INTRODUCTION TO GESTURE RECOGNITION

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ABSTRACT
This paper describes the modular approach to Gesture Recognition, Concept behind GRS, both Static and Dynamic. Different approaches to the GR problem are evaluated. The complex task of Gesture recognition from image sequences was decomposed by first identifying the hand pose from frames and recognizing gesture. GR enables humans to interface with the machine (HMI) and Virtual environments. In this paper, we propose gesture modeling techniques which represent each gesture as a sequence of sub-gesture. The applications of gesture recognition are infinite, ranging from sign language through medical rehabilitation to virtual reality. This paper gives an overview of different methods for recognizing the hand gestures using Matlab, also proposed some algorithms which plays a pivotal role in image processing.

KEYWORDS: *Image Processing and Pattern Recognition, HMI, Classification tools, Neural Network, Segmentation.*

I. INTRODUCTION

In past decade the computational power of computer has doubled every fifteen months, while the human computer interface has not changed too much. In our daily life we use gestures to point, emphasize and navigate, speech to communicate. Gesture is a stochastic process.[1] it can be viewed as random trajectories in parameter spaces which describe hand or arm spatial states. A gesture is a movement usually of the body or limbs that expresses or emphasizes an idea by Webster's dictionary..The identification and recognition of posture, gait, proxemics, and human behaviours is also the subject of gesture recognition techniques.[2] This could potentially make conventional input devices such as mouse, keyboards and even touch-screens redundant. The primary goal of gesture recognition research is to create a system which can identify specific human gestures and use them to convey information or for device control.[3]

II. GESTURE TYPES

In computer interfaces, the two types of gestures are distinguished. When we consider online gestures, which can also be regarded as direct manipulations like scaling and rotating and in contrast offline gestures which usually processed after the interaction is finished. The main classification of gesture is

2.1. Static Gesture

It can be described in terms of hand shapes. Posture is the combination of hand position, orientation and flexion observed at some time instance. Static gestures are not time varying signals.eg. Facial information like a smile or angry face.[4]
Static gesture (pose) recognition: The user assumes a certain pose or configuration

- Template matching
- Neural networks
- Pattern recognition techniques

2.2. Dynamic gesture

Dynamic Gesture is sequence of postures connected by motions over a short time span. In video signal the individual frames define the posture and the video sequence define the gesture. eg. Taking the recognized temporal to interact with computer.[4]
Dynamic gesture recognition: With prestruck, stroke and poststrock phases.

- Time compressing templates
- Dynamic time warping
- Hidden Markov Models
- Conditional random fields
- Time-delay neural networks
- Particle filtering and condensation algorithm
- Finite state machine

III. GESTURE RECOGNITION APPROACHES

For any system the first step is to collect the data necessary to accomplish a specific task. For hand posture and gesture recognition system different technologies are used for acquiring input data. Present technologies for recognizing gestures can be divided into vision based, instrumented (data) glove, and colored marker approaches. Figure 1 shows an example of these technologies

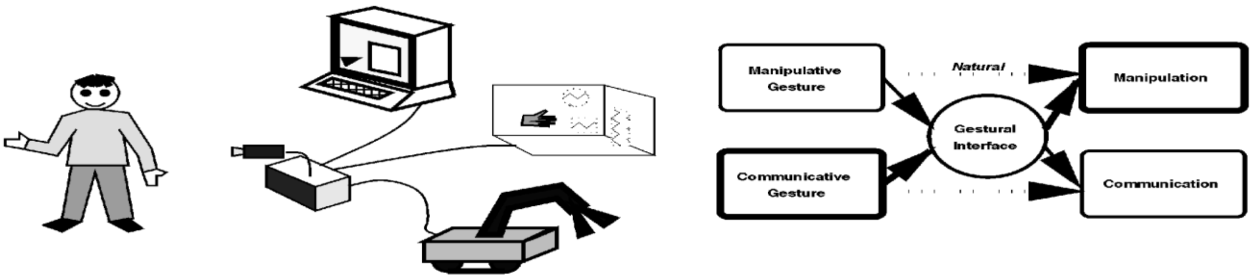


Figure 1: Recognizing gestures technologies

3.1. Vision Based approaches

In vision based methods the system requires only camera(s) to capture the image required for the natural interaction between human and computers and no extra devices are needed. Although these approaches are simple but a lot of gesture challenges are raised such as the complex background, lighting variation, and other skin color objects with the hand object, besides system requirements such as velocity, recognition time, robustness, and computational efficiency .[6].

3.2. Instrumented Glove approaches

Instrumented data glove approaches use sensor devices for capturing hand position, and motion. These approaches can easily provide exact coordinates of palm and finger's location and orientation, and hand configurations .however these approaches require the user to be connected with the computer physically .which obstacle the ease of interaction between users and computers, besides the price of these devices are quite expensive it is inefficient for working in virtual reality .[7]

3.3. Colored Markers approaches

Marked gloves or colored markers are gloves that worn by the human hand with some colors to direct the process of tracking the hand and locating the palm and fingers, which provide the ability to extract geometric features necessary to form hand shape .The color glove shape might consist of small regions with different colors or as applied in where three different colors are used to represent the fingers and palms, where a wool glove was used. The amenity of this technology is its simplicity in use, and cost low price comparing with instrumented data glove .However this technology still limits the naturalness level for human computer interaction to interact with the computer. Above is a figure showing the approach of gesture recognition and table 1 shows some parameter used in this approach [8].

Table 1: Parameter for gesture reorganisation approach

Parameters	Data-Glove based	Vision based
Computing Power	computational power not an issue(less)	more computing power
User Comfort	quite cumbersome(wear a tracking device, glove)	complete freedom
Hand Size	problem with glove-based solutions(due to different hand sizes)	not an issue
Calibration	more critical	Simple
Portability	Freely available (hand tracking is not involved)	difficult (due to camera placement issues and computing power requirements)
Cost	Expensive(tracking device)	Inexpensive
Noise	bounded with data	Minimal
Accuracy	high level	high level

IV. GESTURE RECOGNITION SYSTEM COMPOSED OF SEVERAL STAGES

Most of the researchers classified gesture recognition system into mainly four steps after acquiring the input. These steps are: Extraction Method or modelling, features estimation and extraction, and classification or recognition as illustrated in Figure 2.

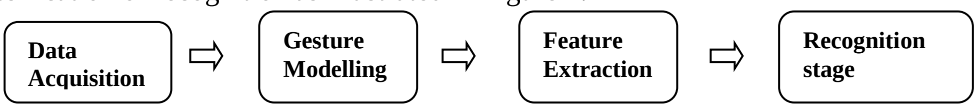


Figure 2: Block diagram of Gesture Recognition System

4.1. Data Acquisition

This step is responsible for collecting the input data which are the hand, Face or Body gestures and classifier classifies the input tested gesture into required one of classes.

4.2. Gesture Modeling

This employed the fitting and fusing the input gesture into the model used; this step may require some pre-processing steps to ensure the successful unification.

4.3. Feature Extraction

After successful modeling of input data or gesture, the feature extraction should be smooth since the fitting is considered the most difficult obstacles that may face; these features can be location of hand/palm/fingertips, joint angles, or any emotional expression or body movement. The extracted features might be stored in the system at training stage as templates or may be fused with some recognition devices such as neural network, HMM, or decision trees which have some limited memory should not be overtaken to remember the training data.

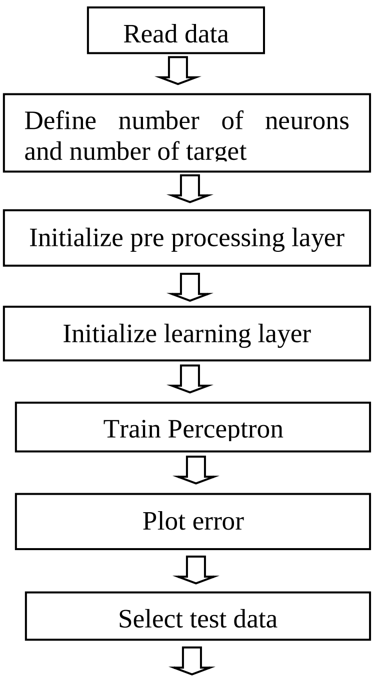
4.4. Recognition Stage

This stage is considered to be a final stage for gesture system and the command/meaning of the gesture should be declared and carried out, this stage usually has a classifier that can attach each input testing gesture matching class.

V. GESTURE RECOGNITION METHODS

Recently, several approaches have been proposed to implement hand-gesture to speech systems [9], [10],[11]. The three most popular models of sensing gloves are VPL Data Glove are Virtex Cyber Glove [12], and Matte1 Power Glove. They all have sensors that measure some or all of the finger joint angles. Each has its own advantages and disadvantages. The use of neural networks for the recognition of gestures has been examined by several researchers. Neural networks do not make any assumption regarding the underlying probability density functions or other probabilistic information about the pattern classes under consideration. They yield the required decision function directly via training a two layer back propagation network with sufficient hidden nodes has been proven to be a universal approximator [13],[14]. Wibur has trained a neural network to recognize approximately 203 hand gestures derived from the American Sign Language [15] in neural network.[16]. Many methods by gesture recognition using visual analysis have been proposed for hand gesture recognition. C.W.Ng gives a vision based system able to recognize 14 gestures in real time via gesticulation within graphical interface.[17] Hasanuzzaman et al. presented a real time hand gesture using skin color segmentation and multiple-feature based template-matching techniques.[18] Xia Liu and Kikuo Fujimura have proposed the method by depth data for hand gesture recognition.[19] R.S Jadon , G.R.S. Murthy used supervised feed-forward neural net based training and back propagation algorithm for classifying hand gestures into different categories and achieve upto 89%correct results.[11] Nielsen et al. proposed a real time vision system which uses fast segmentation process to obtain the moving hand from the whole image and hand posture is recognized by GR process. They used Hausdroff distance approach for robust shape comparison. Their system recognitions 26% hand postures and achieved 90% recognition average rate.[20]Kulkarni recognize static posture of ASL using neural networks algorithm and the features are extracted using the histogram technique and Hough algorithm. Feed forward Neural Networks with three layers are used for gesture classification where for each 26 character in ASL, 3 samples are used for testing training, 5 samples for training, the system achieved 92.78% recognition rate.[21] Stergiopoulou suggested a new Self-Growing, Self-Organized Neural Gas Network used for detecting hand shape morphology and Gussian distribution model for recognition.[22]Another very important method is suggested by Francis k.h. Quek, Meide Zhao, and Xindong Wu, they used AQ Family Algorithms and R-MINI Algorithms for detection of Hand gestures.[23] Waldherr et al. proposed a vision based interface that instructs a mobile robot using pose and motion gestures in an adaptive dual-color tracking algorithm.[24]Chen et al. proposed a system with four modules : real time hand tracking and extraction, feature extraction, Hidden Markov model training and gesture recognition. Chen recognized continuous gestures before stationary background.[25]

5.1 Learning Rules for neural network: We will define a learning rule as a procedure for modifying the weights and biases of a network. The learning rule is applied to train the network to perform some particular task In supervised learning, the learning rule is provided with a set of examples of proper network behavior where is an input to the network, and is the corresponding correct output. As the inputs are applied to the network, then network outputs are compared to the targets. The learning rule is then used to adjust the weights and biases of the network in order to move the network outputs closer to the targets. And another one is Unsupervised learning.



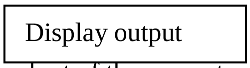


Figure 4: flow chart of the perceptron algorithm

5.2. Perceptron Algorithm: The perceptron learning rule falls in this supervised learning category. Linear networks can be trained to perform linear classification with the function train. This function applies each vector of a set of input vectors and calculates the network weight and bias increments due to each of the inputs. Then the network is adjusted with the sum of all these corrections. We will call each pass through the input vectors an epoch. This contrasts with adapt, which adjusts weights for each input vector as it is presented. Below in figure 4 we can see a flow chart of the perceptron algorithm. It is always operating on the same order. There is a graphical interface only for selecting the test set as it is the only user input.

5.3. Supervised decision-directed learning algorithm (SDDL) by which we can obtain 100% recognition rate for training data. The training patterns are divided into 2 classes: (1) Positive class, (2) Negative Class. SDDL is a two-layer feed forward network by hidden nodes as needed. A more detailed for description of the training procedure is given [15].Positive class is used for extracting the “concept” and Negative provides the counterexamples with respect to “concept”. A "seed" pattern is used as the base of the "initial concept”. After this, we have to check whether there is any negative

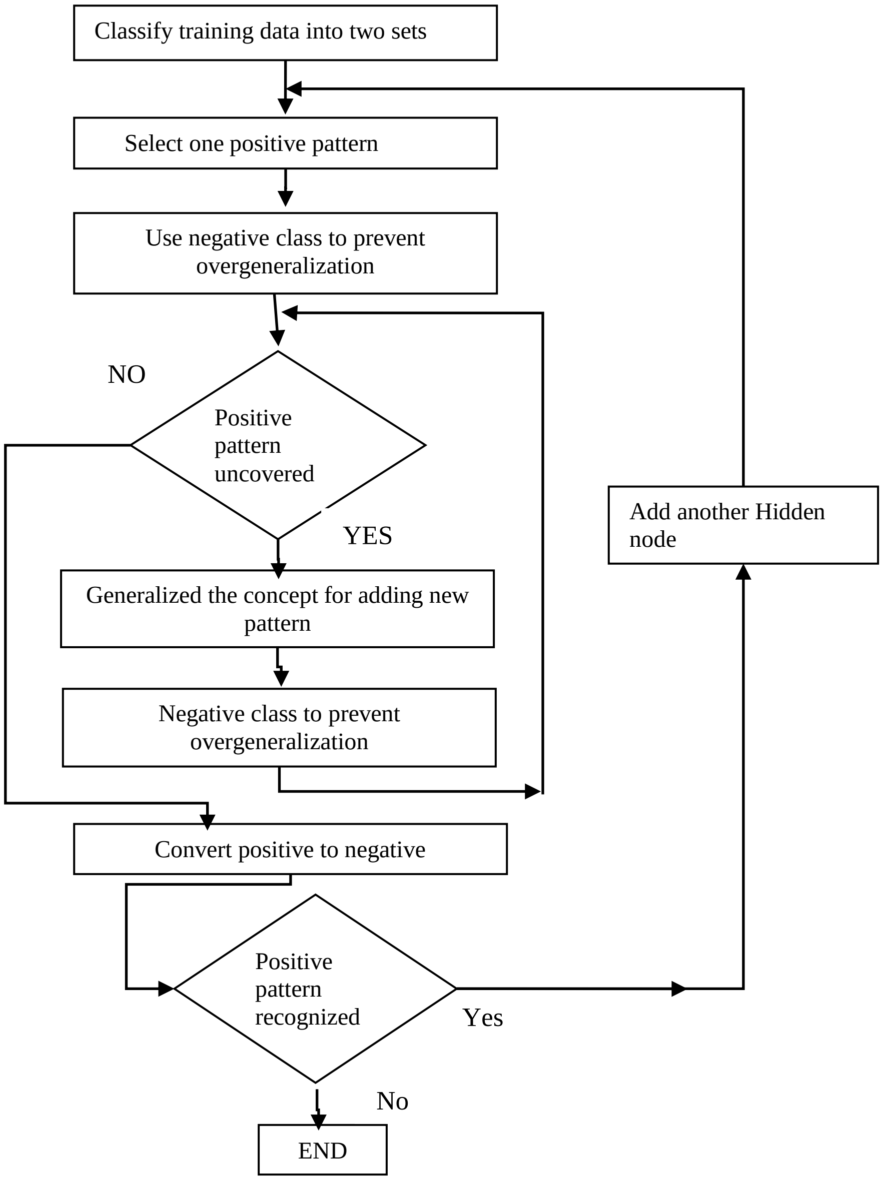


Figure 5: Flowchart of the SDDL Algorithm

pattern in order to prevent the occurrence of "overgeneralization". The following step is to fetch next positive pattern and to generalize the initial concept to include the new positive pattern. This process involves growing the original hyper rectangle to make it larger to include the new positive pattern. A more detailed description of the training procedure is given in [16].

5.4. Hand Segmentation Classification Algorithm

The rapid growing and available compute power, with enabling faster processing of huge data sheets, has facilitated the use of elaborate and diverse methods for data analysis and classification. At the same time, demands on automatic pattern recognition systems are rising enormously due to the availability of large databases and stringent performance requirements. Here it is given a simplest algorithm used for pattern recognition. [26]

1. Convert the RGB image into gray scale image.
2. Segment the image into three equal parts
3. Take the right corner second level parte as left hand image
4. Take the left corner second level part as right hand image.
5. Considering threshold (120), comparing with each pixel, count the number of pixels in the all parts.
6. Based on the pixel count specification we classify either left hand or right hand is raised or both.

There we have two algorithms for hand gesture recognition using MATLAB for Edge detection and Skin detection algorithms.

5.4.1. Edge Detection: Following steps are used for detecting the edges:

1. Image capturing using a webcam or any camera.
2. Converting the captured image into frames.
3. Image pre-processing using Histogram Equalization.
4. Edge detection of the hand by using an algorithm like Canny Edge Detection.
5. Enlargement of the edges of regions of foreground pixels by using Dilation to get a continuous edge.
6. Filling of the object enclosed by the edge.
7. Storing the boundary of the object in a linear array.
8. Vectorization operation performed for every pixel on the boundary.
9. Detection of the fingertips.
10. Tracking of the fingertips in frames to determine the motion.
11. Identification of the gesture based the motion.
12. Insertion of the input stream into the normal input path of the computing device.

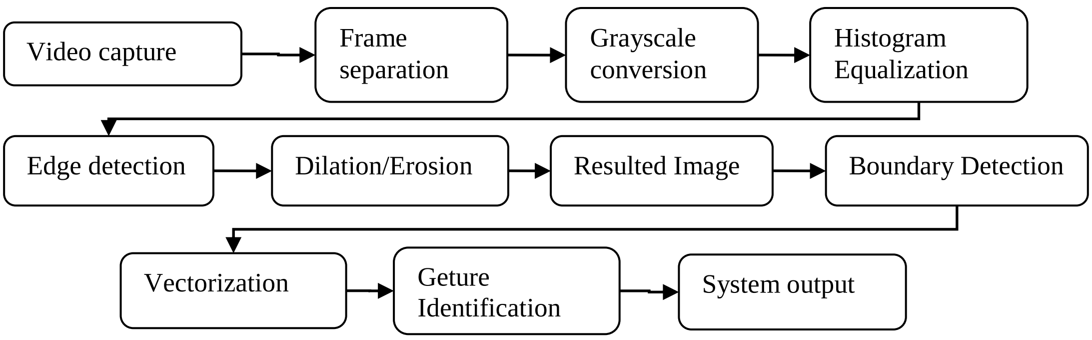


Figure: 6 Block diagram of Edge detection

5.4.2. Skin detection: Following steps are used for skin detection [27]

1. Image capturing using a webcam or any camera.

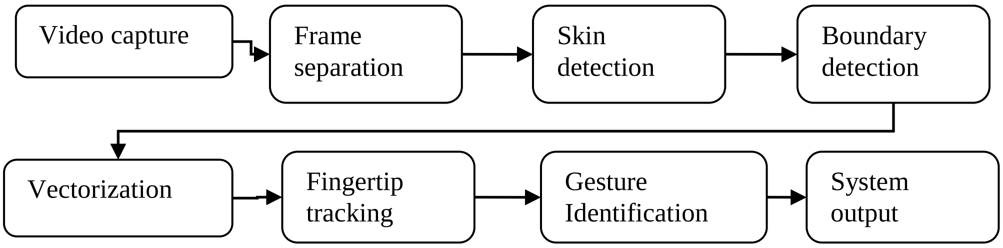


Figure: 7 Block diagram of Skin Detection

2. Converting the captured image into frames.
3. Skin color detection using hue and saturation values of various possible skin tones.
4. Storing the boundary of the object in a linear array.
5. Vectorization operation performed for every pixel on the boundary.
6. Detection of the fingertips.
7. Tracking of the fingertips in consecutive frames to determine the motion.
8. Identification of the gesture based the motion.
9. Insertion of the input stream into the normal input path of the computing device.

VI. CONCLUSIONS

We have summarized the various research fields of computerized human gesture recognition systems. The effectiveness and robustness of the systems has been demonstrated in this paper. This survey prologue the techniques that have been used for hand localization and gesture classification in the gesture recognition literature, but shows that very little variety has been seen in the real-world applications used to test these techniques. Applications that take advantage of depth information in challenging environments (such as hand detection and gesture recognition low lighting, or gesture recognition with occlusions) are still missing, and work on this is ongoing and applications that test the limitations of depth sensors (such as tolerance to noise in depth images, and detecting hands with limited range of motion or in close contact with objects).

VII. FUTURE WORK

Gestures are destined to play an increasingly important role in human-computer interaction in the future. Future work will focus on exploring the visual application and regression models on manifolds. In order to demonstrate the usability of a sign language as a means of controlling a program we incorporated gesture recognition system into a simple virtual reality application. Hand recognition system has scope in many fields like robotics, computer human interaction and hence, making of gesture recognition offline system for real time will play a remarkable role in future research. Support Vector Machine can be modified for reduction of complexity. Our future work will be focused on evaluating our proposed system against a larger gesture vocabulary, on improving architecture, on implementing a continuous and real time gesture recognition platform and also on finding new opportunities to use sensor based system for human machine interaction.

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