Texas A&M University Qatar

ECEN 403:

Project Title:

Hand Gesture Controller

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"An Aggie does not lie, cheat or steal or tolerate those who do."

Abstract:

Gesture control technology is a cutting-edge innovation that greatly enhances the quality of life for individuals with physical disabilities, allowing them to interact with their surroundings. This system allows users to control various functions through finger movements, such as open/close, pause/play, adjust volume, and navigate forward and backward, all from a distance of up to 2 meters. By directly interpreting finger gestures without the need for a dataset, this system reduces latency and provides a seamless user experience. The primary goal of this technology is to empower individuals with physical disabilities to independently access and control functions. In order to efficiently put the system into practice, a computer vision method is utilized to precisely identify various finger combinations as hand gestures with an accuracy rate of almost 95% and a latency of 300 milliseconds. The framework suggested in the study is designed to assist individuals with physical disabilities in controlling their environment.

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Introduction:

- Individuals who are physically disabled encounter particular difficulties when attempting to access and engage. Physical impairments may make it more difficult for a person to interact with others and their environment. Using electronic devices is an area where it is difficult. Conventional user interfaces frequently use manual input methods, such as keyboards or remote controls, which can be challenging for people with physical disabilities. Technological developments have created new opportunities for people with physical disabilities to enhance their lives. Hand gesture control is one of the technologies that enables a person with a disability to use finger movements to interact with devices. The use of hand gesture control could enable people with physical disabilities to carry out tasks that might not be possible.

- ## Motivation:

  People with physical disabilities face unique challenges when trying to access and interact. A person's ability to interact with others and their environment may be hampered by physical impairments. The area where it is challenging is when using electronic devices.

- ## Survey of the relevant literature and highlighting the holes in the solutions available in the literature.

  Experimented work is inspired by the existing and proposed systems in the literature. A deep learning network for hand gesture recognition is presented in a paper [1]. Several well-proven modules are integrated within the network to learn both short-term and long-term features from video inputs while also avoiding intensive computation. For the learning of short-term features, each video input is segmented into a fixed number of frame groups. In comparison to other models, our model demonstrates highly competitive results.

  Great attention has been received by gesture-based real-time gesture recognition systems in recent years due to their ability to efficiently interact with systems through human-computer interaction. Gestures, which are a natural form of action frequently used in daily life interactions, generate a new paradigm of computing interaction when employed as a means of communication with computers. The work has been focused on computer vision, and gesture recognition techniques are implemented, resulting in the development of vision-based, low-cost input software that enables control of the media player through gestures. [2]

  A hand gesture recognition method based on improved YOLOv5 is proposed to address the challenges of low recognition accuracy and slow speed in the presence of complex backgrounds. The YOLOv5 backbone network's CSP1_x module is replaced with an efficient layer aggregation network, allowing for improved learning capabilities and faster recognition speed through enhanced gradient paths. Experimental verification conducted on the datasets demonstrates recognition accuracies of 75.6% and 66.8%, respectively, with a recognition speed of 64 FPS for 640 × 640 input images. The results highlight the proposed method's ability to quickly and accurately recognize gestures with complex backgrounds. [3]

An effective approach to human-computer interaction is focused on the system, which leverages human hand gesture recognition. A video player developed by them can be controlled by the user's hand gestures using the Convex Hull technique with the help of Python and OpenCV, which provide the necessary tools and libraries for image processing and gesture recognition.[4]

A method for hand gesture identification based on shape-based feature detection is discussed in the paper [5]. The system configuration involves the utilization of a single camera to capture the user's gesture and input it into the system. The primary objective of gesture recognition is to develop a system capable of recognizing specific human gestures and utilizing them to transmit information for device control. Operated through real-time gesture recognition, by performing a specific gesture in front of the computer's camera using OpenCV, a hand gesture will be created, allowing control of the system through hand gestures without the need for a mouse.

The system proposed and implemented in [6] introduces a methodology for hand gesture detection based on artificial intelligence. Through this system, the slides of a presentation can be changed in both forward and backward directions simply by performing hand gestures. The utilization of hand gestures simplifies the connection process, making it convenient and eliminating the requirement for additional gadgets.

Problem statement and objective:

Actual inabilities, like paraplegia, tetraplegia, and Parkinson's infection, can enormously restrict the independence of patients regarding home residing. In Qatar, in excess of 53,336 patients endure loss of motion with some type of spinal string injury (SCI), which manifests itself in differing engine impedances. Patients with SCI can experience the ill effects of any scope of appendage portability disability up to and including loss of development. Furthermore, serious SCI can result in the patient experiencing a deficiency of discourse, loss of independent breathing, impeded organ capability, and complete loss of sensation. Patients managing SCI face novel moves performing everyday exercises inside the home and frequently need outer support or even a progress to a assisted residing office. As per the Public Spinal Line Injury Measurable Center (NSCISC), roughly 86% of patients managing SCI are released to private homes, while another 6.6% are released to assisted living offices. The expense of medical services for patients managing SCI can have a critical financial and social impact on the patient and their families. Patients shipped off from assisted living offices can spend almost 177,000 QR each year in medical care costs alone. A considerable number of the patients shipped off confidential homes can't reside independently and require an overseer (home medical caretaker or relative) to help the patient with different errands all through the home. Computational motion acknowledgment is a field that has made huge mechanical headway in the past couple of years. Procedures have been created that use signal acknowledgment to help patients with incapacities, utilizing frameworks including electrooculography (EOG) sensors, gaming peripherals, and camera-based eye tracking among different types of motion input. These frameworks ordinarily experience the ill effects of constraints as to their appropriateness to actual handicaps.

In the first place, the framework might be actually nosy, just like with most human computer communication arrangements.

Second, these frameworks are, for the most part, costly and require impressive outer equipment to infer the signals.

Third, the frameworks, for the most part, expect a bigger appendage portability reach or precision than what might be given by different actual handicaps.

Finally, while these frameworks might exist as independent signal acknowledgment sensors, frameworks that use motion input as a start-to-finish digital application are scant. Miniature harvesting from sources, for example, indoor light, can empower plenty of self-maintainable frameworks. This incorporates medical care frameworks and indoor home-checking frameworks. Self-manageability is particularly significant in wearable gadgets for people with mental and actual disabilities, as any required framework support lessens the viability of such a framework radically.

Objective:

This proposition presents the plan, execution, and assessment of a start-to-finish digital home robotization framework for actual incapacities. The framework, an information glove, uses parts of signal acknowledgment to tackle the issues of cost, rudeness, and precision while giving a structure to the framework. The framework is valued as far as its power utilization to evaluate the viability and reasonability of a gadget that works ceaselessly from home energy.

Approach:

To make the framework as portrayed, an answer is introduced as an equipment/programming co-plan utilizing parts of microcontroller and sensor frameworks, versatile turn-of-events, cloud frameworks, and circuit plans. The framework was constructed iteratively, using ideas of the base practical item followed by upgrades and refinements to make a versatile energy-productive answer for entire home robotization for incapacities.

Here is a basic block diagram for a gesture guide system:

Fig1: Block Diagram

1. **Input Module:**
   - **Hand Gesture Recognition:** This module captures hand gestures using sensors or cameras and translates them into digital signals.
2. **Signal Processing Module:**
   - **Signal Conditioning:** Pre-processes the raw input signals to remove noise and enhance signal quality.
   - **Feature Extraction:** Identifies key features from the pre-processed signals that represent specific hand gestures.
   - **Gesture Classification:** Utilizes machine learning or pattern recognition algorithms to classify the extracted features into predefined hand gestures.
3. **Control Module:**
   - **Gesture-to-Command Mapping:** Maps recognized hand gestures to specific commands or actions.
   - **Command Execution:** Executes the mapped commands to control devices or applications
4. **Output Module:**
   - **Device Control Interface:** Transmits control signals to the target devices (e.g., robots, computers, IoT devices).
   - **Feedback System:** Provides feedback to the user about the recognized gesture or the action being performed.
5. **User Interface:**
   - **Feedback Display:** Displays feedback to the user regarding the recognized gestures or executed commands.
   - **User Interaction:** Allows the user to interact with the system, possibly providing feedback or adjusting settings.

6. **Power Supply:**
   - Provides the necessary power to all components of the system.
7. **Communication Interfaces:**
   - **Sensor Interface**: Interfaces with sensors or cameras to capture hand gestures.
   - **Device Interface:** Interfaces with controlled devices to send commands.
8. **System Controller:**
   - Orchestrates the operation of various modules within the system.
   - Manages communication between modules.
   - Coordinates the overall functionality of the hand gesture control system.

Each of these blocks represents a functional module or component of the hand gesture control system, and they work together to enable gesture-based interaction and control. Depending on the complexity and specific requirements of the system, additional blocks or sub-modules may be included in the diagram.

And here is the Flowchart for a gesture guide system:

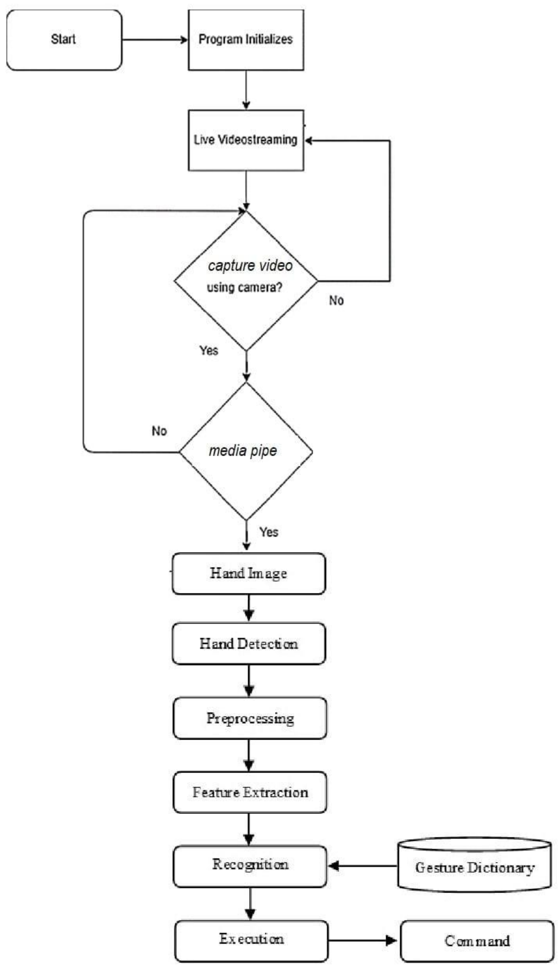


Fig2: Flowchart

Methodology:

Three phases will be expected for the task to be done and tried. In the first stage, the concentrated writing survey is to be finished to additionally grasp the issue. Likewise, in this stage, more information about brain organizations and Python (the coding language) will be investigated. The subsequent stage will zero in on how the plan will look and how the very system of the undertaking will work. The last stage will zero in on making a model for the thought and executing it in actuality.

Data Acquisition: The first step in the process is data acquisition. This involves capturing the hand's position and movement using the sensor. Infrared sensors, for example, emit infrared light that is reflected off the hand and captured by the sensor. Camera-based systems, on the other hand, use a camera to capture images or video of the hand.

Preprocessing: The raw data captured by the sensor is usually noisy and contains irrelevant information. Preprocessing involves cleaning this data to remove noise and extract the relevant features. This could involve techniques such as image segmentation in the case of camera-based systems, where the hand is separated from the background.

Feature Extraction: Once the data has been preprocessed, the next step is feature extraction. This involves identifying and extracting the key features that will be used to recognize the hand gesture. These features could include the position, shape, and movement of the hand.

Classification: The extracted features are then fed into a classification algorithm. This algorithm uses machine learning techniques to classify the hand gesture based on the extracted features. The output of the classification algorithm is a label that identifies the hand gesture.

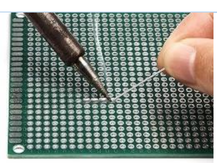
Post-processing: The final step is post-processing, where the recognized gesture is translated into a command that the computer can understand and act upon.

Reinforcing required information: Moreover, Python-compressed lessons will be taken by each colleague to reinforce the coding abilities required for this task to be finished.

Recreation: To recognize a hand movement, a reenactment must be performed, as the sensors recognize the image. However, we must know how far the sensor needs to perceive this data and assume that it is constant. Therefore, at this stage, we will perform a written scan regarding the data and results and re-adjust the handprint to fit the data using software such as SolidWorks.

Estimated Budget and Justification:

No.	Name	Picture	Needs (piece)	1 Piece Price	Total ($)	Shop
1	Raspberry Pi 5 - 8GB		4	94.49	377.96	Amazon
2	LCD HDMI 7 inch 1024x600 Touch Screen		4	45.99	183.96	Amazon
3	Raspberry Pi Dual Fans 5Vdc With Heat sink Cooling System		4	5.50	22.00	AliExpress
4	Raspberry Pi 27W USB-C Power Supply For Raspberry Pi 5		5	12.00	60.00	Canakit56
5	Clear Acrylic Case For Raspberry Pi Camera		4	8.90	35.60	Amazon
6	raspberry pi camera		4	35.00	140.00	Amazon
7	Micro SD 64GB		5	9.45	47.25	Amazon
8	Arduino Nano		4	24.90	99.60	Arduino Store
9	PCA9685 16-Channel 12-bit PWM Servo Motor Driver I2C Module for Arduino		5	8.99	44.95	Amazon
10	D-Planet [4-Pack] 5A DC-DC Adjustable Buck Converter 4~38v to 1.25-36v Step Down Power Supply High Efficiency Voltage Regulator Module		5	13.99	69.95	Amazon

11	MG995 Servo Motor 180° 12 kg.cm Metal Gears		10	39.40	394.00	Amazon
12	lm7809		8	0.41	3.31	Utmel
13	cap 100nF		10	0.70	6.99	Amazon
14	12v dc power supply 5A		5	9.98	49.92	Amazon
15	10k resistor		30	3.50	105.00	Amazon
16	330 ohm resistor		30	0.60	18.00	Amazon
17	Power Switch		12	1.12	15.29	Amazon
18	Project Box		5	26.99	134.95	Amazon
19	Pcb sheet fr4		10	0.99	9.90	Amazon
	Total		**164**		**1818.63**	

The expected budget is 1818.63 $ and we add extra pieces in case they are damaged.

Timeline:

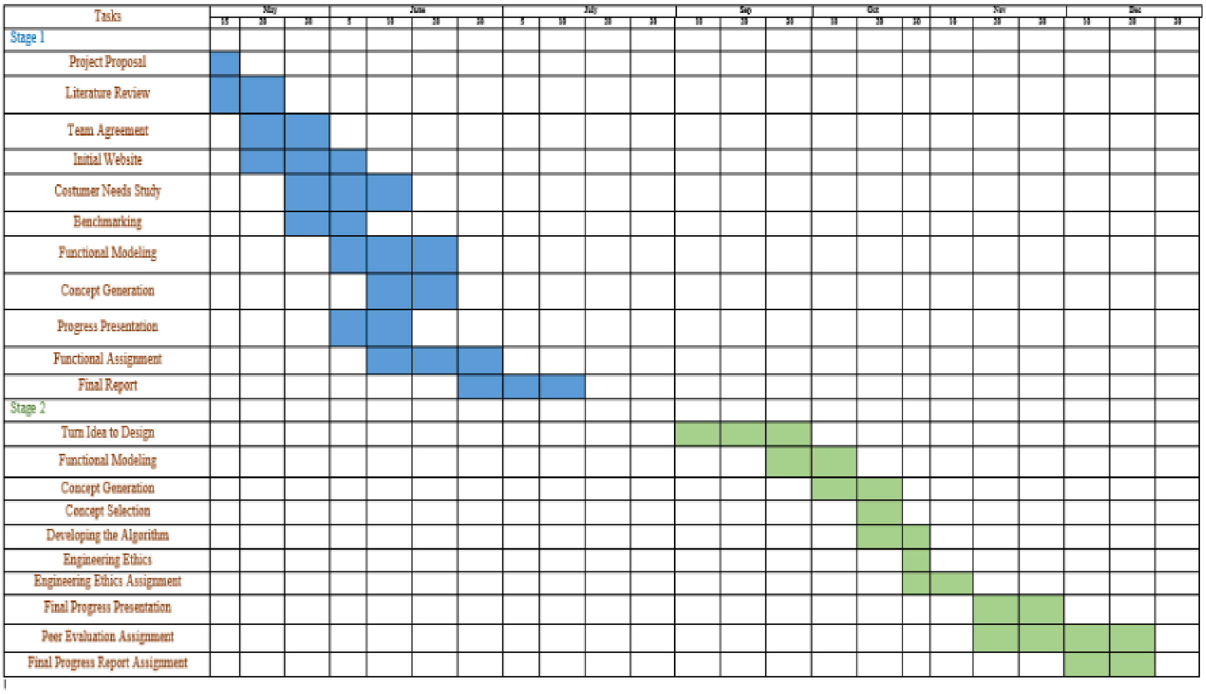


Fig3: Timeline

Conclusion:

In order to put the system into practice efficiently and help people with disabilities continue their lives with minimal effort using our project and reach the most basic needs, a computer vision method or an equivalent processing chip will be used to accurately identify different groups of fingers as hand gestures with an accuracy rate of approximately 95% and an access time of up to 300 ms. The framework proposed in the study is designed to help individuals with physical disabilities control their environment.

References:

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3- Chen R, Tian X. Gesture Detection and Recognition Based on Object Detection in Complex Background. Applied Sciences. 2023; 13(7):4480.

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