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Gesture Control Challenges and Opportunities: A Survey

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ABSTRACT— Hand gesture recognition system has evolved the most in the recent few years because of it is multiple applications and the ability to pave an efficient interaction method between humans and computers. In this paper, a survey of widely recognized existing hand gesture recognition systems is compared to present the merits and demerits. Key issues of gesture recognition systems are also discussed. Future developments along with market analysis are also presented. Experimental results show that all the existing systems have an accuracy of 94%. This demonstrates the feasibility of the system presented.

Keywords- gesture-recognition; sign language translation; human-computer interaction;

I. INTRODUCTION

The gesture recognition market is projected to reach USD 32.3 billion in 2025 from USD 9.8 billion in 2020, at a CAGR of 27.0%. Significant drivers for this present market's development are expanding interest for the network in the auto business, low specialized intricacy and progressed client experience, and developing digitization across a few ventures. The touchless sensing market is projected to reach USD 15.3 billion in 2025 from USD 6.8 billion in 2020 at a CAGR of 17.4%. This paves the way for gesture control.

Gesture control is that the power to perceive and interpret moments of the human body to accompany and control a computer system without direct actual contact. The expression "characteristic UI" is getting ordinarily wont to depict these interface frameworks, mirroring the general absence of any moderate gadgets between the user and therefore the system. Gesture recognition is an ongoing research field that tries to assimilate the gesture channel in HCI (Human-computer interaction).

With the development of today's technology about gesture control, hand gesture recognition plays a vital role in human-computer interaction which enables the system to capture and interpreting hand gestures and executing commands a short time later. In Human-Computer Interaction (HCI), hand motions have a wide number of applications that can ensure the speed of communicating with the computers, give an easy way of interacting.

In hand gestures, there are four categories, conversational-gestures, controlling-gestures, manipulated-gestures, and communication-gestures [3]. The significant condition of correspondence gestures is communication via gestures. Simultaneously, communication through sign language empowers disable people from interacting in a simple manner with computers [4], [5]. The manipulated gestures are used to interact with virtual objects in the natural form.

The finest precision for static gestures was introduced by Liang: "Posture is a specific combination of hand position, orientation, and flexion observed at some time instance ".Liang also defined dynamic hand gestures as "Gesture is a sequence of postures connected by motion over a short time span" [17]. Different methods have been proposed for obtaining fundamental information for recognizing the gesture system. A few techniques utilize additional hardware devices, for example, data glove gadgets and color markers to effectively separate the complete depiction of gesture highlights. Other strategies dependent on the presence of the hand using the skin tone to portion the hand and concentrate vital features. These techniques consider simple common and less expensive contrasting and the strategies referenced previously [17].

The rest of the paper is organized as follows. Section II surveys the existing related work. Section III describes the security architecture from IEEE 802.16 standards and their issues. Section IV is the proposed distributed security architecture with ECDH key exchange protocol. The security analysis of the proposed scheme is presented in section V. The last section VI concludes the paper.

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II. METHODS AND METHODOLOGIES USED

Extraction method and feature extraction: Most of the researchers classified gesture recognition system into mainly three steps after acquiring the input image from the camera(s), videos or even data glove instrumented device. The steps are Extraction Method, features estimation and extraction, and classification or recognition [2].

Figure 1. Basic steps of Gesture recognition [4]

Extraction method and image pre-processing: The extraction Method and image pre-processing Segmentation process are used for recognizing hand gestures. it's the method of dividing the input image (in this case hand gesture image) into regions separated by boundaries[9]. The segmentation process depends on the type of gesture, if it is a dynamic gesture then the hand gesture needs to be located and tracked [9] if it is a static gesture (posture) the input image needs to be segmented alone. The hand should be located firstly to differentiate it from the background and the foreground, generally a bounding box is used to specify the depending on the skin color [10], and secondly, the hand has to be tracked. For tracking the hand there are two main approaches; either the video is divided into frames and each frame has to be processed alone, in this case, the hand frame is treated as a posture and segmented [9] or using some tracking information like shape, complexion using some tools. However, there are some factors that obstacle the segmentation process which are [9]; complex background, illumination changes, low video quality [2], [9]. Some pre-processing operations are applied such as subtraction, edge detection, and normalization to enhance the segmented hand image [13], [14].

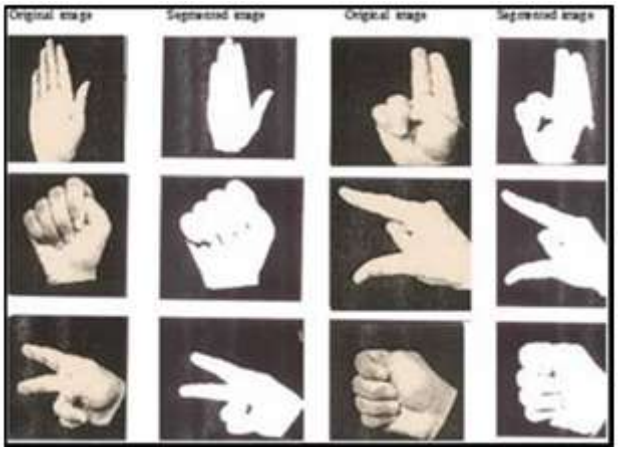

Figure 2. Segmentation Method [19]

Feature Extraction: The segmentation process leads to perfect features extraction and then later plays an important role in a successful recognition [2]. Features of the segmented image can be extracted in different ways. Some methods used the shape of the hand such as hand contour and silhouette [13] while others utilized fingertips position, palm center, etc.

It is applied to decide the right block size that can achieve a good recognition rate [54]. [56] and [57] used Gaussian pdf to extract geometric central moment as local and global features. Figure 5 shows some applications of feature extraction methods. Features representation. a) The segmented image is partitioned into 11 terraces with 8 regions per terrace to extract local and global geometric central moment [56], [57]. The features used must be suitable for the application and the applied classifier. The existing papers used two different feature extraction methods as the hand gesture recognition algorithm, 1.Neural network with hand contour, 2.Neural network with hand complex moments. These two extraction methods were applied because they used different approaches to extract the features like a boundary based for hand contour and region-based for complex

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movements. They help us to identify the strengths and weaknesses of each approach [45].

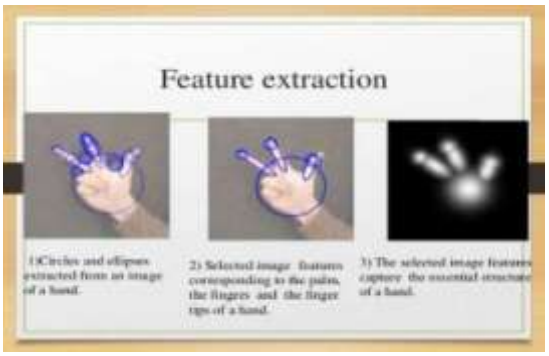

Figure 3. Features Representation

Gestures Classification: After modeling and analysis of the input hand image, the gesture classification method is used to recognize the gesture [37].The feature extracted are sent to training and testing the classification algorithm,

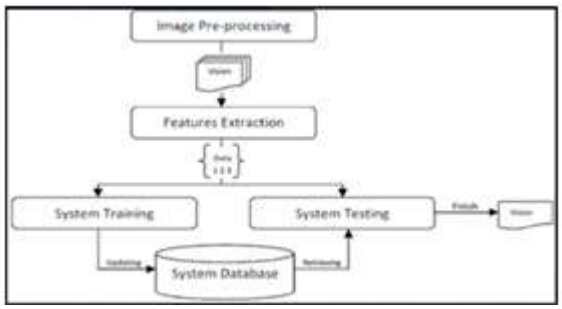

Figure 4. Architecture of Gesture Recognition System[64]

III. EXISTING GESTURE RECOGNITION SYSTEMS

Some of the existing techniques of gesture recognition are discussed here.

Soft gloves: The primitive concept of hand gesture recognition is gloves. This glove consists of 10 flex sensors and 10 force-sensing resistors at the tip of the fingers and the palm to record the movement of the whole hand. This in turn provides high accuracy and low latency in output. It is incapable of recording a combination of gestures and the user is required to wear the gloves whenever needed. The sensors also cost a great deal and need to be replaced frequently [17].

Kinect sensor: This sensor makes use of color image input and depth map input to differentiate each finger. To handle the noisy hand shapes obtained from the Kinect sensor, the proposed finger-earth movers distance (FEMD) measure the dissimilarity between hand shapes. The advantage of this methodology is that noise does not affect the accuracy and skin tone, user behavior has no part in the output efficiency. But this system does not work accurately if other active objects are present. [18]

Continuous-wave Doppler signals: Linear motion-imaging recognizes various definite signatures of the corresponding motions. Using this system provides accurate measurements of high velocities and the digital data can be easily compressed. But it is not possible to record the point of time at which the action was recorded. It is expensive and requires precise positioning [21].

SEMG (Surface Electromyography): This process uses depth information to recognize the hand gesture using the MYO AR band. Making use of this system makes a significant increase in efficiency but it is prone to interrupts by interference from any stimulus [22].

Facial Electromyography: The detected EMGs are passed through a bandpass filter and the features are recorded. Finally, all the combinations are trained and recorded using a fuzzy classifier. This provides the user with accurate and automated readings. It is also capable of measuring even weak emotional states. The only drawback is that even slight variations in facial expressions lead to errors inaccuracy [23].

Barometric pressure sensor: The wristband is composed of an array of 10 sensors that can identify the pressure of tendons and muscles that change

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according to hand gestures. This system is independent of any setup. Light, noise, and other issues do not affect the accuracy. The drawback is that only a limited number of gestures can be identified. A slight change in pressure can lead to the wrong identification of gestures [26].

RGB camera and 3D convolutional neural network: The system describes a command interface based on hand gestures predefined by postures, movement, and relative location [20]. RGB-D images are used to implement fingertip detection.3D CNN takes the input as a 3D volume for better accuracy. It allows us to capture 30 frames per second and enables us to track the movement even at a large distance [27].

Leap motion: The leap motion operates over a small range and has high precision. It is used to record small upper extremity movements. It is extremely helpful in bringing back rotor functions.VR is engaging and interesting so it boosts the users to try their rotor functioning. The results are based only on a trial basis and have no proof of measurement [31].

Mo-Drop: This concept makes use of a combination of videos and articulated poses to get the desired output efficiency. This ensures robustness and the dataset can be augmented with audio. But the drawback is that is a generalized technique and not a targeted technique [19].

Hidden Markov models: The hand gestures are classified as one-handed and two-handed gestures. Then the directive gestures are recognized as output. This exists as one of the most simple and natural ways of hand gesture recognition. Temporal occlusions affect the accuracy of the system [24].

Single-camera: The web camera is used as an input device to recognize the gestures such as clicking on a mouse, a few shortcuts, and movement of the cursor Easier to use. No external hardware and processing techniques are needed. A single-camera does not provide accuracy due to noise [34].

Wi-catch: A novel device free gestures recognition system utilizes the channel state information to recognize the motion of Hands. Two hand gestures are recognized with good accuracy. The interference elimination and moving hand tracking in a complex indoor environment. Too many noises in the spectrum curve that relates to the movement and DC component hard to recognize [6].

APPLICATIONS

There is a wide scope for the domain of gesture recognition and it is still in the process of evolution. The widely used application are listed here.

Gaming Interface: In the virtual reality (VR) environment, the posture and the movement of the user's body are used as input and is replicated in the game or the surrounding in the system. This is possible using gesture recognition of not only the face but also the whole body [29].

Sign Language translation: Gesture recognition is the primary contributor to sign language translation. People make use of hand gestures and they are interpreted into readable text, sound, or any other form of output. This system enables the speech-impaired to communicate with the outer world more easily and efficiently [30], [28].

Smart home and device application: A home equipped with lighting, heating, and other electronic devices which will be controlled remotely by a smartphone or a computer may be a smart home. Gestures such as entering into the room, clapping, or snapping of fingers can control the working of the devices. [32] .The evolvement of existing devices such as smartphones for a more efficient way of usage [25], [35].

Health monitoring devices: The proper functioning of all the tendons and muscles is monitored using devices where gesture recognition is applied. For each gesture, we make there is a unique combination in the movement of the tendons and muscles. A wrist band can identify the working of all the tendons when secured in the user's wrist and they are asked to perform various gestures [26].

Physical therapy: It allows the therapist to maintain patient motivation and extract detailed information on their movements. For example, stroke can result in the seizure of movement in one side of the patient's body. Gesture recognition is used to monitor the movement of the proper functioning hand and using it to replicate the affected hand movement [31].

Synthetic human expressions: The field of robotics is still evolving and has not reached all of its peak features. One such feature is human expressions. Scientists are looking for ways for robots to be able to replicate human expressions so that they are more realistic. Gesture recognition paves a way for robots to replicate human facial expressions accurately [33].

Musical Gestures: The lead musician in an orchestra is the most important role. If errors are made by him then the whole musical piece is considered a waste. Since humans are devoid of mistakes, gesture recognition systems are used to replicate the hand gestures of the lead musician in his place [18].

Examination monitoring: In online examinations the user's device (laptop, smartphone) is used to monitor the student's credibility which is possible by gesture recognition of the student. Similarly, a lock screen using facial recognition is also performed using gesture recognition.

CHALLENGES IN GESTURE RECOGNITION

Since gesture recognition is a developing field there are challenges that have a negative impact on the accuracy. Some of them are:

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Non-standard backgrounds: Gesture recognition should bring efficient results no matter the background. It should work whether you're within the car, at home, or walking down the road. Machine learning gives you how to show the machine to inform the hand aside from the background consistently.

Movement: Common sense suggests that gesture is quite a movement than a static image. Gesture recognition should thus be ready to recognize patterns, ex. instead of recognizing just a picture of an open palm, we could recognize a waving movement and identify it e.g., as a command to shut the currently used application.

Combination of movements: What is more, gestures could contain several movements, so we'd like to supply some context and recognize patterns like moving fingers clockwise and showing a thumb might be wont to mark some limited number of files or some particular area. If the movement can't be captured then the system's only static movements are often recorded which can't be an efficient system.

Diversity of gestures: There is much diversity in how humans perform specific gestures. While humans have a high tolerance for errors, this inconsistency may make the detection and classification of gestures more difficult for machines. This is also where machine learning helps. Machines are known to make fewer to no errors so they are much more reliable and easy to use. They also do not tire out and that is an advantage that users can exploit.

IV. FUTURE OF HAND GESTURE RECOGNITION

Despite the high performance of the new strategies talked about during this paper, hand gesture recognition is so far an advancing point that needs more investigations [4]. According to recent marketing research, technological advancements and simple use are factors increasing the acceptance of gesture recognition technology within the consumer industry [16].

The touchless sensing market is projected to reach USD 15.3 billion in 2025 from USD 6.8 billion in 2020 at a CAGR of 17.4%. The escalating demand for touchless sensing technologies in smartphones and touchless biometric solutions with upgraded tracking and controlling functionalities will create opportunities for the market. But the major restraint for the market is higher switchover costs coupled with user resistance. The increasing use of biometric equipment in the automobile, consumer electronics, commercial, and industrial sectors is expected to drive the growth of the touchless biometric equipment market. As biometric deployments begin to expand into markets and environments that are characterized by end-users who may possess less ideal skin conditions to use fingerprint technology, contactless biometric sensor technology is proving to be a viable solution.

Recently Google announced a replacement approach handy perception implemented in Mediapipe –a cross-platform framework for building multimodel machine learning pipes, with this new method, real-time performance is often achieved even on mobile devices, scaling to multiple hands. As hand gesture recognition was as of late applied in some gaming comforts and other technologies has expanded the business pace of these consoles it is normal to continue to develop increasingly more after some time. The subject is required to develop more than 28% from the year 2017 to 2024 [16].

V. CONCLUSION

In this research, a literature survey on the techniques used in gesture recognition systems was conducted. The main techniques widely-studied were touch-based and touchless based systems. The goal in systems of hand gesture recognition is to pave an efficient interaction method between the system and humans. There are many applications in this field such as virtual reality, sign language recognition, robot control, human-computer interaction, and much more. Already existing systems range from the early smart gloves to the recent use of Media Pipes in the field of gesture recognition. Thus this field is in a constant stage of evolvement. The gesture recognition gives a promising way to make the interaction manner simple and easier.

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