesture.

4.2.2 User Characteristics

The user should have at least a basic knowledge of windows and web browsers, such as install software like Matlab, etc and executing a program, and the ability to follow on screen instructions. The user will not need any technical expertise in order to use this program.

4.2.3 General Constraints

This section contains general constraints; more details are available in Specific Requirements section:

- The program will be coded in Matlab.
- Most any operator should be able to be shown how to use the system.

4.3 Specific Requirements

4.3.1 Functional Requirements

In the functional requirement we have to design the system interface with the functional entities for achieving real time visualization of system response and parametric variation. Here the development of GUI is important to visualize the hand position, its movement and response being generated. On the basis of these parameters the precise output can be accomplished. The real time presentation of the hand movement and its responding results, division of shapes area etc, would ensure optimal gesture recognition and precise response or command generation for applications. The overall system designing will be done on the MATLAB platform.

4.3.2 Non-functional Requirements

- **Usability:** The user is facilitated with the control section for the entire process in which they can arrange the position of hand at the centre of ROI under consideration, the variation of palm position and respective command generation etc can be effectively facilitated by mean of user interface. The implementation and calibration of camera and its resolution can also be done as per quality and preciseness requirement.
- The frame size, flow rate and its command variation with respect to threshold developed and color component of hand color, can be easily calibrated by means of certain defined thresholds.
- **Security and support:** Application will be permissible to be used only in secure network so there is less feasibility of insecurity over the functionality of the application. On the other hand, the system functions in a real time application scenario, therefore the camera, color and platform compatibility is also must in this case. IN case of command transfer using certain connected devices or wireless communication, the proper port assignment would also be a predominant factor to be considered.
- **Maintainability:** The installation and operation manual of the project will be provided to the user.
- **Extensibility**: The project work is also open for any future modification and hence the work could be defined as the one of the extensible work.

4.3.3 External Interface Requirements

An interface description for short is a specification used for describing a software component's interface. IDLs are commonly used in remote procedure call software. In these issues the machines on moreover last part of the "link" might be utilizing dissimilar operating systems and computer languages. Interface Description recommends a bridge among the 2 diverse systems. These descriptions are classified into following types:

- **User Interface:** Theexternal or operating user is an individual who is interested to introduce a novel Algorithm for shape based hand gesture recognition in real time application scenario. The user interface would be like axis presenting real time movement of human hand and its relative position with respect to defined centroid or morphological thresholds.

- **Restoration with Text Removal Software Interface:** The Operating Systems can be any version of Windows, Linux, UNIX or Mac.
- **Hardware Interface:** In the execution of this project, the hardware interface used is a normal 32/64 bit operating system supported along with better integration with network interface card for better communication with other workstations. For better and precise outcome, a high definition camera with calibrated functioning with defined RGB or YBR color format is must. Since the proposed system functions in real time application, therefore the camera quality and its color accuracy would be important. In the proposed system the background also plays a vital role, therefore the background segmentation or calibration with well defined frame rate or resolution would be must. Such cautions would ensure optimal recognition and tracing of hand gesture.

4.3.4 Resource Requirement

4.3.4.1. About Matlab

The proposed simulation work is developed in Matlab. MATLAB is an elevated height level language as well as interactive surroundings that make possible to present computationally concentrated tasks sooner than with conventional programming languages like a C, C++, and FORTRAN.

MATLAB identify how to be used for a wide assortment of applications, including indication as well as image processing, communications, control design, test along with measurement, financial modeling furthermore analysis, in addition to computational biology. Add-on toolboxes (collections of particular intention MATLAB functions) enlarge the MATLAB environment to resolve exacting classes of troubles inside this application region.

MATLAB present an amount of features used for documenting as well as sharing the work. Individual preserve combine the MATLAB code with additional languages along with applications, moreover allocate the MATLAB algorithms as well as applications.

4.3.4.2 Key Features

- ✓ High intensity language for methodological computing
- ✓ improvement environment for running code, files, as well as data
- ✓ Interactive tools used for iterative examination, design, along with trouble resolving

- ✓ Mathematical intention for linear algebra, static information, Fourier investigation, filtering, optimization, as well as numerical incorporation
- ✓ 2-D as well as 3-D graphics purpose for envisage data
- ✓ Tools for constructing custom graphical user crossing point
- ✓ Functions intended for consolidate MATLAB based algorithms with another applications as well as languages such as Fortran, COM, C, C++, Java, with Microsoft Excel.

4.3.4.3 Developing Algorithms and Applications

MATLAB present a high-level language as well as improvement tools so as let single quickly build up and examine the algorithms as well as applications.

4.3.4.4 The MATLAB Language

The MATLAB language ropes the vector as well as matrix operations that are essential to engineering along with technical troubles. It facilitates speedy improvement and implementation.

Through the MATLAB language, individual preserve program as well as build up algorithms earlier than with conventional languages because single do not required performing low-level governmental tasks, such as pronounce variables, identifying data kinds, along with distributing memory. In several containers, MATLAB remove the required for 'for' loops. As a consequence, single line of MATLAB code can frequently replace numerous lines of C or C++ code.

By the similar time, MATLAB present each and every features of a conventional programming language, including mathematics operators, flow control, data structure, data kind, object-oriented programming (OOP), as well as debugging features.

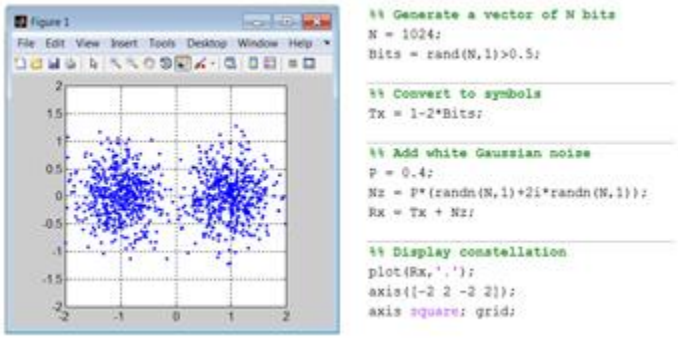


Figure 4.1 A communications inflection algorithm which produce 1,024 random bits, present modulation, adds compound Gaussian sound, as well as plots the result, every in presently 9 appearance of MATLAB code.

MATLAB lets single perform commands or assemblage of commands individual by a time, with no compiling with linking, enabling single to rapidly iterate to the best solution.

For speedy execution of important matrix along with vector computations, MATLAB employ processor-optimized libraries. For general-purpose scalar calculation, MATLAB produces machine-code commands utilizing its JIT (Just-In-Time) collection equipment. This machinery is obtainable on the majority of platforms, afforded execution velocity that rivals those of established programming languages.

4.3.4.5 Development Tools

MATLAB incorporate improvement tools that assist individual to execute their algorithm professionally. These incorporate the subsequent:

- **MATLAB Editor**: presented standard suppression along with debugging features, like a setting breakpoints with particular stepping
- **Code Analyzer**: ensures the code for troubles and advocates alteration to make the most of presentation and maintainability
- **MATLAB Profiler**: proceedings the time expend executing every row of code
- **Directory Reports**: Scan every the files inside a index and report on code competence, file dissimilarity, file dependency, as well as code coverage

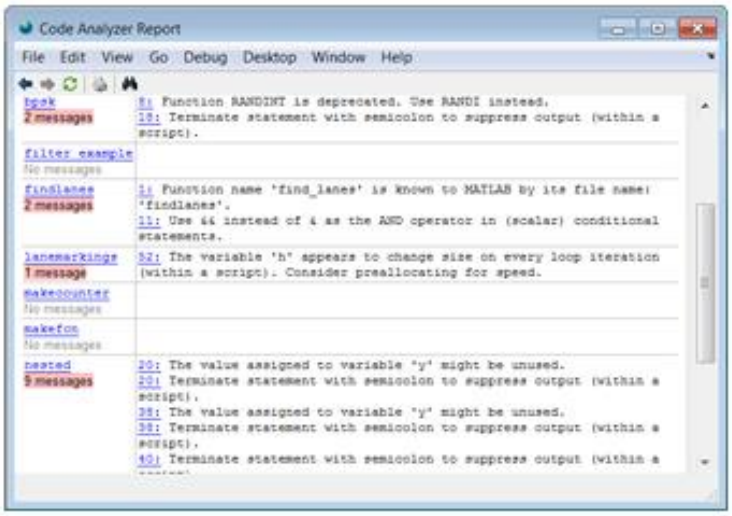


Figure 4.2 A Code examine reports, which consist of recommendation for creation the code faster and easier to preserve.

4.3.4.6 Designing Graphical User Interfaces

Individual can employ GUIDE(Graphical User Interface Development Environment)the interactive tool to layout, design, as well as change user interfaces. GUIDE lets particular include inventory boxes, pull-down menus, press on buttons, radio buttons, as well as sliders, and MATLAB plots along with ActiveX controls. On the other hand, single can generate GUIs programmatically employ MATLAB functions.

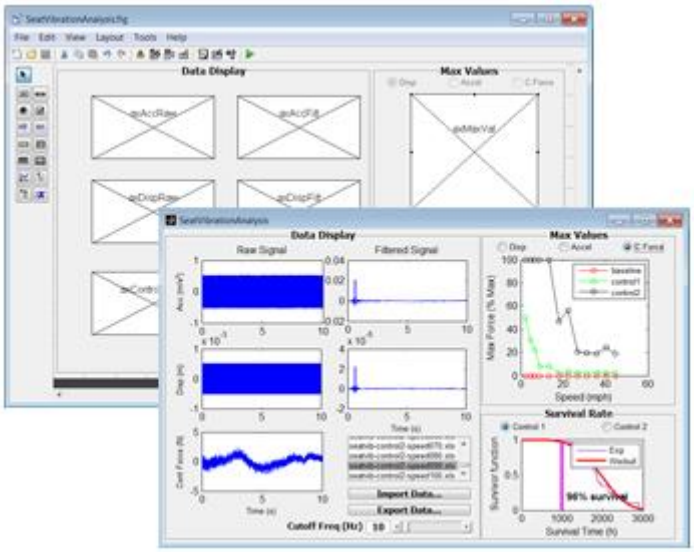


Figure 4.3 GUIDE layout of a vibration study GUI (top) jointly with the concluded interface (substructure).

4.3.4.7 Analyzing and Accessing Data

MATLAB maintains the whole data analysis procedure from obtain data from outside devices in addition to databases, during preprocessing, apparition, and numerical investigation, to producing management excellence output.

4.3.4.8 Data Analysis

MATLAB facilitates interactive tools along with command-line purpose for data study operations, comprising:

- Interpolating as well as decimate
- extort segment of data, scaling, as well as averaging
- Threshold as well as smooth
- connection, Fourier investigation, and filtering
- 1-D peak, valley, as well as zero finding
- essential statistics and curve fitting

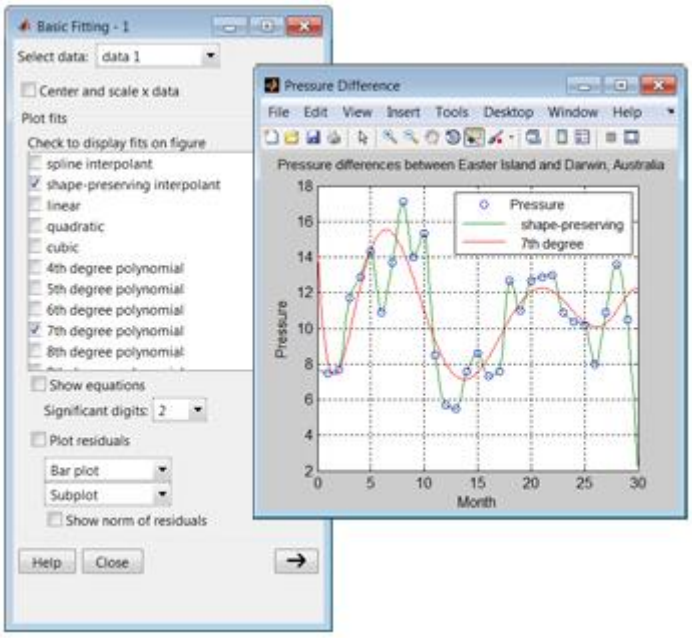


Figure 4.4 Plot show curve fitted to the review averaged atmospheric demands differences involving Easter Island as well as Darwin, Australia.

4.3.4.9 Data Access

MATLAB is a well-organized proposal for entrance data from files, additional applications, databases, along with outer devices. We can examine data from admired file formats, such as Microsoft Excel, $ASCII$ text or binary files, picture, sound, and video files as well as scientific files, like as HDF and $HDF5$. Low stage binary file Input/output functions allow you effort with data files in some format. Further functions let single examine data from Web pages as well as XML.

Individual call other applications and languages, like$C, C++$, COM object,$DLLs$, Java, FORTRAN, as well as Microsoft Excel, and contact FTP sites in addition to Web services. Using Database Toolbox, individual can also access data from $ODBC/JDBC$compliant databases.

Particular preserve obtain data from hardware devices, such as the computer's sequential port or noise card. Using Data possession Toolbox, one can stream survive, measured data honestly into MATLAB for analysis as well as visualization. Instrument Control Toolbox makes possible communication with $GPIB$ and VXI hardware.

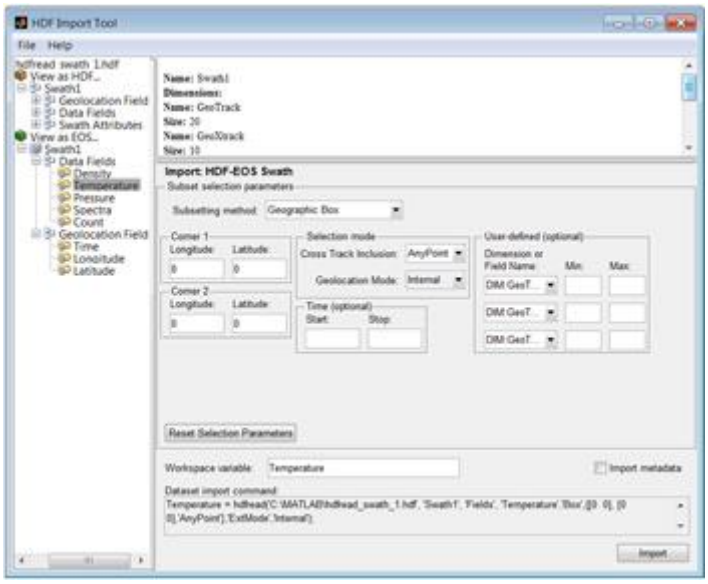


Figure 4.5 HDF data from a satellite selected as well as significance into MATLAB by the MATLAB HDF Import Tool.

4.3.4.10 Visualizing Data

The entire the graphics features that are essential to imagine engineering as well as technical data are obtainable in MATLAB. These contain 2-D with 3-D plotting purpose, 3-D quantity apparition functions, tools for interactively generating plots, and the capability to export consequences to every admired graphics formats. We are able to modify plots by adding manifold axes; altering line colors and markers; adding explanation, LaTEX equations, as well as legends; and drawing figure.

4.3.4.11 2D Plotting

Single can envision vectors of data through 2-D plotting function that generate:

- Line, area, bar, and pie charts
- Direction and velocity plots
- Histograms
- Polygons and surfaces

- Scatter/bubble plots
- Animation

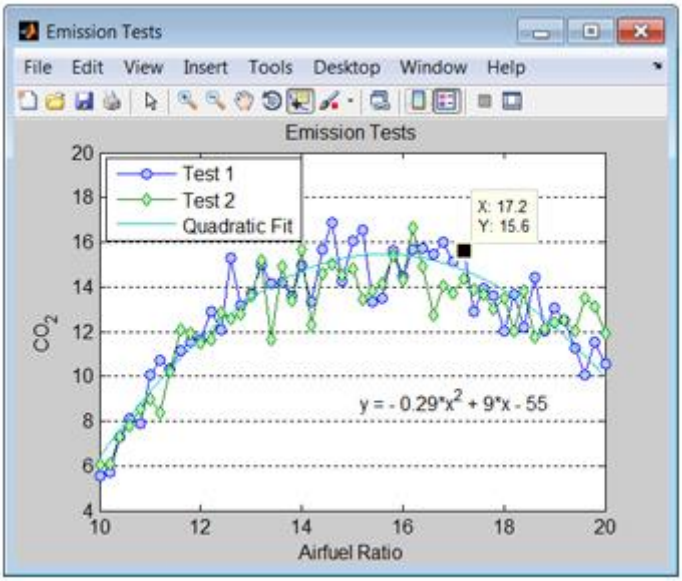


Figure 4.6 Line plots of manifold engine release test results, with a curvature built-in to the raw data.

4.3.4.123D Plotting and Volume Visualization

MATLAB presents functions for imagine 2-D matrices, 3-D scalar, as well as 3-D vector data. Individual can employ these functions to imagine and understand large, frequently multifaceted, multidimensional data. One can identify plot individuality, such as camera presentation angle, perspective, lighting produce, light source locations, in addition to transparency. 3-D plotting functions consist of:

- Surface, contour, and mesh
- Image plots
- Cone, slice, stream, and is surface

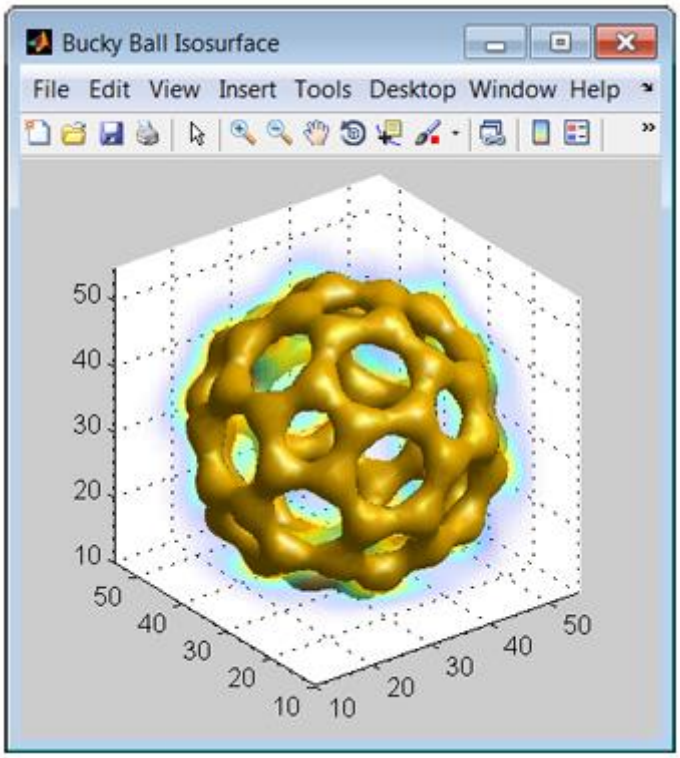


Figure 4.7 A 3-D is surface plot illuminating the geodesic ground construction of a carbon-60 fullerene particle.

4.3.4.13Creating and Editing Plots Interactively

MATLAB afford interactive tools for designing in addition to alteration graphics. From a MATLAB figure window, it is able to present the subsequent tasks:

- Drag and drop innovative data sets onto the figure
- modify the property of some article on the figure
- Zoom, rotate, pan, as well as modify camera perspective and lighting
- Add annotations along with data tips
- illustrate shapes
- produce a function that preserve be use again with dissimilar data

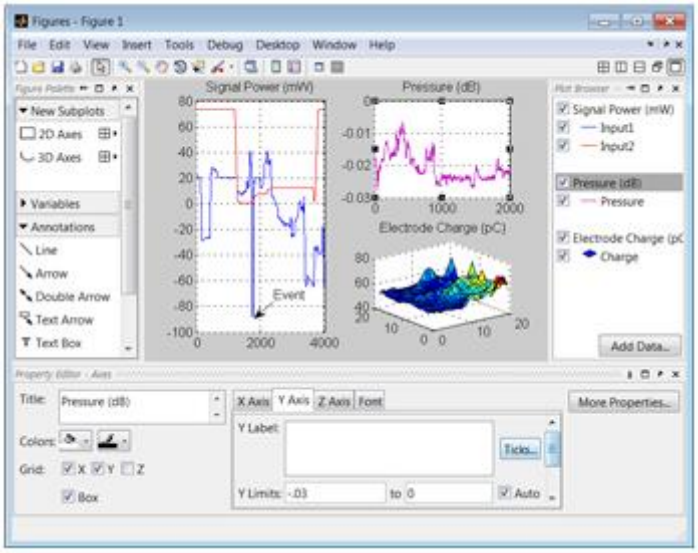


Figure 4.8 An assortment of graphs, build interactively by exhausted data sets on the plot window, generate new subplots, altering property such as colors as well as fonts, and addition annotation.

4.3.4.14 Importing and Exporting Graphic Files

MATLAB consent to individual read and writes common graphical along with data file formats, such as GIF, $JPEG$, BMP, EPS, $TIFF$, PNG, HDF, AVI, and PCX. As a consequence, individual can export MATLAB plot to additional applications, like a Microsoft Word along with Microsoft PowerPoint, or to desktop distribute software. Previous to export, single be able to generate and concern style templates, cover up characteristics such as layout, print, as well as line width, to get together publication stipulation.

4.3.4.15 Performing Numeric Computation

MATLAB hold mathematical, arithmetical, and engineering functions to maintain the entire common engineering as well as science operations. These functions, build up by specialist in mathematics, are the organization of the MATLAB language. The center math function utilizes the LAPACK as well as BLAS linear algebra subroutine libraries along with the FFTW Discrete Fourier Transform documents. For the reason that these processor-dependent

libraries are determine to the dissimilar platforms that MATLAB supports, they implement sooner than the equal C or C++ code.

MATLAB presented the subsequent kind of functions for presenting mathematical operations with examining data:

- Matrix manipulation as well as linear algebra
- Polynomials and interpolation
- Fourier analysis and filtering
- Data analysis and statistics
- Optimization and numerical integration
- Ordinary and partial Differential equations(ODEs and PDEs)
- Operations on sparse matrix.

MATLAB is able to execute arithmetic on a wide variety of data kind, including dual, singles, as well as integers.

Add-on toolboxes afford particular mathematical calculating functions for region including indication processing, optimization, statistics, emblematic math, incomplete discrepancy equation solving, along with curve fitting.

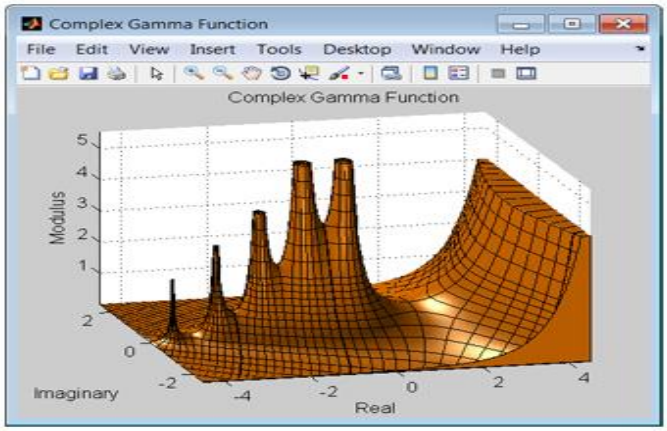


Figure 4.9 Plot performances the multifaceted valued gamma function on the multipart plane, where the elevation of the exterior is the modulus, or complete value, as well as the curve lines are modulus and phase.

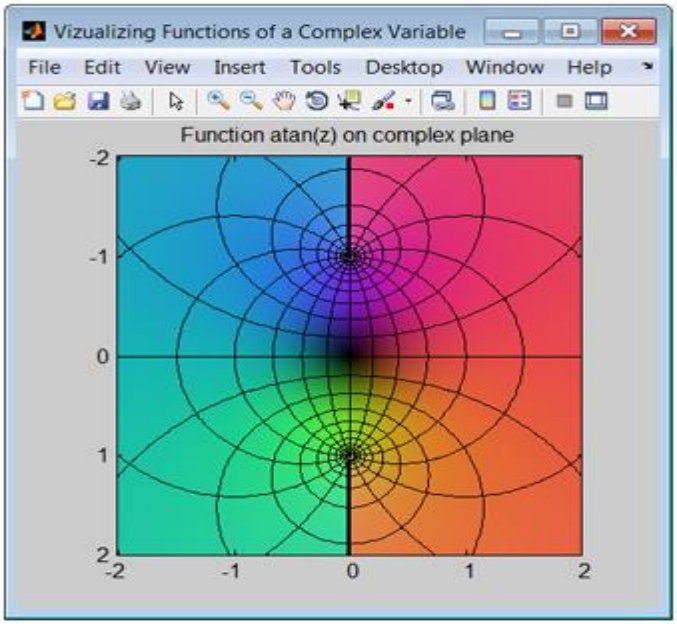


Figure 4.10 Plot of multifaceted function atan (z). Contour lines for the genuine and imaginary parts are cover up on a color image presentation importance and phase.

4.3.4.16 Publishing Results and Deploying Applications

MATLAB present a quantity of attribute for documenting as well as distribution our effort. Particular can integrate the MATLAB code with additional languages along with applications with organize the MATLAB algorithms moreover applications as separate programs or software modules.

4.3.4.17 Publishing Results

MATLAB facilitates us the export of results as plots or as whole report. One container export plots to every popular graphics file formats as well as subsequently import the plots into additional packages,like that Microsoft PowerPoint or Microsoft Word, individual can mechanically distribute the MATLAB code inside HTML, Word, LaTEX, and additional formats.

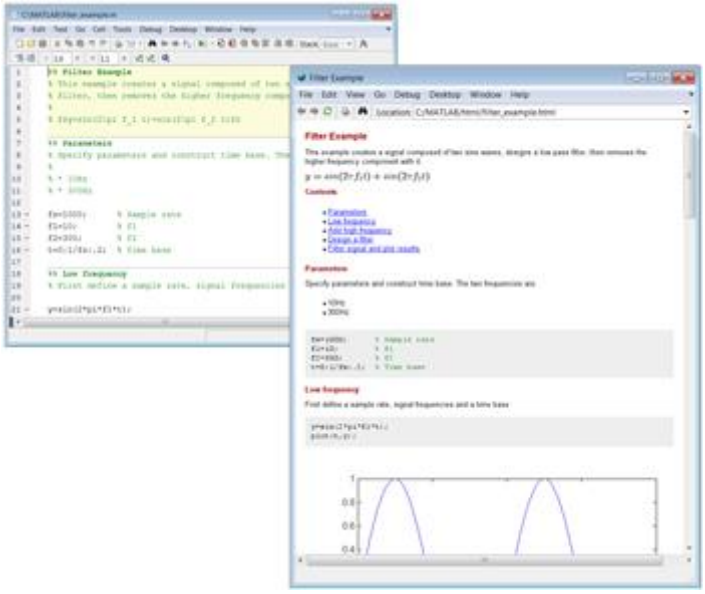


Figure 4.11 MATLAB program (left) distribute to HTML (right) employing the MATLAB Editor. Consequences output to the command window or to plots are incarcerated and included, as well as the commentaries are turned into segment headings along with body text into the HTML.

To generate additional multifaceted reports, such as simulation run along with multiple parameter tests, single can use MATLAB Report Generator.

4.3.5 Hardware Requirement

- Processor: Intel Pentium IV Processor
- High defintion camera with RGB color format support and high defintion reslution supopprt facility.
- RAM: 2 GB
- Hard Disk: 20 GB
- Monitor: 15”
- Keyboard: Standard 102 keys
- Mouse: 3 buttons

4.3.6 Software Requirement

- Operating System: Any Version of Windows, Linux or Unix
- Programming Tool: Matlab

4.4 Summary

This chapter gives the details of the scope of the project, product perspective, acronyms and abbreviations, functional requirement, non functional requirements, resource requirements, hardware requirements, software requirements etc. Again the non functional requirements in turn contain user requirements, assumptions and dependencies, external user interfaces etc.

Chapter-5

IMPLEMENTATION

5.1 Introduction

The implementation phase of any project improvement is the better significant phase like it acquiesce the concluding explanation, which explain the trouble on hand. The completion phase occupies the definite materialization of the thoughts, which are articulated in the study certificate and build up inside the design phase. Completion is supposed to be great mapping of the design article in an appropriate programming language in organize to attain the essential ultimate product. Frequently the product is insolvent owing to inaccurate programming language preferred for implementation or inappropriate technique of programming. It is enhanced for the coding part to be straight connected to the design part in the wisdom if the design is into terms of article leaning terms afterward implementation ought to be if possible holding out in an object oriented technique. The reason relating to the programming languages as well as platform preferred are illustrated in the subsequently pair of segment.

The implementation stage in a system project in its own right, it involves

- Careful planning
- Investigation of the current system and the constraints on implementation.
- Training of staff into the recently build up system.

5.2 Implementation

Implementation of some software is constantly come first by significant decisions concerning assortment of the stage, the language utilized, et cetera. These assessments are frequently subjective by numerous factors such as genuine environment during which the system workings the velocity that is necessary, the security apprehension, and additional implementation exact details. There are 3 main implementation choices that have been absolute earlier than the implementation of this development. These are as given subsequently:

1. Assortment of the stage (Operating System)
2. Collection of the programming language for progress of the application
3. Coding guideline to be followed

5.3 Implementation Requirements

Software Requirement:

- The language chosen for this project is MATLAB 2010a
- Operating System used: Microsoft windows XP

5.4 Selection of the platform

Windows® XP present the major reliable edition of Windows constantly with the most excellent security as well as privacy features Windows has always presented. On the whole, security is enhanced inside Windows XP to assist you have a *secure, safe, as well as confidential* computing occurrence. Windows XP existing into 2 version-Windows XP Home version for home utilized, and Windows XP proficient for businesses of every extent. Security features inside Windows XP Home version build it yet safer intended for you to store and look through at the Internet. Windows XP Home version approach with developed in Internet link Firewall software that presents you with a flexible protection to security intimidation while you are linked to the Internet mainly if you utilize for all time on connections like a cable modems as well as DSL. Windows XP specialized consist of the entire of the security abilities of Windows XP Home Edition, in adding additional security administration features. These significant novel safety features determination decrease your IT costs as well as develop the safety of your business systems. Windows XP Home version security service is intended to be stretchy, as well as get into account a broad diversity of security and privacy condition that you will countenance as a home consumer. If you are previously recognizable with the security model during Microsoft® Windows NT® edition 4.0 along with Microsoft® Windows® 2000, you can identify several of the security features inside Windows XP Home Edition. By the equal time, you can also discover a quantity of familiar features that is distorted considerably beside with innovative features that will get better your aptitude to handle system security. For instance, if you employ the Internet to talk online or to send as well as accept e-mail, you might be susceptible to hacker attack. To defend you from these problems, Windows XP has integrated improved security features that build your online knowledge yet safer. Let's obtain a appear on the significant security as well as privacy features inside Windows XP Home Edition which build you with your information additional secure though you are containing the majority creative Windows user experience always. Windows XP Professional consists of a quantity of features that businesses are able to utilize to defend preferred files, applications, as well as

additional resources. These features consist of access control lists (ACLs), security groups, along with Group Policy-in other to the tools that agree to businesses to configure and handle these features. Mutually they present a powerful, yet stretchy, access control communications for business networks.

Windows XP recommend thousands of security associated setting that preserve be implemented independently. The Windows XP operating system also consist of previously describe security templates, that businesses container implement with no alteration or utilize as the essential for a additional modified security configuration. Businesses will relate these security templates have been given while the:

- Generate a resource, like a folder or file contributes to, as well as moreover allow the defaulting access control catalog settings or implement custom admittance control catalog settings.
- Place client inside the standard security groups, such as Users, Power Users, as well as Administrators, and utilized the defaulting ACL settings that used to those security groups.
- Make use of the fundamental, companionable, secure, as well as Highly Secure Group Policy templates that is presented with the operating system.

All of the Windows XP security features-$ACLS$, security groups, as well as Group Policy-have default settings that will be customized to suit an exacting association. Businesses are also able to build utilize of relevant tools to implement with change access control. Several of these tools, like the Microsoft administration Console snap-ins, are mechanism of Windows XP specialized. Additional tools are integrated with the Windows XP specialized source Kit.

5.5 Selection of Language

For the implementation of this development we required supple systems implementation language. Compilation ought to be comparatively uncomplicated compiler, present low-level entrance to memory, present language build that map professionally to machine instructions, as well as necessitate minimal run-time hold up. Program ought to be accumulating for an extremely wide diversity of computer platforms as well as operating systems with least modify to its source code. For the Graphical User Interface (GUI) programming, language preferred must

be easy to employ, secure, structural design neutral as well as portable. Further necessities of GUI are:

1. **User interface management:** Windows, menus, toolbars as well as additional presentation mechanism be hold up by the language.
2. **Data and presentation management:** language is necessity enclose a wealthy toolset for proposing data to the user as well as influence that data.
3. **The Editor:** The language is supposed to contain an editor, an influential and extensible toolset for constructing convention editors.
4. **The Wizard Framework:** A toolset for effortlessly making extensible, user responsive Wizards to direct users during additional multifaceted responsibilities.
5. **Configuration management:** somewhat than boringly put in writing code to admittance remote data as well as handle and save user-configurable settings, et cetera. The entire of this is being able to be glowing managed by Matlab. Consequently Matlab is preferred for the GUI improvement.

5.6 Coding guidelines

The subsequent are the guiding principle subsequent throughout the implementation of the development of the project.

- Initialize the entire member data as well as confined variables. Every pointers ought to be initialized to apposite values or$NULL$.
- A counter variable that is utilize merely in for loop must be initialized inside that loop, relatively than on the top of the function, where, variables confirmed in nested loops determination be frequently constructed as well as destructed. During cases where building or destruction is costly, it might be preferable to affirm the variable outside the loop.
- Utilize tracing declaration at serious points inside the code.
- For the entire of data kind definition has been utilized.
- The total message configure is accumulated in header file.
- The entire functions must not go beyond more than 100 lines.
- Function pointers are not used.
- All the code should be properly indented
- Use conditional compilation statements wherever required.

5.7 Implementation Strategy

In this research work and the proposed project activity we have proposed a highly robust and effective approach for hand gesture detection in real time scenario and the developed system has been enhanced for being employed for certain command generation applications which can be employed for device applications. For hand gesture recognition and real time implementation we have considered that if the background regimentation is accomplished prior and then in a real time frame sequences, retrieved from camera, the distinguish between real time palm area and the segmented background, on the basis of relative compactness value, the ROI for hand gesture can be achieved. The shape based architecture can give better results in real time if it is implemented with certain defined .thresholds which is independent of color factor as it happens in tradition color based gesture recognition. Again, the implementation of certain morphological approach to distinguish hand shape, can be a potential scheme to enhance preciseness of detection. Therefore, in this research work, few morphological schemes, centroid consideration, palm division and threshold based finger tracing with thumb calibration etc have been employed. This makes the system robust in terms of accuracy and precise results.

Unlike conventional schemes, this system doesn't consider any prepared image databases and on the basis of available databases the classification to be done. In our proposed system, we have made our system responsive in real time application environment. Considering a gesture recognition in real time scenario, without possessing any available databases, is a big deal and therefore, in such circumstances, the proper frame synchronization and pixel by pixel analysis would be must.

In this research work initially, the camera is calibrated so as to receive video sequences in applicable frame resolution as sequence. Again the entire GUI is divided and respective window is created. Once the complete Window has been generated then the background registration is achieved so as to prove a still reference for further video analysis and process. Now, the sequence of frames is generated and respective median are calculated for every frames. On the basis of these frames the background is estimated and then certain threshold parameters are assigned on the basis of which the distinction between gesture and registered background can be done. Once the gesture has been retrieved in terms of pixels and flowing image sequences in GUI interfaces, then the morphological operation is applied that removes unwanted blobs and then the distance between two hand edges are calculated. Initially this distance is estimated from left and then the pixels having more differences as compared to average defined are removed.

The retrieved posture image is then divided into two parts while removing elbow region from consideration. In order to provide better accuracy, the right size image part is ignored while considering left part for analysis and vice versa. Thus for each section relative compactness is calculated along with radial distances. On the basis of compactness value and associated radial distance the ultimate value is evaluated which decides the gesture count and on that basis the respective commands are generated. In this noble approach there is no need of any external databases to train algorithms. This makes this system more applicable and realizable for applications.

The pseudo code for the developed system model and algorithms have been given as follows:

5.8 Algorithm Description for Shape based Hand Gesture recognition system

File name: MainFinal.m

Input: real time hand gesture through Camera.

Output: Gesture detected, generated commands as per gesture provided

Pseudo Code:

1. *Close serial data or Web cam data*
2. *Clear all temporary file*
3. *Close all running process*
4. *Interface Web connectivity with functional port*
5. *Initiate Serial port*
6. *Delete image acquisition*

   delete(imaqfind)
7. *Calibrate webcam*

   vid←videoinput('winvideo',1,'YUY2_320x240');

   vid←videoinput('winvideo',1,'RGB24_320x240');
8. *Trigger configuration for webcam*
9. *Configure Camera as Manual*
10. *Set No of frames per trigger*
11. *Set total triggers count*

    Trigger count←Infinite

12. Select color format/color space as RGB

13. Start Video

Trigger video

13. Update variable to store video frames

im←getdata(vid,1);

14. Display video on GUI Axis

imshow(im);

15. Define window size

w_size← round(size(im,2)/2);

16. Update number of row

Nr← size (im,1);

17. Perform for Background registration

18. Select a Level value to denote process

L ← 5;

19. Update frames

frames← zeros(nr,size(im,2),3,L);

20. Process waitbar

h1←waitbar(0,'Please wait while adjusting the background');

for ii = 1:L

waitbar(ii/L)

trigger(vid);

Update Image variable im

Im←getdata(vid,1); % Get the frame in im

21. Update a value Ic with Im

Ic←im;

22. Update matrix of frame

frames (:,:,:,ii)←Ic;

end

23. Stop background registration

close (h1)

24. Perform median to get background

25. Update a variable BG with median value

BG ←median (frames,4);

26. Assign Thresholds

Cl2 ← 1.47;

P1 ← 0.75; % in percentage

27. Initialize a variable Cth with unity

Cth ← 1;

Count ←zeros(1,5);

28. Load color component

load color

29. Initiate loop

for i=1:300

trigger(vid);

30. Update Im

Im ←getdata(vid,1); % Get the frame in im

Ic ←im;

bw ←moving_mask(Ic,BG);

31. Subplot GUI for proper dispaly

subplot(2,3,[1 2]);

imshow(im)

bwbc ←bw;

32. Apply morphological operations

33. Apply Morphological operation

34. Update a binary image value

bw ←bwmorph(bw,'dilate',4);

bw ←bwmorph(bw,'bridge');

bw ←imfill(bw,'holes');

35. Apply morphology to eliminate small blobs

Bw ←bwareaopen(bw,1000);

BW2 ←bwperim(bw);

diff1 ←zeros(1,size(BW2,2));

36. Start calculating distance between two hand edges from left

forkk = 3:size(BW2,2)

ids ←find(BW2(:,kk));

if ~isempty(ids)

37. Update a difference value

diff1(kk) ← ids(end)-ids(1);

```
                else
            diff1(kk) ←0;
        end
end
    38. Take average of first 10 values
            av10 ← mean(diff1(2:12));
    39. Find value having more difference then average values
            idval ←find(diff1>(av10+20));
            if ~isempty(idval)
    40. take first value as start of wrist
if length(idval)==1
        cutw ←idval(1);
else
cutw ←idval(2);
end
bw(:,1:cutw) ←0;
    41. Calculate Compactness for left part of Palm
    42. Find out centroid
            [xsys] ←find(bw);
            xbar ←round(mean(xs));
            ybar ←round(mean(ys));
    43. Take the left portion and calculate compactness
    44. Update a variable with binary image for left side
            bwLeft ←bw;
    45. Delete all right hand side values
            bwLeft(:,ybar+10:end) ←0;
    46. Calculate compactness
            CL ←calculate_compactness(bwLeft);
            BW2 ←bwperim(bw);
            P ←sum(sum(BW2));
            A ←sum(sum(bw))
            Ca ←(P*P)./(4*pi*A);
    47. Plot the processed image for compactness presentation
            subplot(233)
```

imshow(bw)

hold on

plot(ybar,xbar,'r');*

plot(ybar,[1:size(bw,1)],'g-')

hold off

title(['Compactness Ca= ' num2str(Ca)])

subplot(234)

imshow(bwLeft)

title(['Compactness CL = ' num2str(CL)])

pause(0.1)

48. Estimate Radial Distance

49. Take right side portion of the hand

bwright =bwbc;

bwright←bw;

50. Delete all left hand side values

bwright(:,1:ybar-5) ←0;

subplot(235)

51. Calculate perimeter points

BWR ←bwperim(bwright);

Show image

imshow(BWR);

52. Use Generated Gesture Sequence As Certain Applicable Commands

subplot(2,3,[1 2]);

ifCa<=Ca1

disp('0 : stop');

title('0');

Count(1) = Count(1)+1;

Count(2:5) = 0;

if Count(1)>0

fwrite(s,'s','char');

end

elseifCa>Ca1 &&Ca<=Ca2

if CL<Cl1

```
        disp('1 : left');
        title('1');
Count(2) = Count(2)+1;
Count(3:5) ← 0;
Count(1) ← 0;
if Count(2)>Cth
fwrite(s,'a','char');
end
else
disp('6:right')
title('6');
Count(3) ←Count(3)+1;
Count(4:5) ←0;
Count(1:2) ←0;
if Count(3)>Cth
fwrite(s,'d','char');
end
end
else
    53. Calculate radial distance
[B,L] = bwboundaries(bwright,'noholes');
if size(B,1)==1
            Co = B{1,1};
elseif size(B,1)>1
forss = 1:size(B,1)
                        Calculate Size
siz(ss) = length(B{ss,1});
end
    54. Evaluate maximum vale in matrix
    55. Update matrix
            [val ix] <- max(siz);
            Co ←B{ix,1};
else
continue;
```

```
end
    56. Update Distance
dist←sqrt((xbar-Co(:,1)).^2+(ybar-Co(:,2)).^2);
 Calculate threshold
Thrd←max(dist)*P1;
        W = (dist>Thrd);
    57. Find out total regions
        [L Totalfingers] ←bwlabel(W);
        subplot(2,3,6)
        plot(dist);
        hold on
    58. plot threshold line
        plot(1:length(dist),Thrd,'r-')
        title(['Finger = ' num2str(Totalfingers)])
                hold off
        subplot(2,3,[1 2]);
        if CL<Cl2
ifTotalfingers == 2
disp('2 : reverse')
title('2');
            Increment count
                Count(4) = Count(4)+1;
        Count(1:3) ←0;
        Count(5) ←0;
if Count(4)>Cth
fwrite(s,'x','char');
        end
        elseifTotalfingers ==3
        disp('3')
        title('3');
        elseifTotalfingers ==4
disp('4')
title('4');
else
```

```
disp('Unknown');
end
else
ifTotalfingers == 1
disp('1')
title('1');
disp('1 : left');
title('1');
Count(2) ←Count(2)+1;
Count(3:5) ← 0;
Count(1) ←0;
if Count(2)>Cth
fwrite(s,'a','char');
end
elseifTotalfingers ==2
disp('2 : reverse')
title('2');
Count(4) ←Count(4)+1;
Count(1:3) ← 0;
Count(5) ← 0;
if Count(4)>Cth
fwrite(s,'x','char');
end
elseifTotalfingers ==3
disp('9')
title('9');
elseifTotalfingers ==4
disp('5 : start')
title('5');
Count(5) = Count(5)+1;
Count(1:4) ←0;
if Count(5)>Cth
fwrite(s,'w','char');
end
```

```
                else
disp('Unknown');
end
end
end
end
end
```

59. *Clkose serial data*

```
fclose(s)
```

File name: Moving_Mask.m

Input: Real time hand gesture binary data and background segment reference pixel data (im, BG)

Output: Detected Hand gesture

1. *Seprate R G B*

```
Rbg = BG(:,:,1);
Gbg = BG(:,:,2);
Bbg = BG(:,:,3);
```

2. *Calculate density diff*
3. *Apply Sobel operator or compass operator*

```
s = [1 2 1; 0 0 0; -1 -2 -1];
```

4. *Update horizontal and vertical feature mapped pixels after convolution with Sobel operator*

HRdens ←conv2(Rbg,s);

VRdens ←conv2(Rbg,s');

HGdens ←conv2(Gbg,s);

VGdens ←conv2(Gbg,s');

HBdens ←conv2(Bbg,s);

VBdens ←conv2(Bbg,s');

5. *Estimate density function using horizontal and vertical components*

DensRf ← (HRdens+VRdens)./9;

DensGf ← (HGdens+VGdens)./9;

DensBf ← (HBdens+VBdens)./9;

Densbg ←cat(3,DensRf,DensGf,DensBf);

im ←double(im);

6. *Calculate color difference*

diff ←abs(BG-im);

diff ← max(diff,[],3);

bw ← (diff>30);

7. *Calculate density diff*
8. *Seprate R G B*

R1 ←im(:,:,1);

G1 ←im(:,:,2);

B1 ←im(:,:,3);

9. *Calculate and update density diff*

HRdens1 ←conv2(R1,s);

VRdens1 ←conv2(R1,s');

HGdens1 ←conv2(G1,s);

VGdens1 ←conv2(G1,s');

HBdens1 ←conv2(B1,s);

VBdens1 ←conv2(B1,s');

10. *Based on updated horizontal and vertical components of real time data calculate density function*

DensRf1 ← (HRdens1+VRdens1)./9;

DensGf1 ← (HGdens1+VGdens1)./9;

DensBf1 ← (HBdens1+VBdens1)./9;

11. *Calculate final density value*

Dens1 ←cat(3,DensRf1,DensGf1,DensBf1);

diff1 ←abs(Dens1-Densbg);

diff1 ←max(diff1,[],3);

12. *Update a variable with those pixels having difference value more than threshold 30*

    bw1 = (diff1>30);

13. *Update Binary image*

    bw1 ←bw1(2:end-1,2:end-1);

    BW ←or(bw1,bw);

14. *Perform close operation or morphology operation*

    BW ←bwmorph(BW,'bridge');

    BW ←imfill(BW,'holes');

    bwcl ←bwmorph(BW,'close');

    bwcl ←bwmorph(bwcl,'open');

    bwcl ←bwareaopen(bwcl,150);

File name: calculate_compactness.m

Input: Binary image bw

Output: Value of compactness for segmented hand part in real time

1. *Perform perimeter function for binary data using Matlab function and operate it on binary data being received from camera*
2. *Update binary data*

   BW2 = bwperim(bw);

   P = sum(sum(BW2));

   A = sum(sum(bw));
3. *Calculate perimeter as per equation*

   *C=(P*P)./(4*pi*A);*

Thus, taking into consideration of the above mentioned Pseudo code and sequential flow, the final system model for Hand gesture recognition system has been developed which not only

ensures optimal function for real time data without any preloaded training details but it also generates certain feature based commands which can be employed for certain device functions.

Chapter-6

TESTING

Testing is an important phase in the development life cycle of the product; this was thephase where the error remaining from all the phases was identified. Therefore, the system functional testing exhibits a very significant responsibility for quality assurance and ensuring the reliability of the software. During the testing, the program to be tested was performed with certain defined test scenarios and the output of the program for the test cases was evaluated to determine whether the program is performing as expected. In case of any error the irregularity were detected and corrected for optimal functioning by employing following testing approaches and phases and correction was recorded for future references. Thus, a series of testing was performed on the system before it was ready for implementation.

6.1 Test plans

In this test plan all major activities are described below:

- Unit testing
- Integration testing
- System testing

6.1.1 Unit Testing

Unit testing focuses verification effort on the unit of software design. Employing the unit test paradigms, developed in the development design phase of the system design as a guide, significant control conduits are validated for uncovering or unleashing errors in the developed system models. The developed interfaces of individual module were tested to ensure proper flow of the information into and out of the modules under consideration. Boundary conditions have been verified properly. The every comprising and autonomous paths have been executed for assuring that all statements in the module can be effectively executed minimum once and all error-handling approaches was taken into consideration.

The individual unit has been tested in depth under varying parameters so as to make it ensure that the developed system could not have to face any failure with varied implementation conditions. The system model testing has been accomplished while

developing individual models and ultimately the individual unit was verified to be functional as per expectations in varied functional circumstances.

In our research or project work we have prepared few individual functions that are further integrated to accomplish overall research objectives. These unit models are calculate_compactness.m, calibration.m, moving_mask.m, Config_webcam.m ,color.mat

The individual testing phases for each module have been given as follows:

Sl # Test Case : -	UTC-1: Config_webcam.m
Name of Test: -	Camera calibration
Item being tested: -	Binary image input through camera
Sample Input: -	Binary image data
Expected output: -	Camera is functional and the binary data is visualized on axis defined using image show function
Actual output: -	Same as expected output.
Remarks: -	Successful

Sl # Test Case : -	UTC-2 Moving_mark.m
Name of Test: -	Masking the ROI (Gesture in real time data sequence)
Item being tested: -	Binary images, segmented background, Sobel operator
Sample Input: -	RGB format real time video data or gesture data
Expected output: -	Masking of the gesture or distinguishing gesture from background (ROI segmentation)
Actual output: -	Same as expected output.
Remarks: -	Successful

Sl # Test Case : -	UTC-3 Calculate_compactness.m
Name of Test: -	Calculation of compactness for divided hand into left and right parts and finding compactness for palm half as well as fingers
Item being tested: -	Real time binary data of hand, perimeter (p) and Area (A)
Sample Input: -	Hang gesture video
Expected output: -	Compactness value CL and CA
Actual output: -	Same as expected output.
Remarks: -	Successful

6.1.2 Integration Testing

Data can be lost across certain developed interface and a particular model can have any conflicting effect on other module and sub functions in case these two modules are when combined they might loss to deliver optimal results. In order to examine such effectiveness the integration testing is accomplished. The integration testing is nothing else but a symmetric technique to construct a program structure while simultaneously conducting tests to unleash any possible errors allied with the system or inter-module interface. The all incorporating sub functions or modules are combined together so as to exhibit ultimate function. In the following section, the integrated module has been tested and the allied responses have been mentioned.

Sl # Test Case : -	ITC-1 MainFinal.m
Name of Test: -	Load Main file MainFinal.m
Item being tested: -	Over all integrated System architecture functioning
Sample Input: -	Every parameters of the Architecture
Expected output: -	Overall system functioning with all features. (Hand gesture detected and as per specified instruction the generation of gesture based commands.
Actual output: -	Same as expected output.
Remarks: -	Successful

6.1.3 System Testing

After the integration testing, the software was entirely combined as a single unit system model; the errors caused due to interfaces have been unleashed and the raised errors have been corrected in the final series of software tests, validation tests begin. Validation test proceeds when the software functions in such a manner which can be expected by the user or customer. In this testing the system was tested according to the system requirement specification. System testing was in fact a succession of diverse tests whose principal rationale was to fully work out the computer-based system. Though, the individual test has a diverse principle all work to bear out that all comprising system elements are functional efficiently and are integrated properly and they perform expected functions.

Sl # Test Case : -	STC-1
Name of Test: -	Compatibility check for the application
Item being tested: -	
Sample Input: -	
Expected output: -	
Actual output: -	Same as expected output.
Remarks: -	Fail

Sl # Test Case : -	STC-2
Name of Test: -	System testing for OS
Item being tested: -	Older version of Windows
Sample Input: -	Install and execute the project in older version of OS.
Expected output: -	Should show some compatibility issue.
Actual output: -	Same as expected output.
Remarks: -	Successful

Sl # Test Case : -	STC-3
Name of Test: -	System testing for performance time

Item being tested: -	Average time of execution in two different PC with dual core and Pentium processor
Sample Input: -	Install and execute the application and record the average time of operation in both environments.
Expected output: -	The execution in dual core is faster than Pentium.
Actual output: -	Same as expected output.
Remarks: -	Successful

The above mentioned test results exhibits that the every modules and associated sub functions are working efficiently and these are capable of functional with any circumstances as developed for. In the next chapter, the retrieved results have been obtained. The sequential system implementation and its resulting functions have been presented in that chapter.

Chapter-7

RESULTS AND ANALYSIS

In this presented research work, a highly robust and efficient hand gesture recognition system with precise gesture based command generation scheme has been developed. The proposed system is functional with real time gesture data which is facilitates by means of an image capturing device or camera. A different approach as compared to conventional database and supervised training based schemes; the proposed scheme facilitates a highly robust mechanism which do accomplishes gesture detection irrespective of color of skin or change in data. The proposed scheme doesn't employ any training sequences and it takes into consideration of a background registration approach as reference. With respect to background references the segmentation of gesture has been done along with geometrical based compactness detection. The variation of compactness with respect to certain defined thresholds represents signifies certain gesture segmentation. Overall system considers two predominant factors, one is compactness of left half of hand encompassing palm space and another represents the radial distance. Conglomerating this variable altogether a final real time variable has been defined which states the gesture count.

In order to accomplish overall objectives the following steps have been employed; feature extraction, compactness (Cl and Ca) estimation, radial distance estimation etc.

Being a threshold based scheme the proposed system considers following threshold parameters:

Compactness I (CA): The situation or event with compactness (Ca) less than defined threshold 1.65 represents the pattern zero while its value as 1.65 to 2.53 gives pattern either 1 or 6. Similarly, another compactness variable (Cl) with contemporary value less than 1.47 represents 1,2,3 and 4 and on contrary the Cl value more than 1.47 gives 5, 6,,7, 8 or 9.

The snaps of the developed modules and its results have been presented as below.

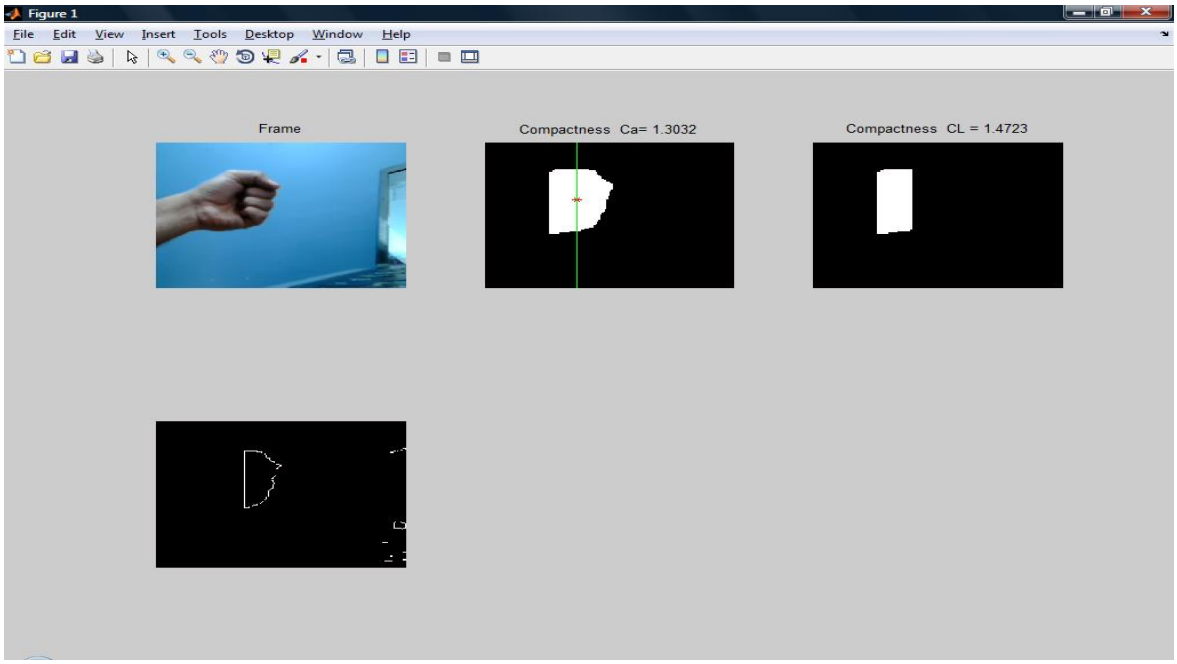


Figure 1
File Edit View Insert Tools Desktop Window Help
Frame
Compactness Ca= 1.3032
Compactness CL = 1.4723

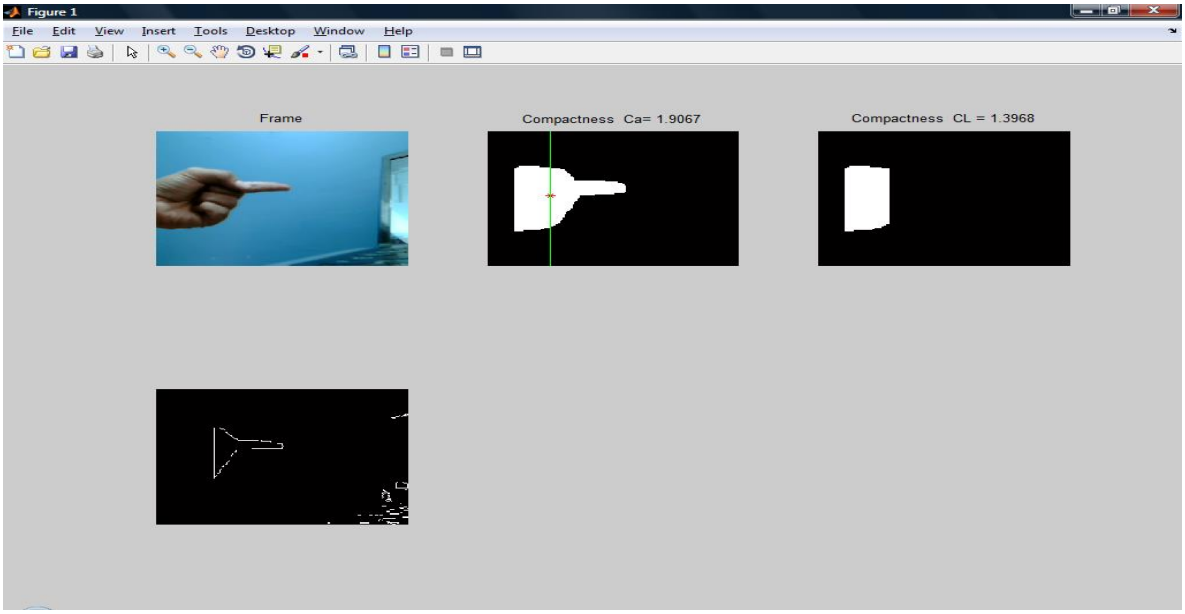


Figure 1
File Edit View Insert Tools Desktop Window Help
Frame
Compactness Ca= 1.9067
Compactness CL = 1.3968

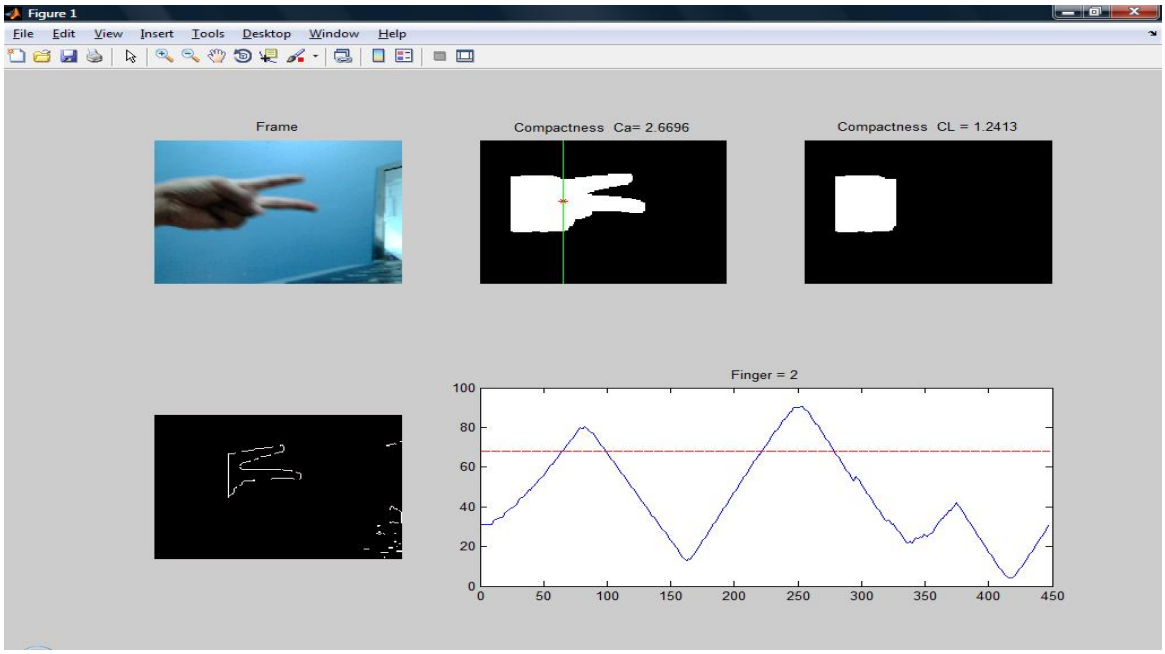


Figure 1
File Edit View Insert Tools Desktop Window Help
Frame
Compactness Ca= 2.6696
Compactness CL = 1.2413
Finger = 2
100
80
60
40
20
0
0 50 100 150 200 250 300 350 400 450

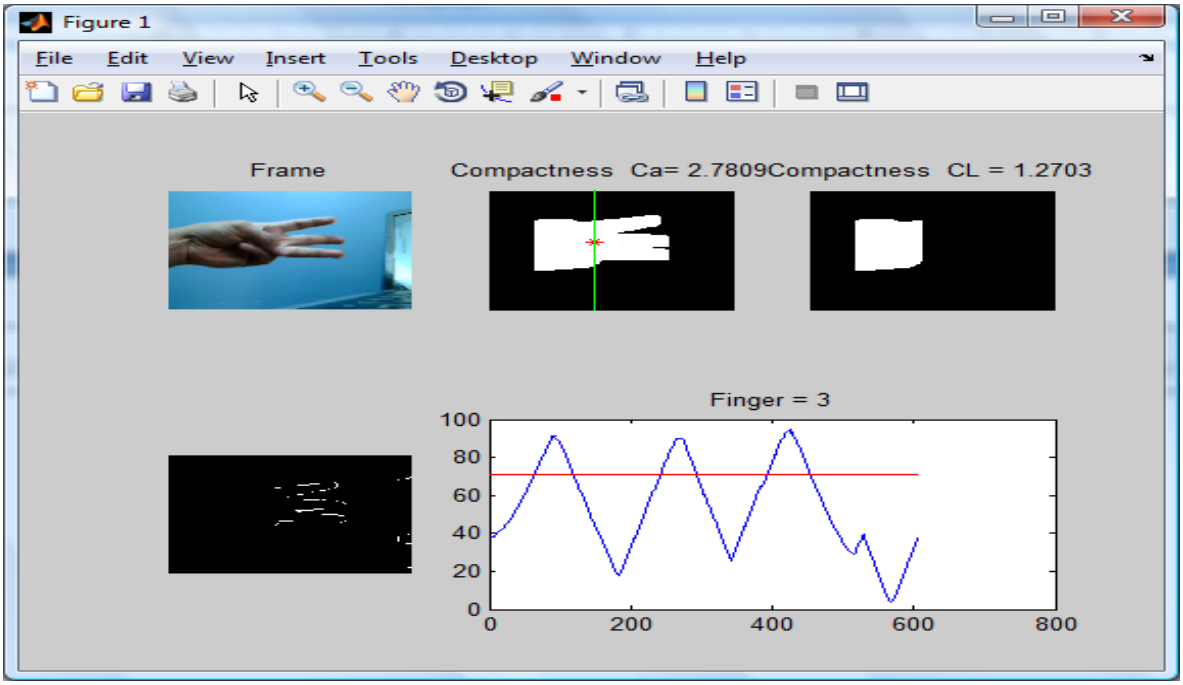


Figure 1
File Edit View Insert Tools Desktop Window Help
Frame
Compactness Ca= 2.7809Compactness CL = 1.2703
Finger = 3
100
80
60
40
20
0
0 200 400 600 800

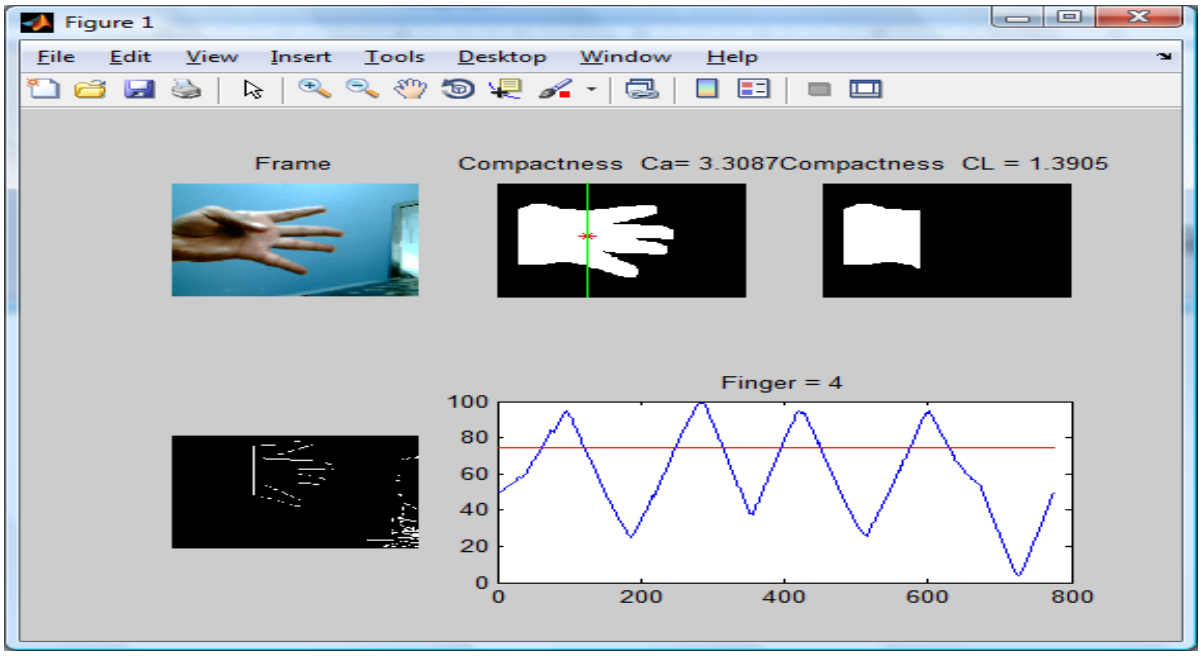


Fig 7.1: Snaps of developed modules and its results

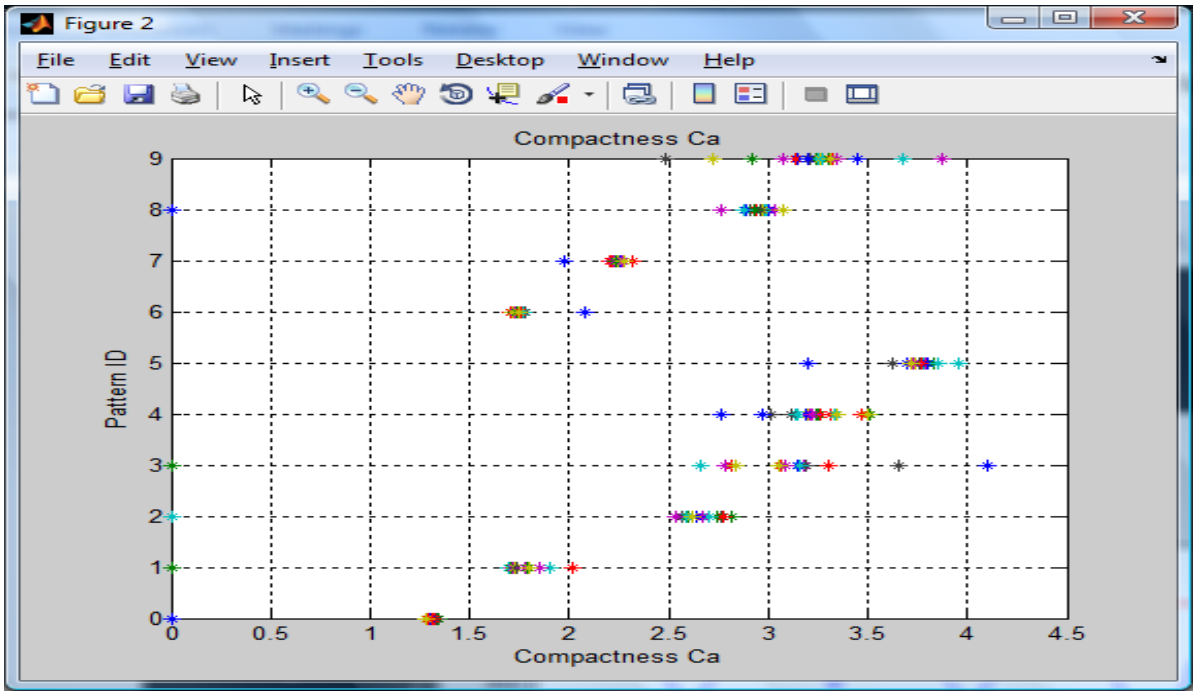


Fig7.2**:-**Thresold values for Compactness I(Ca) for hand patterns from zero to nine

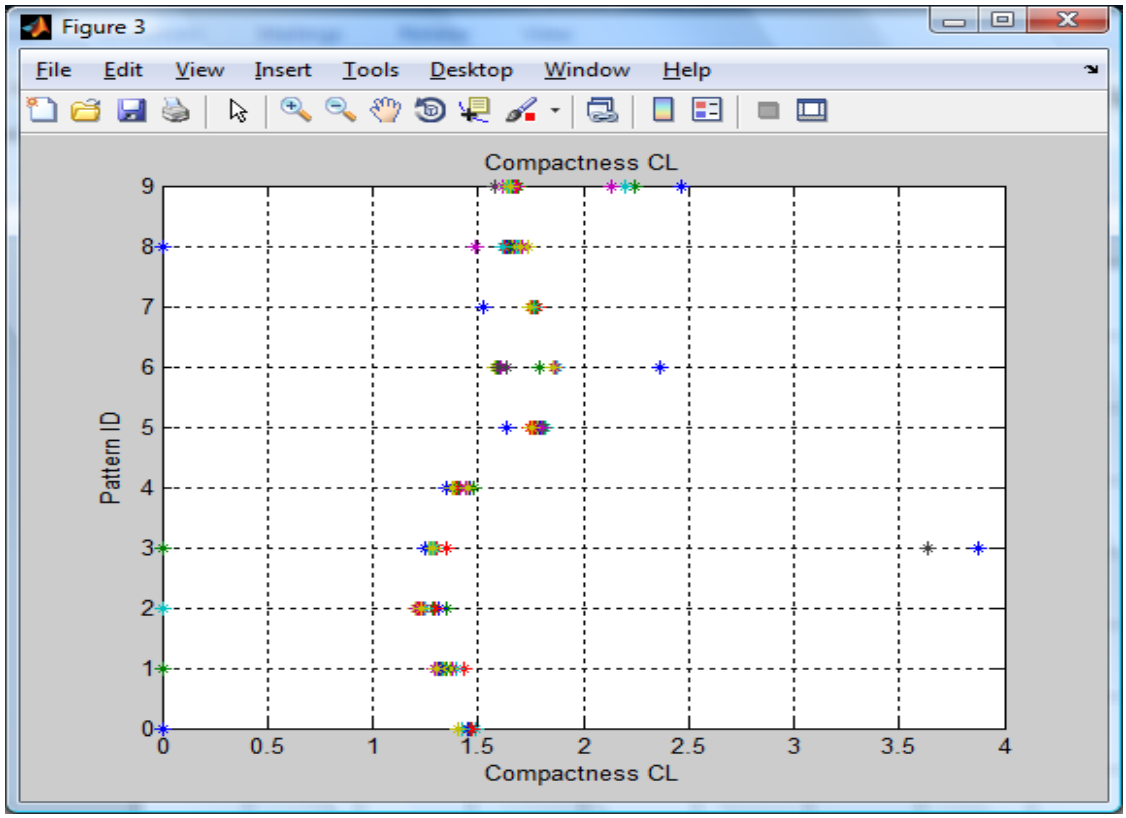


Fig 7.3**:-** Threshold values for Compactness II(Cl) from zero to nine

Chapter-8

CONCLUSION

In present scenario and the era of advanced technologies, automation and advanced device development are on its zenith. A number of researches have been developed for utilizing human gesture or human behavior/traits as instruction to achieve certain task. Hand gesture is one of the predominant human traits which can assure huge application development based on hand gesture movement. A number of researches have been done for human hand gesture detection. A number of schemes are there fort gesture recognition and the individual approaches encompass its strengths as well as limitations. Numerous existing or traditional approaches exhibits hand gesture identification using training sets and based on image data based training. Very few researches have been initiated for natural gesture based posture or gesture identification. In this research work or project a highly efficient and robust hand gesture identification or detection scheme has been developed which is rooted on the shape based scheme or identification scheme. The proposed system in this thesis has encompassed a shape based gesture detection which functionally encompasses three independent features. The predominant features under consideration are feature calculation, compactness estimation and radial distance. In this work compactness which is a geometrical parameter has been considered for defining gesture pattern. There have been defined thresholds for segmented gesture space and on the basis of thresholds the classification for real time hand gesture has been done. The consideration of compactness which varies as per hand geometry has been enriched with manual variation and therefore it makes the system robust for varied user case and operational conditions. Unlike traditional systems, the developed system functions with real time gesture data which can be processed using a high quality camera devices.

This is the matter of fact that the proposed system has exhibited better in terms of overheads, computational flexibility, color independence, and accuracy, but still it possess potential for optimization using certain artificial intelligence schemes. Since the proposed system might vary as per change in orientation of hand, certain 3D feature mapping or extraction schemes can be explored and further can be employed with threshold for classification.

Taking into consideration of a simple real time hand gesture recognition and associated pattern based command generation system, the proposed system has exhibited optimal performance and

with certain future enhancement the proposed system can play a very significant role in human gesture based device development.

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APPENDIX

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