

COMPARATIVE STUDY AND ANALYSIS FOR GESTURE RECOGNITION METHODOLOGIES

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ABSTRACT

The diverse applications of hand gesture recognition system accepted it great attention especially in the past few years, besides the recognition system ability to interact with machine naturally and efficiently through human computer interaction. Hand gestures recognition system has different applications on different domains including virtual environments, graphic editor systems, sign language translation, games, and robot control. In this paper a survey of some recent hand gesture recognition systems is presented. Application areas are explained with the system challenges as well. Description of hand gesture recognition system phases which are segmentation, feature detection and extraction, and classification. A review of hand gesture systems are discussed and summary of these systems are given with comparisons on different evaluations criteria such as recognition rates, database used, invariant factor, and different methods used for hand gesture recognition systems phases. And finally advantages and disadvantages of these systems are explained.

Keywords: *Gesture Recognition System, Feature Extraction, Segmentation, Classifications, Hand Posture.*

I. INTRODUCTION

Making the hand gesture understood by the computer considered as a problem in human computer interaction (HCI) [1], where the gesture used to control a robot system or translate meaning information [1]. Hand gesture recognition system has a great attention especially with human computer interaction vision area where the interaction is easy and friendly to control machine such as robot [2]. Complex background, changing lights conditions, and the articulated nature of the hand considered the most challenges of hand gesture recognition system [2]. Sine posture is a certain pose, and the gesture is a sequence of postures in real time systems where time factor is important [2] [3], posture can be defined as a static gesture [3].

Acquiring data for hand gesture systems are depending on the system application, some systems use hand vision and skin color detection method to extract the hand gesture data [4], other systems used instrumented devices data glove [6], which required the user to wear some extra devices attached to the computer, or color glove to extract the hand

shape using colors in the glove [4]. Generally former method considered more natural and less cost comparing with the last two methods [4].

Some of the recent reviews that discussed hand gesture recognition system and applications especially human computer Interaction HCI, games, and robot control are available in [5][7]. This paper demonstrates the advantages of hand gesture recognition system, and it is up to date, with explanations and comparisons in different gesture recognition systems.

This paper organized as follows: the following subsection explained application areas on hand gesture recognition system. Section 2 explained hand gesture challenges. Section 3 demonstrates system methodology of hand gesture recognition. A review of gesture recognition methods are described in section 4. Summary of research results and conclusion are shown in section 5.

II. APPLICATION AREAS ON HAND GESTURE RECOGNITION SYSTEM

Gesture recognition system applications have been various and numerous with its spread on different application domains [3][11] which include sign language translation, virtual environments, editing graphical systems, etc. some of these applications are included below :

- Sign Language Recognition.
- Robot Control.
- Graphic Editor Control.
- Virtual Environments (VEs).
- Numbers Recognition.
- Television Control.
- Lie detection.
- Manipulating in virtual environments.
- Communicating in video conferencing.
- Distance learning assistance.
- Defining aids for the hearing impaired.

III. HAND GESTURE RECOGNITION: SYSTEM METHODOLOGY

The main steps for gesture recognition system can be summarized into four stages as explained in Figure 1, these stages are: acquired hand gesture, segmentation which represents the main step for extracting hand gesture, hand features extraction and identification of the input gesture. In the following subsections an explanation of these stages will be demonstrated in detail.



Figure 1: General steps for gesture recognition system.

3.1 Acquired hand gesture

The traditional methods for acquired hand gesture are either by using camera(s), video [8], or data glove. Recently, various methods are used for this purpose, in order to perfectly detect the input hand, these methods include: stereo color images such as Bumblebee stereo camera [16], infrared camera [2], 3D depth map value of the input image [16], and Time of Flight camera (ToF). These devices are used for accurately detecting of hand gesture.

3.2 Segmentation

One of the main steps for extract hand gesture is to segment the hand from the background; in general most of the studies used plain or simple background to facilitate the hand extraction process, while others used complex background which represents a real challenge especially in the applications that require an interaction in the real environments such as virtual reality systems. However, many factors can effects on the robustness of the segmentation process such as illumination changes, occluded other skin objects with hand region and cluttered background. A lot of techniques and algorithms have been proposed to alleviate these problems [9][16].

3.3 Features Extraction

The features vector depends mainly on the hand segment, and the nature of the gesture application determined the type and number of the extracted features [2]. Features can either be geometric features that depend on some cues that are extracted from the segmented hand such as the centroid of the hand, fingertips and bases, and wrist area, where these cues will help to determine hand rotation angles and some distance metrics. Non- geometric features considered the whole hand as a features vector and try to classify accordingly. [2] represents the feature vector with 13 parameters, [8] divided the hand image into blocks that represent the brightness measurements.

3.4 Classification

The final ring of the recognition sequence is to classify the input gestures correctly depending on the features extracted and the classifier type [3]. The utilized tools for classification are various such as software computing tools, and statistical modeling [3]. Statistical models such as HMM usually used to classify dynamic gestures [9][16], PCA [14], FSM [13]. While software computing tools represented by Artificial Neural Network ANN [10][12], fuzzy set [2], Genetic Algorithms GAs [15], etc.

IV. AN OVERVIEW OF GESTURE RECOGNITION SYSTEMS

Trigo [10] analyzed three different geometric shape descriptors used for gesture recognition systems which are; invariant moments, k-curvature, and template matching. The input image segmented manually and different tests have been applied to examine the robustness of each of the selected method. MLP artificial neural network used as a classifier for these methods.

Al-Hamadi [16] constructed a system that recognized the alphabet characters (A - Z) and numbers (0 - 9) using stereo color camera images and 3D depth map information of the input image to acquire the input video sequence of the dynamic gesture using motion trajectory and simplify hand extraction process. Three features are used in the proposed system; orientation, location, and velocity for Cartesian systems [16]. The database videos used for system training were 720 video samples, and 360 video sequences for system testing, HMM used as the classification tool.

Ravikiran [17] identified nine alphabet characters of American Sign Language for the open fingers only; the input gestures are segmented using Canny edge detector, then the boundary are traced to detect the fingertip of each opened finger, then the system recognized the gestures accordingly. 5 users are used for preparing system database.

V. SUMMARY OF RESEARCH RESULTS AND CONCLUSION

Gesture recognition considered as an open area research and different algorithms can be used for different applications. The following tables show summaries of the discussed hand gesture recognition systems. In Table 1 a summary of evaluations of recognition rates and the type of database used in the pointed system. Table 2 explains the various methods and tools used for segmentation, features extraction, and recognition. Table 3 demonstrates the advantages and disadvantages of these discussed recognition systems.

Table 1: Summary of Recognition Rate and Database used for Hand Gesture Recognition Systems

| Method | Recognition Rate | Gestures used in Database |
|--------|------------------|---|
| [17] | 95% | Subset of American Sign Language consists of 9 samples |
| [9] | 90.45% | Arabic numbers from 0 to 9 |
| [10] | 98.85% | 6 Gesture (open, victory, gun, pointing, thumb, close) |
| [16] | 98.33% | Own Database; alphabet characters (A-Z) and numbers (0-9) |

Table 2: Summary of Segmentation, Features Vector Representation, and Recognition of Gesture Recognition Systems

| Method | Segmentation | Features Vector Representation | Classifier |
|--------|------------------------|---|---|
| [17] | Canny edge operator | Locate fingertips using fingers' boundary-trace method | Classify open fingers depending on the locating fingertip |
| [9] | GMM and YCbCr space | Orientation quantization | HMM |
| [10] | Segmented manually | Different groups of these three features(Invariant Moments, K-curvature Geometric, Shape Descriptors) | Multilayer Perceptron Artificial Neural Network |
| [16] | color and 3D depth map | 3D combined features of location, orientation and velocity | HMM |

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