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An interactive and networked IoT device to aid visually impaired people in navigation: An Innovative Study

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Abstract— *The main purpose of this innovative study is to build a smart IoT device to aid the visually handicapped in their mobility and navigational needs. This paper will lay the groundwork for creating a wearable smart gadget to record the user's movements. The new technology being suggested uses range-based sensors and is designed to function equally well inside and out. It consists of two modules: one is supposed to be worn on the user's ears, while the other may be connected to the user's leg. The two modules can simultaneously monitor the user's immediate environment due to their wireless connectivity. Voice commands saved on a memory card housed in the ankle module provide contextual information about the user's immediate surroundings and are delivered to them through headphones. Additionally, the IoT device has suitable communication mechanisms to prevent any potential disruption between itself and other nearby gadgets, allowing for its operation in a crowded environment.*

Keywords— Innovation, Visually impaired people, sensor module, camera, microcontroller, signal classifier, Wireless module

I. INTRODUCTION

More than 25 million individuals in the United States have low eyesight. There is a common misconception that blindness means total helplessness. Indeed, visually impaired people cannot do things like drive a vehicle, but many people who have lost sight manage to live self-sufficient lives. Many continue to hold full-time jobs, raise families, and participate in extracurricular activities [1]. Visually impaired people may make several adaptations to their everyday routines to improve their quality of life. For example, if they have some vision remaining, some aids might make it easier for them to see. There is a wide variety of magnifiers on the market, each with its purpose. Magnifying lenses and miniature telescopes that attach to eyeglass frames are also available. These are helpful since the user may go on to other tasks with ease. Telescopes are for long-distance viewing, while magnification tools are used for close-up work (like a ball game, for example) [1]. In addition, portable magnifiers may be placed on a tabletop or hand-carried for use anywhere. Magnifiers that can be carried in one's hand are useful for reading small print, such as price labels, tickets, and recipes. The tabletop model is ideal for reading the paper or working on arts and crafts at home. Opportunities for blind or visually impaired people have expanded greatly because of technological developments, which may help them get and keep their chosen jobs [1,2]. Those who are blind or visually challenged may still use many of the same computer applications as sighted users, thanks to the availability of text-to-speech and screen magnification software. The user may read the text on the screen in braille with the help of other apps like JAWS. Most individuals can use a computer regularly and do most contemporary office duties using one or more of these tools. The IoT device proposed in this study can track a user is every step and record information about the terrain, landmarks, and other things encountered along the way [2]. In particular, this will help a visually impaired person avoid getting lost while traveling large distances on foot.

II. RESEARCH PROBLEM

The problem that this innovation will solve is to help people with vision impairment navigate through places without difficulty. Visually impaired people face a significant challenge when moving around freely and effectively. Therefore, my proposed innovation looks at helping them tackle significant barriers and challenges in their mobility and navigation. The difficulties of living with sight loss or poor vision are just one of several that the visually impaired must face every day. Visually impaired people are no different from those who can see [3]. For blind people, particularly those who have lost full vision, navigating unfamiliar environments is the greatest difficulty. A blind person's familiarity with their home allows them to navigate it without assistance. When living with or visiting a blind person, be mindful not to rearrange their belongings without first consulting with them. Tactile tiles are a great way to make public spaces accessible to those with visual impairments [4,5]. Regrettably, though, this is seldom practiced. This situation is a major obstacle for blind persons who would otherwise desire to visit the location. Even those with good eyesight will have trouble keeping track of where they are and where they have been. The IoT device proposed in this study can track a user is every step and record information about the terrain, landmarks, and other things encountered along the way. In particular, this will help a visually impaired person avoid getting lost while traveling large distances on foot. Work and study are being put into bettering the lives of the visually impaired and the blind. The inability to explore or operate in remote areas is a concern the proposed technology would seek to address as a vital tool for the visually challenged population.

III. LITERATURE REVIEW

A. Assistive technology

A person's functional skills due to a visual impairment may be maintained, increased, or improved with assistive technology [6]. Low vision assistance and assistive technologies are used interchangeably in certain contexts. Although low vision aids may be electronic and non-electronic equipment, assistive technology can relate to a broader spectrum of electronic or technology-based products and solutions. Digital resources, magnifying software, reading applications, communication devices, and even high-tech eyewear devices might fall into this category [7]. The functioning capacities of people who are blind or have low vision may be enhanced via assistive technology. In this piece, I will examine the many assistive technologies available, how they might be used, and how they stack up against one another. Many scholars have explored how low-vision assistive technologies and high-tech visual aids could suit the specific needs of blind people.

With the use of assistive technology, people who were previously incapable or had difficulties doing certain chores can again do them independently, fostering their sense of independence [8,9]. It may signify a great deal to blind or visually challenged people. These activities include trying something new, like reading the menu at a cafe, having fun, going grocery shopping, roaming freely, or just leading a normal life. Many grown-ups are looking for aids to help them keep in touch with their loved ones and participate in community activities [9]. Others may want to enhance their eyesight so that they may participate in more physical activities and sports. A person's specific requirements must be considered while determining the most appropriate assistive technology.

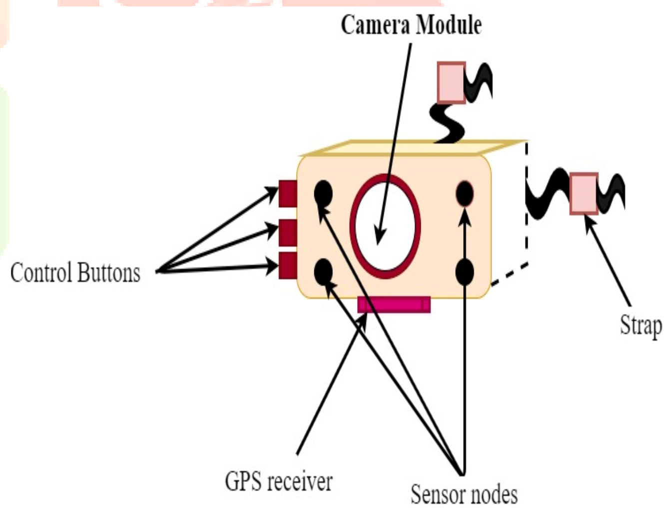
B. Original contributions

My proposed technology is an ultrasonic sensor-based wearable device that can identify features like signs and buildings. My goal in creating this tool was to provide the user with as many options as possible, making their experience with the IoT device more productive and less dependent on outside support. This technology combines many components, such as a camera, sensors, and a global positioning system (GPS), to offer the user effective real-time navigation. This IoT device is built from lightweight materials so that it may be easily strapped onto the user's ankles. What makes my suggested gadget stand out is that it facilitates better navigation by giving the user's location history as well as their intended destination. Mileage, structures, signage, and other things seen on a user's journey will all be recorded by this gadget using cameras, sensors, and GPS. As a result, the user can track their movements without asking for directions from strangers. This IoT device is crucial if the user wants to return to their former location without help. The primary objective is to provide better user navigation and experience. So far, most aids for the visually impaired are either prohibitively expensive or too cumbersome for everyday usage. Adding a gadget to the traditional white cane can make it more cumbersome. Generally speaking, technologies that rely on vision fall into the category of being both bulky and costly since they have cameras [10]. There are now compact cameras on the market, but their price remains a major consideration.

Smartphones, which are utilized in certain applications to aid the visually handicapped, are also pricey. In this study, I suggest a lightweight and cheap aid for the visually impaired that addresses the problems mentioned earlier. This gadget may be worn as a module. Long-range sensors are built in. Users may fasten these modules to their ankles. This tool efficiently aids the user's movement by covering more ground before and behind him. This device's ability to identify impediments will inform the user when to go when to halt, and when to take evasive action. In order to determine whether or not the device is successful, the experimental evaluation of its use is also carried out. The device's primary components are its cameras, GPS, wireless connection, sensor module, microcontroller, transceiver, and signal classifier.

C. Device Design

I. Design



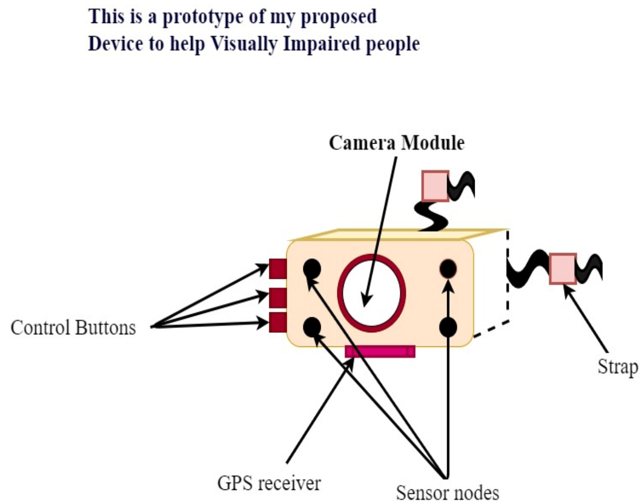


Fig i: A prototype of the device

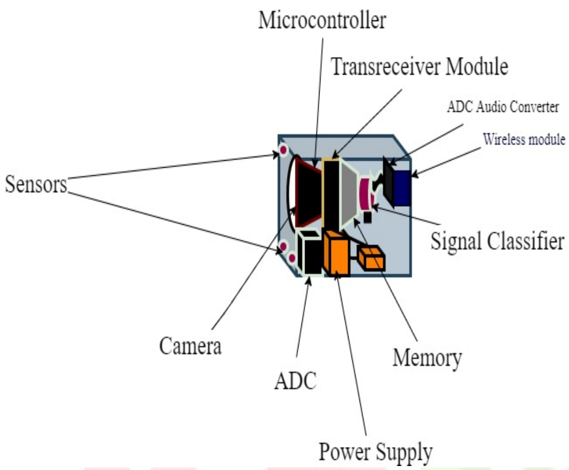


Fig ii: Components of the IoT device

II. *How it works*

This device operates by collecting information about where the user goes and where they came from as they move from one location to another. The device runs on tiny replaceable batteries that should be checked every three to six months. My proposed innovation is integrated with sensors, a camera, and GPS for gathering data. The analog-to-digital converter (ADC) takes the raw data from the three inputs mentioned earlier and formats it for further processing. The data is subsequently sent to a microcontroller, which performs the appropriate analysis depending on the input. These could include data gathered from the camera, GPS, and sensors. The primary objective is to regulate a particular function of the data stored in the device and interpret the results based on the information provided by the central processor. The primary purpose of the transceiver module is to send and receive signals. The transceiver is integrated into local area networks' NIC (network interface card). It can send signals across the network line as well as receive them. The system includes a signal classifier for analyzing incoming data and drawing conclusions. These inputs will be processed and translated into a spoken, visual, or written form.

The most important result is sound, which will be enhanced and sent through a wireless module to the user's headphones. Aspects such as distance and landmarks play an extremely significant role in the intelligent navigation of this gadget. At first, the device's camera and color sensor will take pictures and log their colors into its memory. The user's location data from a global positioning system (GPS) may be used to calculate how long they have been on the go. When the user is ready to return to their previous location, they need just hit the device's "return" button. The device's ability to convey its message is amplified when connected to a headset. The signal will be sent to the headphones wirelessly through an audio transmission.

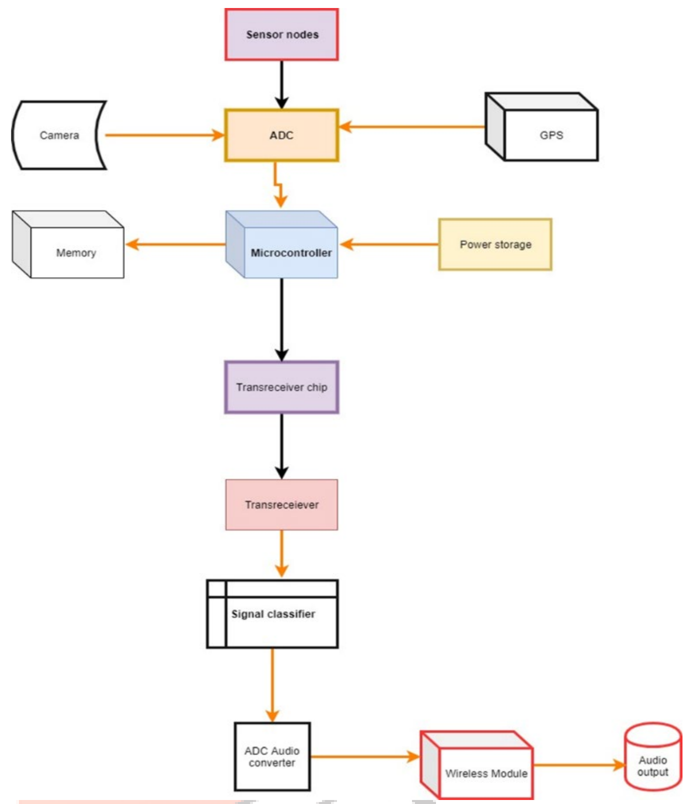


Fig iii: Data flow in the proposed device

My proposal is predicated on the concept of object recognition. The objective is to positively identify an item based on one or more of its attributes, such as its features, edges, corners, and color intensity. Object detection works similarly to item recognition in that it involves finding the object of interest in an image and comparing it to either a template or a known form or pattern. The idea is implemented via real-time environment tracking to benefit vision-assisted navigation. The ability to measure distance and locate obstacles is thanks to ultrasonic sensors. Since ultrasonic sensors use sound waves to function, their ability to identify barriers is less susceptible to environmental noise and other interference. Distance may be gauged using ultrasonic sensors, which operate based on reflected sound waves. A single sensor may detect the activity of additional sensors in the area. The ultrasonic sensor sends sound waves and detects obstacles by picking up the echoes. Then, the time difference between the sensor and the object is used to calculate an estimated distance.

The sensor measures the distance to whatever is immediately in its field of view (from 3 cm up to 400 cm). It operates by emitting a burst of ultrasonic and then picking up the reflected signal. Ultrasound is used to 'ping' the obstructions. The pulseIn() method on the Arduino board first delivers a small pulse to activate the detector, then it listens for a pulse on the same pin[11,12]. This time may be translated into a physical distance using the speed of sound. Ultrasonic transducers constitute the ultrasonic distance sensor. These transducers will function as transmitters, transforming the electrical signal into different wavelengths at 40 kilohertz [13]. It then sends out pulses while the other plays the role of a receiver. The receivers pick up these signals and retransmit them with a width that varies with the item's proximity to the detector. It is possible to determine the distance to an item by measuring the elapsed time between when the signal was sent and received. Understanding the speed of sound in the air makes this a realistic possibility.

Ultrasound may be "downmixed" to produce an audible secondary signal if it is processed in such a way as to undergo this transformation. Difference frequencies convert data acquired from ultrasonic sensors into the audible range. The device's built-in speakers or the user's headphones may hear the signal. Each audio stream is sampled at 8 kilohertz [13,14]. The signal loudness adapts according to the strength of the original high-frequency impulses. When out and about, a GPS may be used to find the closest restaurants, hotels, and other attractions, and it can also be used virtually to find them before a trip. Restaurants, hospitals, and hotels are examples of how the many attractions are organized. Tourists may quickly and easily look up the location and other relevant details about a certain attraction with just a few keystrokes. It is possible to plot a course to a certain landmark using the feature as a destination. The GPS relays the vehicle's speed, location (latitude and longitude), altitude, and heading when in motion. A "look-around" option makes the system call out all landmarks and intersections along the route.

IV. THE SIGNIFICANCE OF THIS INVENTION

Achieving one's independence is the most beneficial thing to an impaired person. Some adaptations can let blind people live on their own. Many pieces of adaptive technology that would make it possible for a blind person to lead an independent life are not widely sold or readily accessible. The ability to aid blind individuals in increasing their productivity is one of the essential advantages of this development. By doing so, the need for permanent care for the blind may be postponed or avoided altogether. There are over 200 million individuals who have poor vision yet do not have access to low-vision aids[14,15]. This breakthrough has limitless potential for facilitating accessibility for persons with a wide range of needs, from an improved movement for those with mobility issues to better communication for those with hearing or visual impairments and beyond. These devices help blind people in many ways, such as avoiding collisions, navigating new environments, and receiving valuable knowledge about their physical vicinity. The ability to navigate is crucial for living a normal life. Most individuals agree that vision is important but have difficulty pinpointing what kinds of visual information they utilize and when [16,17]. Although most individuals can see themselves traversing a tight space without sight, such as a night-time trip from their bedroom to the restroom, very few have experience doing so in a huge, new space. Blind people must become adept at relying on their other senses and using intelligence that sighted people frequently disregard to become proficient and safe navigators.

V. FUTURE

The visually handicapped community in the United States will benefit greatly from this technology. Increased usage of AI means mass manufacture of this tool is in the future. As technology continues to improve, this smart gadget will probably become both more powerful and more capacious. Smaller transducer probes and more insertable probes may be produced to improve the quality of medical imaging of the body. There is a high likelihood that the United States will lead the way in developing and popularizing 3-D smart technologies. Ultrasound machines as a whole are expected to shrink, maybe becoming handheld for usage in the field [18]. Research into ultrasonic imaging in conjunction with heads-up or virtual reality displays is an intriguing new topic. It utilizes 3D data to calculate measures to help the sight-handicapped navigate different environments automatically [19]. Dimensions may be collected and calculated up to six times faster using this approach than using manual or semi-automated methods for 2D testing.

VI. CONCLUSION

This paper aimed to build an intelligent device that would assist visually impaired persons in navigating comfortably in any environment. The device's primary elements are its cameras, GPS, wireless connection, sensor module, microcontroller, trans-receiver, and signal classifier. My invention's sophisticated sensors and signal conversion set it apart from previous efforts. The purpose of this technology is to aid the visually impaired in their daily lives by allowing them more freedom of movement, independence, and productivity. Experts in the field predict that ultrasound technology will continue to advance to make it more accessible to consumers. This gadget will make the user's life easier, including efficiency, portability, accuracy, and simplicity. Eventually, it will be used by the blind as a primary means of orientation and mobility. This device's ability to help the vision-handicapped maintain social connections is a key differentiator from other smart technologies. This technology opens up a new world of possibilities for those with visual impairments. People who are blind may use this device to learn how to travel about a new city or to a certain location since more and more services are becoming vocally activated. Visually impaired people may go about their daily lives and enjoy the world just like everyone else; they may need to adapt their methods somewhat. This proposal is committed to expanding opportunities for those with physical impairments.

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