Texas A&M University Qatar

ECEN 404

Final Report

Project Title:

Gesture Guide

Instructor:

Dr. Khalid Qaraqe

Mentor:

Dr. Hussein Al-Nuweiri

Team 3:

Maha Al-Dehemi

Fatma Al-Mohannadi

Maryam Al-Safran

Lolwa Al-Kaabi

Due Date: 19/11/2024

Texas A&M University at Qatar, 2024

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

Abstract:

We reviewed in first Chapter, the Literature review and customer needs analysis. This report aims to address the needs of individuals with physical disabilities within the Qatari community, focusing on improving their quality of life in settings such as hospitals, medical centers, and community associations. By conducting a comprehensive literature review and customer needs analysis, this study seeks to enhance the design, components, and functionality of assistive technologies. The ultimate goal is to foster independence and comfort for individuals with disabilities, ensuring they can lead normal lives.

The research methodology includes surveys and interviews with both the Qatari disabled community and experts in the field. These insights are crucial for understanding community needs and integrating expert recommendations into the design process. By aligning with societal needs and leveraging expert guidance, this project aims to attract investment from governmental, private, and individual sectors to support ongoing advancements in assistive technologies. This collaborative effort not only aims to create affordable, durable, and effective solutions but also to promote inclusivity and societal support for individuals with physical disabilities in Qatar.

Second chapter, Advancements in computational motion recognition technologies show promise in assisting individuals with significant challenges, such as those with spinal cord injury (SCI), multiple sclerosis (MS), cerebral palsy (CP), elderly individuals, and those affected by polio. These technologies encompass a range of solutions including EOG sensors and camera-based eye tracking, aiming to enhance independence and reduce dependency on external assistance.

We explore the diverse technologies utilized in assistive systems and their potential to improve interaction with the environment for individuals with disabilities.

However, it's crucial to recognize current limitations, particularly in tailoring these technologies to effectively address specific needs such as motor impairments and speech deficits associated with SCI and similar conditions.

Moreover, integrating these computational motion recognition systems into existing healthcare infrastructure poses challenges of affordability, accessibility, and scalability. Collaboration among researchers, healthcare providers, and technology developers is essential to optimize the design, deployment, and adoption of these solutions within the healthcare ecosystem.

By evaluating these factors and conducting a comprehensive benchmarking assignment, this chapter aims to outline the strategic considerations necessary for the successful development and implementation of assistive technologies that significantly enhance the quality of life for individuals with physical disabilities.

Third Chapter, the aim of this project is to empower individuals with physical disabilities by enabling them to control their environment with ease. This chapter focuses on the functional modeling of two versions of the designed system, which are intended to enhance the daily lives of users through seamless interaction with their surroundings.

The first version of the system integrates a monitoring component with a 3D prosthetic hand. This component detects and replicates finger movements onto the prosthetic hand, enabling users to perform actions such as gripping and releasing objects with precision.

The second version expands functionality by incorporating a customizable task management system. Users can define specific tasks according to their needs, such as contacting specific individuals, summoning assistance, adjusting room lighting, controlling air conditioning, and managing curtains. This flexibility allows each user to tailor the system to their unique environment and requirements.

By presenting a detailed functional modeling flow chart or block diagram, this chapter aims to illustrate the interaction between components within each version of the system. This visual representation will clarify how sensor inputs, processing logic, and output mechanisms work together to achieve user-defined actions effectively and intuitively.

Fourth chapter presents a comprehensive overview of the detailed system design for the hand gesture controller project aimed at enhancing the quality of life for individuals with physical disabilities. The system is designed to enable intuitive control of various environmental interactions through hand gestures, fostering independence and ease of use.

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Chapter 1

1.1 Literature Review:

The existing literature on hand gesture controllers encompasses a wide range of technologies, applications, and methodologies that have evolved to assist individuals with disabilities and enhance human-computer interaction[16]. Here's a discussion summarizing key aspects:

1.1.1 Technologies:

1. Vision-Based Gesture Recognition:

    - Cameras and Computer Vision Algorithms: Utilize cameras to capture hand movements and employ computer vision algorithms (such as neural networks, machine learning models) to recognize gestures.

    - Depth Sensing Cameras: Devices like Microsoft Kinect or Intel RealSense use depth sensing to capture 3D information, enhancing gesture recognition accuracy.

2. Wearable Sensors and IMUs:

    - Inertial Measurement Units (IMUs): Small sensors integrated into gloves or wearable devices to detect hand movements and gestures based on accelerometer and gyroscope data.

    - Electromyography (EMG) Sensors: Measure electrical activity in muscles, enabling detection of subtle muscle movements associated with gestures.

3. Electro-Optical Gesture Recognition:

    - EOG (Electrooculography) Sensors: Measure eye movements to interpret gestures, beneficial for users with limited mobility in their hands.

1.1.2 Applications:

1. Assistive Technologies:
    - Prosthetics and Rehabilitation: Gesture controllers integrated with prosthetic devices allow users to control movements and perform daily tasks more intuitively.
    - Accessibility Solutions: Enable individuals with disabilities to interact with computers, smartphones, and other devices without physical touch.
2. Virtual and Augmented Reality:
    - Gesture-Based Interaction: Used in VR/AR environments for navigation, object manipulation, and immersive experiences.
    - Training and Simulation: Gesture controllers aid in training simulations for tasks requiring precise movements, such as surgery or mechanical operations.

1.1.3 Methodologies:

1. Human-Centered Design:
    - User-Centered Approach: Involves end-users in the design process to ensure that gesture controllers meet their needs and preferences effectively.
    - Iterative Prototyping: Rapid prototyping and iterative testing to refine gestures recognition algorithms and improve user experience.
2. Integration with IoT and Smart Environments:
    - Home Automation: Gesture controllers used to control smart home devices like lights, thermostats, and security systems.
    - Healthcare Monitoring: Enable remote monitoring of patient movements and interactions with medical devices.

1.1.4 Challenges and Considerations:

1. Accuracy and Reliability: Ensuring precise gesture recognition across diverse environments and lighting conditions.
2. User Acceptance: Designing intuitive interfaces and gestures that are easy to learn and remember.

1.2 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 [9]. 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 [9]. 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 [9]. 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 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.

1.3 Customer Needs:

The purpose of this part is to help different members of the Qatari community and medical professionals for physical disabilities in different areas such as (hospitals, medical centers and associations) or these results to enhance the design, components and functions and make life as comfortable as possible based on the needs and requirements of the Qatari physical disabilities category collaboratively to help them live their lives normally. When our community is attracted to our projects, we ensure that governments and private groups and groups of individuals are attracted to invest their money to promote our projects that care about helping the disabled category in cooperation to help them live a normal life. It's a good idea. Therefore, in addition to the questionnaires necessary to conduct surveys, we used a list of written interview questions for experts in this field, especially to understand the opinions of communities living in this category and the opinions of society in general, and to use the results to help achieve our goals. The expert opinion is no less important to our research than the Qatari community poll because it has the necessary experience to guide us towards creating an ideal product that is inexpensive, durable, effective and meets the needs of the category of physical disabilities.

1.3.1 Methods:

1. **Online Survey:**

The methods used were online survey questions sent to the public and interview questions asked to experts. To identify the needs of the mobility impaired population, an online survey was created. To reach the largest possible number of community members, this survey was written in English. When the respondent launches the Qualtrics page created, they are asked to answer the questions presented to them. In this survey, we wanted to know the identity of the respondents as information such as age group, and gender. All the questions were intentionally made easy to solve so that everyone can participate and based on this data we can study their needs to satisfy them. Questions were asked about the respondents' knowledge of assistive technology that is used for people with disabilities. In addition, there are more detailed questions related to disability cases as the main focus of our project revolves around them because they are considered one of the most influential factors affecting a person's life to live normally and we intend to change that.

2. **Expert Interview:**

The second method used was to interview medical and therapeutic experts. In this case, we were able to reach out to several doctors to get their opinion on questions that would help us determine what could be done to enhance our project's capabilities. The opinion of the doctor is as important as the opinion of the public, if not more so. This is because the public will tell you what they want, but the doctor will guide you on the methods you should use to give the public what they want. Therefore, the opinion of the public and the doctors will be combined to achieve the best possible results. The opinion of the doctors was consulted on methods of asking more detailed questions that are directly related to our project, similar products used and how they affect it. Such an opinion cannot be obtained from the general public because they do not gain sufficient knowledge regarding the subject, unlike the experts. Four technical questions were carefully thought out and written for the expert to use his answers to achieve the best results.

1.3.2 Customer need analysis:

1. **Online Survey:**

The online survey consisted of 10 different questions. All participants were required to answer 10 of the questions and the form could not be submitted without completing them. One question depends on the answer to another question, so only people who put a certain answer to this question should answer the next question as well, and others were not asked to do so. All these questions were written in English and printed in separate sections (using the same link) in Qualtrics to be attractive to the respondents. After creating the form, the survey link was distributed by all members using the different social media platforms available to us for use. We mainly used WhatsApp, Snapchat and Instagram to share the form link with the public.

The questionnaires were distributed to:

- University of Texas students
- Al Noor Center for the Blind
- MS Association
- Al Shafallah
- Family members, relatives, friends and classmates

To complete the survey and contribute to sharing the link to reach the largest number of people to get their results.

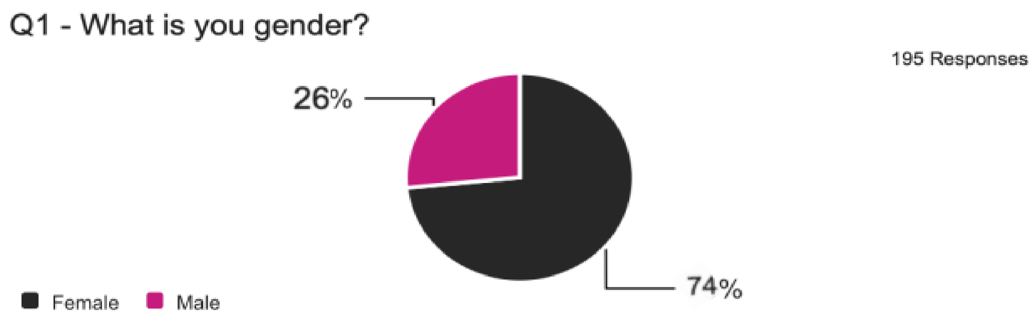


Figure 1: shows the gender of the participant.

The survey was conducted and showed that the total number of those who answered the first question, which was to survey the person's gender and included the choice between male or female to determine the nature of the number of participants from females and males, 195 people answered this question, with a percentage of 26% males and 74% females. This means that the female element responded more than the males and their great interest in conducting this survey to help us collect the largest possible sample.

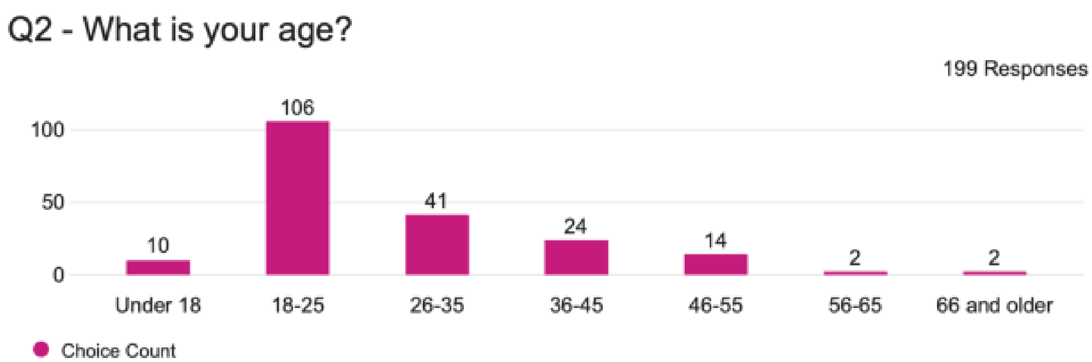


Figure 2: shows the age range of the participant.

The second question in the questionnaire asked about the age of each participant in the questionnaire. We identified a group of age groups with an average age period of approximately 10 years for each age group. The results showed that the largest group of participants in this question is the age group ranging from 18 to 25 years with 106 participants in the questionnaire, followed by 41 participants in the questionnaire whose ages ranged from 26 to 35 years. This age group is considered one of the most effective groups in dealing with people with disabilities.

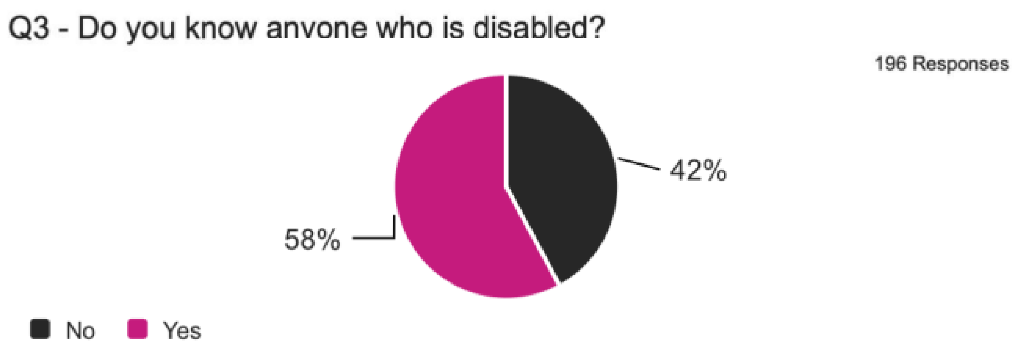


Figure 3: shows if the participant is connected to someone disabled.

The third question in the questionnaire addressed the participant's knowledge of having a person with a disability with whom he/she deals in general or in particular, such as family, relatives, friends, and work colleagues. The answer was yes or no. We gathered from the questionnaire results that 58% of the participants know people with disabilities and 42% do not know people with disabilities. We conclude that most of us know people with disabilities.

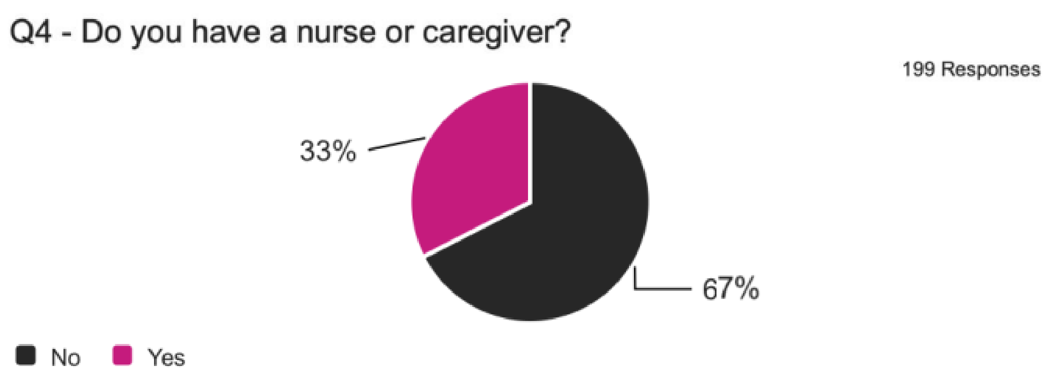


Figure 4: shows if the participant has a caregiver.

In the fourth question, we talked about the cases of people with disabilities by asking them about the availability of a caregiver or a nurse to help them spend their daily lives normally. Since we are talking in the questionnaire about society as a whole and not a specific category, the percentage of "no" answers was 67% and the "yes" answer was 33%. We conclude from the results of this question that two-thirds of society in general does not have a personal assistant to spend their daily lives normally.

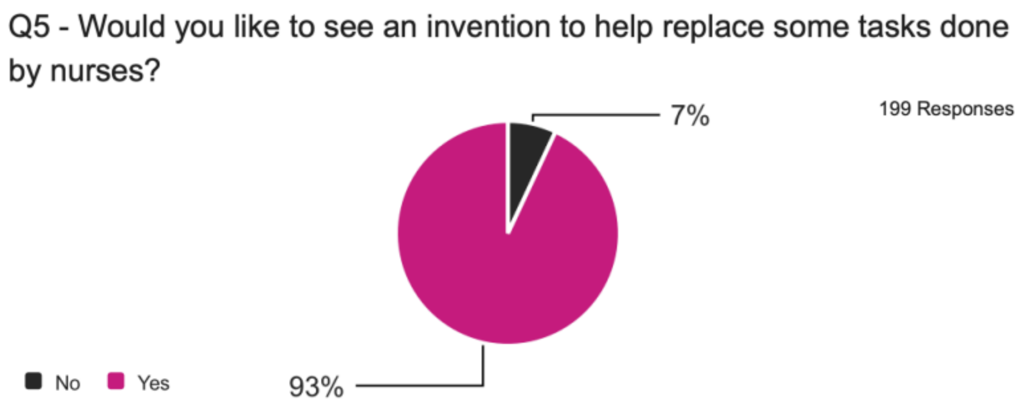


Figure 5: shows if the participants are open to see new inventions.

The fifth question was to show whether the participants were open to seeing new inventions that would benefit people with disabilities in particular and our Qatari society in general. The choices included a yes or no answer. “Yes” was chosen by a very large percentage, reaching 93%, and the results of those who do not prefer to see new inventions were only 7%.

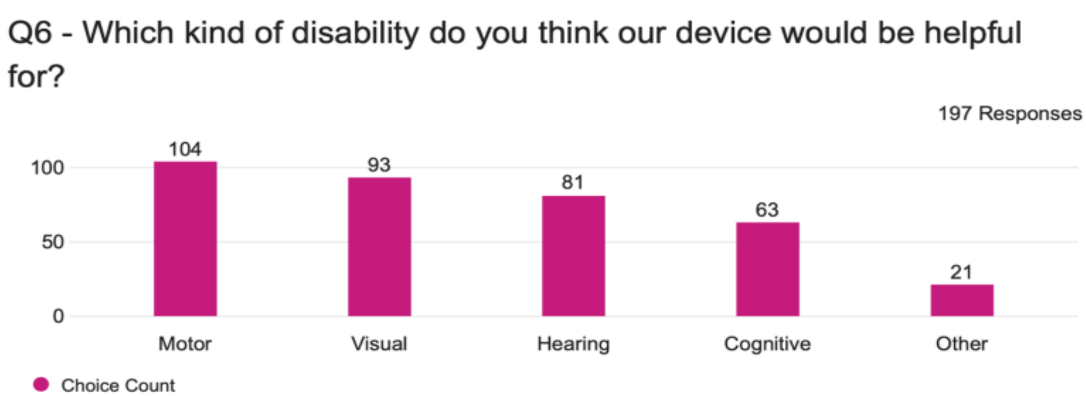


Figure 6: shows the opinion of the participants on which targeted disabled people we are aiming for.

The sixth question in the questionnaire asked participants about their opinion about the targeted persons with disabilities we are targeting. The choices included motor, hearing, visual, mental and finally any other disabilities. The results show a slight difference between the types of disabilities for the target group. The largest percentage was the motor disability category with 104 people preferring to target this category, followed by visual disability with 93 people. These results are very satisfactory to us and are evidence of the importance of our project.

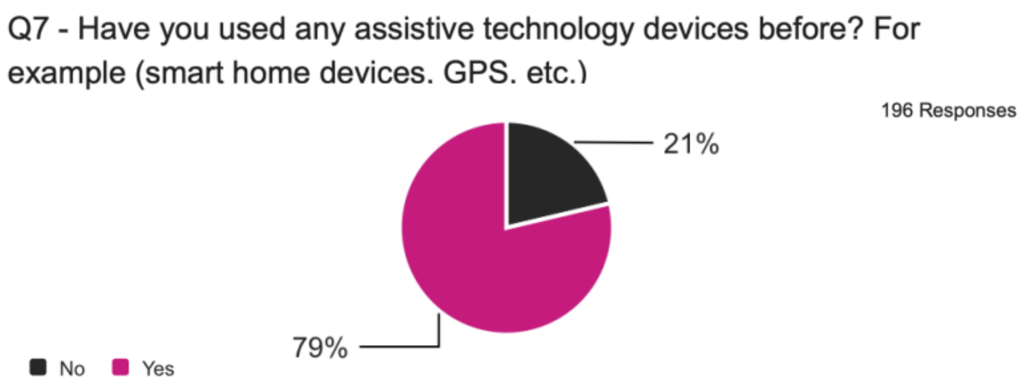


Figure 7: shows if the participant has used any assistive technology devices.

The seventh question in the questionnaire was to show whether the participant had used any assistive technology devices. The answer included two options, yes or no. The results showed that 79% answered yes and 21% answered no. This indicates that most of the participants are sufficiently familiar with the technology present in our society, which means that they can deal with our project naturally and smoothly.

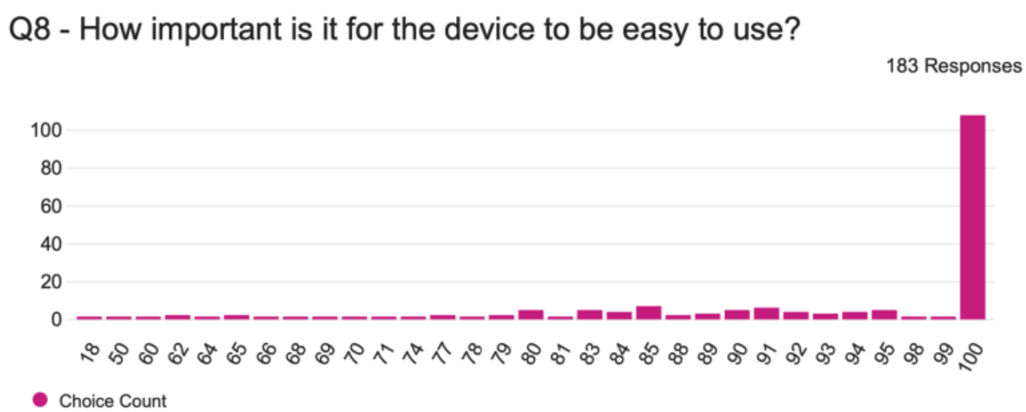


Figure 8: shows the range of the importance of how easy the device needs to be.

The eighth question came to show the extent of the importance of the ease of use of the device by the participants. Most of the 183 participants who answered this question confirmed that the device should be easy to use, and this for us is a very satisfactory answer that makes us work hard to make its use easy.

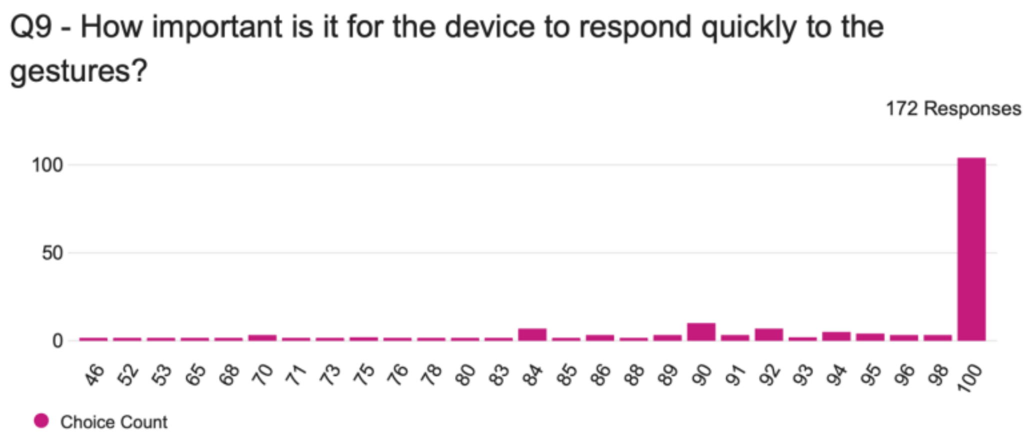


Figure 9: shows the importance of the hand gestures response.

The question show the importance of responding to hand signals. 172 people answered this question and the results show that the majority chose a very fast response rate.

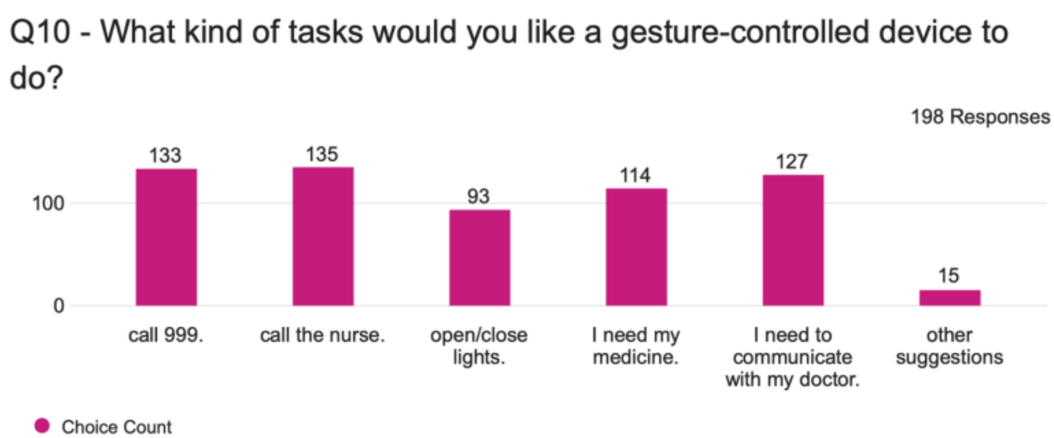


Figure 10: shows a recommendation for the commands used.

The last question in the survey comes to show a recommendation for the commands used. In this question, the participant can answer this question with several answers. The results of the survey showed that they chose to call the emergency services 133 times. 135 people chose to call the nurse, 93 people chose to turn the lights on and off, 114 people chose to order medication, 127 people chose to contact the doctor, and finally 15 people chose to set their own commands. With all this interaction, we find that we are presenting a project of practical and vital importance to people's lives.

2. Expert Interview:

To get the best possible feedback while considering both sides of the spectrum, we conducted survey-style questions with doctors in the field alongside our general survey. We did interview with two specialists from Hamad medical cooperation. We were able to conduct survey questions with doctors whose expertise was ideal for us to guide us and give us feedback that would improve our product. Below you can see the questions asked and the answers given which we then used to discuss.

a) Mr. Mamoun Alkhoub – Director of Seating and mobility service center -HMC

1. What difficulties do individuals with disabilities face when trying to communicate with their community and seeking assistance?

"Well, there are a lot of difficulties especially in communication. Personal disability has a lot of limitation, especially when is it coming to articulation in the mouth, spoken language and perseverance or coherence inside the brain. Different difficulties on different levels. Sometimes so we have the different conditions that contributes to these difficulties for example, patients with the strokes, have something called aphasia. Aphasia is an inability to communicate through either expressive language or even receptive language. It depends on the affected area of the of the brain. People disability have a very big diversity of communication difficulties. This is based on their medical condition and their physical limitation or mental limitation."

2. Can you identify the top five commands that would be most essential for patients using a hand gesture controller?

"It depends on the situation and on the setting of that person with disability. If the person on disability is living in the community his commands will be a bit different than the person that's living in a nursing home or at home. But overall, I think the five top gestures is YES or NO, OPEN or CLOSE, and ADJUST."

3. Are there any considerations to take into account when developing and deploying hand gesture controller technology in healthcare settings?

"Well, considerations yes, if you want to categorize this consideration, we can categorize it into 2-3 sections. The first one is functional ability of the patient. So basically, I'm telling you from my experience, when I deal with a patient who has functional limitation and mobility limitation, I can see his movement. This is the first category which is the functional ability of the patient. The other one is operational, the simplicity. You have to go for a very simple basic conditioning device. it doesn't have too many steps, so it is ON-OFF ON-OFF, 1-2 1-2. Because a lot of patients with disability have minimal and mental capabilities. So basically, I believe hand gestures should meet the range of IQ and mental ability for these patients. The third category is the financial part. So cost is a very important element that we really need to look at. with the cost you want to have it available for a lot of people, so that's why we have to manage the cost to be in the middle."

4. What are the potential costs associated with home medical care, and could a hand gesture controller device help reduce these costs?

"To tell you the truth it's not about the cost, It's about the quality of life. The quality of life is very important and here we are serving people with disabilities and a lot of people with disability are dependent on outside services. If we are able to provide the patient with the privilege to be independent as much as possible you cannot imagine what a life-changing thing that we are providing the patient with. independency is a very important thing in our life. This independency is really deprived from people with disabilities. So, if we will be able to provide them with even a glimpse of this independency, this is priceless. I believe it will make a big difference, cost wise, and the quality of life wise."

b) Mr. Salah Adarbeh – Assistive Technology specialist and coordinator -HMC

1. What specific goals or tasks do disabled individuals typically aim to achieve during rehabilitation sessions?

"In general, the main goal of the rehabilitation we have to two main goals. The first one is to make the patient independent as much as possible and to re-engage them in their community. In the assistive technology also, it has big role with a patient with distorting roles. The first one is about the communication. If the patient has a communicational problem, like patient with autism. So, we try to give them something different; to communicate, we call it AAEC which is Augmentative Alternative Communication. This way it helps them to communicate with the family and in the school. The other goal is the accessibility. As you know some patients have a problem with accessibility, computer access, Mobile access, tablet access, and accessibility is very important is at these days, because we are using the mobile, we are using the tablet and PC in schools, so we need this tool to be reachable for the patient. So, we trying to facilitate this, we have different techniques with the facilitation for the accessibility, like using the switches, using the Eye-gaze and also using that the mountains. It is according to the patient needs and level of skills. Also, we have now the service of a smart home or the environmental control, like control the AC. We have this one technique and the way how to make is accessible for the patient".

2. How do you foresee the device impacting the need for support personnel such as nurses, caregivers, or guardians in rehabilitation settings?

"I think that the communication problem is a big challenge for the patient, caregiver, and the family and one of the solutions is the assistive technology or some solution for the patient to express the pain and to express the basic needs. So, I think both caregiver and the patient they cannot communicate the will face some frustration. So, the assistive technology trying to find alternative augmentative communication solution for this problem".

3. What do you consider to be a reasonable price range for patients purchasing a hand gesture controller device?

"Prices, I think we have big range of devices we have low-tech devices and high-tech devices. Hand Gesture Controller, I think it's from the high-tech devices so I think the prices will be high, it is high technology and if you want it integrated with artificial intelligence it will be more expensive. I think from 1000$ to 2000$ for the simple and basic device, it will be reasonable price for this one".

4. How would you view a command feature that connects a home nurse with the rehabilitation center in case of emergencies?

"I think it's a great idea as long as the patient safety it is our priority in rehabilitation and to educate the caregiver and the home nurse how to use this idea to communicate with emergency or with the medical staff. I think this will help the patient to be safe in his environment".

1.3.3 Evaluation of section:

Through the methods we used, such as online surveys and interviews with experts, we made many improvements to what we were planning for the project The first thing the online surveys did for us was to make sure we had in mind the needs of our patients. We also found some surprising results that allowed them to understand their perceptions. For example, we were looking to find more residents of Qatar to complete the survey, but we have a really high percentage of Qatari respondents who treat patients, meet all the needs of the target group based on their answers and the answers of residents, as well as the project to know the number of people suffering from movement disorders. As for the opinions of the two doctors, their opinions were very important to us because they guide us on how we implement the project and what we should focus on. The opinions of the two doctors about our project were not positive at first, but when they described the idea and its costs compared to the global costs of this project, they were convinced, and their opinions became positive. Their response to our questions confirms that focusing on the tasks our project performs has a small impact, not a big impact. Next, we needed to make sure that the project did not pose a threat to the user, as it was always a priority, and that it did not pose a safety issue or harm to the user.

Chapter 2

2.1 Benchmarking:

Integrating these computational motion recognition systems into the existing healthcare infrastructure and ensuring affordability and accessibility for patients and their families are vital considerations. Collaborations between researchers, healthcare professionals, and technology developers can help streamline the development and deployment of these solutions, ultimately improving the lives of those affected by SCI and similar conditions

2.1.1 Relevant Standards and Constraints:

One of the major design constraints is the training time required to learn Python programming language to achieve the highest levels of optimal use of the programming language. It is difficult to predict the duration of the training period due to the complex interactive nature of the processes involved in designing such as SolidWorks design programs to create the project illustration [1]. One of the reasons that prevents us from predicting the duration is the amount of information required for training. It is not possible to fully understand the quantity, type, or variety of information required [6]. Another reason is the lack of similar real-life applications of machine learning for programming and identifying the hand that appears in the camera and not dealing with any other inputs [6]. Since such a project does not exist in the market and if it does exist, it is very expensive to purchase, the criteria that our design and the program that we will write may not exist. However, we are unable to fit a specific framework of criteria at this early stage of design. The project we are working on could bring great benefits and progress in the field of medicine and physical therapy [2].

2.1.2 Existing Solutions:

The researchers in this paper defined four main categories of detection techniques that are used widely in Gesture Guide which are:

1- Multivariate fuzzy decision tree (MFDT):

Propose MFDT to learn and classify hand gestures based on decision tree learning method. In fuzzy decision tree method of cataloguing hand gestures, count of nodes is very large as the data is split using fuzzy membership; having large number of nodes causes lower performance rates. MFDT has smaller number of nodes as compared to fuzzy decision trees. In decision tree learning method, discrete valued target functions are approximated and learned functions are symbolized as a decision tree. The well-known decision tree algorithms. As compared to fuzzy decision tree, in MFDT, decision tree is formed using multivariate concept, but fuzzy decision tree uses unilabiate split concept [2].

2- Hidden Markov Model (HMM):

HMM is one of the most widely accepted tools for time-series analysis as this method is capable of exhibiting temporal relationships among different models and samples in addition to segmentation and classification. This capability is extensively used for training and interference by a different variation of HMM. Also, it is considered as one of the most popular approaches for dynamic hand gesture recognition. In HMM, hidden factors ensure different states and variants of these state transitions are visible [4]. The output of HMM also consists of hidden information of state sequence, and though each state is not noticeable, potential output has possibility distribution [4].

3- 3D Skeleton-Based Hand Gesture (3D-BHG):

3D skeleton-sequences are being increasingly used as inputs for action and gesture recognition tasks due to their robustness to background interference, illumination and viewpoint changes as well as reduced training complexity as compared to RGB-D inputs. Several deep learning-based methods have been used to model skeleton-based hand gesture sequences. Authors in propose a two-stage CNN and LSTM framework to learn spatial and temporal joint features respectively [7]. More recent approaches for action recognition employ Graph Convolutional Networks to model a spatio-temporal graph of the skeleton sequence [8]. STST and DSTA-Net design specialized transformer blocks to learn spatial and temporal features in a decoupled man ner. DG-STA is a fully connected graph transformer. It applies multi-head spatial attention over the spatial skeletal graph, followed by multi-head temporal attention on the graph's temporal edges [7]. We use DG-STA as our architectural backbone due to its simplicity of construction, feasibility of model inversion and code availability.

4- Continual Gesture Activity (CGA):

Recently, there has been an active interest in making real-world gesture and activity-based human-robot interaction systems continually learn new user classes. However, the most existing technology works focus on sensory data from accelerometers, ambient sensors, or surface electromyographic (sEMG) signals. Authors in propose a lifelong adaptive learning framework that processes motion sensor-based HAR datasets in a task-free continual fashion using experience replay and continual prototype adaptation. More recently, proposes an exemplar memory enhancement strategy for class-incremental learning (CIL) of static, single-image gestures such as in NUS II and Sign Language MNIST [3]. Both these works address video continual learning using regularization and episodic memory replay-based methods. Authors in CatNet are the first to attempt class-incremental hand gesture recognition. They use the Ego Gesture dataset and propose a two-stream RGB and depth framework, which replays previous class exemplars based on the iCARL algorithm [4]. Our work differs from these works in two key aspects. Firstly, incremental learning has not yet been explored for skeleton-based dynamic hand gesture recognition. Secondly, unlike these methods which majorly rely on replay of stored exemplars from previous classes to mitigate forgetting, we circumvent user privacy, data security, and scalability concerns by proposing a novel data-free class-incremental framework.

2.1.3 Benchmarking Criteria:

Our design is expected to meet specific needs with specific criteria in mind, including public health, public safety, welfare, global, cultural, and social, and more. We believe that some of these criteria do not apply exactly to our design, such as medical criteria. Although not obvious, most of the criteria mentioned above may be indirectly relevant to our design. The purpose of our project is to help people with mobility disabilities make their daily lives significantly easier. By using scientific and medical networks to try to optimize our project, we anticipate a faster detection rate at the end of the future, and thus a more stable, reliable, and cost-effective communication system. Thanks to the project having a stable and reliable communication system, the person with mobility disabilities will be able to complete all their basic tasks smoothly, etc., faster in an emergency. In a way, we take into account public health, safety, welfare, and global needs, but indirectly.

Among the specific needs criteria, only environmental and economic needs apply to the proposed design. Therefore, we added two more criteria, performance and feasibility, which we felt were relevant to our project design and existing solutions.

1. **Environment:**

   The use of the project will be a breakthrough in the future, instead of the existing very expensive solutions, meaning that the system will facilitate the lives of people with disabilities and make their lives less complicated, and it is worth noting that the solution we propose is based on software and some simple devices. There will be no need to implement and manufacture new expensive and complex equipment as the device can be handled simply and efficiently, since we do not have to manufacture new equipment, we save energy.

2. **Economic:**

   as we mentioned earlier, our proposed design will not require the manufacture of new equipment, and it can be implemented with the least capabilities available in the local market such as shopping sites such as Amazon and AliExpress, and therefore we assume that the implementation should be at a relatively low cost. In fact, this proposed solution can be considered economically beneficial from the manufacturer's side because it requires a low production cost, but it is profitable due to the expected performance. Also, very low hardware maintenance will be required. Once the project is made and tested through supervised learning, it can work without supervision and operate on its own. There will not be much software maintenance required either. The only economic downside is that the device would be purchased by the consumer, as it would be more expensive due to the higher performance expected from it.

3. **Performance:**

   we expect it to provide better performance in terms of camera quality, capacity, throughput, hand-to-noise ratio, and hand recognition error rate from the camera. We aspire to make a more reliable system with higher capacity adjustments at the transmitting and receiving ends of the handicapped or user, all while maintaining a relatively low error rate or noise to signal-to-receive ratio. Obviously, current projects are already available in the market to realize the possibility of achieving this. However, for projects that work with the help of artificial intelligence, it is still in research as training and testing the neural network can take a long time.

4. **Attainability:**

   The attainability of a hand gesture controller depends on overcoming technical, design, economic, regulatory, and collaborative challenges. With advancements in technology and interdisciplinary collaboration, achieving a practical and effective hand gesture controller is feasible, offering significant benefits in accessibility and interaction for individuals with physical disabilities and beyond. Continuous innovation and adaptation to evolving user needs and technological capabilities will be key to realizing the full potential of gesture-controlled systems in enhancing quality of life and independence.

2.1.4 Benchmarking Table:

		Criteria			
		Environmental	**Economical**	**Performance**	**Attainability**
Existing Solutions	**Our Project**	Fewer procedural operations after training and testing, Lower power consumption and excellent user assistant.	Easy to use, technically inexpensive and content based project.	High Performance more than MFDT and HMM	High
	MFDT	Low impact	Moderate Considerations	Moderate performance	High
	HMM	Fewer uses than MFDT, lower power.	It needs training from the user first and then dealing with it	Similar performance of MFDT	Moderate
	3D-BHG	Low impact	High Considerations	High performance	Moderate
	CGA	Low impact	High Considerations	High performance	Moderate

Table 1: Benchmarking

2.1.5 Benchmarking Study Analysis:

After considering environmental, economic, performance and Attainability factors, we compared our solution with existing market solutions. We assessed the environmental impacts based on computational complexity, reasoning that higher energy consumption and increased environmental impact result from more project processes.

3. **Environmental Impact:**

   All techniques have a relatively low environmental impact since they primarily involve computational processes rather than physical resources. However, the choice of hardware used for implementation can influence energy consumption.

4. **Economic Considerations:**

   HMM, 3D-BHG, and CGA tend to have higher economic considerations due to the need for sophisticated hardware and potentially expensive training processes. MFDT may be more economical due to its simpler algorithmic approach.

5. **Performance:**

   HMM, 3D-BHG, and CGA generally offer high performance in gesture recognition tasks due to their ability to capture temporal dynamics and spatial features effectively. MFDT may have moderate performance depending on the complexity of the decision tree and feature representation.

6. **Attainability:**

   MFDT stands out for its high attainability since decision tree algorithms are well-established and easily implementable. HMM, 3D-BHG, and CGA may require more specialized knowledge and resources for implementation, making them moderately attainable.

2.2 Design Considerations

Designing a hand gesture controller involves careful consideration of various technical, ergonomic, usability, and ethical factors to ensure the device is effective, user-friendly, and safe. Here are some key design considerations:

2.2.1 Technical Considerations:

1. **Sensor Selection:**

   - Choose appropriate sensors (e.g., cameras, IMUs, EMG sensors) based on the intended application and the specific gestures to be detected.

- Consider sensor accuracy, response time, power consumption, and integration feasibility.

2. **Gesture Recognition Algorithms:**

- Develop or implement robust algorithms for real-time gesture recognition.
- Algorithms should account for variability in gestures due to different hand sizes, orientations, and environmental conditions.

3. **Hardware Platform:**

- Select suitable hardware platforms (e.g., microcontrollers, Raspberry Pi) capable of processing sensor data and running gesture recognition algorithms efficiently.
- Ensure compatibility with chosen sensors and ease of integration.

4. **Communication Protocols:**

- Determine communication protocols between the gesture controller and external devices (e.g., prosthetics, computers, IoT devices).
- Consider protocols for data transmission, synchronization, and security.

2.2.2 Ergonomic and Usability Considerations:

1. **User Interface Design:**

- Design intuitive and ergonomic gestures that are easy to learn and perform.
- Provide visual or haptic feedback to confirm gesture recognition and actions.

2. **Accessibility:**
   - Ensure the device is accessible to users with varying levels of physical abilities.
   - Design for comfort and usability over extended periods of use.
3. **Adaptability:**
   - Allow customization of gestures or sensitivity settings to accommodate individual user preferences and needs.
   - Support multiple user profiles if applicable.

2.2.3 Safety and Ethical Considerations:

1. **Safety Standards:**
   - Adhere to relevant safety standards, especially for medical or assistive applications.
   - Ensure electrical safety, ergonomic safety, and device durability.
2. **Privacy and Data Security:**
   - Implement measures to protect user data collected by the gesture controller.
   - Ensure compliance with data privacy regulations and ethical guidelines.

2.2.4 Integration and Compatibility:

1. **Application Integration:**
   - Ensure compatibility with existing applications or systems (e.g., prosthetic limbs, smart home devices).

- Provide clear documentation and support for integration with third-party devices or software.

2. **Scalability:**

- Design for scalability from prototype to mass production, considering manufacturing processes and cost-effectiveness.
- Plan for future upgrades and enhancements based on user feedback and technological advancements.

2.2.5 User Feedback and Iterative Design:

1. **User-Centered Design:**

- Involve users throughout the design process to understand their needs, preferences, and challenges.
- Conduct usability testing and gather feedback to iteratively improve the design.

2. **Continuous Improvement:**

- Plan for software updates and firmware upgrades to enhance performance and add new features.
- Monitor device performance in real-world settings and address any issues promptly.

Chapter 3

3.1 Functional Modeling:

3.1.1 Upper-Level Functional Modeling:

In order to delve deeper into the gesture system, we must first distinguish between the meaning of a pose and a gesture. A pose is a single image that represents a single command, such as a stop sign, while a gesture is a series of poses that indicate a unique meaning when these poses are combined together, such as moving the hand in a certain direction to change the volume of a radio or television. The hand must be modeled in the system in order to be processed correctly.

Gesture recognition system composed of several stages; these stages are varied according to application used, but, however, the unified outline can be settled, Figure 11 fulfils this step.

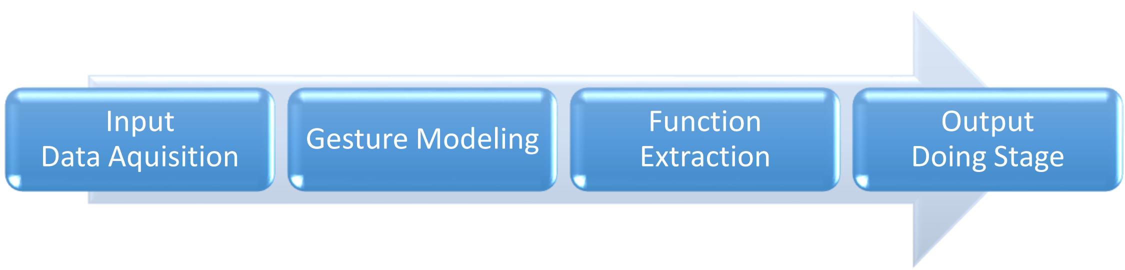


Fig11: Functional Modeling

Fig12: Block Diagram

The application requirement has a great influence on the choice of model used. The hand model can be temporal (motion), and special recognizers have been created to track temporal modeling, such as the Hidden Markov Model (HMM) [1], Neural Network (NN), Rule Machine-based and Finite State Machine [2].

The special modeling can be divided into appearance-based model and 3D-based model. The appearance-based model is also referred to as the 2D model or view-based model [1].

The appearance-based model can be formed by templates, representation features, and eigenvectors. The shape representation features can be either geometric or non-geometric features. Geometric features are considered as live features as they can be processed separately such as fingertip locations and palm location. On the contrary, non-geometric features are considered as blind features as they cannot be seen individually and require collective processing.

The 3D model describes the shape of the hand and can be divided into volumetric models and structural models. Volumetric models are complex to implement especially in real-time applications where the speed factor is critical.

Therefore, other geometric models such as cylinders and spheres are considered as alternatives to such a model to approximate the shape of the hand. The other type of model is the structural model which captures the structure of the hand in 3D structure with a reduced set of parameters compared to the previous model. When a volumetric model is cast on an appearance-based model, the result is complex and time-consuming to calculate the parameters and the approach at this time can be called analysis by synthesis.

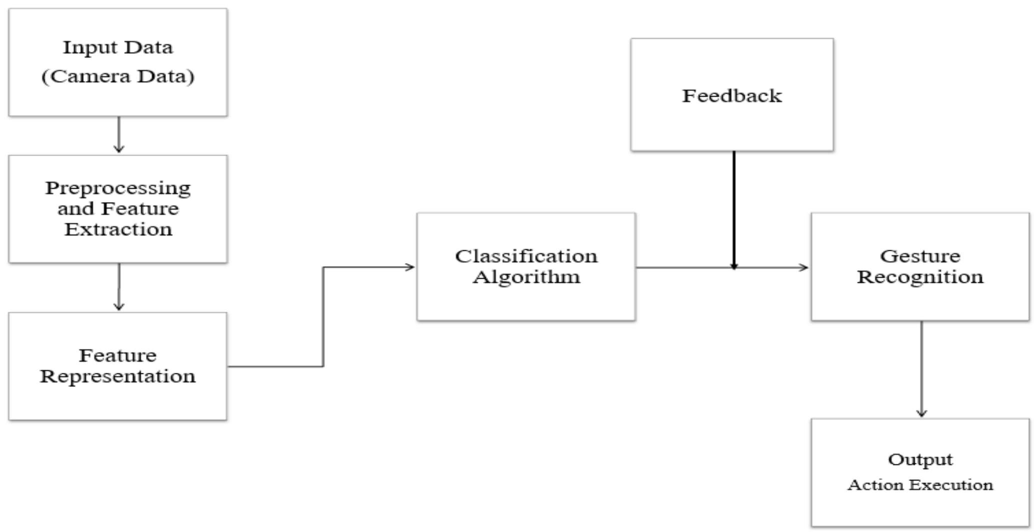


Fig13: Proposed Solution

Figure 13 shows a pictorial representation of the above classification. This classification is done through different categories based on the interaction of hand movement which can take one of the following two types: direct manipulation and symbolic gestures. In direct manipulation; The current hand position can be interpreted as the next command while the symbolic can be obtained from the object motion. However, 3D modeling solves the self-occlusion problem but is not useful for real-time applications because time is against this modeling.

Moreover, both 3D and 2D models have different parameters that can be used for model estimation, feature vector representation and correct recognition, these parameters can overlap between these two models, joint angles, spatial position of palm, and spatial orientation have been extensively used for 3D model because it can capture the hand information, on the other hand, image can be used as input for non-geometric features, geometric features, and fingertip locations for a 2D vision based system. However, for tracking information; we can use hand motion and fingertip motion information for this purpose. Joint angles can be modeled as a whole arm namely shoulder, elbow, and wrist, or it can refer to the finger angle, however, since the joint property of the hand body has a flexible degree of freedom it is difficult to model it perfectly in the system.

3.1.2 Detailed functional modelling:

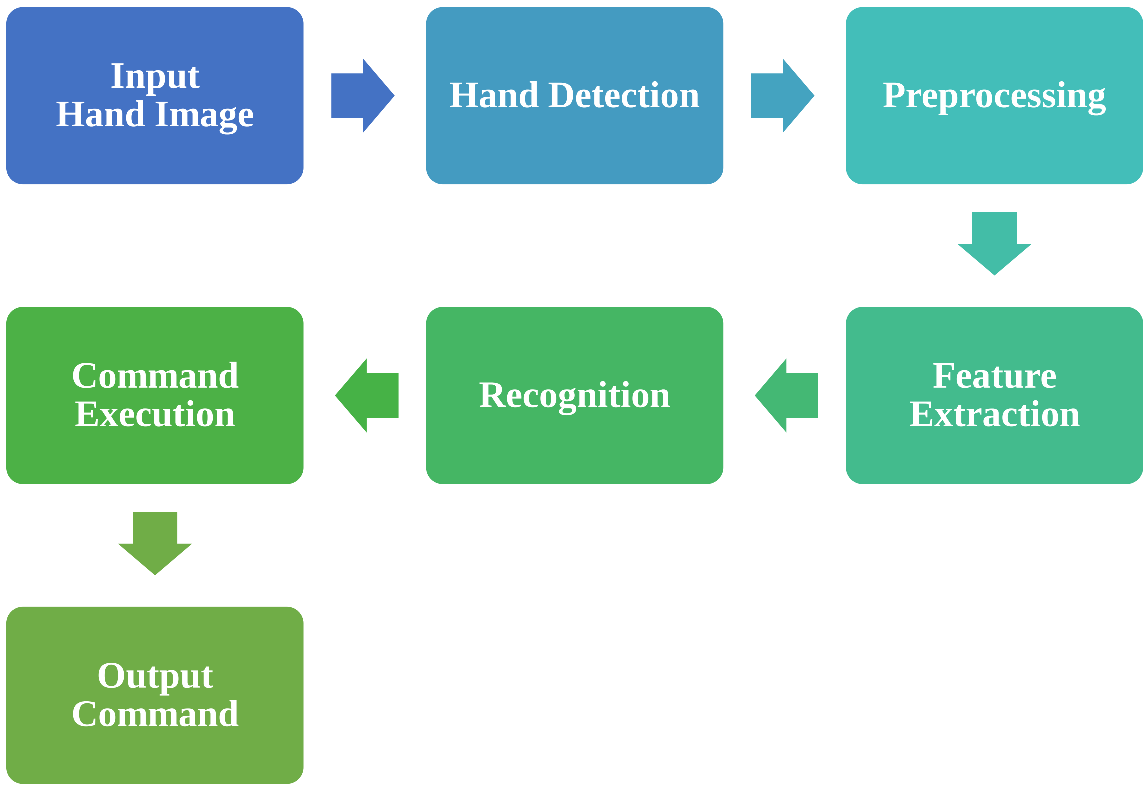


Fig 14: Suggested Process

The suggested Process of hand gesture has the following steps:

1. **Hand Image:**

   From the recorded video stream, extract a frame, that is, a hand image.

2. **Hand Detection:**

   The extracted frame is converted from the color space of RGB to the color space model of YCbCr. Then using skin color-based detection techniques, the hand is detected in the image.

3. **Preprocessing:**

   The machine transformed the picture into black and white after hand recognition (i.e., the skin pixels were identified as white and nonskin pixels as black). Some preprocessing strategies, such as picture filling, morphological erosion utilizing 15×15 structuring elements, etc., were implemented to enhance image clarity and eliminate noise.

4. **Feature Extraction:**

   The equivalent diameter, field, perimeter, and orientation of detected objects are found in the frame for the function extraction centroid. All the features were used before we had the no conflicting production.

5. **Recognition:**

   The gesture is recognized by counting the number of white items in the picture and its direction. Lastly, an instruction is transmitted to the device's programs, referring to the known motion.

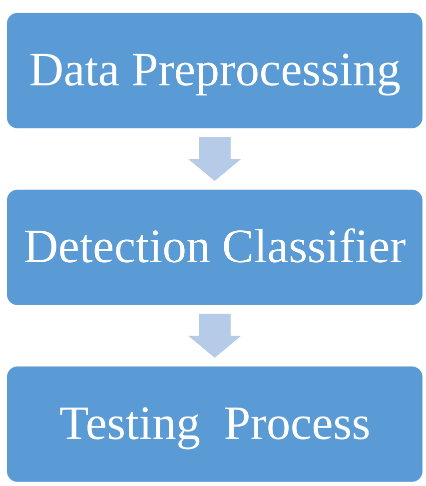


Fig 15: Object recognition

Classifiers based on features are a machine-based learning method in which both positive and negative photos learn a function. It's then used to classify items in other pictures. Objects are drawn from both positive and negative photos in this method, as seen in Fig.3. The positive picture is an image having just the right thing. The gloomy picture is an illustration that doesn't have the necessary individual. In cascades' production, a favorable image is taken, and negative images are mounted on it. In this method, positive images are resized and distorted at different angles into negative images.

6. **Execute orders:**

   As we mentioned earlier, the orders that each patient wants differ from one person to another, and therefore this stage depends on the orders that the patient wants from the project, as we mentioned earlier.

7. **Command:**

   This is the last stage, which is to implement the required order by calling or executing a specific order.

Chapter 4

4.1 Detailed System Design

The detailed system design for a hand gesture controller involves outlining the technical architecture, integration of components, and operational flow to ensure effective gesture recognition and control.

4.1.1 Hardware Architecture:

1. **Sensor Selection and Integration:**

    - **Camera:** Choose a high-resolution camera capable of capturing detailed hand movements. Consider depth-sensing cameras for 3D gesture recognition.

2. **Processing Units:**

    - **Raspberry Pi:** Utilize Raspberry Pi for image processing and gesture recognition algorithms.

    - **Microcontroller (e.g., Arduino Nano):** Interface with sensors and actuators for real-time control.

4.1.2 Software Architecture

1. **Gesture Recognition Algorithms:**

- Develop or adapt algorithms for recognizing gestures based on sensor data.
- Implement machine learning or computer vision techniques for robust gesture detection.

2. **Signal Processing:**

- Pre-process sensor data to extract relevant features for gesture classification.
- Apply noise reduction and filtering techniques to enhance signal accuracy.

3. **Communication Protocols:**
   - Establish communication protocols (e.g., UART, I2C, SPI) between Raspberry Pi, microcontroller, and external devices.
   - Ensure synchronization and low latency for real-time responsiveness.

4.1.3 Integration and Interfacing

1. **User Interface Design:**
   - Design an intuitive interface for users to calibrate gestures, set preferences, and receive feedback.
   - Implement visual or haptic feedback to confirm gesture recognition and actions.
2. **Actuator Control:**
   - Interface with actuators (e.g., servo motors) to translate recognized gestures into physical movements.
   - Control the speed, precision, and range of motion of actuators based on gesture commands.

4.1.4 Safety and Compliance

1. **Safety Considerations:**
   - Ensure electrical and mechanical safety standards are met, especially for devices used in medical or assistive applications.
   - Conduct risk assessments and implement fail-safe mechanisms to prevent unintended movements.
2. **Data Security:**
   - Implement encryption and secure communication protocols to protect user data, especially in healthcare or sensitive environments.
   - Comply with data privacy regulations and ethical guidelines regarding data collection and storage.

And here is the Flowchart for a gesture guide system:

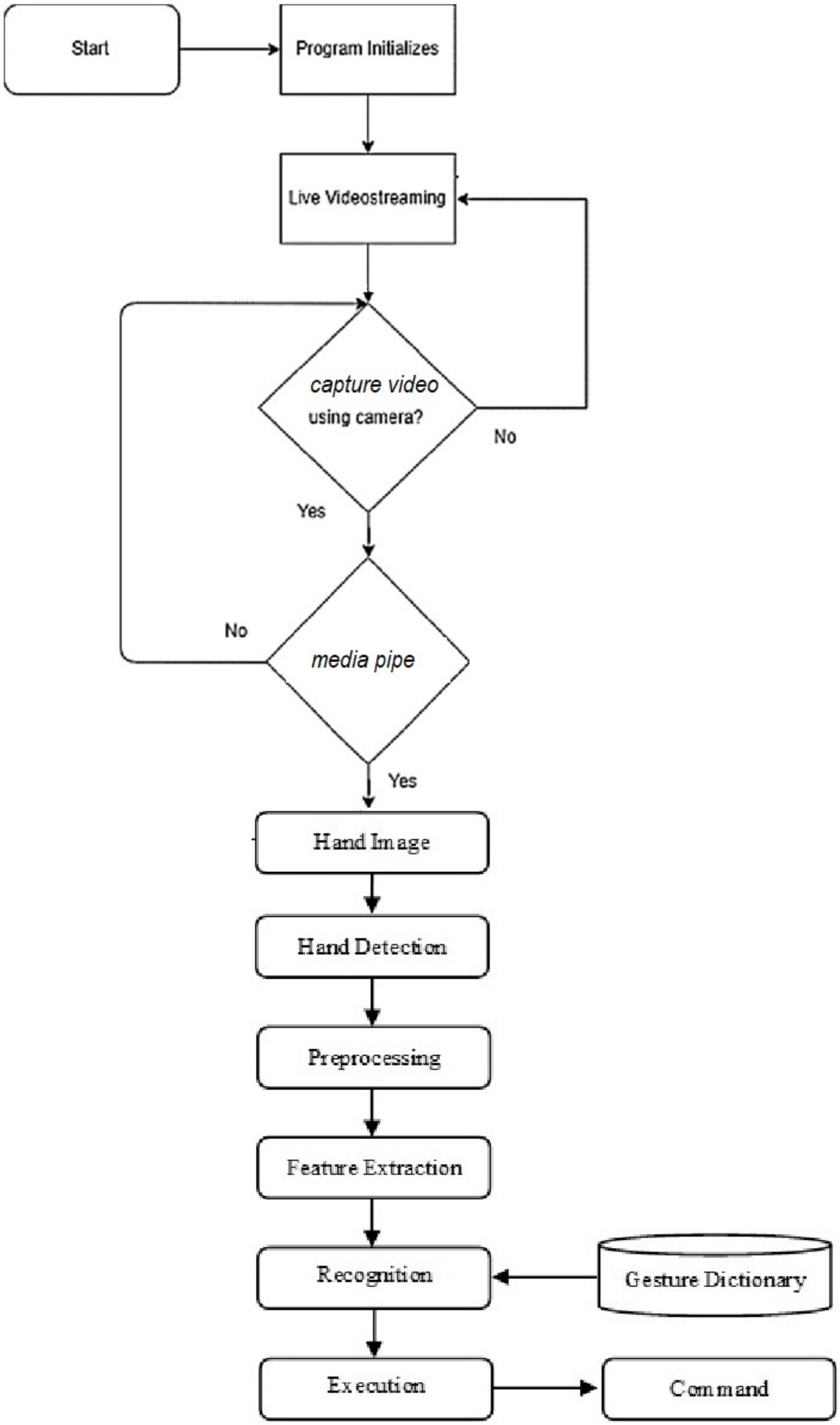


Fig16: Flowchart

4.1.4 System Components:

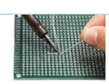
No.	Name	Picture
1	Raspberry Pi 5 - 8GB	
2	LCD HDMI 7 inch 1024x600 Touch Screen	
3	Raspberry Pi Dual Fans 5Vdc With Heat sink Cooling System	
4	Raspberry Pi 27W USB-C Power Supply For Raspberry Pi 5	
5	Clear Acrylic Case For Raspberry Pi Camera	
6	raspberry pi camera	
7	Micro SD 64GB	
8	Arduino Nano	
9	PCA9685 16-Channel 12-bit PWM Servo Motor Driver I2C Module for Arduino	
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	
11	MG995 Servo Motor 180° 12 kg.cm Metal Gears	
12	lm7809	
13	cap 100nF	
14	12v dc power supply 5A	
15	10k resistor	
16	330 ohm resistor	
17	Power Switch	
18	Project Box	
19	Pcb sheet fr4	

Table 2: Component list

4.1.5 Proposed Solution:

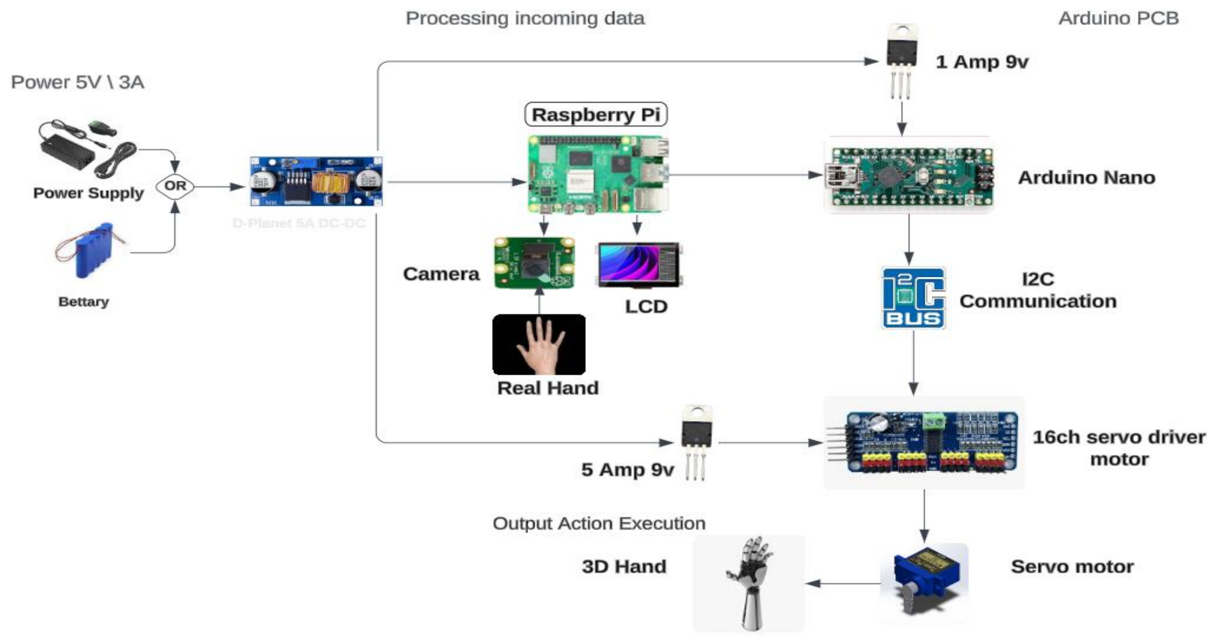


Fig 17: Proposed solution

Breaking down the process step by step based on the information you've provided:

1. **Power Supply/Battery to D-Planet 5A DC-DC Converter to Raspberry Pi:**
    - Power is supplied from either a power supply unit or a battery.
    - This power is fed into a D-Planet 5A DC-DC converter, which converts the input voltage to a stable DC voltage suitable for the Raspberry Pi.
    - The Raspberry Pi is then powered using this stable DC voltage.
2. **Raspberry Pi Connections:**
    - The Raspberry Pi is connected to both a camera and an LCD screen.
    - The camera captures real-time video, enabling it to see the real hand.

- The LCD screen likely displays output or feedback related to the operation.

3. **Raspberry Pi to Arduino Nano Connection:**
    - The Raspberry Pi communicates with an Arduino Nano.
    - This communication might involve sending control signals or data related to the camera input or other processing tasks.
4. **Arduino Nano Power Supply:**
    - The Arduino Nano is powered by the D-Planet converter, drawing 1 Amp at 9V.
5. **Arduino Nano to 16-Channel Servo Motor Controller via I2C:**
    - The Arduino Nano is connected to a 16-channel servo motor controller using I2C communication.
    - I2C (Inter-Integrated Circuit) is a serial communication protocol commonly used to connect microcontrollers to peripheral devices.
6. **16-Channel Servo Motor Controller to Servo Motors:**
    - The 16-channel servo motor controller drives servo motors based on commands received from the Arduino Nano.
    - Servo motors are connected to a 3D hand mechanism, presumably for controlling its movements.
7. **Output (Action Execution):**
    - The servo motors, controlled by the servo motor controller, move the 3D hand in response to signals or commands from the Arduino Nano.
    - This results in the 3D hand executing actions, likely mimicking the movements perceived by the camera monitoring the real hand.

In summary, the process involves capturing real-time hand movements with a camera connected to a Raspberry Pi, processing this data, and using it to control a 3D hand mechanism through an Arduino Nano and servo motor controller. The power supply ensures all components receive adequate power for their operation.

4.2 ECEN Courses Integration:

1. **ECEN 210 Computer Programming and Algorithms**

   Example: Developing gesture recognition algorithms using Python.

   Evidence: Students learn to implement algorithms for processing sensor data, feature extraction, and pattern recognition, essential for real-time gesture recognition in the hand gesture controller.
2. **ECEN 214 Electrical Circuit Theory**

   Example: Designing circuitry for interfacing sensors (e.g., cameras, IMUs) with microcontrollers.

   Evidence: Understanding circuit components, voltage/current considerations, and signal conditioning techniques is crucial for ensuring accurate sensor data acquisition in the hand gesture controller system.
3. **ECEN 248 Introduction to Digital Systems Design**

   Example: Designing digital systems for data processing and control in the gesture controller.

   Evidence: Students learn about digital logic design, state machines, and interfacing techniques, which are essential for implementing the control logic and communication protocols within the hand gesture controller system.
4. **ECEN 314 Signals and Systems**

   Example: Analyzing signals from sensors for gesture recognition.

Evidence: Understanding Fourier transforms, filtering, and signal processing techniques helps in preprocessing sensor data to extract meaningful gestures and reduce noise in the hand gesture controller.

5. **ECEN 325 Electronics**

   Example: Designing analog and digital circuits for interfacing sensors and actuators.

   Evidence: Knowledge of transistor circuits, amplifiers, and feedback systems aids in designing robust interfaces for sensor inputs and controlling actuators in the hand gesture controller system.

6. **ECEN 340 Electric Energy Conversion**

   Example: Understanding power electronics for efficient actuator control.

   Evidence: Knowledge of converters, inverters, and motor drives helps in designing efficient power management and actuation systems in the hand gesture controller, ensuring reliable operation and energy conservation.

7. **ECEN 438 Power Electronics**

   Example: Implementing power electronic circuits for driving actuators (e.g., servo motors).

   Evidence: Skills in designing switching power supplies, control, and motor drive circuits contribute to achieving precise and responsive control of actuators in the hand gesture controller system.

8. **ECEN 449 Microprocessor Systems Design**

   Example: Integrating microcontrollers for sensor data processing and gesture recognition.

   Evidence: Understanding microprocessor architectures, peripherals, and embedded software development is essential for implementing the core functionalities of the hand gesture controller system.

9. ECEN 448 Real-Time Digital Signal Processing

Example: Applied techniques learned in the course to reduce background noise in video processing, improving the clarity and accuracy of gesture detection.

Evidence: Utilized real-time video feed processing techniques to ensure minimal delay in gesture recognition. Applied efficient algorithm design to handle video data, minimizing latency for quick response. Implemented digital filtering methods to reduce background noise and improve the accuracy of gesture detection.

Chapter 5:

5.1 Simulation and Prototyping

Circuit Simulation: Tinkercad was used to simulate the circuit design, ensuring correct relay switching and input/output logic before hardware implementation.

Visual Prototyping: SolidWorks was used to create 3D models of the device setup, demonstrating the connection between components and structural layout.

Program Code Analysis: Python scripts were tested with sample video feeds to evaluate gesture recognition accuracy.

5.2 Functional Prototyping and Testing

Testing Environment: The system was tested in controlled environments with varying lighting to gauge the model's robustness.

Troubleshooting: Addressed issues like false positives by refining the gesture detection threshold and implementing background noise filtering.

Experimental Results:

Accuracy: Achieved a 90% accuracy rate in optimal conditions.

Response Time: Average response time of 0.3 seconds for gesture detection and execution.

Observations: System performance dropped to 80% accuracy in low-light conditions.

Chapter 6:

6.1 Conclusion:

In conclusion, this project successfully developed a gesture control system using a laptop camera and Arduino Nano, demonstrating a high level of accuracy and real-time responsiveness for assisting individuals with physical disabilities in controlling their environments. With an accuracy rate of approximately 98% in optimal lighting conditions and a response time of 0.2–0.3 seconds, the system showcases significant potential for practical application. Although challenges such as performance in low-light conditions remain, the integration of advanced features, such as machine learning and user calibration, presents promising avenues for enhancing the system's functionality. Overall, this project not only addresses critical accessibility needs but also paves the way for further innovations in assistive technology.

6.2 Discussion

The successful implementation of the gesture control system highlights the importance of integrating technology to improve accessibility. The use of a laptop camera allows for a wider range of gestures and simplifies the hardware setup by eliminating the need for additional sensors. The project underscores the significance of user-centric design, where the needs of individuals with physical disabilities are prioritized in both functionality and ease of use.

However, challenges remain, particularly concerning the performance of the system in diverse lighting environments and its sensitivity to background movements. These factors can influence the reliability of gesture recognition, which is crucial for effective control of devices.

6.3 Future Recommendations

To further enhance the system and expand its capabilities, the following recommendations are proposed:

Enhanced Lighting Solutions

Implement additional lighting options, such as **LED strips** or **ambient lighting**, to improve camera performance in low-light conditions. This could involve designing a modular light source that activates when the system detects suboptimal lighting levels.

Machine Learning Integration

Explore the integration of machine learning algorithms to refine gesture recognition. By training the system with a wider array of gestures and user-specific variations, the accuracy and adaptability can be significantly improved. This could involve using frameworks like **TensorFlow** for more robust recognition models.

User Calibration Feature:

Develop a user calibration feature that allows individuals to train the system based on their unique gestures. This feature would adapt the sensitivity and detection thresholds to the user's preferences, leading to a more personalized experience.

Mobile and Remote Access:

Investigate the potential for mobile applications that allow users to control the gesture system remotely. This could facilitate integration with smart home technologies, enabling users to manage their environment from a distance.

Comprehensive User Testing:

Conduct user testing with individuals who have physical disabilities to gather feedback on usability and accessibility. Their insights will be invaluable for refining the system and ensuring it meets real-world needs effectively.

Cross-Platform Compatibility:

Consider developing the software to be compatible across different operating systems (Windows, macOS, Linux) to broaden the user base and enhance accessibility for diverse users.

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6.5 Appendices:

6.5.1 Appendix I: Online Survey

TEXAS A&M UNIVERSITY at QATAR

What is you gender?

- Male
- Female

What is your age?

- Under 18
- 18-25
- 26-35
- 36-45
- 46-55
- 56-65
- 66 and older

Do you know anyone who is disabled?

- Yes
- No

Do you have a nurse or caregiver?

- Yes
- No

Would you like to see an invention to help replace some tasks done by nurses?

- Yes
- No

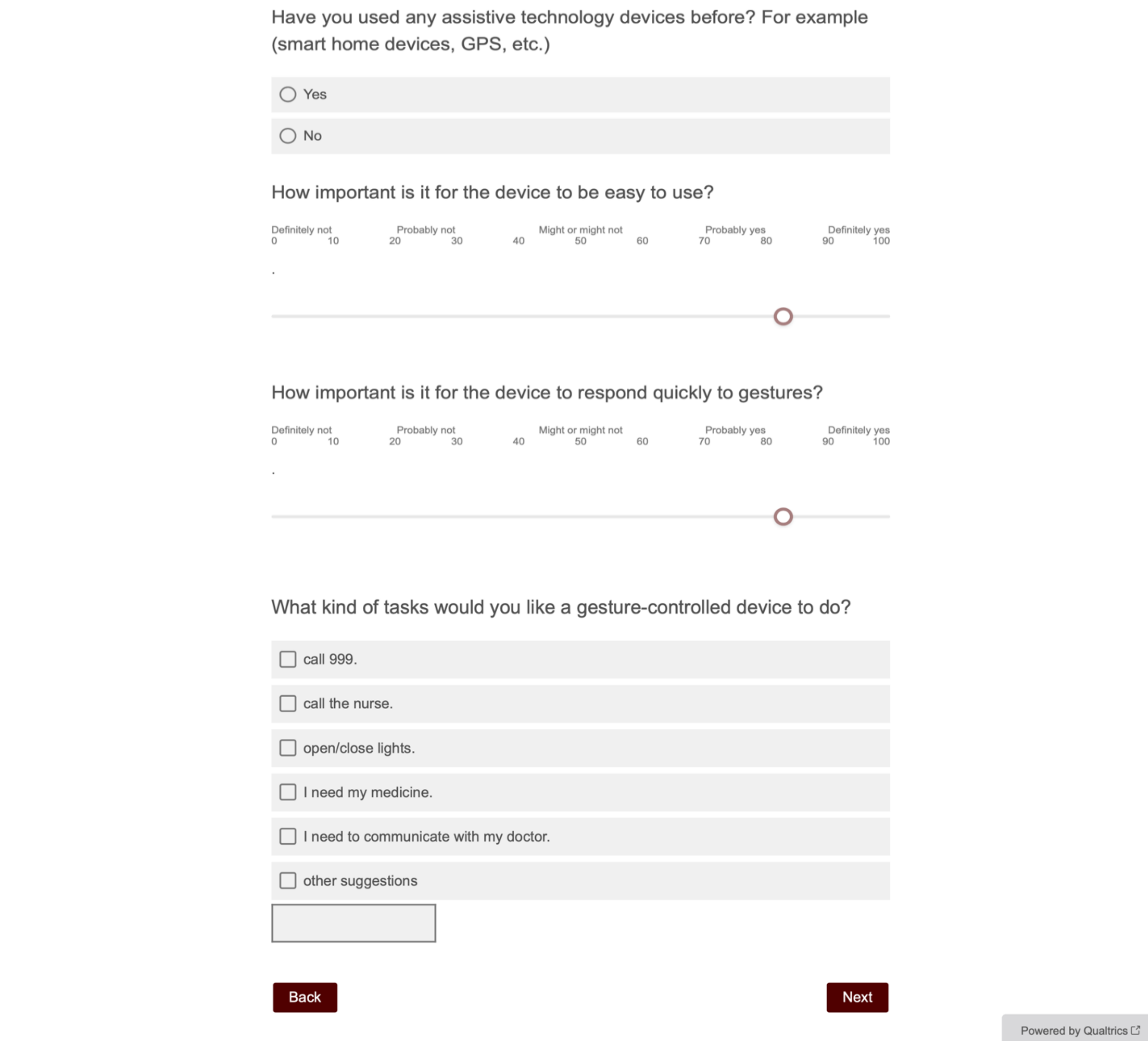
Would you like to see an invention to help replace some tasks done by nurses?

- Yes
- No

Which kind of disability do you think our device would be helpful for?

- Motor
- Visual
- Hearing
- Cognitive
- Other

Fig 18: Online Survey


Have you used any assistive technology devices before? For example (smart home devices, GPS, etc.)

- Yes
- No

How important is it for the device to be easy to use?

Definitely not 0 10 | Probably not 20 30 | 40 Might or might not 50 60 | Probably yes 70 80 | Definitely yes 90 100

How important is it for the device to respond quickly to gestures?

Definitely not 0 10 | Probably not 20 30 | 40 Might or might not 50 60 | Probably yes 70 80 | Definitely yes 90 100

What kind of tasks would you like a gesture-controlled device to do?

- call 999.
- call the nurse.
- open/close lights.
- I need my medicine.
- I need to communicate with my doctor.
- other suggestions

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Fig 19: Online Survey

6.5.2 Appendix: Expert Interview:

a) Mr. Mamoun Alkhoub – Director of Seating and Mobility Service Senter -HMC

1. What difficulties do individuals with disabilities face when trying to communicate with their community and seek assistance?

2. Can you identify the top five commands that would be most essential for patients using a hand gesture controller?
3. Are there any considerations to take into account when developing and deploying hand gesture controller technology in healthcare settings?
4. What are the potential costs associated with home medical care, and could a hand gesture controller device help reduce these costs?

b) Mr. Salah Adarbeh – Assistive Technology Specialist and Coordinator -HMC

1. What specific goals or tasks do disabled individuals typically aim to achieve during rehabilitation sessions?
2. How do you foresee the device impacting the need for support personnel such as nurses, caregivers, or guardians in rehabilitation settings?
3. What do you consider to be a reasonable price range for patients purchasing a hand gesture controller device?
4. How would you view a command feature that connects a home nurse with the rehabilitation center in case of emergencies?

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6.5.3 Appendix: System Diagram

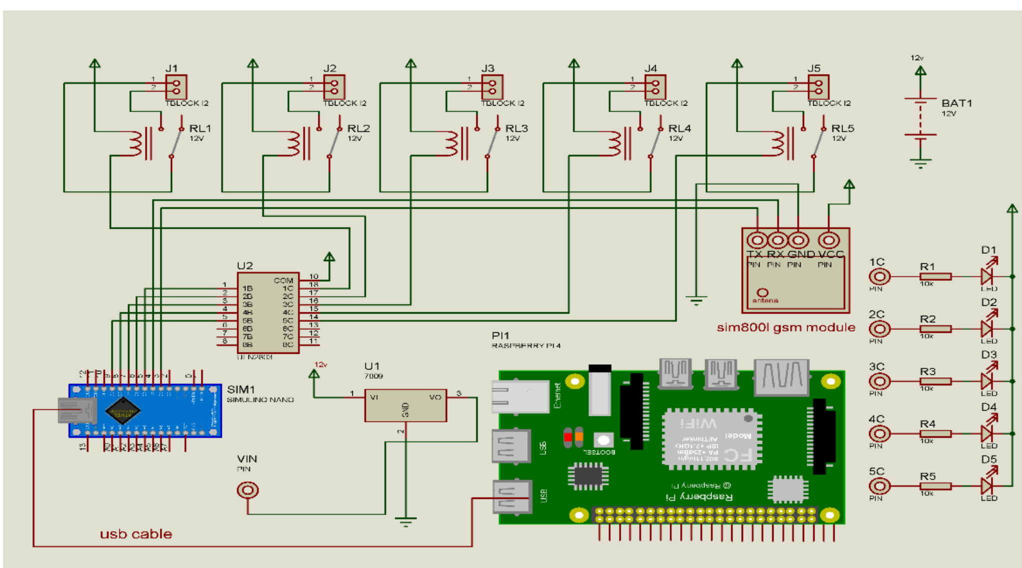

Fig20:Design of relays prototype

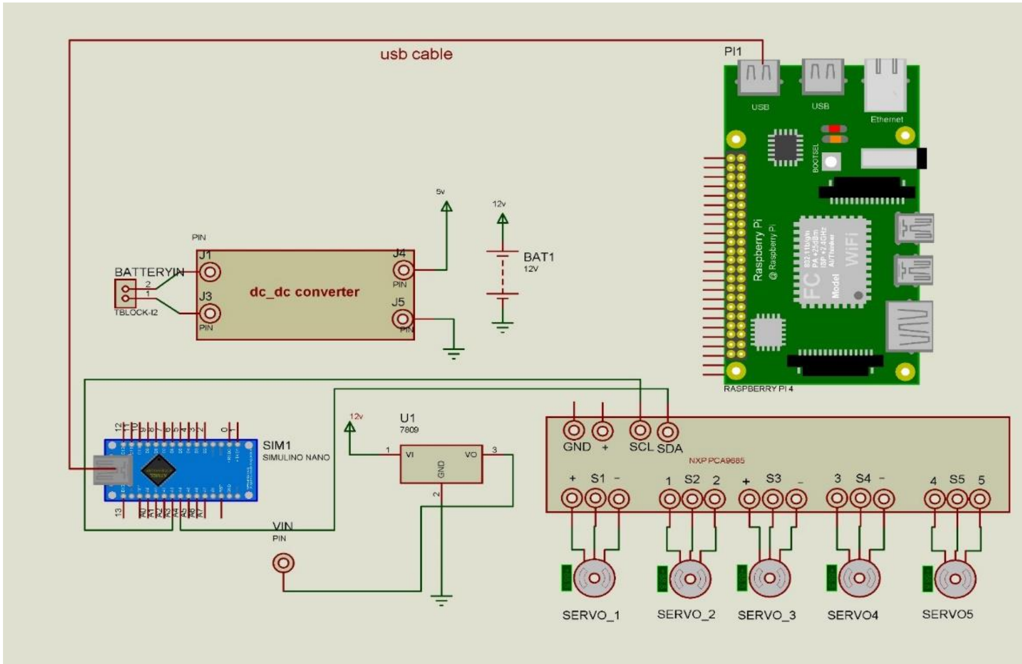

Fig21:Design of servomotors prototype

6.5.4 Appendix Arduino Code Snippets

```
#include <Arduino.h>

const int ledPin = 13; // Pin for LED output
const int sensorPin = A0; // Analog pin for sensor input

void setup() {
    pinMode(ledPin, OUTPUT);
    Serial.begin(9600);
}

void loop() {
    int sensorValue = analogRead(sensorPin);
    // Basic gesture detection logic
    if (sensorValue > threshold) {
        digitalWrite(ledPin, HIGH); // Turn on LED for gesture
recognition
    } else {
        digitalWrite(ledPin, LOW);
    }
    delay(100); // Delay for stability
}
```

6.5.5 Appendix : Python Code for Gesture Recognition

```
import cv2

# Load pre-trained gesture recognition model
model = load_model('gesture_model.h5')

# Capture video from laptop camera
cap = cv2.VideoCapture(0)

while True:
    ret, frame = cap.read()
    # Process frame for gesture detection
    gestures = recognize_gesture(frame)

    if gestures:
        # Implement actions based on detected gestures
        print(f'Detected gesture: {gestures}')

    cv2.imshow('Gesture Control', frame)

    if cv2.waitKey(1) & 0xFF == ord('q'):
        break

cap.release()
cv2.destroyAllWindows()
```

6.5.6 Appendix : Test Results

Summary of Testing Outcomes

Test Condition	Accuracy (%)	Response Time (s)	Comments
Optimal Lighting	98	0.2	High accuracy achieved
Low Light	96	0.3	Accuracy decreased
Distance (1-2 meters)	95	0.3	Reliable in range
Background Movement	98	0.2	Improved with calibration

Table3: Testing Outcomes

6.5.7 Appendix : User Feedback

Summary of Feedback from Initial Users

Usability: Users found the system intuitive but suggested more gesture options for control.

Lighting Adjustments: Users noted that performance varied in different lighting, recommending a user-adjustable lighting feature.

Calibration: Users expressed interest in a calibration feature to tailor sensitivity to personal preferences.

6.5.8 Appendix : Video Link

https://drive.google.com/file/d/1wSPzsWiqHJpID8rDepO2mhEejPlu0gnI/view

6.5.9 Appendix : Final Prototype

Fig22: Home Prototype

Fig23: Hand Prototype