IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Design of an Assistive Object Finding Device for Visua lly Impaired Users

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Abstract: People who have visual impairments have problems finding their personal items. This research has seen the design and development of an Assistive Object Finder Device based on the use of Radio Frequency (RF) Technology to help in locating objects tagged by the system. A user-oriented design approach involving literature review, user study, ergonomics study, concept development, computer aided design (CAD) model design and prototyping has been applied in the design of the device. Tactile buttons, audio feedback and ergonomic design make the usage of the device very easy.

Index Terms **-** Assistive Technology, Visual Impairment, Object Finding System, Wearable Device, Smart Watch, Object Detection, Blind Assistance, Audio Feedback, Human-Centered Design, Accessibility.

I. INTRODUCTION

Losing one's keys, wallet, or medication is an everyday occurrence for most people. However, for millions of visually impaired individuals, this is an obstacle preventing them from leading an autonomous life. Although white cane and guide dogs help them navigate through public space, these items cannot help visually impaired people recognize a specific object put on the table or a shelf. Modern technology has brought forth wearable devices that could simplify this task for visually impaired people. However, to be able to detect objects using these devices, it was required to attach a special Bluetooth or RFID tag to each item that would be needed to locate. Thanks to modern computer vision technology, we can now eliminate the need for these tags; however, current products are either too bulky or expensive, require constant access to the internet or provide users with ambiguous audio instructions. This paper intends to introduce a compact and affordable wearable device that would help visually impaired individuals detect a specific object.

NEED OF THE STUDY.

Challenges Faced by Visually Impaired Individuals in Object Localization

Generally, detecting objects in the environment around them becomes a significant problem for visually impaired individuals. An environment of everyday life consists of various objects, obstacles, and contextual information which can be easily understood by people who can see. However, without the ability to see, only tactile, acoustic, or smell clues can be used, which are rather insufficient for complicated environments. This means that it becomes difficult for visually impaired people to detect objects in the environment because they spend additional time on finding the needed objects, while feeling frustration at the same time. What is more, there is a greater possibility of getting injured because visually impaired people do not have enough information regarding objects near them.

Limitations of Existing Assistive Devices

The current assistive device that can perform tasks of object detection and localization fails to satisfy needs because of the following deficiencies. Current devices could include ultrasonic, infrared, or simple RFID sensors that give inaccurate information about the distance or objects themselves. Current assistive devices

might be heavy, costly, or too complex to install and calibrate. Furthermore, current devices only show binary outputs, no detailed information about the object or its position is provided. Most of the current assistive devices lack a user-friendly interface, therefore, users with different technical skills will find it hard to operate them. Also, some devices cannot adapt to a number of environments, thus cannot work efficiently in cluttered or dynamic environment. The above-mentioned deficiencies prove the need for smart, lightweight and inexpensive devices capable of delivering precise information about the object position in real-time mode.

The Growing Need for Technological Innovation

Since the speed of development of sensors, machine learning, and embedded computing increases, there comes a great opportunity to create intelligent assistive devices that can help the visually impaired. With more people living in the cities, there are more complicated conditions to navigate through. Traditional techniques of navigation and guidance will not be sufficient enough to manage such complexity; therefore, there is a need for more advanced systems that will analyze complicated situations, recognize specific objects, and provide necessary information for the user. Using artificial intelligence with portable devices will help in creating smart devices that will be able to learn from the patterns of the environment.

Enhancing User Independence and Confidence

There are several reasons why this research needs to be done, one of which is to enhance the autonomy of visually impaired people. By equipping them with accurate devices that enable them to find their stuff quickly, their levels of confidence can be enhanced. Due to enhanced autonomy, the people will have the ability to do various things without seeking help from others. Consequently, they will be self-dependent and not helpless because they will be in a position to find their personal stuff on their own. In addition, their quality of life will be improved and they will become socially active people.

Addressing Cost and Accessibility Barriers

The majority of the present-day assistive devices are rather expensive and as such it becomes quite problematic to limit them for use by just a few individuals from the community of visually impaired people. This is because of the high price of the materials used, the complexity of the production process, or the use of proprietary materials. This problem is quite serious in underdeveloped countries or resource poor areas due to lack of finances. Development of cheaper technology is highly essential with the help of cheap sensors, open-source software, and readily available components. These devices will become available to many people through wide distribution to enable them benefit from the technological advances.

Promoting Integration and Ease of Use

For any assistive technology to have real utility, there should be a seamless integration of the technology in the activities of the user as well as the technology being user-friendly. Complex user interfaces, unfamiliar technology jargon, and bulky devices can prevent the utilization of the technology by individuals who are not familiar with technological gadgets. It is therefore necessary to design simple technologies that can be used by the users without requiring any training. Information can be provided to users in the form of audio signals, vibration signals, or simply visual signals without confusing the user regarding his or her environment.

Summary of literature survey

According to the literature review, many results have been achieved in the creation of assistive technologies for blind people, especially, in the area of wearable technologies, object recognition, navigation and human-centered design. Technologies such as Bluetooth, GPS, RFID, IoT, computer vision, fuzzy logic and haptics have been reviewed in an attempt to provide increased accessibility and independence for visually impaired individuals. In most cases, it has been demonstrated that a positive result has been attained regarding navigation and object recognition and increased safety of users. However, it should be noted that many technologies are smartphone-based and require many calculations while being targeted at navigation rather than locating lost objects. Literature pays much attention to ergonomics and user-centered design.

Design of the Research

The experimental design of this research involves a wireless object localization system that employs an RF module having one transmitter and three receivers acting as tags. The transmitter is mounted on the user's arm; the transmitter is used as the control unit and when triggered by pressing the button, the transmitter sends RF signals to the three receiver tags mounted on different objects around the environment. The receiver tags detect the RF signals transmitted from the transmitter and upon detection of the RF signals, the receiver tags produce an audio signal to alert the user of the object's presence and relative location. The experimental design makes it easy for the user to locate objects by just pressing the transmitter, hence the transmitter sends the signal to the corresponding tags.

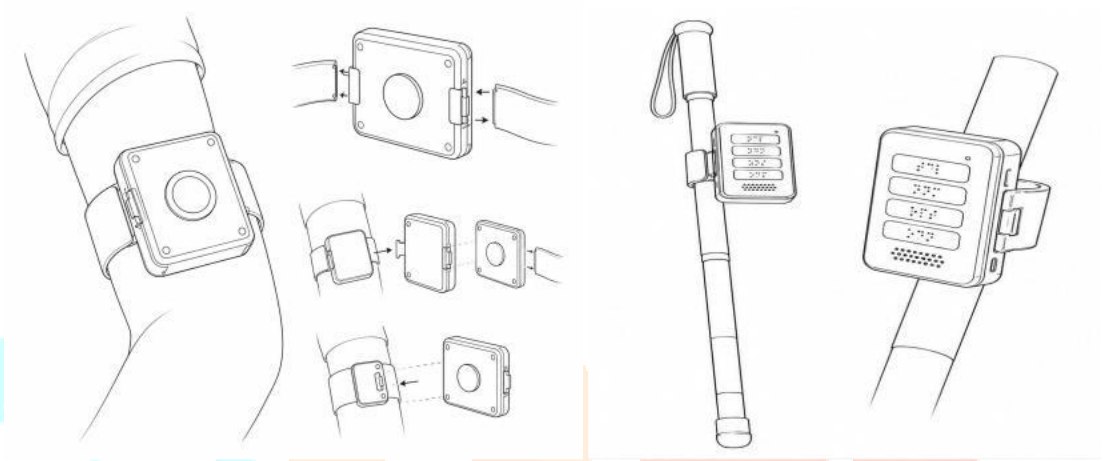

Fig 1: Design Sketch transmitter and receiver

Fig 2: 3D Models

Requirements Analysis

Requirement analysis was carried out so as to determine the functional and technological requirements for the assistive object finder. The system will need to have an effective wireless communication arrangement between the transmitter and the multiple receiver tags. The transmitter that should be attached to the user's arm should be designed in a manner that will ensure its usage is easy and that it has three identifiable buttons for each receiver tag of the objects. The receivers will need to be light and portable and able to receive any radio frequency signals from the transmitter and emit a beep sound. Sources of energy used for the transmitter and the receiver should be reliable enough to power the devices for a considerable amount of time. Also, the range of operation has to be determined so as to prevent any form of signal interference while detecting the

receivers. Lastly, the user interface should be easily understood and provide audio feedback that should be audibly understood by the visually impaired people.

Architectural System

The system has been made with the aid of an architecture, which is modular as well as integrated, to make effective communication possible between the transmitter and the receiver tags. The transmitter, which has been made in a way such that it can be worn conveniently on the arm of the user, comprises a microcontroller along with three push buttons connected to it. Every one of these buttons relates to one particular receiver tag. When any of these buttons is pressed, then a RF signal is generated by the microcontroller and the identification code of the receiver is embedded in this RF signal, which is further transmitted using the high frequency RF module up to a distance of 30 meters.

The receiver tags, which have been attached to the required objects, are light weight and compact and every one of them comes with an RF module, which continuously receives the signals being transmitted from the transmitter. On receiving the correct RF signal, every receiver tag initiates an audio buzzer present internally, which produces an alarming sound.

The power supply to the transmitter and receiver tags is provided by rechargeable batteries.

Usually, the design of the product is durable, portable, and easy to use so that it can be utilized by visually impaired people on a regular basis with an effective range of 30 meters.

Fig 3: Final Product transmitter and receiver

Hardware Selection and Integration

The ESP32 board is the CPU of this project. This board manages the RF transmission and button presses and generates audio signals. The small size of this board and its low energy consumption makes this board suitable for mobile applications. RF Transmitter Module: This module is fitted in the arm-worn transmitter circuit and generates encoded RF signals when corresponding buttons are pressed.

RF Receiver Modules: These modules are fitted in each object-based receiver PCB and monitor the RF signals that travel up to 30 meters and trigger the alarm system. Both the transmitter and receiver units contain the rechargeable battery modules (such as Li-ion or Li-Po) that are mounted on a dedicated PCB board together with the charging circuit, power regulating circuitry, and the power management circuitry. The built-in buzzer is mounted on a dedicated PCB and generates the audible alarms. The buzzer is connected to the microcontroller so that the control over it can be achieved. Three push-buttons are fitted in the transmitter PCB and allow selecting the desired object. All these modules are installed on dedicated PCB boards.

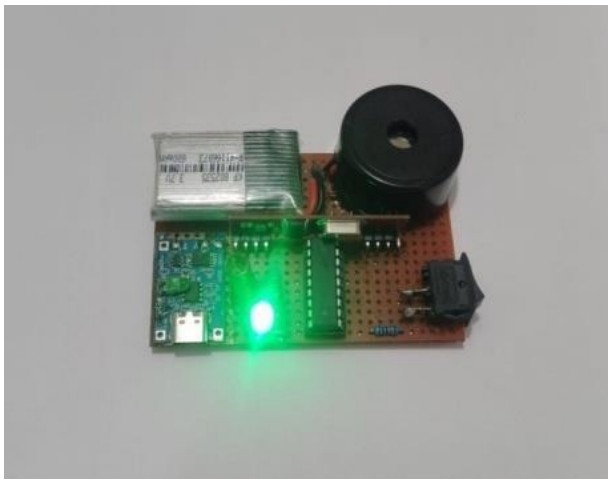

Fig 4: Circuit connection

Production of Prototypes

The process of creating the prototype of the product was carried out systematically in terms of designing, assembling, and testing. To start with, there was the integration of the selected PCB modules and electronic components on the circuit board designed to ensure that the hardware works. The process of assembling the prototype was through the soldering of the components on the PCB, followed by the connection of the RF modules, microcontroller, power supply, buttons, and buzzers.

Performance Testing and Evaluation

Tests on the performance of the device were conducted in order to measure its reliability, range, and responsiveness. Performance tests indicated that RF communication between the transmitter and the receiver module is reliable within the range of 30 meters. It was determined whether the alarm will be triggered when the object is sensed, and also whether the usability of the device is easy through the use of buttons and audio alert. Tests for power performance were done in order to determine whether the system is stable during operation for long hours.

Key Physical Features

- Compact rectangular form factor for comfortable handling.
- Rounded edges to improve user comfort.
- Large tactile buttons for easy operation without visual assistance.
- USB Type-C charging for convenient power replenishment.
- Audible buzzer and LED provide confirmation during operation.
- Lightweight enclosure suitable for prolonged wear.
- Magnetic rear mount allows quick attachment and removal from the strap.
- Can be used as:
  - Upper-Arm Wearable
  - Hand-Held Remote
  - Blind Walking Stick Attachment

Conclusion

The key focus of the current project was put on development of the Assistive Object Finder Device for Visually Impaired Users in order to facilitate finding the missing personal objects. Following the user-centred approach to the design methodology, the project included the following stages: literature review, user study, concept generation, ergonomic evaluation, computer aided design modelling, rendering and prototyping of the product which enabled creation of an ergonomic and convenient for use product. The developed design consists of the following components: wireless object tracking system, tactile controls, audio hints and compact size which allows wearing the device on the upper arm or fixing it to the mobility aid like white cane. The developed prototype showed that a simple but effective assistive device could significantly improve confidence of visually impaired people in performing their routine activities. Ergonomics, accessibility, operability and portability were taken into account at the stage of development of the product

in order to ensure ease of use of the proposed product. In addition, a modular design allows adapting the device for various types of installation without losing its ergonomics and convenience.

ACKNOWLEDGMENT

I would like to acknowledge and express my gratitude to all those who have made this project possible. First of all, I would like to thank my academic supervisors and mentors, Mr. Pratheek Achar for their guidance and support throughout the course of the research. I express my sincere gratitude to the HoD, Dr. Srinivasa and the management of M S Ramaiah University for the co-operation and resources provided. I would also like to thank and express my deepest appreciation for Mr. Pratheek Achar for the knowledge and experience gained from him throughout the course, as well as the encouragement and guidance he has provided.

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