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Hand Gesture Detection and Pose Estimation Using Image Processing: A Survey

Younis E. Abdalla, T. Iqbal, M. Shehata.
 Memorial University of Newfoundland
 St. John's, NL, Canada. A1B3X5
 yea764@mun.ca, tariq@mun.ca, mshehata@mun.ca

Abstract – Recently, human computer interaction (HCI) technology is becoming more important and usable technology in different fields such as medicine and computer games. There are many new possible applications based on this technology. Fully body skeleton, head and facial features, and hand gestures based algorithms are well stabilised in literature. In this paper, real time applications for hand detection, tracking and recognition are surveyed and classified. The details of a system that responds to real time hand activity from the detection algorithm, which uses various key point textures to distinguish the hand and to track it is presented. Offline input or database feeds the system ~~from~~ training input hand model to simulate the real time hand pose. The purpose of this survey is to obtain and demonstrate a suitable approach for the particular requirements of an application.

Left justification?

on sensor type (direct contact sensors or contactless sensors) [7]. In fact, the visual based approach is a big stone in image processing research and it has high influence in our life.

Keywords – Human, Interaction, Vision Algorithms, Hand, Tracking.

I. INTRODUCTION

Human-Computer Interaction (HCI) technology is serving a huge number of people in their special purposes in different aspects of life [1] [2] [3] [4]. At the top of this list are disability people equipment support, smart teaching technology and entertainment industry. The essential target of building this type of interaction between human and machines is to eliminate the direct contact among them and provide a remote control method easy to operate by human organs [5]. The high degree of freedom DOF of hand makes it the most efficient and challengeable method in all approaches compare with facial and body skeleton methods. The main computer interaction approaches are: audio based approach, sensor based approach and vision based approach as is in figure (1). Speech recognition is the best example for audio based [6]. Sensor based approach obtained a way to interact with sensing applications such as mouse, touch screen and smell sensors and that control these devices based

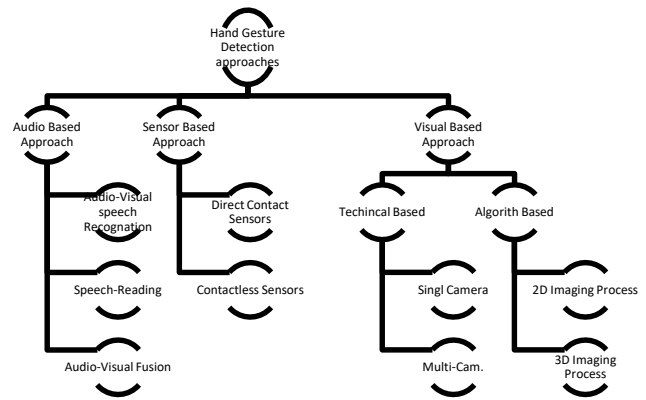


Figure 1: Vision detection approaches

Hand tracking, however can be classified into model based approach and image mapping based approach as shown in the figure (2).

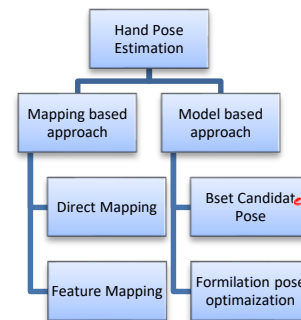


Figure 2: Hand pose estimation is classified to two approaches mapping and model based approach.

Tracking hand task ~~can~~ based on detection approach and pose estimation approach as well to allocate the hand position and fit it with correct pose model. ^{is the objective} As you can see in figure (1) the vision-based approach is based on two different techniques: single camera as one category, and multi-cameras and stereo camera are classified in ~~one~~ ^{an} other category. In both classifications the input either to be RGB stream or Depth stream can provide 2D or 3D view [8]. Medical applications are mostly built on hand tracking to obtain sophisticated ~~response~~ ^{interest} in tele-surgery for example. ~~Nevertheless, interact with the equipment, medicines and patients have great attention in vision literature, therefore, using a virtual reality has a great interest to be used in medical applications; for instance, Virtual Reality Mirror Visual Feedback (VRMVF) [9] [10] [11]. However, because of the high degree of hand freedom, precise tracking is still a challenge for the most of applications.~~

The relationship between the human and the machine to utilize the insignificance [?] of the machine and the called Man-Machine Interaction (MMI) [7], in fact, this may come as another name to describe the human machine interaction (HCI) [7] [3]. In general, human machine interaction can be characterized by its functionality and usability ~~to refer to the set of used functions~~ and ~~the~~ operation level of the system ~~respectively~~ to specify the system efficiency [7]. ^{??}

II. ART OF BACKGROUND ^{??}

Hand pose estimation in computer vision, still very active in research. In last decades, many smart applications were billed and they added some new enhancement to human life [12] [13] [14]. These applications to detect the hand gesture, distinguish and estimate its pose [15], recognize the meaning of those different sign languages and translate that to what the person ordered the machine to do. The Canesta virtual keyboard is one example of this application as you can see in the figure (3) [16].



Figure 3. Canesta Keyboard

The system will track the hand and the figures motion to transfer the keystrokes back to the device and print the precise message on designated screen [17] [18].

Hand gesture detection in computer vision is to detect hand based on its own gestures and pose [19] [20] [21] [4]. Vision based methods are different as in figure (1), and many algorithms have been proposed using color or depth images from one or more video cameras.

III. PIPELINE OVERVIEW

In this system, firstly, hand will get detected [22] [23], and then background subtraction and image filtering process should be done. Tracking task will track specific hand gestures in real time [24] [8]. Hand recognition translates the hand behavior to understandable profile [15].

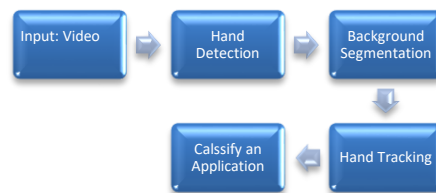


Figure 3: System Frame work

The difficulties of gesture recognition are a result of using a regular camera which produces a noise, ambiguity and tracking failure [25]. Therefore, combine the RGB input with projective depth input solve these problems. The proposed camera is Microsoft Kinect camera [26].

IV. SEGMENTATION BASED TECHNICAL APPROACH

Image segmentation techniques play an important task in image recognition algorithms. There are many segmentation algorithms available and do the same job. Some of them as examples are: Main Shift Segmentation, Efficient Graph-based Segmentation and Hybrid Segmentation Algorithm [27]. Segmentation methods can be classified mainly into two categories which are area-based and model-based as in the figure (4).

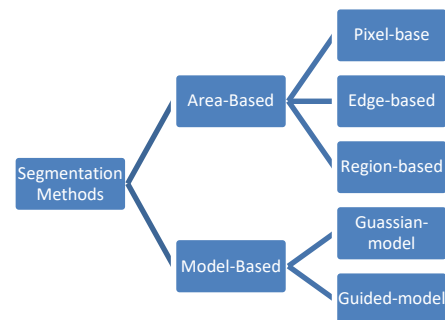


Figure 4: Segmentation Based Approaches

4-1 Area-Based Segmentation.

In [28] area-based segmentation theoretically was ~~approved~~ ^{proposed}. There are many applications and studies used this technique from small area presented by a pixel-based segmentation up to wide area presented by region-based segmentation.

4-1-1 Pixel-Based Approach.

The segmentation modeling can be done based on the pixel intensity. For example, Gaussian noise model in [29]. The pixels will be segmented according to designated threshold to as follows: if the pixel intensity, presented as $P(X_t)$ and the threshold is as h_t , then the segmentation will be as:

if $P(X_t) > h_t$ $P(X_t)$ is a foreground Pixel

if $P(X_t) < h_t$ $P(X_t)$ is a background Pixel

4-1-2 Edge-Based Approach.

This method was used by [30] [31] [32] [33] to recognise gestures in real time. A quicker segmentation process of hand was obtained and the systems were able to identify the hand poses. Basically, segmentation is segment an image into several smaller parts to make it superior analyzed. Many algorithms are based on Edge-based method. The Canny edge detector is common use for different applications [34] [35]. Also there are many other algorithms based on Edge-based segmentation such as: Hough transform, and Laplacian of Gaussian (LoG) [36] [37].

4-1-3 Region-Based Approach.

In this technique the image will be classified into a number of regions. There are a number of algorithms based on region segmentation: sub-NNs [38], Region merges [39] [40], Watersheds regions [41], Region splitting [42] [43], and Region grow [44].

4-2 Model-Based Segmentation.

This segmentation based on reducing the user dependency [45]. Segmentation task based on defended outlines [46].

4-2-1 Gaussian-Based Approach: [47] [48] [49] [50] [51] [52]

4-2-2 Guided-model Approach: [53] [54] [55] [56] [57] [8] [58]

V. APPEARANCE BASED MODEL

The model can be classified based on the input. Kinect from Microsoft can provide two stream format inputs [59]. Also, some models can be based on 2D or 3D image format which can be extracted differently [60].

A. RGB Stream Input Model

In this model the segmentation process is based on the skin color since the model has the three channels RGB [61].

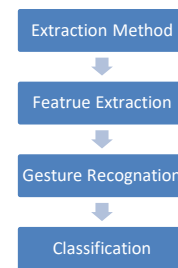


Figure 4: Gesture recognition system & classification Process

The issue with RGB models is the Skin-color verity ^{??} [62]. One of common ^{on} technique normally used to convert the RGB-to-HSV as one way to filter the color under different scale and solve the Skin-color issue. Figure (5) shows the block diagram of such system.

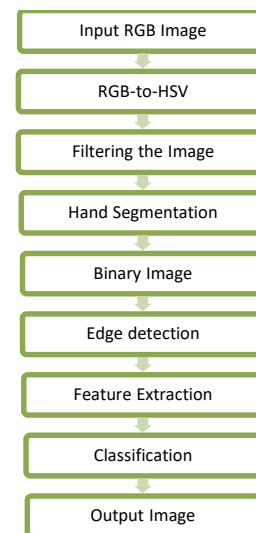


Figure 5: Skin-color filtering block diagram

B. Depth Stream Input Model

The difference of depth image ~~than~~^{and} the RGB doesn't need to convert the input color [62], however, background subtraction done before applying the segmentation method. The depth image in some way is projected on the top of the RGB image [24]. This provides an accurate depth value for each pixel in the RGB image [63]. Pose estimation done by matching filtered real time image with the out hand model. [53] [64] Use a single depth camera to detect a hand and track it. The method was reliable and super-fast [65]. Detection guided tracking method was used and the represent a novel depth input model [8]. Figure (6) shows a depth model diagram.

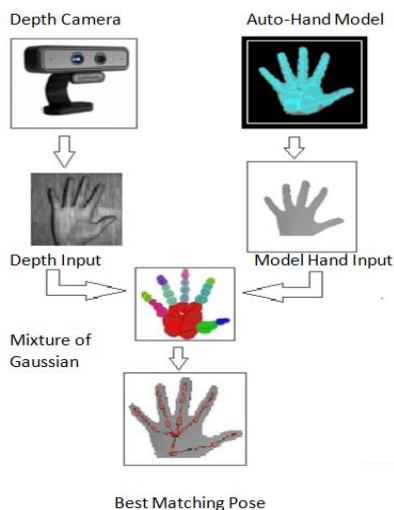


Figure 6: Depth stream model for hand detection and pose estimation

Depth input is a depth map of pixels and each pixel represent depth value [66]. These values compensated by Gaussian mixture in a homogeneous region [53] [67] [68]. 3D volumetric hand model is generating as is in figure (7). Gaussian mixture ~~will be~~ applied to hand model as well to find best fitting pose matching real time depth map as in figure (8).

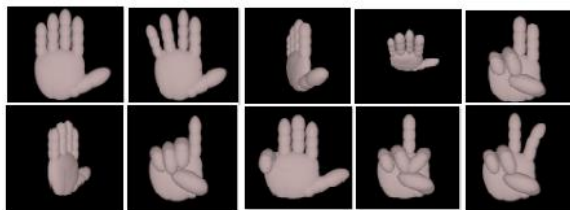


Figure 7: Set of Auto-Hand model



Figure 8: Depth maps of a hand in different poses from the depth camera

VI. DISCUSSION

Hand gesture detection ~~is~~^{is} small and important subdivision of human computer interaction (HCI), however, is widely used and has matured literature. The inputs for all hand detection systems can be mainly classified to three categories: RGB input stream, Depth input stream, and Hybrid input streams as is in table (1).

Table 1. comparison between hand's application based on the input technology.

Input	Weakness	Strengths
RGB	-skin color issue - illumination issue	-natural view -cheap application -long distance target capture -easy to troubleshooting
Depth	-unnatural view (B&W) -short distance target capture -De-noising measurement	-no illumination effect -moderate price
Hybrid	-high algorithm complexity -expensive -hard for troubleshooting -power consumption	-high accuracy -less failure -de-noise model

Hand modeling is an important task which represents the hand in good manner and its gesture well understandable [69]. In same study the hand modeling classified into two categorise: spatial as 2D & 3D imaging implementation, and temporal which algorithm modeling based such as the Kalman filter [70]. All these algorithms depend on correct segmentation and background concepts for hand detection [71]. Some methods are hardly being classified under ~~each~~ previous approaches. It is distinguished that color imaging approaches can be more useful when it works dependently with depth imaging approaches. However, this should be changed in future.

VII. CONCLUSION AND FUTURE WORK

The efficiency of a human machine interaction application is reflected on the importance of hand gesture tracking and recognition. The importance can be leveled ~~form~~^{from} games, applications up to the medical applications. In this survey, overview study was done to classify the approaches, differences and their challenging, weakness and strength. Many approaches achieved high contribution and robustness in real time hand tracking.

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