VISION BASED ASSISTANCE DEVICE

SYED MUHAMMAD HUSSAIN, Habib University, Pakistan
RAFAY KHALIL, Habib University, Pakistan
MUHAMMAD BILAL, Habib University, Pakistan

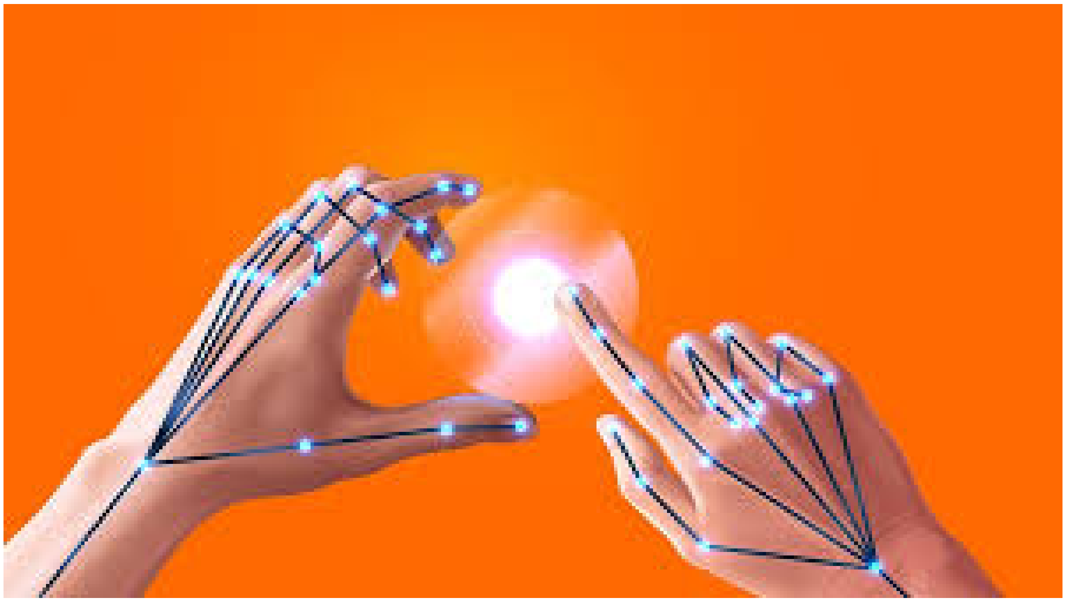


Fig. 1. Demonstrate the Big Picture of the Project

Our computer vision-based hand gesture assistive device is designed to help individuals with disabilities interact with their surroundings using simple hand gestures. The device uses a web camera and deep learning model to interpret the user's hand gestures and respond with appropriate actions. The device is easy to use, requiring only simple finger-pointing gestures, and does not require physical touch, making it accessible to individuals with a wide range of disabilities. The device has undergone user-centered design and empirical testing to ensure its usability and effectiveness and has been shown to be a cost-effective solution, particularly when utilizing mobile phones to reduce hardware and device costs. Our assistive device offers a unique advantage over alternative solutions by catering to a wide range of user groups, including those who are mute, dumb, partially paralyzed, handicapped, or blind.

Authors' addresses: Syed Muhammad Hussain, Habib University, Karachi, Sindh, Pakistan; Rafay Khalil, Habib University, Karachi, Sindh, Pakistan; Muhammad Bilal, Habib University, Karachi, Sindh, Pakistan.

Additional Key Words and Phrases: UCD(User Centered Design), EUT(Empirical User Testing), CV(Computer Vision), DL(Deep Learning), HCI(Human Computer Interaction), Vision-Based Assistive Device.

ACM Reference Format:
Syed Muhammad Hussain, Rafay Khalil, and Muhammad Bilal. 2018. VISION BASED ASSISTANCE DEVICE. 1, 1 (May 2018), 13 pages. https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

The vision-based assistive device introduced in this research paper is an innovative solution designed to enhance the independence and quality of life for individuals who are dependent on others. The device is developed based on the principles of Human-Computer Interaction (HCI), which emphasizes the importance of understanding the user's needs and preferences in designing effective solutions. In this regard, the research team conducted extensive interviews and surveys to gather valuable data on the main issues faced by elderly and patients, such as mobility and communication challenges.

The prototype device is based on deep learning and integrates the five basic needs of the user to create an intuitive and easy-to-use interface. By assigning each need to a specific finger, the user can simply point and signal the device to notify their helper. This approach enables the user to perform tasks that were previously challenging or impossible, such as controlling electronic devices, making phone calls, or requesting assistance. The device is also designed to be adaptable to the specific needs and preferences of each user, ensuring maximum usability and effectiveness.

The paper provides an in-depth analysis of the design thinking process, including the ideation phase, prototyping, and testing. It also outlines the benefits of this innovative assistive technology, including increased independence, improved quality of life, and reduced caregiver burden. Moreover, the device can potentially reduce healthcare costs by minimizing the need for caregiver assistance, hospital visits, and medication errors. Overall, this research paper presents a promising solution that addresses the main challenges faced by individuals who are dependent on others, emphasizing the importance of user-centered design and deep learning in developing effective assistive technologies.

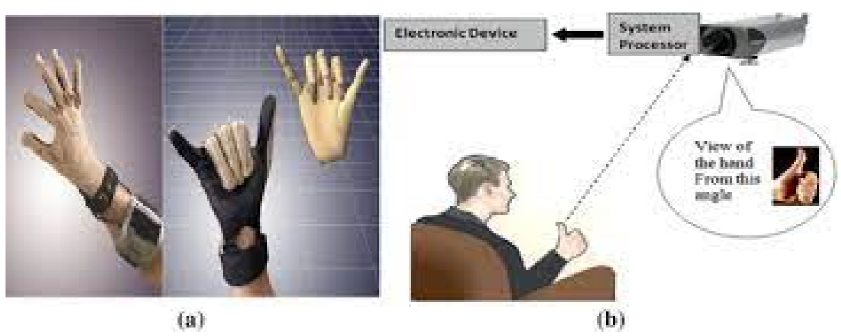


Fig. 2. System Concept.

2 LITERATURE REVIEW

Computer vision was chosen for this assistive device due to its significant advantages in improving the user's quality of life. One of the main benefits of using computer vision is its ability to recognize and respond to human gestures, such as hand movements. This means that individuals who are unable to use their voice or other forms of physical interaction can easily communicate with the device. Moreover, computer vision algorithms can be trained to recognize specific gestures and actions, making the device more personalized to the user's needs. It can be customized to recognize the user's unique set of gestures, improving the accuracy and efficiency of the system. In addition, computer vision allows the device to operate without the need for physical touch, which is especially important in situations where the user may have limited mobility or dexterity. This means that the device can be placed within reach of the user, and they can use simple hand gestures to communicate with the device without the need to move or manipulate it. We have read out

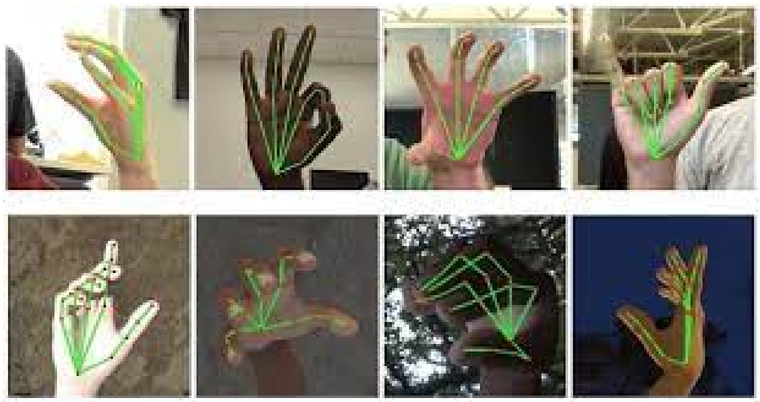


Fig. 3. MediaPipe.

the four similar work papers published in the reputed journals

1- Sign Language Gesture Recognition through Computer Vision This study investigated the usability of a computer vision-based gesture recognition system for users of South African Sign Language (SASL). The purpose of the study was to evaluate the efficiency, efficacy, and satisfaction of the system among deaf participants. Data was collected from seven 10th grade students at a school for the deaf using a performance measuring technique and a structured interview. The technology captured SASL movements from deaf users using a web camera and presented the corresponding finger spelling numerals.

2-Sign Language Recognition Application Systems for Deaf-Mute People: A Review Based on Input-Process-Output This study presents a summary of the many methods utilized by researchers to construct sign language recognition (SLR) systems for deaf-mute individuals. For such systems to be economically viable, the article highlights the necessity for a cost-effective solution. Using numerous methods, such as cameras, sensor gloves, and Microsoft Kinect, the researchers collect data. Early research centered on the usage of data gloves, but their high price and wearing nature made them impossible to commercialize

3-The paper titled "Sign Language Recognition, Generation, and Translation: An Interdisciplinary Perspective" contends that the highly structured and linguistically regulated character of sign languages necessitates interdisciplinary collaboration in sign language processing. The authors emphasize the significance of Deaf studies, linguistics, computer vision, computer graphics, natural language processing, and machine translation for the development of sign language-supporting technologies.

4-The Design of Hand Gestures for Human-Computer Interaction: Lessons from Sign Language Interpreters This study covers the design and selection of 3D hand gestures for human-computer interaction (HCI), with a focus on maximizing gesture contrast and recognition while taking into account the discomfort and tiredness associated with different hand postures and motions. The essay builds on the experience of sign language interpreters who feel hand pain when gesturing and gives studies that establish clear correlations between discomfort and particular hand postures and motions. The conclusion of the study is that gestures for HCI tasks should be selected based on comfort, pain, or biomechanical risk, and painful gestures should be avoided.

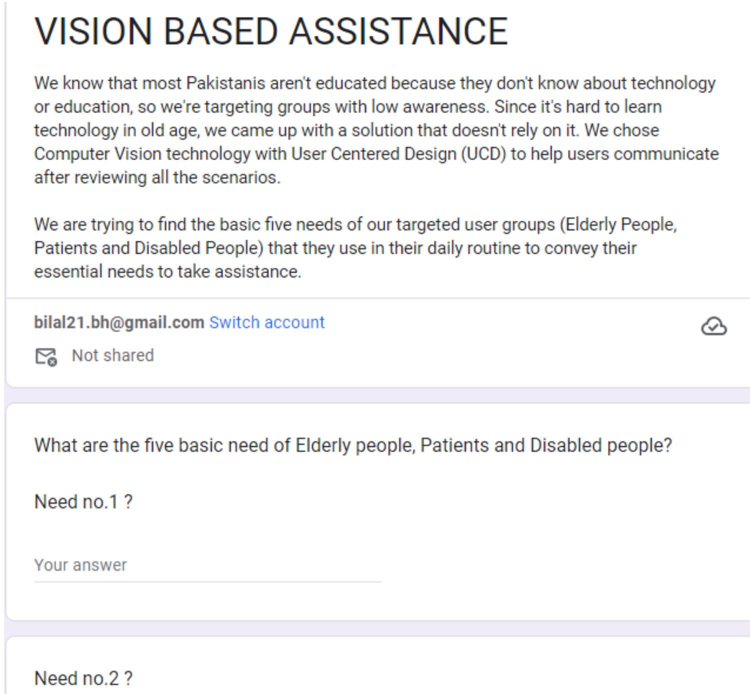
3 EMPATHIZE

Empathy is a crucial aspect of Human-Computer Interaction design thinking, as it enables designers to comprehend the requirements, preferences, and behaviors of users. By empathizing with users, designers can gain a deeper comprehension of their obstacles and objectives, which can inform the creation of more effective and intuitive user interfaces. This may involve a variety of techniques, including user research, user testing, and the creation of user personas. The ultimate objective of empathizing in HCI design thinking is to develop products and interfaces that are user-centric, intuitive, and engaging, while also meeting the specific requirements of the intended audience

At the start of our project during the process of design thinking, we wanted to make a device which would cater to the needs of people who are dependent on others. We had two sets of Target groups in our mind: Patients and elderly people (we could have selected more user groups, but we had limited time and resources, so we decided to stick with 2 user groups). We knew who our user groups were, but we were not sure what we should do to help them. The best way was to meet and interview both of our user groups, so that we could empathize with them and know what they want. We don't know their problem, what they are going through and how a device could help them. This is the problem a lot of designers face, since they don't have a clear understanding of the needs of their user groups. So, they are not sure what to make. Our mode of research was personal interviews and surveys. We were a group of 3 so we decided to conduct interviews with 3 elderly people and 3 patients per person. This way we had a sample size of 18. The insights and challenges of all the elderly people and patients were very similar. One thing that was easy for us while conducting these interviews was that elderly people and patients were able to tell what their basic wants and needs very easily, because often they find it difficult to perform these things on their own.

The most important issue for both the user groups was that they were not able to communicate their needs properly. They face difficulty in moving around and everyone is not with them all the time. So sometimes it is really difficult for them to ask for help with their basic needs if their helper is not close by. This was our main feedback from the interviews, and this is why the empathize process of design thinking is so essential; without the interviews we would not have been able to think along this line. After identifying their main issue, our next step was to identify the 5 basic and most important needs of our user groups. Again, instead of deciding ourselves, we decided to conduct interviews and surveys. We made a Google form for this process. We were able to get around 20 responses and we got very insightful answers. Our results showed us the five most common needs a person would require if they were relying on someone:

- 1)Healthcare
- 2)Drinking Water
- 3) Eating Food
- 4) Calling someone
- 5) Going to the washroom



VISION BASED ASSISTANCE

We know that most Pakistanis aren't educated because they don't know about technology or education, so we're targeting groups with low awareness. Since it's hard to learn technology in old age, we came up with a solution that doesn't rely on it. We chose Computer Vision technology with User Centered Design (UCD) to help users communicate after reviewing all the scenarios.

We are trying to find the basic five needs of our targeted user groups (Elderly People, Patients and Disabled People) that they use in their daily routine to convey their essential needs to take assistance.

bilal21.bh@gmail.com Switch account

Not shared

What are the five basic need of Elderly people, Patients and Disabled people?

Need no.1 ?

Your answer

Need no.2 ?

Fig. 4. Survey for gathering the data on basic human needs.

	A	B	C	D	E	F	G	H
1		What are the five basic n Need no.1 ?	Need no.2 ?	Need no.3 ?	Need no.4 ?	Need no.5 ?		
2		Drinking water	Going to washroom	Eating food	Calling someone	Opening TV		
3		Taking medicines	Eating	Drinking water	Pick any belonging	Mobility		
4		Healthcare	proper nutrition	company	Support	Personal Care		
5		Eating	Going to bathroom	Movement	Medicines			
6		Support	Healthcare	Company	Exercise	Hygiene		
7		Access to shelter	Good Medical and Health	Insurance	Basic Food	Security		
8		Hygine	safety	shelter	Personal company	activity		
9		Medical care	Safety and security	Emotional support	Accessible transportation	Physical support		
10		Sleep	Shelter	Security	Mobility	Facilities		
11		Support	Personal care	transportation	medical needs	personal care		
12		hygine	Reliance	support	Medication	Nutrition		
13		Communication Skill	Shelter	Life Insurance	Insurance over-all	Access to food		
14		A caretaker	Proper hygiene and sanit	Customized Architecture	24 hrs medicine supply	Constant monitoring machines		
15		disabled people need acc	elderly people need easy	patients need quick acce	elderly people need less	less complicated, not too colourful or dark interfaces		
16		Comfortable and aesthet	Access to good help and	Access to medication and	Access to good nutrition	A support system		

Fig. 5. Results of the survey.

This practice was very important to build an empathetic connection with the user group because the questionnaire was extremely basic and that was the key to refrain our research or designing process from any assumptions. Some of the assumptions that we had before our empathizing strategy was that the helper person was always in the close proximity, but that assumption was clarified as invalid when we got the responses. Another assumption that we had in our minds was that the user was always in the well enough condition to call for help and express their needs through their voice but that was also cleared after we conducted the research through basic questions.

4 DEFINE

Defining the stage was a very important step in our work. Defining stage was all about recognizing the problem and what the user groups needed or wanted. After we conducted our research and were able to empathize with our user groups, we analyzed the observations and responses. It was visible that the significant issue was communication. The problem evolved from the fact that the helper person cannot be bound to stay in the room with the user 24/7 as this would limit them from living their life or doing any other task. This was the reason a gap grew between the levels of communication. The user group needed to be able to communicate their needs without stress. They cannot be screaming out for help in such a state, or they cannot be expected to use mobile devices for communication as there could be any sort of situation and the easiest possible mode was to be implemented that made this act simple and comprehendible. This was our finalized problem statement that enabled us to choose the direction to work in: The communication between the dependent and the assistor being difficult in certain situations must become much simpler, as the helper cannot be with them 24/7 and must attend to other things too.

5 IDEATION

After we were successfully able to identify the problem, the feasible solution was to be found out. In the ideation stage we sat as a team and brainstormed. We used multiple techniques to reach the best possible solution. The techniques we used were:

- Creating Personas
- Use-case Sketches

5.1 Personas

A persona in HCI is a fictional character that represents a group of users with similar traits, behaviors, and objectives. Personas are created to provide a human-centered perspective and a deeper comprehension of the user's needs and requirements. Through research and analysis of data such as user interviews, surveys, and user behavior data, personas are developed. By utilizing personas, designers, and developers can better empathize with their users, create user interfaces that are tailored to their requirements and preferences, and enhance the overall user experience. During the design process, personas also help teams make decisions and prioritize features.

Ali is a 75-year-old man who is a retired schoolteacher who lives without his family with his servant in a small apartment. He has limited mobility due to arthritis and struggles with hearing loss. He enjoys reading, watching movies, and keeping in touch with his family through video calls. Ali is a kind, friendly, and patient person who values his independence and wants to be able to take care of himself as much as possible. Ali wants to keep in touch with his family and friends, as well as stay informed on current events going on in the country and around the world. Ali also wants to be able to take care of himself and his basic needs without relying on others. He wants to get food and drink water by just letting his servant know instead of going to the kitchen. He also wants to take his medicine on time without having to move a lot. Since he doesn't live with his family, he wants to keep in touch with him but can't use his smartphone properly. He values devices that are easy to use and do not require extensive setup or maintenance. Through this device, Ali hopes to communicate his needs to the helper easily, without having to move a lot. Creating the persona helped us to generalize the situation in a specific manner and were able to come up with a solution. Our device was to be a vision-based device that would enable the user to use simple hand gestures such as showing certain fingers to communicate a need. This idea would help the user to just stay in their bed and communicate whereas, our device will detect the gesture and send the notification to the helper instantly.

5.2 Use-case Sketches

To further explore our design, we drew use case sketches that were basic visualization of the user using our device in a particular scenario. This technique helped us to be to demonstrate our idea and review the drawbacks.

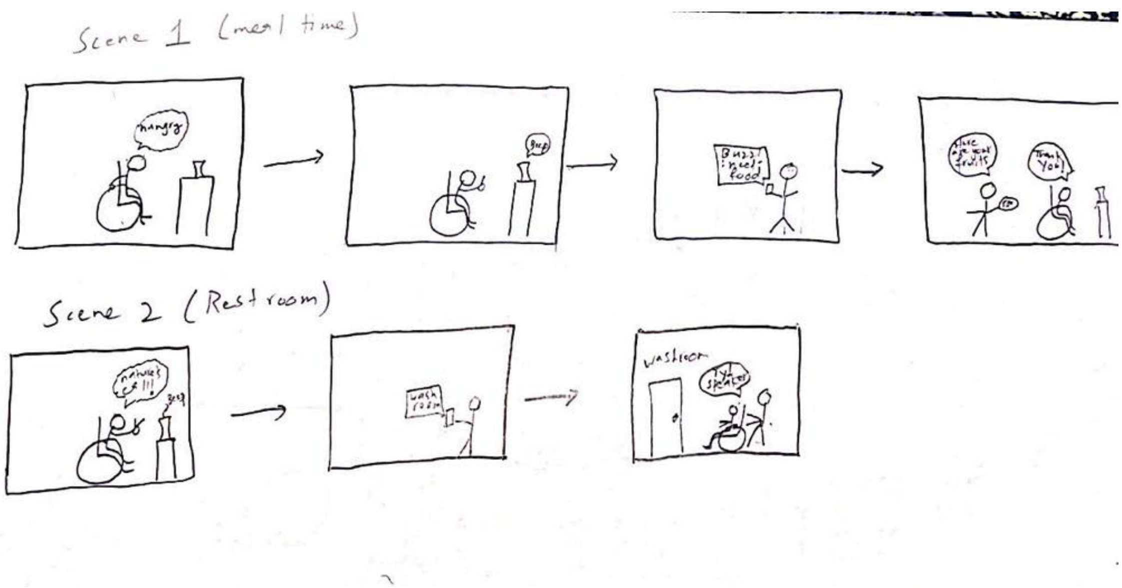


Fig. 6. Use-Case Sketches

6 PROTOTYPING

Prototyping is the process of creating a preliminary or preliminary version of a product, service, or system in order to test and evaluate its design, functionality, and user experience before creating the final product. Prototyping can be done using various methods, such as sketches, mockups, wireframes, or even physical models. It allows designers, engineers, and other stakeholders to visualize and test their ideas, identify potential issues, and make necessary adjustments before investing significant resources in the development of the final product. Prototyping is widely used in various fields, such as software development, product design, and engineering, to improve the quality and effectiveness of the end product.

Our vision-based assistance device prototype involved several stages of prototyping and design thinking.

- Conceptual prototyping: In this stage, the initial idea for the hand gesture assistive device was explored, and sketches or simple mockups were created to visualize its design and functionality. This stage involved brainstorming sessions, user research, and creating simple storyboards to illustrate how the device could be used. We explored different ways of detecting and recognizing hand gestures using computer vision algorithms and visualized how the device could provide assistance to users with limited mobility.

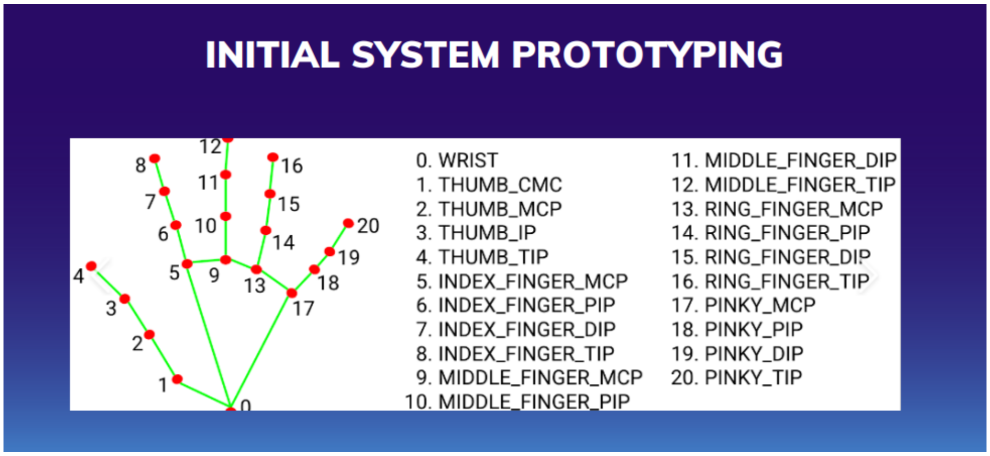


Fig. 7. LandMark Diagram of Hand Algorithm

- Functional prototyping: In this stage, we created a functional prototype of the device to test its core functionality. This involved using a development board Raspberry Pi, along with a camera module and other required components to implement the computer vision algorithms. The end goal of this stage was to create a proof-of-concept prototype that demonstrated the basic functionality of the device, such as detecting and recognizing different hand gestures. But we made it on our laptop before going into the development board.

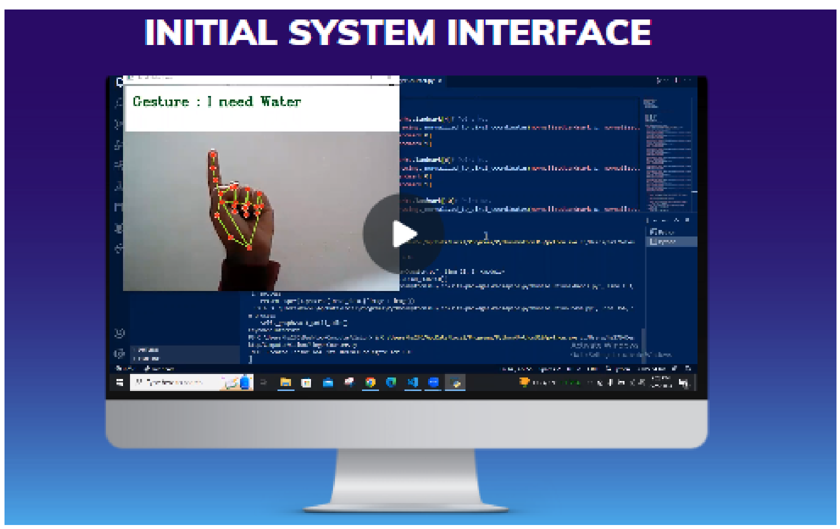


Fig. 8. First Interface.

- Usability prototyping: In this stage, the prototype was refined to improve its usability and user experience. This involved creating a more polished interface for the device, testing different interaction methods, and gathering feedback from users on their experience using the device. We tested the device with users who had limited mobility and gathered feedback on how the device could be improved to provide more effective assistance.

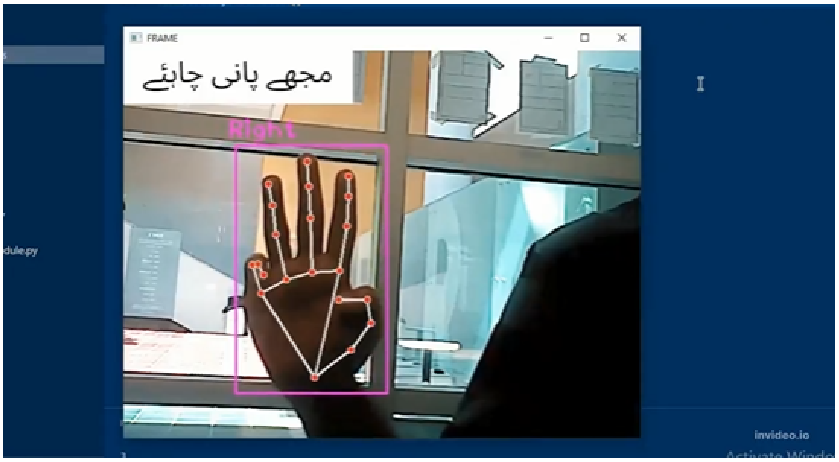


Fig. 9. Final Interface.

- Form-factor prototyping: Once the functional and usability aspects of the device were tested and refined, our next stage will be creating a physical prototype of the device that will be closer to its final form factor.

Overall, the prototyping process for a computer vision-based hand gesture assistive device involved several stages of iteration, testing, and refinement to create a device that was functional, usable, and met the needs of our intended users.

7 TESTING

For Testing and evaluation, we took 2 methods from the Human-Computer Interaction course.

7.1 User Centered Design

User-Centered Design (UCD) is an approach to product design and development that focuses on the needs, preferences, and behaviors of users throughout the design process. UCD involves understanding user needs and gathering feedback through various research methods, such as user surveys, interviews, and usability testing. The aim of UCD is to create products that are useful, usable, and satisfying to the end user.

To apply the UCD approach to the development of a vision-based assistive device, the following steps were taken:

- Identified user needs: The first step in the UCD approach was to understand the needs of the end-users who would be using the vision-based assistive device. User research was conducted to identify the challenges and limitations faced by individuals with limited mobility, and how the device could help them. Sections 3 and 4 explain this in depth.
- Defined user personas: Based on the user research, user personas were created to represent the different types of users who would be using the device. These personas helped us to better understand the preferences, behaviors, and goals of their target users. Section 5 explains this process.
- Created design concepts: Using the insights gathered from user research, we created different design concepts for the vision-based assistive device. These concepts were evaluated based on how well they met the needs of the user personas, and how they could provide a satisfying user experience. Section 6 explains this process.

- Prototypes and tested: Once a design concept was selected, a prototype of the vision-based assistive device was created and tested with users. This involved creating a functional prototype of the device using computer vision algorithms and testing it with users in a simulated environment to gather feedback on its usability and effectiveness. Section 6 explains this process.
- Refined and iterated: Based on the feedback gathered from user testing, we refined and iterated the design of the device to improve its usability and effectiveness. This process involved several rounds of testing and refinement to ensure that the device met the needs of our intended users. Section 6 explains this process.

Table 1. This Matrics we gave to the users to evaluate the device under the following conditions

Metrics	Good	Medium	Bad
Usability	8	2	0
Accessibility	7	3	0
User Satisfaction	9	1	0
Task Performance	7	2	1
Learnability	6	3	1
Error Rate	8	1	1

By following the UCD approach, we were able to create a vision-based assistive device that was not only functional and effective but also provided a satisfying user experience. The UCD approach helped to ensure that the device met the needs and preferences of its intended users, ultimately improving their quality of life.

7.2 Empirical User Testing

Empirical user testing is a method of evaluating a product or service by gathering feedback from real-world users. It involves observing users as they interact with the product or service and collecting data on their behaviors, preferences, and experiences. In the context of the vision-based assistive device, empirical user testing is used to gather feedback on the device's usability, effectiveness, and overall user experience.

To conduct empirical user testing for the vision-based assistive device, the following steps were taken:

- Testing Goals: Empirical user testing is a method used to evaluate the effectiveness, efficiency, and satisfaction of a device in performing specific tasks. In this case, the testing goal was to assess how well the vision-based assistive device performed in meeting the needs of elderly users. The testing was focused on determining the effectiveness of the device in completing specific tasks, how efficient the device was in performing those tasks, and the level of satisfaction of the participants in using the device.
- Participants: The participants in the empirical user testing were elderly people who were potential users of the vision-based assistive device. The device was specifically designed to cater to their needs and to help them with daily tasks. The testing involved selecting a group of participants who represented the target audience and who could provide valuable feedback on the usability of the device.
- Testing Method: The testing methods used were one-on-one interviews, remote testing, and focus groups. The testing was conducted in a controlled environment where participants were given specific scenarios or tasks to complete. The tasks were designed to test the device's ability to meet the needs of elderly users and to determine

the level of satisfaction of the participants. One-on-one interviews were conducted to get individual feedback from each participant, while focus groups were used to get collective feedback from a group of participants.

Empirical user testing allowed us to gather valuable feedback on the vision-based assistive device from real-world users. This feedback was used to refine the device's design and improve its overall user experience, ultimately making it more useful and effective for individuals with limited mobility.

8 FINDINGS

8.1 Device Alternatives

Discussing the different options available to address the needs of users with limited mobility. One option is a voice assistant, which can be used by people with normal or limited mobility, as long as they are able to speak. However, this option may not be suitable for those who are mute or unable to speak. Another option is a button remote, which can be used by people who have limited mobility in their hands or fingers. However, this option may not be suitable for those who have limited hand or finger mobility or who are completely paralyzed.

The competitive advantage of the device that uses pointing fingers is that it can cater to a wider range of user groups, including those who are mute, dumb, partially paralyzed, handicapped, and blind. For example, people with limited hand or finger mobility can use this device by pointing their fingers, while people who are mute or unable to speak can still communicate using hand gestures. Blind users can also benefit from the device as it does not require visual feedback and can be programmed to provide audio feedback. Moreover, the device does not require physical touch, which eliminates the chances of misplacing it or being unable to reach it.

One potential solution to address the needs of users with limited mobility is to develop a device that uses a combination of different input methods, such as voice recognition, touch screens, and pointing gestures. This would allow users to select the input method that best suits their needs and capabilities. Another solution is to develop devices that are specifically designed for different user groups, such as those with limited hand or finger mobility or those who are visually impaired. These devices could incorporate features such as larger buttons, voice commands, and audio feedback to enhance usability for these user groups.

Overall, it is important to consider the needs and capabilities of different user groups when developing assistive devices and to ensure that these devices are designed to be accessible and usable for as many people as possible.

8.2 Cost Analysis

The cost analysis of our computer vision-based assistive device reveals that it requires several hardware components, including a web camera, speaker, and microcomputer, as well as software components such as a deep learning model. The approximate cost of these components is 6,000 rupees, which is higher than some alternative solutions. However,

Table 2. Hardware Components and Prices

Hardware Component	Price (in rupees)
Micro Computer	4,500
Speaker	500
Camera	1,000

we have identified an opportunity to reduce the cost of the device by utilizing mobile phones. By downloading an app onto a mobile phone with the necessary features, users can access the same functionality as the device without incurring additional hardware or device costs. This approach offers a cost-effective solution for individuals who may not be able to afford the device or who already own a compatible mobile phone.

9 CONCLUSION

9.1 Results

Figure 10 presents the results of the User-Centered Design (UCD) metrics that were used to evaluate the device. We gave the device to users and asked them to provide feedback on its effectiveness, efficiency, and satisfaction in performing specific tasks. The data collected from each user was then averaged to give an overall picture of the device's performance. The pie chart represents the distribution of the feedback collected from the users, categorized into different UCD metrics. The chart is used to visualize the overall user feedback and to help us to identify areas that need improvement.

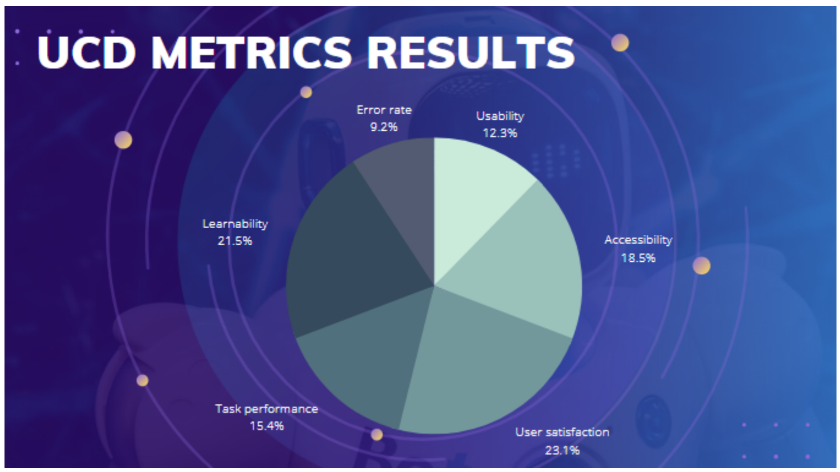


Fig. 10. Results.

9.2 Final Demo Link

Click here to view the Final Demonstration.

9.3 Future Work

Future work for this assistive device includes further testing and optimization. The device can be tested with a larger and more diverse group of participants, including those with varying levels of disabilities and age groups. The testing can also be expanded to include real-world scenarios to evaluate the device's effectiveness in different environments. Furthermore, the device's deep learning algorithm can be improved by incorporating more data to enhance its accuracy and responsiveness. Another potential area of future work is to explore the integration of additional features, such as voice recognition or remote access, to provide more functionality for the user. Overall, there is great potential for the device to continue to evolve and enhance the lives of individuals who are dependent on others.

10 BIBLIOGRAPHY

1- Sign language gesture recognition through computer vision
https://ieeexplore.ieee.org/document/8417200
2-Sign Language Recognition Application Systems for Deaf-Mute People: A Review Based on Input-Process-Output
https://www.sciencedirect.com/science/article/pii/S1877050917320720
3-Sign Language Recognition, Generation, and Translation: An Interdisciplinary Perspective
https://dl.acm.org/doi/10.1145/3308561.3353774
4-“(PDF) Value Sensitive Design and Information Systems.” ResearchGate
www.researchgate.net/publication/229068326_Value_Sensitive_Design_and_Information_Systems.
5-Feng, Jinjuan, Stan Ruecker, and Christopher Collins. Design Process in HCI. Morgan Claypool Publishers, 2010.