Seminar Report
On
RASPBERRY PI HEAD-MOUNTED CYBERNETIC AUGMENTATION

VII SEMESTER

INFORMATION TECHNOLOGY

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CERTIFICATE

This is to certify that **NIKHIL PAONIKAR** and **SAMUEL KUMAR** have completed Seminar on major project "**RASPBERRY PI HEAD-MOUNTED CYBERNETIC AUGMENTATION**" under my supervision for partial fulfillment of VII Semester, Bachelor of Engineering in INFORMATION TECHNOLOGY of RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR.

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ABSTRACT

Raspberry Pi Head-mounted Cybernetic Augmentation (RpHCA) is a subset of wearable technology that will primarily function as an assistive enhancement to acquire real-time data from the surrounding environment. This data is then converted to comprehensible information that can aid the user to make better decisions immediately, or store it on a private cloud server for later perusal. The primary means to obtain this data is through a camera module integrated with the Raspberry Pi.

The concept of RpHCA emerged from the concept “human enhancement”. Human enhancement is any action of improving upon the natural limitations of the human body by natural or artificial means. In technological context, our ubiquitous use of easily accessible, usable technology like smartphones, tablets and other wearable technology like smartwatches, optical head-mounted display like Google Glass are forms of human enhancement. The primary role of RpHCA is to function as an interactive brain-computer interface that responds to the user’s voice in real-time.

Our goal here is to create a cost-effective alternative to wearable tech like Google Glass and Microsoft's HoloLens. RpHCA would be a fully functioning human enhancement which would not be just another wearable device, but a step forward in technology subfields of augmented reality, artificial intelligence and wearable technology.

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CHAPTER I

INTRODUCTION

1. INTRODUCTION

1.1 OVERVIEW

The terms “wearable technology” refers to electronic devices, particularly computers that are incorporated into items of clothing and more eminent in accessories which can comfortably be worn on the body. Wearable devices are capable of performing many of the same computing tasks as smartphones, tablets and laptops; however, in some cases, wearable technology are proficient enough to outperform these portable devices entirely. Wearable tech tend to be better engineered and often employ cutting edge technologies that are rarely found in hand-held technology on the market today. These relatively new wearable devices can provide sensory and scanning features not usually seen in mobile and laptop devices, such as biofeedback and tracking of physiological function.

Generally, wearable devices have some form of communications capability and facilitate the wearer with access to information in real time from the internet or a local network. Similar to local storage, data-input capabilities are also a feature of such devices. Examples of wearable devices include watches, glasses, contact lenses, e-textiles and smart fabrics, headbands, beanies and caps, jewelry such as rings, bracelets, and hearing aid-like devices that are designed to look like earrings.

Raspberry Pi Head-mounted Cybernetic Augmentation, or in short RpHCA, is being developed to make it function as a cybernetic human enhancement. It is engineered to acquire data from the surrounding environment of the user through a camera integrated within the head-mounted augmentation and processing that data in real-time via the Raspberry Pi. The information obtained by processing this data will be then projected onto a semi-transparent glass which would be suspended to the anterior of the augmentation. This information may be further forwarded to the wearer’s private cloud server for later processing or simple storage. This augmentation also has an artificial intelligence that responds to the user’s voice and performs the instructed tasks. The system has the capability of recognizing faces, common objects and familiar environments.

On the hardware side, a Raspberry Pi is being used as the primary computer along with a camera module. The processed information will be displayed on the screen of a smartphone or a 2.4" TFT LCD, which will then be projected on a semi-transparent glass mirror via a projection lens, custom-cut from a 3x Fresnel magnifying lens. The head-mount and other mounting parts will be manually constructed.

1.2 PROBLEM STATEMENT

Presently, the industry captains of tech industry are betting that consumers will want to wear internet-connected watches and computerized glasses. But there are several reasons people aren't flocking to buy them just yet. The major obstacle is the selling price of these devices; they’re quite expensive and in most cases, a smartphone or another device is needed to optimize the wearable to work as intended.

There is another core element that needs to be improved if we want to get more battery life out of future smart watches: GPS. GPS tracking sucks out much more battery life than powering a color display. Wearable devices from Google, Motorola and even Apple have been criticized for poor battery life for reasons other than GPS support. Recording video would drain Google Glass' battery pretty quickly, and even with an absent GPS built in, the Moto 360's battery life was not enough to keep it powered on for more than 5 hours when it was first released in 2014.

Furthermore, there are the incessant issues of privacy and stress. Pertaining to Google Glass, people are not aware if and when they are being recorded by Glass wearers unlike a regular camera or cell phone when it is much more obvious when they are recording; what’s more people even behave differently when they believe that they could possibly be recorded. As a result, people are socially wary and even shun people who wear Google Glasses.

Comprehensively, it is evident that currently there is no wearable device that is cost-effective and energy-efficient. Even the most critically acclaimed devices do not perform as well as they should. This calls for a solution to these problems, and the best way to get around to it is by building something new that would at the very least attempt to disrupt the wearable tech market. This device not only requires to be cost-effective, but also interoperable with other devices.

1.3 OBJECTIVE

Our objective is to develop a head-mounted cybernetic augmentation for the chief purpose of making it function as an assistive human enhancement. The efficiency of the augmentation relies on the AI to be developed. The AI, aside from mechanical controls, will be an alternate user interface designed to recognize and respond to the wearer’s voice, and perform instructed tasks.

1.4 ORGANIZATION OF REPORT

In Chapter 1, an introduction to the project is given, where an overview of Raspberry Pi Head-mounted Cybernetic Augmentation is delineated. In Chapter 2, a review of literature with an account of work done previously and the need for the proposed system is explained. In Chapter 3, a technical description of the proposed system is set. It covers the analysis, modeling and design of the system. UML diagram of the proposed system are also included along with short description of the modules. Chapter 4 states the conclusion for Raspberry Pi Head-mounted Cybernetic Augmentation.

CHAPTER II

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature survey was done with the chief purpose of understanding the limitations of existing wearable technology and artificial intelligence. Existing wearable tech, though highly advanced and almost ahead of their age, are not economically affordable to the common people. Nevertheless, this technology has limitless applications that can only be effectuated once we account for the influence of such technology on our daily lives and normal functioning of technology.

It has been noted that there are more than 2,000 AI user interfaces are consistently being developed; but only a handful are deployable in the general market. Few wearable devices feature an AI that works as and when commanded by the user. Most of them work within a predefined set of conditions and are not intelligent enough to distinguish between a command and a statement. This led us to come up with a system that uses the grasps of the internet to help the AI respond to requests like playing music, answering questions, get news, and local information, recognize faces and familiar environments. Post-installation, real-time data from surroundings, like a human face is captured and a database is referred to compare the extracted features from the captured picture. An analysis is performed on the picture using the Raspberry Pi and the results are displayed on the AR display (eye-piece).

2.1 LITERATURE SURVEY

According to Kevin Warwick in [1], what constitutes a Brain-Computer Interface (BCI) can be extremely broad. A standard keyboard could be so regarded. It is clear however, that virtual reality systems, e.g. glasses containing a miniature computer screen for a remote visual experience (Mann 1997), are felt by some researchers to fit this category. Certain body conditions, such as stress or alertness, can be indeed be monitored in this way.

In their paper on a wearable personal cloud [2], authors Hasan and Khan describe personal terminal devices as interactive devices capable of wireless communications like WiFi, Bluetooth, ZigBee. Such devices include, but are not limited to, smartphones, smartwatches, tablet computers, smart-glasses, health monitors, and other IoT devices. They even posit that this kind of wearable tech may utilize lower hardware specifications to function as resource constraint devices, in terms of computational power, battery, memory and storage.

Computer vision [3] is the technology in which machines are able to interpret/extract necessary information from an image. Computer vision technology includes various fields like image processing, image analysis and machine vision. It includes certain aspect of artificial intelligence techniques like pattern recognition. The machines which implement computer vision techniques require image sensors which detect electromagnetic radiation which are usually in the form of ultraviolet rays or light rays.

In his paper [4], Ronald T. Azuma describes a unique characteristic of augmented reality; besides adding objects to a real environment, AR also has the potential to remove them. Current work has focused on adding virtual objects to a real environment. However, graphic overlays might also be used to remove or hide parts of the real environment from a user. For example, to remove a desk in the real environment, draw a representation of the real walls and floors behind the desk and "paint" that over the real desk, effectively removing it from the user's sight. This has been done in feature films. Doing this interactively in an AR system will be much harder, but this removal may not need to be photorealistic to be effective.

Furthermore, in [5], Durlach tells us that augmented reality might apply to all senses, not just sight. So far, researchers have focused on blending real and virtual images and graphics. However, AR could be extended to include sound. The user would wear headphones equipped with microphones on the outside. The headphones would add synthetic, directional 3-D sound, while the external microphones would detect incoming sounds from the environment. This would give the system a chance to mask or cover up selected real sounds from the environment by generating a masking signal that exactly cancelled the incoming real sound. While this would not be easy to do, it might be possible as discerned in [6]. Another example is haptics; the science of applying touch (tactile) sensation and control to interaction with computer applications. Gloves with devices that provide tactile feedback might augment real forces in the environment. E.g., a user might run his hand over the surface of a real desk. Simulating such a hard surface virtually is fairly difficult, but it is easy to do in reality. Then the tactile effectors in the glove can augment the feel of the desk, perhaps making it feel rough in certain spots. This capability might be useful in some applications, such as providing an additional cue that a virtual object is at a particular location on a real desk.

In [7], Sin and Zaman used the glasses metaphor to present virtual heavenly bodies on AR markers which they can manipulate in front of them. Students wore a head-mounted display so that both of their hands would be free to handle the markers containing the virtual solar system. A similar study in [8], by Shelton and Hedley had argued that this visualization is advantageous because students can more easily understand concepts such as day and night when they can test for themselves what happens when one side of the earth is occluded.

The Raspberry Pi is a credit card-sized computer that plugs into your TV and a keyboard. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word processing, browsing the internet, and playing games. It also plays high-definition video. It is designed to cost around Rs. 2,600 for the latest model. [9]

CPU	1.2 GHz, X64 ARMv8
WLAN	802.11n
Bluetooth	4.1
RAM	1 GB
USB ports	4; 2.0
HDMI port	1
Ethernet port	1
Interfaces	Camera, display
Micro SD card slot	1
GPU	VideoCore IV
GPIO pins	10

Table 2.1.1 Raspberry Pi technical specifications

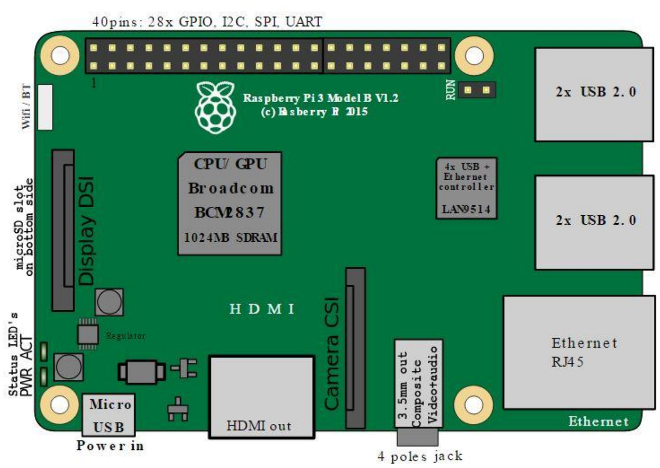


Fig. 2.1.1 Raspberry Pi block diagram

According to Reaz, et al. in [10], artificial intelligence has played a crucial part in the design and implementation of future houses. Early research focused on the control of home appliances but current trends are moving into a creation of self-thinking home. In the recent years many research projects were performed utilizing artificial intelligence tools and techniques. Also, research projects employing multi-agent system (MAS); is a system composed of several agents, capable of speedy mutual interaction between them, action prediction, artificial neural network, fuzzy logic and reinforcement learning. It is found that the combination of tools and techniques are crucial for successful implementation. A platform for future relative studies between different algorithms, architectures which serves as a reference point for developing more cutting edge smart home technologies has been theorized.

According to Sherri Stevens in her research on the leading voice controlled UIs in [11], a major issue in the marketing research industry is the fact that the majority of surveys are not well suited to a mobile device. In many cases, it is difficult to see all of the answer choices on a small screen device, as answer choices on a second page are less likely to be selected. Using the text to voice feature on mobile phones may be a solution to this problem. We tested several long answer lists – resulting in sensible data. This area of research should be explored further as a way to obtain reliable research data from respondents using a small screen device when long answer lists are unavoidable.

Many applications exist for both T2V and V2T, but they tend to be either specific to an operating system, specific to a browser or integrated into a survey system. As a result, it can be difficult to implement a voice application that works across devices and browsers. We found only one major survey system that had the text to voice feature available. In our adult test which we ran on the Decipher survey platform, which does not have text to voice available, we decided to limit the survey to respondents on iPhone 5s and 6s to simplify the instruction process. If we had wanted to include other device/operating system combinations, we would have had to either intercept the information, serve the correct instructions or provided some sort of look up process.

OPTIONS FOR CODING/TRANSCRIPTION OF VOICE:

METHOD	DESCRIPTION	ISSUES
Via a Google API	Google provides a Voice to text API for both Android Devices and its later version of its Chrome Browser.	Works only on Google Products It seems like it was designed for short messages; not long verbatim. Not good for some short command driven questions; i.e. answer with A, B or C. It tries to find logical sentences.
In-house manual transcription	The process involves representing oral text (either audio or video files) into a written text format (word documents, PDF or simple text), across medical, business, legal, media and other such fields. This requires providing high quality services with high accuracy, speed and timeliness.	Very time consuming. Work on a 12:1 ratio. 1 minute of audio can take up to 12 minutes to code. Also limited to the lingual capabilities of staff.
Using a Crowd Service like Amazon Mechanical Turk	We send the audio to anonymous crowd workers to transcribe. Can be cost effective. We can also find people with a variety of language capabilities.	Takes some time to optimize the crowd. For instance you might need to break the audio into chunks. Does not allow for real-time question routing.
Third Part Voice APIs	For instance Nuance provides cross device voice transcription capability.	Require development resources. Volume based cost. Real time routing is possible.

Table 2.1.2 Comparison of methods for Voice automation

2.2 FEASIBILITY STUDY

By taking into consideration the results of the initial exploration, the survey is now bolstered by an exhaustive feasibility study. A feasibility study is an assessment of the practicality of a proposed plan or method in context to workability, monetary impact, ability to meet needs and effective use of the resources. Here, we address the following factors of feasibility:

1. Technical feasibility
2. Economic feasibility
3. Schedule feasibility
4. Operational feasibility

A feasibility study evaluates the project's potential for success; therefore, perceived objectivity is an important factor in the credibility of the study for potential investors and lending institutions. It must therefore be conducted with an objective, unbiased approach to provide information upon which decisions can be based.

2.2.1 Technical feasibility

The technical feasibility assessment is focused on gaining an understanding of the present technical resources of the organization and their applicability to the expected needs of the proposed system. It is an evaluation of the hardware and software and how it meets the need of the proposed system. This assessment is based on an outline design of system requirements, to determine whether the company has the technical expertise to handle completion of the project.

RpHCA is at its core, a hardware based project whose functionality is effectuated by discrete software based modules. To assess its technical feasibility, the following modules are taken into consideration:

- Raspberry Pi 3 model B is a single-board computer which will be the main computing unit.
- A 3.2 inch LCD display or a smartphone screen which will be projected on a semi-transparent mirror via a Fresnel lens.
- Pi NoIR camera v2 which has a Sony IMX219 8-megapixel sensor. It does not employ any infrared filters which allow us to see in the dark with infrared lighting.

The augmentation will be head-mounted, which calls for the manual construction of a head-mount, preferably made using aluminium.

- The voice-controlled augmentation will also have an alternate control for hands-on configuration and minute tweaking. This can be put into operation using a wireless keyboard and mouse or a smartphone running a Linux-based OS.
- The augmentation will be powered using a 10,000 mAh powerbank with an output of 5 volts and 2 ampere.
- To receive voice-input, and to get the voice output, a headset with a 3.5 mm jack will be required.
- RpHCA will have a voice responsive UI which will be built on Speech Synthesis Markup Language (SSML), an XML-based markup language for speech synthesis applications. Though SSML will be used for processing voice input, the brains of the overall operation will be an AI system which will be custom designed.
- Facial recognition software made using Intel's OpenCV and implemented with the help of Matlab.

All in all, the acquisition of all hardware modules and subsequent integration with the software modules is concluded to be technically feasible.

2.2.2 Economic feasibility

The purpose of the economic feasibility assessment includes quantification and identification of all the benefits expected from the proposed system. It typically involves a cost/ benefits analysis. The financial and the economic facts during the preliminary investigation are tabulated below.

Module	Cost (in INR)	Cost (in USD)
Raspberry Pi 3 model B	2,600	35
3.2 inch LCD display and Fresnel lens	1,900	27
Pi NoIR camera v2	2,300	33
Manually constructed aluminium head-mount	300	5
Wireless keyboard and mouse (optional)	1,200	34
10,000 mAh powerbank	1,300	18
Headset with microphone	100	3

Table 2.2.2.1 Cost of RpHCA modules

The total cost comes out to be ₹9,599 or $155. Thus, the proposed system is economically feasible.

2.2.3 Schedule feasibility

A project will fail if it takes too long to be completed before it is useful. Typically this means estimating how long the system will take to develop, and if it can be completed in a given time period using some methods like payback period. Schedule feasibility is a measure of how reasonable the project timetable is.

Given our technical expertise, the expected deadlines to finish the modules have been found to be reasonable. A functioning prototype is expected to be developed within 30 days. Though it is necessary to determine whether the deadlines for the creation are mandatory, their integration to form a single system is not; it is expected to be an iterative process, based on the agile SDLC model.

So we addressed the following issues:

- Changes that will be brought with the system, specifically voice integration and AI learning.
- Organization structures that may be disturbed with the addition of subsequent modules (regression testing).
- New skills that will be required are building Python scripts, developing a self-learning AI and minor hardware integration.

2.2.4 Operational feasibility

Operational feasibility is a measure of how well a proposed system solves the problems, and takes advantage of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development.

Certain parameters are required to be considered at the early stages of design if desired operational behaviors are to be realized. A system serves its intended purpose most effectively when its technical and operating characteristics are engineered into the design. Therefore, operational feasibility is a critical aspect of systems engineering that needs to be an integral part of the early design phases.

To ensure success, RpHCA's operational outcomes will be imparted during design and development. These include following design-dependent parameters:

Reliability	RpHCA must be technologically reliable in the sense that its interfaces, components and battery must not malfunction.
Maintainability	The only maintenance that is required would be scheduled cache-cleaning and backups.
Interoperability	Once authenticated, the augmentation should be able to communicate with other systems.
Usability	RpHCA must be user-friendly but user-adaptive; more tweaking options for expert users and zero revelations of its intricate workings to naïve users.

Table 2.2.4.1 Operational feasibility parameters

CHAPTER III

PROPOSED SYSTEM

3. PROPOSED SYSTEM

3.1 DRAWBACKS OF CURRENT SYSTEM AND NEED FOR PROPOSED SYSTEM

3.1.1 Drawbacks of current system

Google Glass, the company's innovative wearable computer built into a pair of eye-spectacles, allows users to access e-mail, texts, and the Internet via voice and physical commands, while keeping their eyes on the world; a huge step forward in the nascent of augmented reality in the tech world. However, the social norms for the product haven't yet been established; Google cautions wearers to be prepared for disruptions when wearing them in the real world.

Aside from the popularity of Google Glass and acceptance of its use in daily life is somehow bolstered, we would merely be neglecting the economic and budgetary points of view of the buyer -- the hefty price tag of $1,500.

Moreover, most wearable technology available in the market is fragile. Products like Google Glass are made of delicate materials and are intricately engineered to function as a single unit.

Another issue that sprouts up when the words "wearable tech" comes into mind is interoperability. Consider Apple's Watch, it is designed to work within Apple's established app ecosystem; it is unequivocally incompatible with Android or Microsoft products. Similarly, in the case of Google Glass, it is engineered to work consistently with Google's services.

3.1.2 Need for proposed system

In the proposed system, we intend to overcome the drawbacks of current system by proposing a cost-effective and energy-efficient solution. The whole idea of flexible tech often seems a bit far-fetched. In the media, we may stumble upon articles about dazzling new wearable gadgets like foldable tablets and roll-up televisions. Though technological advancements like these are interesting and inspiring, but it makes one wonder how soon this kind of tech will be available to the common consumer and whether the common man even be able to afford it when it hits the market. The cost of developing Raspberry Pi head-mounted cybernetic augmentation is around $150; around 10% of the cost at which Google Glass is sold.

Besides low cost, we also aim to make RpHCA as non-disruptive as possible. It won’t bother the user with any unnecessary messages, notifications or advertisements. An intuitive UI would maintain a smooth flow of operations. The users will understand its behavior and effect without use of reason, experimentation, assistance, or special training.

Unlike currently available wearable tech, RpHCA is significantly robust in its physical design and would not be rendered useless if dropped by accident. It also maintains interoperability across varying platforms like Windows, Mac, Android and Unix-based and Unix-like operating systems.

3.2 PROJECT PLANNING AND SCHEDULING (GANTT CHART)

3.2.1 PROJECT PLANNING

Project planning is a key constituent of project management, which entails using illustrative scheduling tools such as Gantt charts to plan and tick off action items on the schedule.

First, the scope of project is defined and relevant methods for completing the project are determined. Following this step, the time needed to undertake each task is allocated and grouped into a work breakdown structure. Project planning is often used to organize different areas of a project, including project plans, workloads and the management of teams and individuals. The logical dependencies between tasks are defined using an activity network diagram that enables identification of the critical path. Project planning is inherently uncertain as it must be done before the project is actually started. Therefore the duration of the tasks is often estimated through a weighted average of optimistic, normal, and pessimistic cases. The critical chain method adds "buffers" in the planning to anticipate potential delays in project execution. Then the necessary resources can be estimated and costs for each activity can be allocated to each resource, giving the total project cost. At this stage, the project schedule may be optimized to achieve the appropriate balance between resource usage and project duration to comply with the project objectives. Once established and agreed, the project schedule becomes what is known as the baseline schedule. Progress will be measured against the baseline schedule throughout the life of the project. Analyzing progress compared to the baseline schedule is known as earned value management.

3.2.2 SCHEDULING (GANTT CHART)

A Gantt chart is a horizontal bar chart developed as a production control tool in 1917 by Henry L. Gantt, an American engineer and social scientist. Frequently used in project management, a Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project. Following figure represents a Gantt chart for Raspberry Pi Head-mounted Cybernetic Augmentation.

Sr. no.	Task	Start date	End date
1	Project domain selection	1-Oct	14-Oct
2	Literature survey	15-Oct	31-Oct
3	Raspberry Pi setup	1-Nov	15-Nov
4	Modifying Linux distro for RpHCA	16-Nov	30-Nov
5	AVS API integration	1-Dec	15-Dec
6	Coding for IUI	16-Dec	31-Dec
7	Training IUI	1-Jan	14-Jan
8	Integrating camera module	15-Jan	22-Jan
9	Coding for facial recognition	23-Jan	31-Jan
10	Coding for object recognition	1-Feb	7-Feb
11	Setting up the Eye-piece and head-mount	8-Feb	14-Feb
12	Coding for Augmented reality display	15-Feb	28-Feb
13	Testing	16-Nov	15-Mar
14	Documentation	16-Mar	22-Mar
15	Deployment	23-Mar	31-Mar

Fig. 3.2.2.1 Gantt chart for Raspberry Pi Head-mounted Cybernetic Augmentation

3.3 SYSTEM DESCRIPTION AND SRS

3.3.1 SYSTEM DESCRIPTION

3.3.1.1. Purpose

The purpose of this document is to present a detailed description of the Raspberry Pi head-mounted cybernetic augmentation. It will explain the purpose and features of the system, the functions of the system, what the system does, the constraints under which it operates and how the system will react to external stimuli. This document is intended for all kinds of users, varying from the naïve ones to the experts.

3.3.1.2. Scope of Project

Intelligent user interfaces (IUIs) are human-machine interfaces that aim to improve the efficiency, effectiveness and spontaneity of human-machine interaction by reasoning and acting on models of the user, domain, task, discourse, and media; specifically verbalized natural language. Whereas practical systems are possible today, the multimedia interface of the future may have facilities that are much more sophisticated. These interfaces may include humanlike agents that converse naturally with users, monitoring their interaction with the interface (e.g., keystrokes, gestures, facial expressions) and the properties of those interactions (e.g., conversational syntax and semantics, dialog structure) over time and for different tasks and contexts. Equally, future interfaces will likely incorporate more sophisticated presentation mechanisms.

The impact of wearable tech is already being felt in education, communication, navigation, and entertainment; but perhaps the greatest potential lies in healthcare. Wearable technology started to revolutionize healthcare by assisting doctors in the operating room and providing real time access to electronic health records. Smart wearable devices such as miniature cameras can easily be worn on a garment while being controlled via a mobile app. This development is largely due to the availability of better touch screens and higher resolution cameras. Hence, this opens up another area of mobile app development wherein smart mobile apps will be created specifically to control various wearable devices.

At present, much of the hype around wearable technology focuses on consumer devices; specifically Apple Watch, Google Glass, and devices from Pebble, Jawbone and Fitbit. But many industry watchers believe it will be businesses and not consumers driving the wearables trend. Technological costumes are not just clothes and offer a wide range of applications for their use in e-learning projects. Their potential is currently in full exploration. Numerous projects are being developed in collaboration between academia and corporate fields, as they work together to further study and understand the possibilities of these emerging innovations.

3.3.1.3. Glossary

Term	Definition
Raspberry Pi	The main computer in the augmentation used for processing data.
IUI	An intelligent user interface which has sophisticated knowledge of the domain and/or a model of the user, thus allowing the interface to better understand the user's needs and personalize or guide the interaction.
AVS	Alexa Voice Services is an intelligent cloud service that allows developers to voice-enable any connected product with a microphone and speaker.
AR	The output will be displayed as augmented reality; a view of reality is modified or augmented by the Pi.
AR display	An eye-piece consisting of a semi-transparent mirror on which the display will be projected to transfigure it into an AR display.
Head-mount	The main housing base of the augmentation on which all modules will be integrated as a single unit.
Auditory feedback	The feedback given by the AI user interface using AVS.

Table 3.3.1.3 Glossary

3.3.2. Software Requirements Specification

A software requirements specification (SRS) is an elucidation of the way a software system will be developed. It exhibits functional and non-functional requirements, and may include a set of use cases that describe user interactions that the software must provide.

3.3.2.1. Overall description

This document contains the problem statement that the current system is facing which is hampering the economic feasibility of currently available wearable devices. It further contains a list of the functions and the description of the role played by the user of the proposed system. It also elaborates on the acceptance criteria that would build a solid foundation for the design of RpHCA so that it can compete with wearable tech that are already out in the market.

3.3.2.2. Product perspective

Raspberry Pi head-mounted cybernetic augmentation is supposed to be an assistive human enhancement. It is a user-adaptive wearable technology that has an intelligent user interface as its primary UI. The following are the features included in RpHCA:

- Cross platform support: Offers operating support for most of the known and commercial operating systems.
- User-adaptability: The ability to toggle between modes for expert, regular and naïve users.
- Vocal input: Can communicate with RpHCA via verbal communication.
- Camera: RpHCA can take pictures on command.
- Object and facial recognition: RpHCA can recognize objects and faces that it has been familiarized with.
- Augmented visual output: RpHCA has an eye-piece to facilitate augmented reality display.
- Vocal feedback: RpHCA can communicate and reply back to the user via simulated voice.

3.3.2.3. Design constraints

Every system has to compromise power in lieu of flexibility, convenience for security and adaptability instead of robustness, or vice versa. The constraints in development process of RpHCA are as follows:

- Synchronization: To make regular backups and updates, internet connection is required.
- Web search: RpHCA needs to be connected to the internet if the user decides to make a web search.
- Language requirements: The primary UI for RpHCA is via vocal communication, and the language that it is designed for is English.

3.3.2.4 Acceptance criteria

The quality attributes making up the acceptance criteria for Raspberry Pi head-mounted cybernetic augmentation, focusing on business acceptance testing are as follows:

i) Usability
   - RpHCA should be user-adaptive in the sense that it should be usable by expert users and naïve users with ease.
   - The augmentation must primarily function as an assistive enhancement.

ii) Performance
   - RpHCA should display accurate information after processing data.
   - It should allow the user to be as productive as they are while using a regular personal computer.

iii) Reliability
   - The augmentation must be energy-efficient; its battery life must be preserved while in standby mode and it should be consistent.
   - There shall be no excess heating of any modules. To ensure heat dissipation, heat sinks will be installed on the Raspberry Pi.
   - There should be negligible freezing while RpHCA is being used.

iv) Upgradability

- For added processing power, real-time manipulation of large data, more Raspberry Pis may be required. The system must be able to accommodate additional computers.
- There should be enough room to integrate additional modules.
- RpHCA must be interoperable with other systems.

v) Competitive edge

- RpHCA has a distinct advantage over existing products like Google Glass, Apple Watch primarily because of battery life and lower cost.
- In contrast to virtual reality goggles, RpHCA employs the use of augmented reality, which will not hinder the user while performing daily functions.

3.4 SYSTEM ANALYSIS

The system analysis/requirements gathering process is intensified and focused specifically on software. To understand the nature of the program(s) to be built, the software engineer ("analyst") must understand the information domain for the software, as well as required function, behavior, performance, and interface. Requirements for both the system and the software are documented and reviewed with the customer.

It is a process of collecting factual data, understand the processes involved, identifying problems and recommending feasible suggestions for improving the system functioning. This involves studying the business process, gathering operational data, understand the information flow, finding out bottlenecks and evolving solutions for overcoming the weaknesses of the system so as to achieve the organizational goals. System analysis also includes dividing the complex process involving the entire system, identification of data store and manual processes.

The major objectives of system analysis are to find answers for each business process; what is being done, how it is being done, who is doing it, when is he doing it, why is it being done and how can it be improved? It is more of thinking process and involves the creative skills of the system analyst. It attempts to give birth to a new efficient system that satisfies the current needs of the user and the scope for future growth within the organizational constraints. The result of this process is the logical system design.

System analysis is the iterative process that continues until a preferred and acceptable solution emerges. Requirement analysis also provide software designer with a representation of information, function, and behaviour that can be translated to data, architectural, interface, and component-level designs.

Finally, the requirements specification provides the developer and the customer with the means to assess quality once software is built. Software requirements analysis may be divided into five areas of effort:

(1) Problem recognition

Most decision making starts with some sort of problem. The consumer develops a need that they want to be satisfied. If it can be determined when the target demographic develops these needs or wants, it would be an ideal time to advertise to them.

(2) Evaluation and synthesis

The analyst must define all externally observable data objects, evaluate the flow and content of information, define and elaborate all software functions, understand software behavior in the context of events that affect the system, establish system interface characteristics, and uncover additional design constraints.

(3) Modelling

Here, the first technical representation of a system is provided. It deals with the problem of size by partitioning the system.

(4) Specification

It is a description of a software system to be developed. It lays out functional and non-functional requirements, and may include a set of use cases that describe user interactions that the software must provide.

(5) Review

It is a formal review conducted to ensure that system requirements have been completely and properly identified and that a mutual understanding between the government and contractor exists. It ensures that the system under review can proceed into initial systems development and that all system and performance requirements derived previously are well-defined, testable, and are consistent with cost, schedule, risk, technology readiness, and other system constraints.

Initially, the analyst studies the system specification (if one exist) and the software project plan.

3.4.1 Flowchart

A flowchart is a visual (diagrammatic) representation of an algorithm, workflow or process which shows the steps as boxes of various kinds, and their order by connecting them with arrows.

In our system, RpHCA is first initialized and then connects to the internet. Upon retrieval of vocal command from user, it retrieves relevant data from local disk and checks whether or not the system is online; if not, then is connects to the internet, else it proceeds to the next step. It then checks whether the camera will be put into use. If the camera is going to be used, then it captures an image frame when aimed, and then processes it; if not, then it simply skips these two steps. Then RpHCA processes the commands given by user previously and the data it retrieved from the disk. The output is vocalized as well as displayed on the screen.

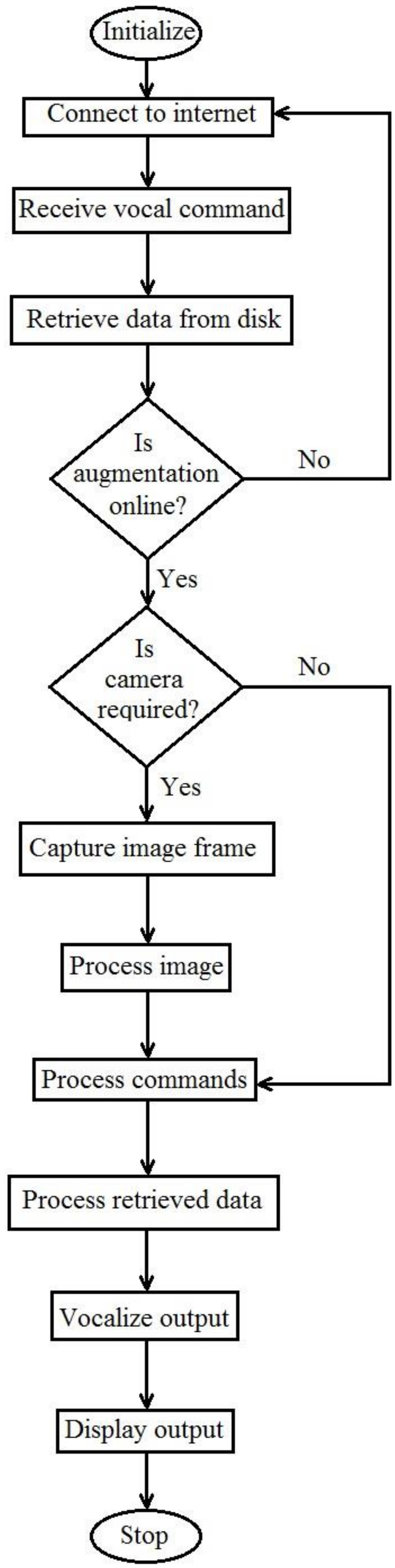


Fig. 3.4.1.1 Flow chart for RpHCA

3.4.2 Data flow diagram

A data flow diagram is a graphical representation of the 'flow' of data through an information system, modelling its process aspects. A DFD shows what kinds of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored.

The following figure shows the level 0 data flow diagram for Raspberry Pi head-mounted cybernetic augmentation. First the user interacts with RpHCA, then it interacts with the external input, i.e. data from surroundings and then process continues further.

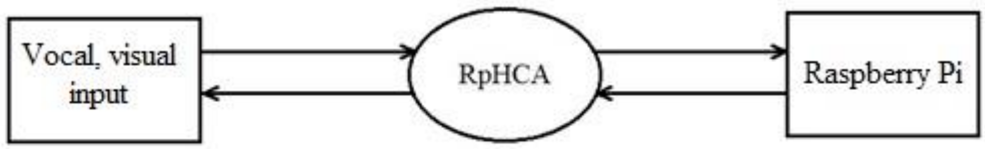
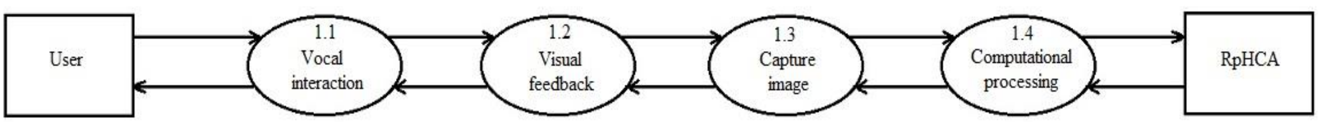


Fig. 3.4.2.1 Level 0 DFD for RpHCA

The figure below shows the level 1 data flow diagram for Raspberry Pi head-mounted cybernetic augmentation. Here, the RpHCA performs multiple functions as the user interacts with the augmentation. As observed in the diagram, RpHCA performs 4 chief functions; computational processing, capturing image, visual feedback and vocal interaction with the user.



3.4.2.2 Level 1 DFD for RpHCA

3.4.3 Class diagram

The class diagram is the main building block of object oriented modelling. It is used both for general conceptual modelling of the systematic of the application, and for detailed modelling translating the models into programming code. Class diagrams can also be used for data modelling.

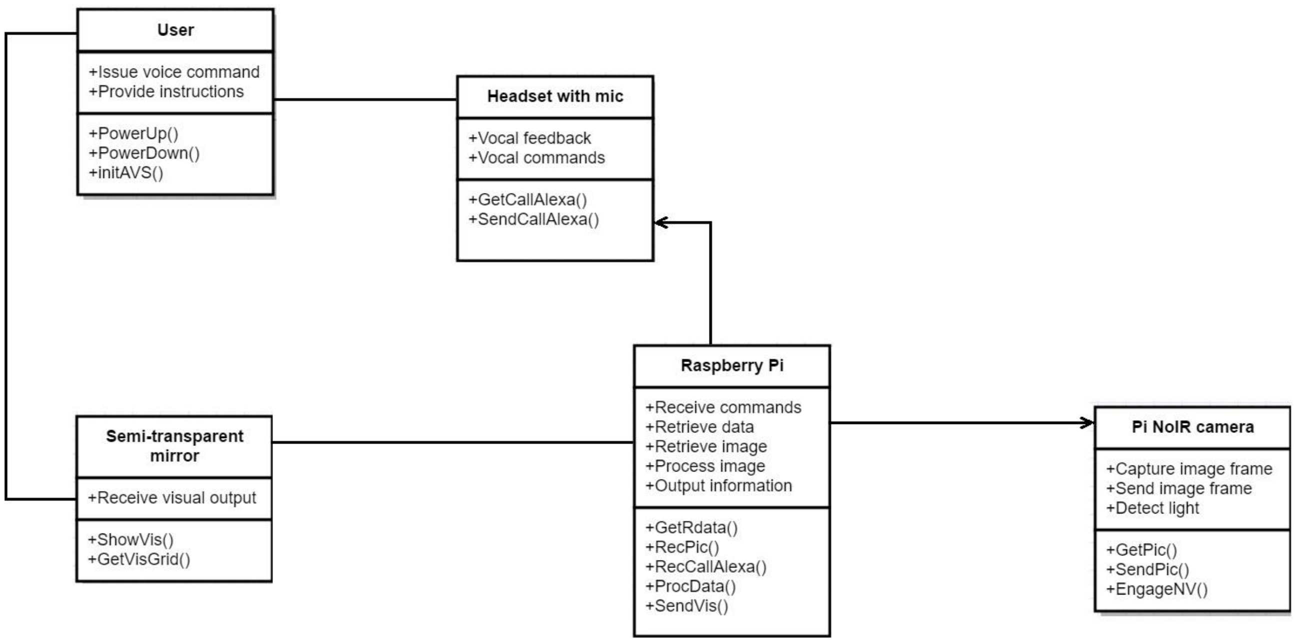


Fig. 3.4.3.1 Class diagram for RpHCA

3.4.4 Use case diagram

A use case diagram is at its core, a representation of the user's interaction with the system and depicting the specifications of a use case. A use case diagram can be used to portray different types of users of a system and the distinctly varying ways that they interact with the system. This type of diagram is typically used in conjunction with the textual use case and will often be accompanied by other types of diagrams as well.

In this case, we have two actors, RpHCA and the user. RpHCA performs actions like receiving voice input from user, receiving instructions, processing data and giving vocal, visual output to the user.

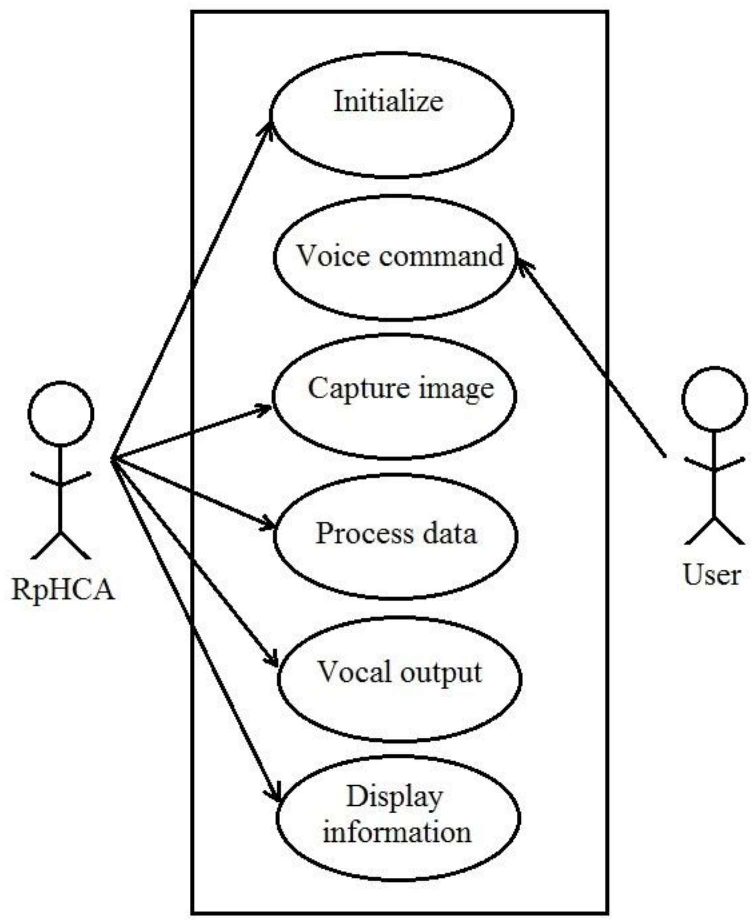


Fig. 3.4.4.1 Use case diagram for RpHCA

3.4.5 HARDWARE AND SOFTWARE REQUIREMENTS

- **Minimum Hardware Requirements**
    1. Raspberry Pi 3, model B
    2. Pi NoIR camera (v2)
    3. 3.2 inch LCD display
    4. 3x Fresnel lens
    5. Smartphone running Android (v4.4+)
    6. Headset with microphone (3.5 mm)
- **Minimum Software Requirements**
    1. 64-bit Linux distribution (Raspbian or Arch)
    2. Alexa Voice Services API
    3. Python, libraries
    4. MATLAB 9.1

3.5 SYSTEM DESIGN

Based on the user requirements and the detailed analysis of the existing system, the new system must be designed. This is the phase of system designing. It is the most crucial phase in the developments of a system. The logical system design arrived at as a result of systems analysis is converted into physical system design. Normally, the design proceeds in two stages: (1) Preliminary or General Design, (2) Structured or Detailed Design.

In the preliminary or general design, the features of the new system are specified. The costs of implementing these features and the benefits to be derived are estimated. If the project is still considered to be feasible, we move to the detailed design stage.

In the detailed design stage, computer oriented work begins in earnest. At this stage, the design of the system becomes more structured. Structure design is a blue print of a computer system solution to a given problem having the same components and inter-relationships among the same components as the original problem. Input, output, databases, forms, codification schemes and processing specifications are drawn up in detail.

In the design stage, the programming language and the hardware and software platform in which the new system will run are also decided. There are several tools and techniques used for describing the system design of the system. These tools and techniques are: (1) Flowchart, (2) Data Flow Diagram, (3) Data Dictionary, (4) Structured English, (5) Decision Table, and (6) Decision Tree etc.

The system design is of three types which are architectural design, logical design and physical design. The architectural design of a system emphasizes on the design of the systems architecture which describes the structure, behaviour, and more views of that system and analysis. The logical design of a system pertains to an abstract representation of the data flows, inputs and outputs of the system. The physical design relates to the actual input and output processes of the system.

3.5.1 SYSTEM ARCHITECTURE

System architecture is the conceptual model that defines the structure, behavior, and views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system. System architecture elucidate the constituents of software components, the externally visible properties of those components, and the relationships between them. The architecture is not the operational software; but a representation that enables software engineers to analyze the effectiveness of the design in meeting its stated requirements, consider architectural alternatives at a stage when making design changes is still relatively easy and reduce the risks associated with the construction of the software.

Raspberry Pi head-mounted cybernetic augmentation uses a bottom-up approach wherein we integrate modules together to give rise to a single unit that makes up the augmentation. The bottom-up architecture of RpHCA consists of hardware comprising of a Raspberry-Pi, AR display (Fresnel lens, semi-transparent mirror, LCD screen), camera module, power bank and head-mount. The software part consists of an intelligent UI, voice interface (AVS), image recognition software and a Linux distro as the OS.

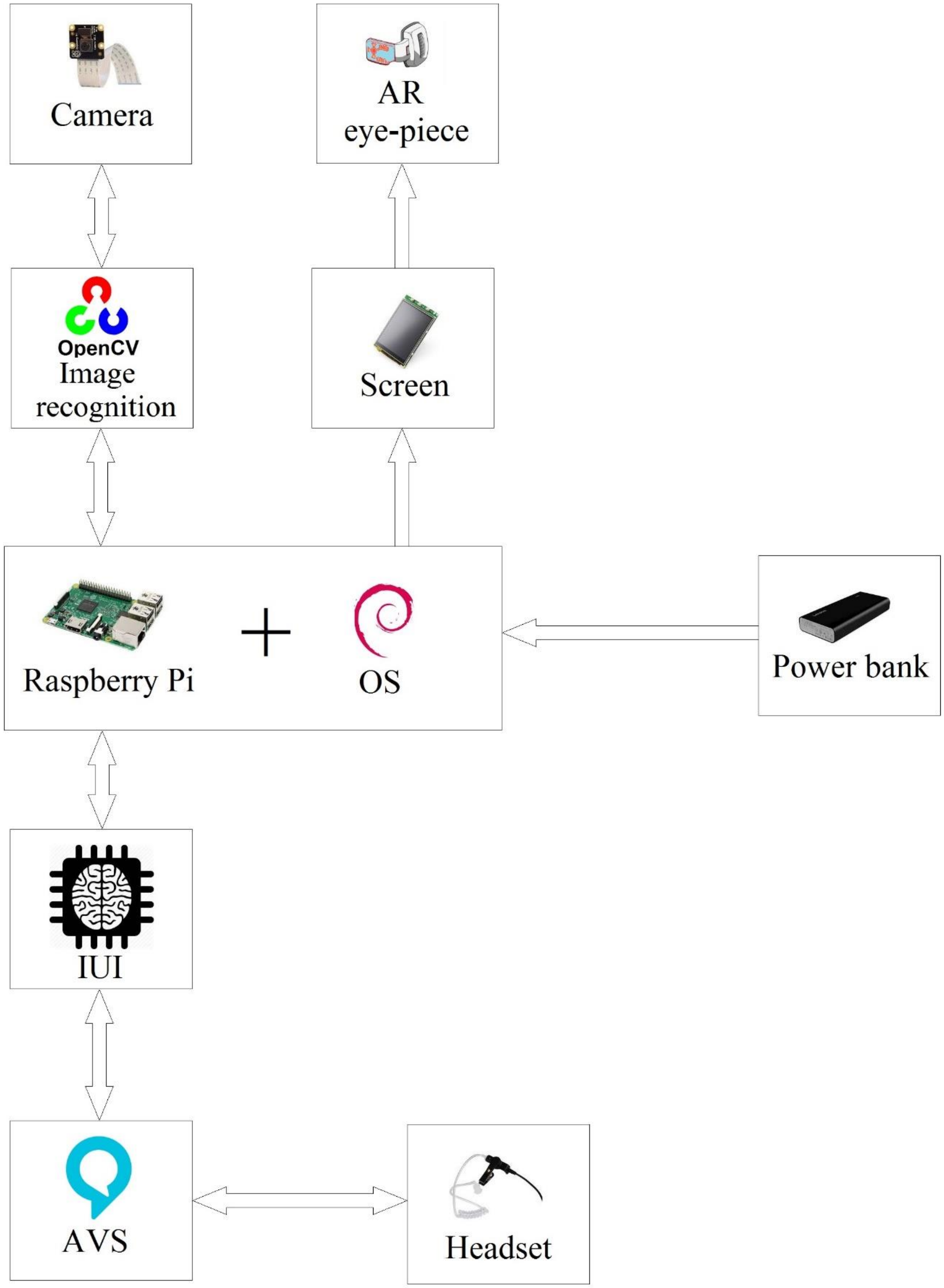


Fig. 3.5.1.1 System architecture of RpHCA

3.5.1.1. Raspberry Pi

Raspberry Pi is a small credit-card sized computer that will be the main computational processing unit of RpHCA. Raspbian, a Linux distro specially designed for Raspberry Pi will work as an intermediary between AVS API, the IUI, OpenCV libraries and drivers of other modules. The images captured by the camera module will be processed on Raspberry Pi, along with the instructions given by the user and any data requests.

3.5.1.2. AR display (eye-piece)

The AR display will be an eye-piece made up of semi-transparent mirror. A 3.2 inch LCD screen will be connected to the Raspberry Pi. The contents of this screen will be projected onto the eye-piece using a Fresnel lens of 3x magnification power. The eye-piece will also have an imaginary grid on the semi-transparent mirror which will be used to map the augmented reality visual output.

3.5.1.3. Intelligent user interface

An intelligent user interface often referred as Interface Agent is a user interface (UI) that involves some aspect of artificial intelligence (AI or computational intelligence). There are many modern examples of IUIs, the most familiar being the Microsoft Office Assistant, whose most recognizable agentive representation was called "Clippy". Generally, an IUI involves the computer-side having sophisticated knowledge of the domain and/or a model of the user.

In RpHCA, the intelligent UI will first be trained for a user. After it has been trained, the IUI will be able to work in synchronization with the user, able to predict the user’s preferences. It will work in conjunction with Alexa Voice Services, able to interpret inputs and perform tasks commanded by the user.

3.5.1.4. Alexa Voice Services

AVS is Amazon’s intelligent cloud service which will be used to voice-enable RpHCA with a microphone and speaker. The user can simply talk to the augmentation to play music, answer questions, get news and local information, take pictures and give tasks to be executed on the OS.

3.5.1.5. Pi NoIR camera v2

The Pi NoIR camera is an infra-red camera module with a Sony IMX219 8-megapixel sensor. It is fully functional as a regular camera, with one difference: it does not employ an infrared filter. This means that pictures taken in daylight will look decidedly curious, but those taken in the absence of any light allow us to see in the dark with infrared lighting.

3.5.1.6. Headset with mic

To use Alexa Voice Services, the user will talk into the microphone built in the headset that will be connected to Raspberry Pi. The intelligent UI will then process the verbalized commands and send the output in the form of auditory signals, i.e. sound in the form of spoken language.

3.5.2 USER INTERFACE DESIGN

3.5.2.1 Intelligent user interface

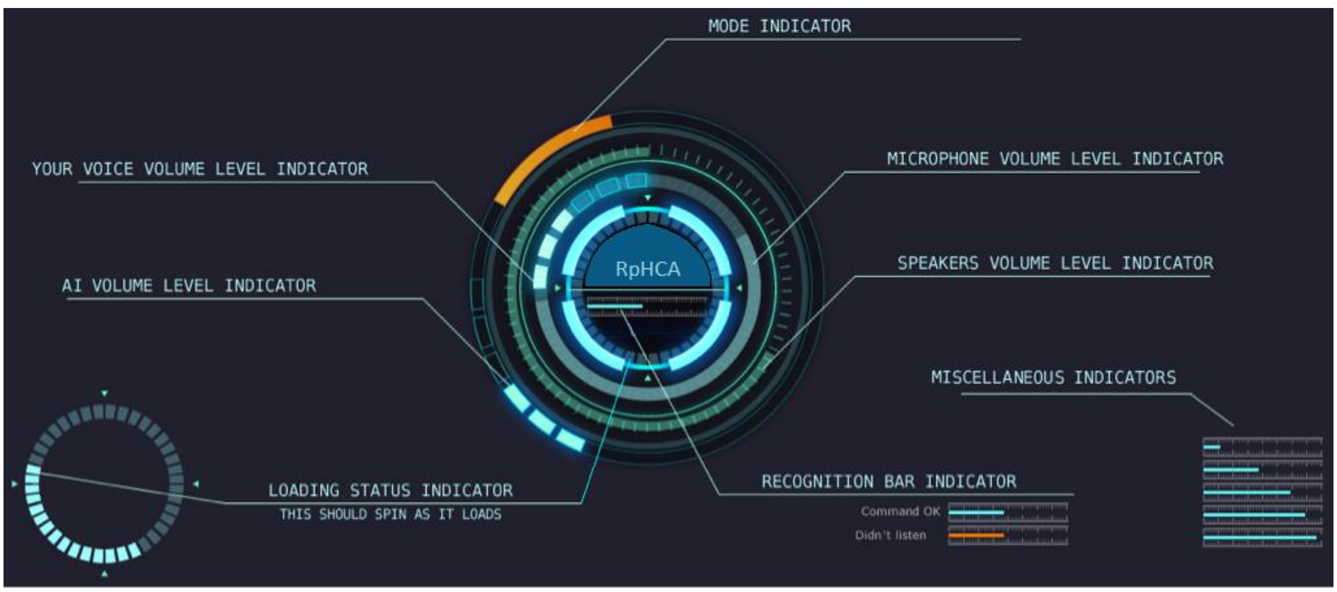


Fig. 3.5.2.1.1 Intelligent user interface display

Raspberry Pi head-mounted cybernetic augmentation will have a minimalist user interface since it will be primarily be controlled vocally. The user will command RpHCA via the microphone present on the headset and will get auditory feedback from the augmentation via the headset. RpHCA will also show information about objects and people in the surroundings, displayed on the AR display (eye-piece). The majority of the indicators; speech volume, AI volume, mic and speaker volume will be shown in concentric circles, while the rest of them will be shown as bars.

CHAPTER IV

CONCLUSION

4. CONCLUSION

Raspberry Pi Head-mounted Cybernetic Augmentation is a cost-effective solution to available wearable technology. Even its battery backup is more than 40 hours which is significantly ahead of current wearable technology. Besides low cost and high energy efficiency, RpHCA is nowhere as disruptive as its competition. It does not bother the user with unnecessary information and its updates, backups are made when the device is being charged.

The overall design of Raspberry Pi Head-mounted Cybernetic Augmentation has six modules; the Raspberry Pi 3, which is the main processing unit of the augmentation. The second module consists of the display screen and the AR display, i.e. eye-piece. The third module is the intelligent user interface that responds to the user's requests via the fourth module; i.e. voice automation, which will be effectuated using Alexa voice services. The visual data acquisition will be done by the fifth module, consisting of a camera without an infra-red filter. The sixth and the last major module will be a headset with a microphone that will be used to receive vocal feedback from the IUI via AVS in addition to commanding RpHCA via vocal commands.

The RpHCA acquires data from the user's surroundings and process it to provide information that will help the wearer make better decisions. It works as an assistive human enhancement by providing real-time information, generated by processing the visual data from the user's surroundings and vocal commands given by the user using the augmentation's AI as an interface.

CHAPTER V

REFERENCES

5. REFERENCES

[1] Reshaping the human condition: exploring human enhancement, L. Zonneveld, H. Dijstelbloem, D. Ringoir, 2008, Amsterdam School for Cultural Analysis (ASCA)

[2] A Cloud You can Wear: Towards a Mobile and Wearable Personal Cloud, Ragib Hasan and Rasib Khan, 2016, University of Alabama at Birmingham

[3] SixthSense: a wearable gestural interface, Pranav Mistry, Pattie Maes, 2008, MIT Media Laboratory

[4] A survey of augmented reality, Azuma, R.T., 1997, Presence: Teleoperators and virtual environments, 6(4), pp.355-385.

[5] Virtual Reality: Scientific and Technological Challenges, Durlach, Nathaniel I. and Anne S. Mavor, 1995, (Report of the Committee on Virtual Reality Research and Development to the National Research Council) National Academy Press. ISBN 0-309-05135-5.

[6] Interacting with Paper on the DigitalDesk, Wellner, Pierre, July 1993, CACM 36, 7, 86-96.

[7] Live Solar System (LSS): Evaluation of an Augmented Reality Book-Based Educational Tool, A.K. Sin and H.B. Zaman, Proc. Int’l Symp. Information Technology (ITSim), vol. 1, pp. 1-6, June 2010.

[8] Exploring a Cognitive Basis for Learning Spatial Relationships with Augmented Reality, B.E. Shelton and N.R. Hedley, 2004, Technology, Instruction, Cognition and Learning, vol. 1, no. 4, pp. 323- 357.

[9] Raspberry Pi - Teach, Learn, and Make with Raspberry Pi, [Online] Available: https://www.raspberrypi.org/help/faqs/

[10] Artificial Intelligence Techniques for Advanced Smart Home Implementation, M.B.I Reaz, 2013, ACTA TECHNICA CORVINIENSIS- Bulletin of Engineering, ISSN 2067-3809.

[11] Giving Voice to Research, Sherri Stevens, 2015, CASRO Digital Research Conference, Nashville.

ANNEXURE I: PROJECT MEMBER-DETAILS

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