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Enhancing Ultrasonic Sensor Goggles for Blinds Using Node MCU ESP8266 Microprocessor

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Abstract: This research paper introduces a novel approach to improve the functionality and efficiency of ultrasonic sensor goggles designed for the visually impaired. Traditionally, Arduino Uno and Nano microcontrollers have been widely used for this purpose. However, this study explores the integration of Node MCU ESP8266 microprocessor as a replacement due to its lightweight, compact design, cost-effectiveness, and built-in Wi-Fi capabilities. Additionally, the smaller form factor of the Node MCU ESP8266 reduces the weight and size of the goggles, resulting in increased user comfort and wearability. The research entails the development of a comprehensive hardware and software architecture for the ultrasonic sensor goggles, incorporating the Node MCU ESP8266 microprocessor. The system's performance is evaluated through a series of tests involving obstacle detection and distance measurement. Comparative analyses are conducted between the traditional Arduino-based goggles and the proposed Node MCU ESP8266 integrated goggles in terms of accuracy, speed, power consumption, and overall user experience.

Keywords*: Ultrasonic sensor goggles, visually impaired, assistive technology, Node MCU ESP8266, Arduino Uno, Arduino Nano, microprocessor integration, Wi-Fi connectivity, obstacle detection, distance measurement, remote monitoring, accessibility, lightweight design, cost-effectiveness.*

1. Introduction

The global population of visually impaired individuals has been on the rise in recent decades. According to the World Health Organization (WHO), approximately 285 million people worldwide are believed to be affected by visual impairment [1]. The concept of smart glasses for the visually impaired, integrating ultrasonic sensors, represents an innovative technology aimed at enhancing the navigation experience of individuals with visual impairments, offering them improved ease of use. The concept involves incorporating ultrasonic sensors into a pair of glasses that can detect objects in the environment and provide the user with audio feedback about the location and proximity of these objects[2]. This audio feedback can be in the form of alerts or signals that the user can hear through a built-in speaker or a vibration mechanism that can be felt by the user.

The use of ultrasonic sensors provides accurate and reliable information about the environment, making it easier for the user to avoid obstacles and navigate their surroundings independently [3]. With the help of smart glasses using ultrasonic sensors, visually impaired individuals can experience greater independence and a higher quality of life by reducing their reliance on others for assistance. The significance of utilizing smart glasses equipped with ultrasonic sensors for the visually impaired stems from their potential to significantly amplify the autonomy and safety of individuals with visual impairments [4]. These technological devices offer a heightened level of environmental awareness, a perspective that might otherwise prove elusive or unattainable for the user. These smart glasses effectively aid users in identifying obstacles [5].

like stairs, curbs, and objects at lower heights, consequently facilitating their ability to move through their environment with heightened assurance and diminished potential for mishaps. Additionally, smart glasses for the blind can help to reduce the social isolation experienced by visually impaired individuals [6]. By allowing users to navigate their environment independently, they can engage more fully in social activities and interact with the world around them more meaningfully. The potential impact of smart glasses for the blind is significant [7]. Such devices hold the promise of enhancing the quality of life for those with visual impairments. by reducing their reliance on others for assistance and allowing them to engage more fully in daily activities. By providing greater independence and safety, they can also help to reduce the emotional and financial burden on caregivers and family members [8].

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2. Literature Review

Mehta, R., & Roy, P. P have explored the use of smart glasses for the visually impaired using different types of sensors, including ultrasonic sensors, infrared sensors, and cameras [9]. One study conducted by evaluated the performance of a smart glasses system that used a combination of ultrasonic and infrared sensors for obstacle detection. The results of the study showed that the system was effective in detecting obstacles in the environment and providing feedback to the user through audio cues [10].

Jiang, J. used smart glasses equipped with a camera and a depth sensor for obstacle detection and navigation. The study found that the smart glasses were effective in detecting obstacles and providing feedback to the user but noted that the accuracy of the system was affected by lighting conditions and the complexity of the environment [11].

N. K. Srivastava and S. Singh, proposed a smart glasses system using ultrasonic sensors was developed and evaluated for obstacle detection and navigation [12]. The study's findings demonstrated that the system was efficient at identifying barriers and giving the user feedback through auditory cues. In low-light circumstances, when other types of sensors might not function as well, the study found that using ultrasonic sensors was advantageous [13].

In research trials, the usage of smart glasses for the blind that employ ultrasonic sensors has shown significant potential. These systems are effective in detecting obstacles in the environment and providing feedback to the user through audio cues, which can greatly enhance the user's safety and independence. However, there are some limitations to the technology, such as the accuracy of the system in complex environments and the potential for interference with other electronic devices [14].

A promising new technology called smart glasses for the blind that use ultrasonic sensors has the potential to significantly enhance the quality of life for those with visual impairments [15]. Further research is needed to address the limitations of the technology and to explore the use of other types of sensors, but the current state of research suggests that intelligent glasses for the visually impaired using ultrasonic sensors are a valuable assistive technology that can provide a range of benefits to users [16].

3. Applications

Looking ahead, the technology showcased in this paper holds promising avenues for future development and application. Beyond its current role in enhancing ultrasonic sensor goggles, the Node MCU ESP8266 microprocessor has the potential to spearhead innovation in various other domains. Two particularly compelling directions for future exploration are:

1.GPS Navigation Enhancement:

The integration of the Node MCU ESP8266 microprocessor's capabilities can extend beyond obstacle detection and distance measurement. With the addition of GPS functionality, the technology could evolve into a comprehensive navigation aid for individuals with visual impairments. By combining the real-time obstacle detection abilities of the ultrasonic sensors with accurate GPS positioning, users could receive real-time auditory cues or haptic feedback guiding them along the best path. This could potentially revolutionize outdoor mobility for the visually impaired by providing context-aware navigation and enabling independent exploration of unfamiliar environments [17].

2.Indoor Navigation Solutions:

Building on the success of the ultrasonic sensor goggles, the technology could be adapted to provide indoor navigation solutions. By incorporating additional sensors such as accelerometers and gyroscopes, the Node MCU ESP8266 microprocessor could assist users in navigating indoor spaces, like shopping malls, airports, or office buildings. This could be particularly valuable for individuals with visual impairments who face challenges when trying to navigate complex indoor environments. The integration of Wi-Fi positioning systems and beacon technology could further enhance accuracy in indoor navigation [18].

3.GPS-Enabled Outdoor Navigation:

Expanding on the capabilities demonstrated in this study, the technology could be harnessed for outdoor navigation assistance. By integrating GPS functionality, the Node MCU ESP8266 microprocessor could evolve into a comprehensive navigation aid for individuals with visual impairments. This system could provide real-time auditory cues or haptic feedback based on GPS coordinates, aiding users in navigating outdoor environments. This advancement would enable safer and more independent outdoor exploration for individuals with visual challenges [19].

Looking ahead, the technology explored in this paper has the potential to find broader applications that could greatly enhance the lives of visually impaired individuals and the blind community, ranging from expanding assistance beyond navigation to fostering inclusivity and accessibility through innovative approaches.

4. Methodology

The evolution of the idea behind using the Node MCU ESP8266 microprocessor in ultrasonic sensor goggles for the visually impaired followed a systematic process, building upon previous iterations to address limitations and enhance overall performance. The methodology involved a series of steps, as detailed below: The project began with the concept of an ultrasonic stick designed to assist visually impaired individuals in navigating their environment. This initial approach, although functional, had limitations related to user comfort, ergonomics, and ease of use. The stick design hindered user mobility and lacked a comprehensive solution for obstacle detection and navigation. Recognizing the limitations of the ultrasonic stick, the project evolved into the design of ultrasonic goggles.

The goggles aimed to provide a more intuitive and integrated solution for the visually impaired. By incorporating ultrasonic sensors into the goggles, the system offered a hands-free approach to obstacle detection and navigation. The initial iteration of the project saw the utilization of the Arduino Uno microcontroller for processing and control. Arduino Uno is well-regarded for its versatility and capability to handle a wide range of tasks, including interfacing with sensors and controlling various components. However, as the project progressed towards the development of ultrasonic goggles, it became evident that a significant transition was necessary. The shift to ultrasonic goggles represented a substantial leap forward, introducing a higher degree of sophistication and functionality to the project. Ultrasonic goggles are specifically designed for applications like obstacle detection and navigation, particularly for visually impaired individuals. It allowed the project to strike a balance between performance and practicality, ensuring that the ultrasonic goggles could fulfill their intended purpose effectively.

This transition resulted in a more compact and lightweight design, improving user comfort. However, the limitations of the Arduino Nano in terms of connectivity and versatility prompted the search for a more suitable alternative. The limitations observed with Arduino Nano led to the exploration of alternative microprocessors that could offer enhanced capabilities, connectivity, and compatibility. The Node MCU ESP8266 microprocessor emerged as a compelling choice due to its lightweight design, built-in Wi-Fi technology, and cost-effectiveness. This microprocessor was integrated into the ultrasonic goggles design to replace the Arduino Nano, marking a significant turning point in the project's evolution.

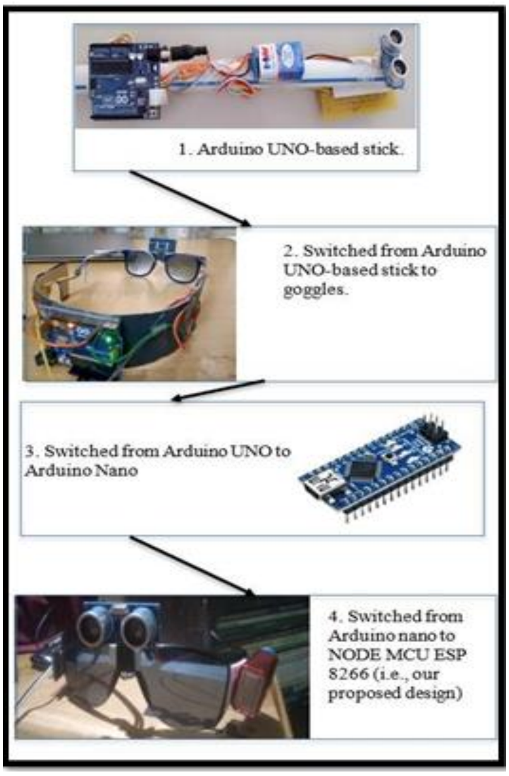

Fig 1. Evaluation of Prototype.

The ultrasonic sensors, power supply, and control mechanisms were reconfigured to align with the new microprocessor. The software code was also optimized to leverage the Node MCU's Wi-Fi capabilities and compatibility with various communication protocols. Comparative analyses were conducted to assess accuracy, speed, power consumption, and user experience against the previous iterations utilizing Arduino Uno and Nano as all of these can be easily depicted in Fig. 1.

TABLE NO.1 Comparison of Arduino UNO, Nano, and ESP 8266

Feature	Arduino Uno	Arduino Nano	NodeMCU ESP8266
Microcontroller	ATmega328P	ATmega328P	ESP8266
Clock Speed	16 MHz	16 MHz	80 MHz
Flash Memory	32 KB	32 KB	4 MB
SRAM	2 KB	2 KB	128 KB
Power Supply	7-12 V	7-12 V	2.5-12 V
Size	68.6 x 53.3 x 18 mm	45 x 18 x 1.8 mm	32 x 25 x 4mm
Weight	25 g	3.5 g	1.8 g
Wi - Fi Connectivity	No	No	Yes

Why Node MCU ESP 8266?

By observing the following TABLE NO 1. We can easily conclude that The Arduino Uno and Arduino Nano do not have built-in Wi-Fi connectivity, so we shall need to use an external Wi-Fi module if you need to connect to the internet. The NodeMCU ESP8266 has built-in Wi-Fi connectivity, so you can connect to the internet without any additional hardware. This is a major advantage of the NodeMCU ESP8266, as it makes it much easier to connect your projects to the internet.

The methodology detailed the evolution from an ultrasonic stick to ultrasonic goggles, with the eventual integration of the Node MCU ESP8266 microprocessor. This iterative approach ensured that each version built Based on the comparison, the ESP8266 (NodeMCU) appears to be the most versatile microcontroller with several advantages over the other options:

Wi-Fi Connectivity: ESP8266 has built-in Wi-Fi connectivity, which is not available in the Arduino UNO and Arduino Nano with ESP8266. This allows for seamless integration with IoT applications, cloud services, and wireless communication. upon the lessons learned from the previous one, resulting in an advanced assistive technology solution that combines accurate obstacle detection, lightweight design, and integrated Wi-Fi connectivity for enhanced accessibility and user experience.

Larger Memory: ESP8266 offers significantly more Flash Memory, SRAM, and EEPROM compared to Arduino. This makes it suitable for projects requiring larger program storage and data handling capabilities.

Smaller Size and Weight: The ESP8266 (NodeMCU) is significantly smaller and lighter than the other options, making it ideal for compact and lightweight projects.

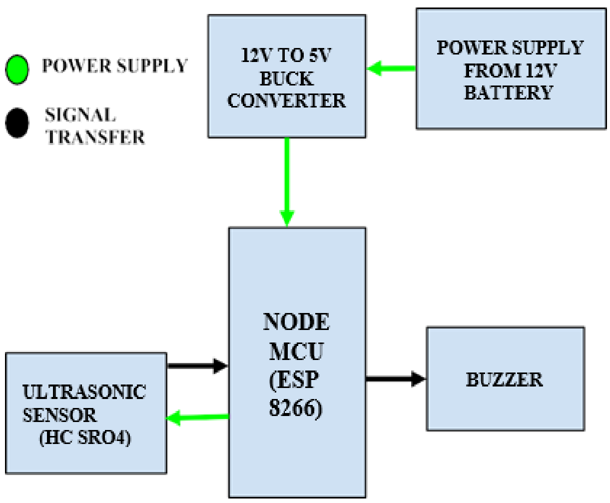

Fig. 2 Block Diagram

4.1.Design and Implementation

Fig. 2 succinctly conveys the central components and their interconnections within our project, illustrating the flow of power and information. Below is the detailed implementation of our model:

A. Hardware Setup: The smart glasses will be designed to be lightweight and comfortable to wear. The ultrasonic sensor will be positioned on the front frame of the glasses to enable front- facing object detection.

B.NodeMCU ESP8266 Programming: We will program the NodeMCU ESP8266 to interface with the ultrasonic sensor. The sensor will continuously send and receive ultrasonic pulses to calculate the distances to nearby objects. Based on the calculated distances, the ESP8266 will trigger the buzzer to provide audio feedback to the user.

C. Power Management:

Efficient power management will be implemented to ensure extended battery life. The glasses may include a rechargeable battery or an energy-saving sleep mode when not in use.

D. Audio Output:

The buzzer's audio output will be designed to be audible but not intrusive, allowing the user to focus on the surroundings while receiving the necessary feedback.

4.2 COMPONENTS USED

Here is a list of the parts that were used to complete this proposed prototype.

TABLE NO.2 List of components used in the system.

Components Name	Quantity	Description
Node MCU ESP 8266	1	Wi - Fi Connectivity, Microcontroller
Ultrasonic Sensor	1	For distance measurement
Buzzer	1	Audio Feedback
Battery	1	3.7 V, 1000 mAh (Avg Battery life 28-30 hr. per charge).
Wires	200 mm	For connection
USB cable	1	Data transfer
Goggle	1	Supporting Structure

4.3 Construction

To transform a regular glass into a smart glass, using NODE MCU ESP 8266 followed the construction process involving the following steps:

1.Power Connection: The positive terminal of the battery is linked to the VIN pin of the Node MCU, while the negative terminal of the battery is connected to the ground (GND) of the Node MCU.

2.Ultrasonic Sensor Wiring: The VCC wire of the ultrasonic sensor is linked to the VIN pin for the power supply. The trigger (TRIG) pin of the ultrasonic sensor is connected to Digital PIN 6 of the Node MCU. The echo (ECHO) wire of the ultrasonic sensor is connected to Digital PIN 5 of the Node MCU.The ground wire of the ultrasonic sensor is connected to the GND pin of the Node MCU.

3.Buzzer Connection: The negative terminal of the buzzer is connected to the GND pin of the Node MCU, and the positive terminal of the buzzer is connected to the VIN pin for power.

Following these steps, the smart glass system was appropriately assembled and operationalized. This configuration allows the ultrasonic sensor to detect obstacles and trigger the buzzer for alerts, providing an enhanced user experience.

4.4 WORKING

1.Ultrasonic Sensing: The ultrasonic sensor emits ultrasonic waves and measures the time it takes for the waves to bounce back from an object.

2.Distance Calculation: Using the measured time and the speed of sound, the ESP8266 calculates the distance between the sensor and the obstacle.

3.Obstacle Detection: If the calculated distance is less than or equal to 300mm (30 centimeters), the system determines that an obstacle is within the recognized distance.

4.Feedback Generation: In this scenario, when the system detects an obstacle within the pre-defined recognized distance, it initiates a specific action through the microprocessor. In this case, the action involves the generation of feedback signals that are directed to a buzzer. The purpose of this alert is to notify the user or operator of the system that an obstacle is within close proximity. This audible warning serves as a real-time indicator of potential danger, prompting the user to take precautionary measures and avoid a collision with the detected obstacle.

5.Buzzer Output: The buzzer emits a sound signal to convey the presence of an obstacle. The intensity, frequency, or pattern of the sound can be adjusted based on the proximity of the obstacle. For example, the buzzer might emit a continuous beep when an obstacle is detected, and the beep frequency could increase as the user gets closer to the obstacle.

6.User Interaction: The visually impaired user listens to the sound emitted by the buzzer to determine the presence and proximity of obstacles within the recognized distance.

Setting the distance recognition to 300mm within a system represents a crucial safety enhancement. This parameter ensures that the system remains vigilant about obstacles in close proximity, thereby offering valuable protection to users. When an object or obstacle comes within 300mm of the user or the system, the software triggers an alert or warning. The system's significance is particularly pronounced in crowded or indoor environments, where the density of people and objects can obstruct the user's line of sight, making it challenging to detect nearby obstacles. In such settings, the system serves as a vital safety net, alerting users to potential risks that might otherwise go unnoticed. Whether it's navigating through crowded spaces or maneuvering through tight indoor environments, the system's close-range detection feature ensures safer mobility by providing early warnings about immediate hazards.

5. Result

Accuracy of the Ultrasonic Sensor that we used:

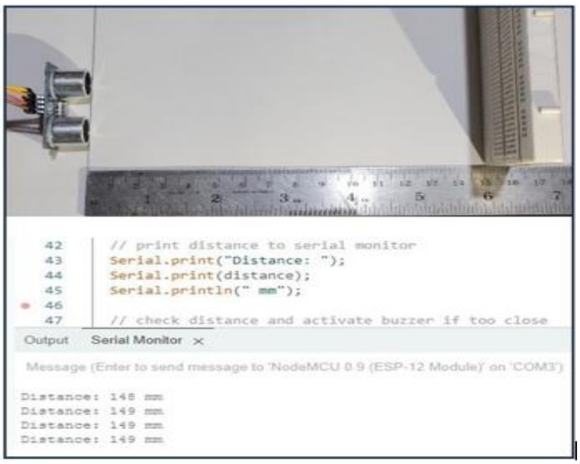

Fig.3.Accuracy testing for 150 mm distance.

Fig.4. Accuracy testing for 250 mm distance.

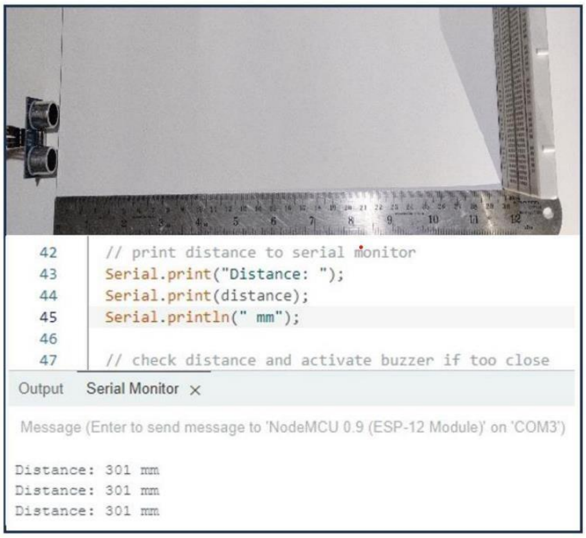

Fig.5. Accuracy testing for 250 mm distance.

Figures 3, 4, and 5 combinedly shows Distance Measurement Accuracy These figures demonstrate the precision of distance measurements obtained from the ultrasonic sensor at distances of 250mm, 300mm, and 350mm.

TABLE NO.3 Accuracy of the ultrasonic sensor

Distance tested	Measured distance	Error
150 mm	149 mm	1 mm
250 mm	250 mm	0 mm
300 mm	301 mm	1 mm

$$\textit{Error} = \textit{Distance tested} - \textit{Measured tested}$$

This equation allows us to quantify the discrepancy between the measured distance obtained from the ultrasonic sensor and the actual physical distance, which serves as the reference point and is depicted in TABLE NO 3. This error calculation, based on data from Fig. 3, Fig. 4, and Fig. 5, is a critical aspect of our analysis. It provides insights into the accuracy and reliability of our distance measurement system by quantifying the variation between the sensor's readings and the real-world distances we physically established for testing purposes.

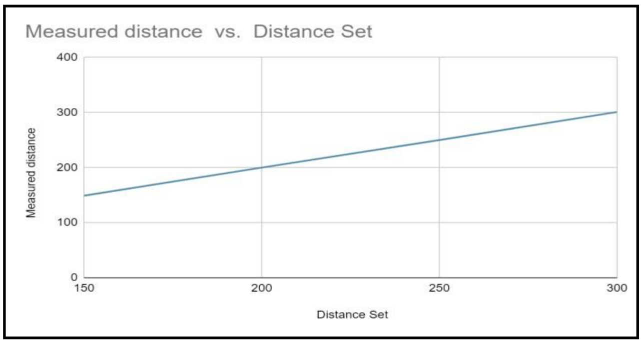

Fig.6 Graph for Accuracy of HC-SRO4

Based on the Fig.6 data, it can be concluded that the measured distances using the ultrasonic sensor are very close to the actual distances. This indicates that the HC-SRO4 is quite accurate in measuring distances.

The model or prototype demonstrates a clear functionality: when the designated region is obstacle-free, an LED indicator remains in an OFF state. However, the moment an obstacle is detected within the predefined distance threshold, typically set at 300 mm, the LED switches to an ON state, emitting a constant source of light. Concurrently, the system triggers the activation of a buzzer, which produces a distinctive sound to provide users with an additional warning of the obstacle's presence. This integration of continuous LED illumination and the activation of the buzzer results in an efficient and multi-modal feedback system. It ensures that users receive both a visual and auditory signal when an obstacle is within the recognized distance, enhancing safety and alerting them to take necessary precautions. This dual-mode alert mechanism proves to be a valuable feature in scenarios where obstacles could pose a danger to users' well-being.

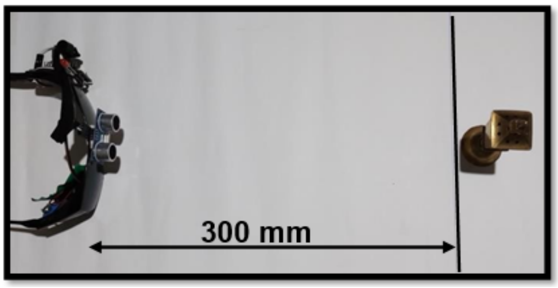

Fig.7 LED and BUZZER are in off state when the obstacle is outside the designated region(i.e. cm).

Fig.7 ciphers the absence of an obstacle, the system will continue to maintain the LED in an OFF state and the buzzer will remain off. This ensures that users are continuously aware of the obstacle's proximity until the obstacle moves beyond the designated region.

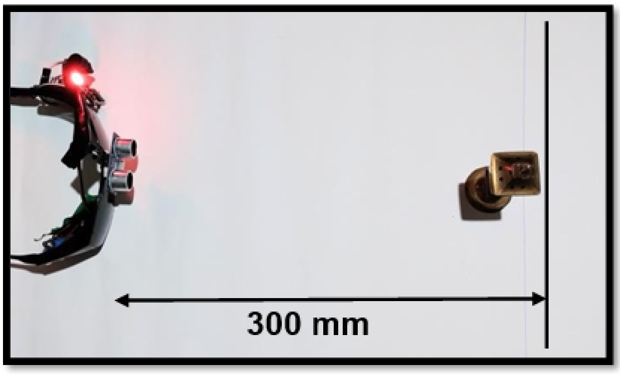

Fig.8 LED and BUZZER are in on state when the obstacle is outside the designated region(i.e., cm).

Fig. 8 depicts continuous illumination of the LED serves the purpose of providing constant visual awareness without generating visual distractions that blinking LEDs might cause. The steady illumination aids in maintaining users' attention on potential obstacles while allowing them to focus on other critical tasks simultaneously.

6. Conclusion

The research paper presents a fresh method for enhancing ultrasonic sensor goggles designed for people with visual impairments. The study explores the use of the Node MCU ESP8266 microprocessor as an alternative to traditional Arduino Uno and Nano microcontrollers. The Node MCU ESP8266 offers advantages like being small, lightweight, cost-effective, and has built-in Wi-Fi.

By incorporating the Node MCU ESP8266 microprocessor, the ultrasonic sensor goggles can be improved in several ways. The smaller size makes the goggles more comfortable to wear because they're lighter. The detailed plan for both the physical parts and the software shows that the Node MCU ESP8266- integrated goggles perform well. They're good at detecting obstacles, measuring distances, working quickly, using less power, and overall providing a better experience for the user.

7. Acknowledgement

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