Enhanced Mobility Aid for the Visually Impaired: An Ultrasonic Sensor and Arduino-Based Smart Walking Stick

Ayuda de movilidad mejorada para personas con discapacidad visual: un sensor ultrasónico y un bastón inteligente basado en Arduino

Auxílio de mobilidade aprimorado para deficientes visuais: um sensor ultrassônico e uma bengala inteligente baseada em Arduino

Shahzor Memon[1(*)], Mirza Muhammad Aamir[2], Sadiq Ur Rehman[3], Halar Mustafa[4], Muhammad Shakir Sheikh[5]

Recibido: 08/08/2024 Aceptado: 29/10/2024

Summary. - This study introduces a smart walking stick for the blind and visually impaired that uses ultrasonic sensors with Arduino and Raspberry Pi. The World Health Organization estimates that 37 million people worldwide are blind. People who are blind or visually impaired frequently rely on assistance from outside sources, which may come in the form of humans, dogs that have been trained, or specialized technological gadgets that play the role of decision-making support systems. We were then inspired to create a smart walking stick in order to get around these restrictions. In order to achieve this, we fitted the stick with ultrasonic sensors at strategic locations that activated the buzzer sound while giving the user information about the surroundings. Our proposal was for a low-cost, lightweight device that uses a microcontroller to interpret signals and emit beeps to notify the visually impaired individual of any obstacles, water, or dark places. The system consists of obstacle and moisture detection sensors that receive, process, and send signals to the alarm system, which then warns the user to take action. The system was conceived and programmed in C, tested for accuracy, and checked by a visually challenged individual. Our technology can identify obstructions within around 2 meters of the user.

Keywords: Ultrasonic sensor, Arduino ATmega328 Microcontroller, Mobility aid, Visually Impaired Person, Alarm system

(*) Corresponding author.

[1] M.E. Assistant Professor, FEST, Hamdard University (Pakistan), Shahzor.memon@hamdard.edu.pk, ORCID iD: https://orcid.org/0009-0008-8867-7070

[2] M.E. Assistant Executive Engineer, Pakistan Water & Power Development Authority (Pakistan), engr.aamir2@gmail.com, ORCID iD: https://orcid.org/0009-0009-5304-1950

[3] Ph.D., Assistant Professor, FEST, Hamdard University (Pakistan), sadiq.rehman@hamdard.edu.pk, ORCID iD: https://orcid.org/0000-0002-6308-450X

[4] M.E, Lecturer, FEST, Hamdard University (Pakistan), halar.mustafa@hamdard.edu.pk, ORCID iD: https://orcid.org/0000-0002-7021-5010

[5] Lecturer, Szabist University (Pakistan), muhammad.shakir@szabist.edu.pk, ORCID iD: https://orcid.org/0009-0005-5902-6461

Memoria Investigaciones en Ingeniería, núm. 28 (2025). pp. 20-31
https://doi.org/10.36561/ING.28.3
ISSN 2301-1092 • ISSN (en línea) 2301-1106 – Universidad de Montevideo, Uruguay

Resumen. - *Este estudio presenta un bastón inteligente para personas ciegas o con problemas de visión que utiliza sensores ultrasónicos con Arduino y Raspberry Pi. La Organización Mundial de la Salud estima que 37 millones de personas en todo el mundo son ciegas. Las personas ciegas o con problemas de visión a menudo dependen de la ayuda de fuentes externas, que pueden venir en forma de humanos, perros que han sido entrenados o dispositivos tecnológicos especializados que desempeñan el papel de sistemas de apoyo a la toma de decisiones. Entonces nos inspiramos para crear un bastón inteligente para superar estas restricciones. Para lograrlo, equipamos el bastón con sensores ultrasónicos en lugares estratégicos que activaban el sonido del timbre mientras brindaban al usuario información sobre los alrededores. Nuestra propuesta era un dispositivo liviano y de bajo costo que utiliza un microcontrolador para interpretar señales y emitir pitidos para notificar a la persona con problemas de visión sobre cualquier obstáculo, agua o lugares oscuros. El sistema consta de sensores de detección de obstáculos y humedad que reciben, procesan y envían señales al sistema de alarma, que luego advierte al usuario para que tome medidas. El sistema fue concebido y programado en C, se probó su precisión y fue revisado por una persona con discapacidad visual. Nuestra tecnología puede identificar obstrucciones a unos 2 metros del usuario.*

Palabras clave: *Sensor ultrasónico, Microcontrolador Arduino ATmega328, Ayuda a la movilidad, Persona con discapacidad visual, Sistema de alarmas*

Resumo. ***-*** *Este estudo apresenta uma bengala inteligente para cegos e com deficiência visual que utiliza sensores ultrassónicos com Arduino e Raspberry Pi. A Organização Mundial de Saúde estima que 37 milhões de pessoas em todo o mundo são cegas. As pessoas cegas ou com deficiência visual dependem frequentemente da assistência de fontes externas, que pode surgir sob a forma de seres humanos, cães treinados ou dispositivos tecnológicos especializados que desempenham o papel de sistemas de apoio à tomada de decisões. Fomos então inspirados a criar uma bengala inteligente para contornar estas restrições. Para tal, equipámos o stick com sensores ultrassónicos em locais estratégicos que ativavam o som da campainha e davam ao utilizador informações sobre o meio envolvente. A nossa proposta foi um dispositivo leve e de baixo custo que utiliza um microcontrolador para interpretar sinais e emitir sinais sonoros para avisar o deficiente visual de qualquer obstáculo, água ou local escuro. O sistema é constituído por sensores de deteção de obstáculos e humidade que recebem, processam e enviam sinais para o sistema de alarme, que avisa o utilizador para agir. O sistema foi concebido e programado em C, testado quanto à sua precisão e verificado por um deficiente visual. A nossa tecnologia pode identificar obstruções a cerca de 2 metros do utilizador.*

Palavras-chave: *Sensor ultrassónico, microcontrolador Arduino ATmega328, ajuda à mobilidade, pessoa com deficiência visual, Sistema de alarme*

1. Introduction. - Vision is the most vital part of human physiology as 83% of information humans get from the environment is via sight. According to a report by the WHO (World Health Organization) estimates that in the world about 1% of the human population is visually impaired. There are over 2.2 billion individuals with a vision impairment of some description across the globe among them about 10% are fully blind (or moderate to severe) distance vision impairment and 90% (about 63 million people) with low vision. In 2015, a survey was conducted by the Royal National Institute of Blind People (RNIB) (Wilson, 2015) including approximately 500 visually impaired persons for whom a collision with an obstacle over three months was reported.

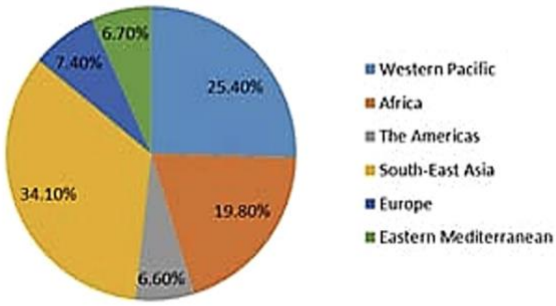

Figure I: A Pie Chart Showing Blind People Across the World.

The most traditional and oldest mobility aids for individuals with vision impairments are the walking cane (sometimes referred to as a white cane or stick) and guide dogs. The most significant flaws of these aids are the required skills and training phase, the range of motion, and the limited information supplied. The rapid growth of current technology, both in hardware and software, has created the opportunity to deliver intelligent navigation capabilities. Recently, various Electronic Travel Aids (ETA) have been designed and developed to assist the blind in navigating independently and safely. Furthermore, the most expensive technical options for assisting blind people in navigating freely have only recently been introduced. While these systems are suitable for outdoor navigation due to the need for line-of-sight access to satellites, they still require additional components to improve resolution and proximity detection in order to prevent blind people from colliding with other objects and thus endangering their lives. In contrast to other technologies, many blind guide systems use ultrasound because it is resistant to surrounding noise. Another reason why ultrasonic technology is widely used is that it is relatively inexpensive. Additionally, ultrasound emitters and detectors are tiny enough to be transported without the need for complicated electronics. In the related research [16], The project developed a low-cost mobility aid using ultrasonic sensors for obstacle detection, providing alerts through LEDs, buzzers, and vibrating motors. It effectively detects objects within 2 to 50 cm, enhancing mobility for visually impaired individuals. The research article [17] presents a voice-based navigation system utilizing ultrasonic sensors for obstacle detection, enhancing mobility for visually impaired individuals. This system integrates real-time voice assistance, ensuring safer travel by alerting users to obstacles and slippery surfaces. In [18] the research presents a mobility stick utilizing ultrasonic sensors and haptic motors to assist visually impaired individuals. This system enhances navigation by providing haptic feedback, while also monitoring movement and potential falls, integrating data through the Internet of Things. In research [19], The Smart Cane is used that incorporates an ultrasonic sensor for obstacle detection, enhancing mobility for visually impaired individuals. This feature alerts users to nearby obstacles, significantly improving their safety and independence while navigating their environment.

It is difficult for blind people to move or live without help. So, blind people generally use a white cane to guide them during moving. Although it can be helpful, it doesn't guarantee saving blind people from risks. These conventional ways can be used for low-level obstacle detection only.

The goal of this study is to develop a theoretical model and a system idea for providing a smart electronic aid to blind individuals. In comparison to traditional navigation systems, blind aid systems can be equipped with depth measurement circuitry, which is useful for sensing the depth when dealing with stairs, and a recorded message is played to notify the obstacle alert. These various units are described in order to create a "smart stick" concept.

2. Motivation. - The proposed system offers a range of features designed to enhance usability, safety, and accessibility for visually impaired users. First, the system integrates lightweight components into the stick, making it highly user-friendly and easy to carry. It provides a fast response to nearby obstacles within a range of up to 2 meters, thanks to the inclusion of ultrasonic sensors. Training for this product is minimal and cost-effective, as it only requires a simple description of the stick's components and their usage positions, unlike the extensive training required for other assistive devices.

For seamless communication, the stick transmits information to the user via earphones. Instead of relying on vague sounds that may cause confusion or social discomfort, the earphones deliver clear, spoken warning messages, helping alert the user without drawing undue attention. Additionally, to improve the independence and ease of use for blind individuals, the stick includes a clap sensor that assists in locating it if misplaced, providing added convenience.

The ultrasonic sensor is crucial for detecting obstacles, pits, and staircases, and it plays a vital role in generating spoken warnings whenever an obstacle is detected. This feature enables the user to alter their path in time to avoid hazards. A water sensor is also included to detect water on the floor, offering timely alerts to help the user avoid potential slips. Moreover, a fire sensor enhances safety by alerting the user to the presence of fire, while a light sensor increases nighttime visibility. This sensor helps notify others in the vicinity of the blind person's presence, encouraging them to make way and allowing the user to walk with ease.

The designed smart stick detects obstacles and can recognize and speak aloud the upward and downward stairs or puddles as shown in Figure 2.

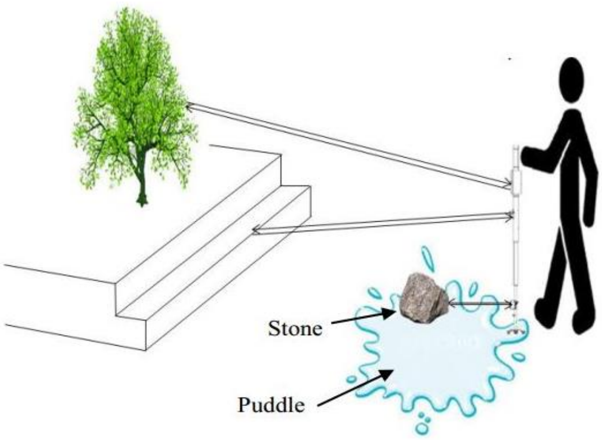

Figure II: Smart stick detects the obstacles in front of a blind person.

3. Experimental Setup and Procedure. - Different sensors are interfaced with Raspberry Pi and after the process, it gives feedback to blind persons by using multi-recorded warning messages if any hurdle is detected within the set range. Figure III Shows the Complete Block Diagram of the Project.

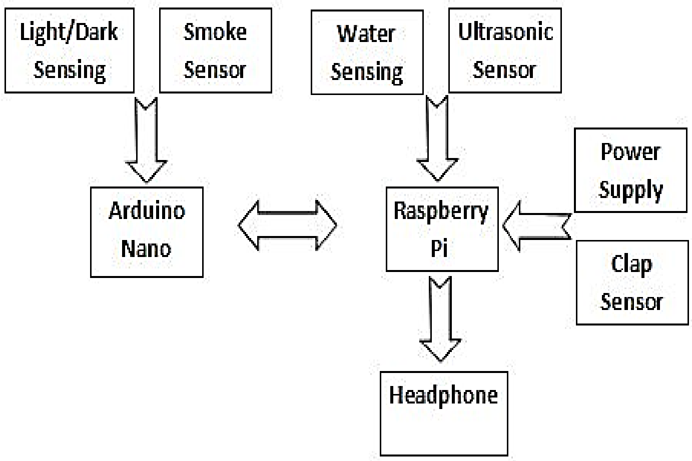

Figure III. System Block Diagram

4. Details of Component. -

4.1 Power Supply. - A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load.

The basic electrical specification of a power supply suitable for a Raspberry Pi is that it supplies a regulated 5V DC (direct current) and can supply a current of up to 700mA. It must have a micro USB plug on the end of the lead.

4.2 Ultrasonic Sensor HC – SR04. -

Specifications

Power Supply: 5V DC
Operating Current: 15mA
Measuring Range: 2 cm to 400 cm (0.78 inches to 157 inches)
Resolution: 0.3 cm
Measuring Angle: ~15 degrees
Ultrasonic Frequency: 40 kHz
Accuracy: ± 3mm

The HC-SR04 sensor uses sonar to measure the distance to an object. It sends out a high-frequency sound wave and measures the time the echo returns after bouncing off an object. Figure IV Shows the Different angles for staircase detection. The distance can be calculated using the following expression:

$$\text{Distance} = \frac{\text{Time} \times \text{Speed of Sound}}{2}$$

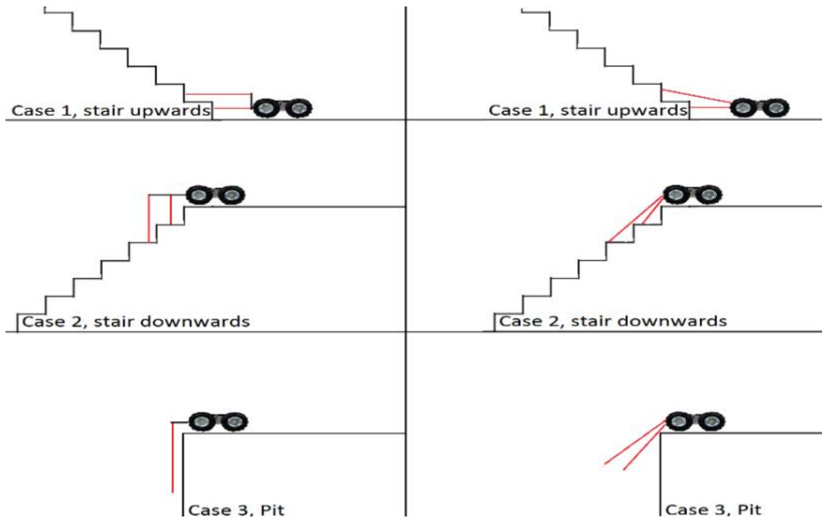

Figure IV. An ultrasonic sensor used for obstacle detection and staircase detection.

4.3 Smoke Sensor (MQ-2). - The MQ-2 smoke sensor is a popular gas sensor for detecting smoke, LPG, butane, methane, alcohol, hydrogen, and other combustible gases. It’s commonly used in gas leak detection systems in homes, industries, offices, and simple air quality monitoring applications.

The MQ-2 sensor uses a small heating element to detect gases. When gases like LPG, smoke, or methane are present, the sensor's resistance changes, causing a voltage drop that can be measured. The sensor’s analog output can be read directly or converted to a digital signal using an analog-to-digital converter (ADC). The smoke sensor has a built-in potentiometer that allows you to adjust the sensor's digital output (D0) threshold. This threshold sets the value above which the digital pin will output a HIGH signal.

The output can be an analog signal (A0) that can be read with an analog input or a digital output (D0) that can be read with a digital input.

https://doi.org/10.36561/ING.28.3
ISSN 2301-1092 • ISSN (en línea) 2301-1106 – Universidad de Montevideo, Uruguay

We will wire the MQ-2 to an Arduino so that the Arduino can read the amount of voltage output by the sensor and sound a buzzer if the sensor outputs a voltage above a certain threshold.

Specifications
Operating Voltage: 5V DC
Power Consumption: Less than 150 mA
Detection Range: 300-10,000 ppm (parts per million)
Output: Analog and digital (threshold adjustable)
Preheat Time: About 20 seconds (for stable output)

4.4 Water Sensing on Floor (HW-482). - A water sensor is used to detect the presence of water and provide an alert in time for path change to avoid slipping. A typical design is a small cable or device that lies flat on a floor and depends on the electrical conductivity of water to decrease the resistance across two contacts.
HW-482, which consists of exposed metal traces or probes on a PCB. these probes are fitted at the bottom of the stick to sense obstacles like water pits, when water contacts these traces, it bridges the gap between them, allowing current to flow and creating a signal that can be read by a microcontroller. This module typically has both analog and digital output options:
Analog Output (AO): Provides a variable voltage corresponding to the amount of water detected.
Digital Output (DO): Provides a simple HIGH or LOW signal when water is detected, with a threshold adjustable via a potentiometer.

Specifications:
Operating Voltage: 3.3V - 5V DC
Output Type:
Digital Output (DO): High/Low signal, adjustable via onboard potentiometer.
Analog Output (AO): Analog voltage signal that varies based on water presence and coverage on the sensor probes.
Current Consumption: Typically, around 20 mA

4.5 Light/Dark Sensing (LDR). - A light sensor is useful at night or dark. When there is darkness, it aware the people in the surrounding area that a blind person is walking and allows space so that the blind person can walk easily.
Light-dependent resistors, LDRs, or photoresistors are generally used in circuits where it is necessary to detect the existence or the level of light. They can be expressed by a variety of names from a light-dependent resistor, LDR, photoresistor, photocell, or photoconductor. Even though other devices such as photodiodes or phototransistors can also be used, LDRs or photoresistors are particularly appropriate electronic components to use. They give large changes in resistance to changes in light level.
Considering their low cost, ease of manufacture, and ease of use LDRs have been used in a variety of different applications.

Specifications:
Operating Voltage: 3.3V - 5V DC
Output Type:
Digital Output (DO): HIGH/LOW output, with an adjustable threshold via a potentiometer.
Analog Output (AO): Variable voltage that corresponds to the light intensity.
Current Consumption: Typically, around 20 mA
Sensitivity Adjustment: Onboard potentiometer for setting threshold levels for digital output

5. Experimental Results and Discussion. - Hardware consists of Raspberry Pi, Arduino Nano, and other components like ultrasonic sensor, smoke sensor, clap sensor, LDR sensor, and water sensor. Hardware connections can be seen below in the figures. In this project ultrasonic sensor is used for obstacle and staircase detection and smoke sensor is used to detect fire and clap sensor is used for stick finding and LDR sensor is used to detect lightness/darkness, and a water sensor is used to detect the water on floor. Figure V demonstrates the complete experimental setup of a blind person stick.

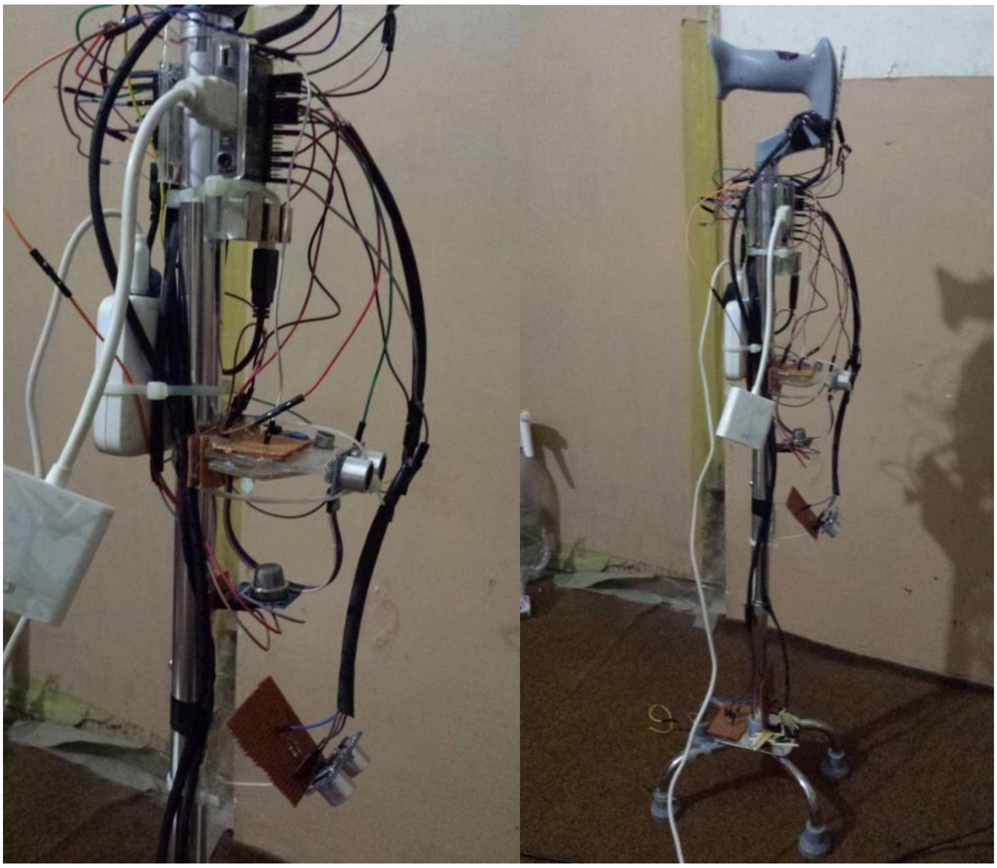

Figure V. Experimental Setup.

The ultrasonic sensor has four output formats: pulse width output, analog voltage output, and serial digital output. The pulse width (PW) representation of the range provides information on the distance between the sensor tip and the obstruction. As a result, the distance value can be estimated with a scale factor of 147uS per inch. The sensor readings fluctuate depending on the topography, in our example, the floor or rising or descending staircases, as seen in Figure VI.

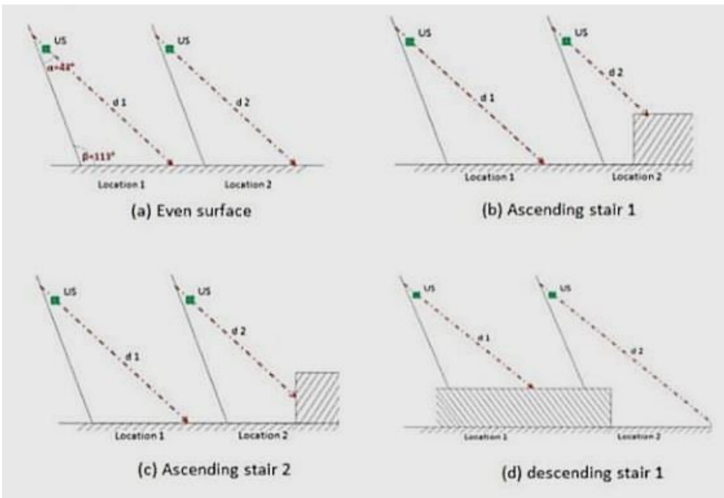

Figure VI. Ultrasonic Sensor Results.

Figure VII depicts three curves that illustrate the distances between the sensor and the nearest obstacle in three walking situations:

The top left curve depicts the distance values obtained while the user walks on a floor with no change in floor state. Because of the wide angle of incidence with the floor, the output of the ultrasonic sensor fluctuates as the user walks. As a result, it is incapable of providing accurate measurements. The bottom curve depicts the values of distance as the user walks on a floor, and the cane detects rising steps.

The top right curve depicts the values of distance when the user approaches falling steps on an even surface.
Logically, when the cane obtains descending (or ascending) steps, the distance values must become larger (or lower) than those acquired with a floor. However, the curves in Figure VII do not appear to show that the sensor readings alter in accordance with floor states. Indeed, vibrations occur during cane movement, causing some mistakes in the ultrasonic output signal.

To separate the three cases experimental data identification rules of the floor, ascending and descending states are developed in the following section.

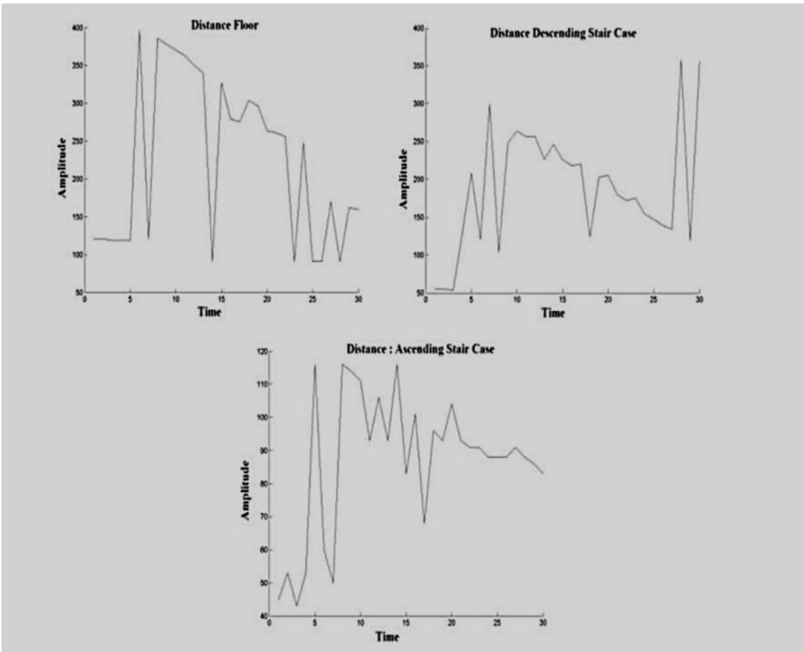

Figure VII. Range sensor raw data – even surface (top left), ascending stairs (bottom) and descending stairs (top right)

To process these three signals effectively and extract useful information for detecting floor surfaces, ascending stairs, and descending stairs, we can apply several signal-processing techniques to distinguish between the three cases.
The raw ultrasonic sensor data shown in each plot is noisy due to variations in the angle of incidence, especially for the flat surface case (top left plot). To reduce noise and improve readability, apply smoothing techniques such as: Moving Average filter, Low-pass filtering to remove high-frequency noise that doesn't contribute to identifying floor state changes and Exponential Smoothing.

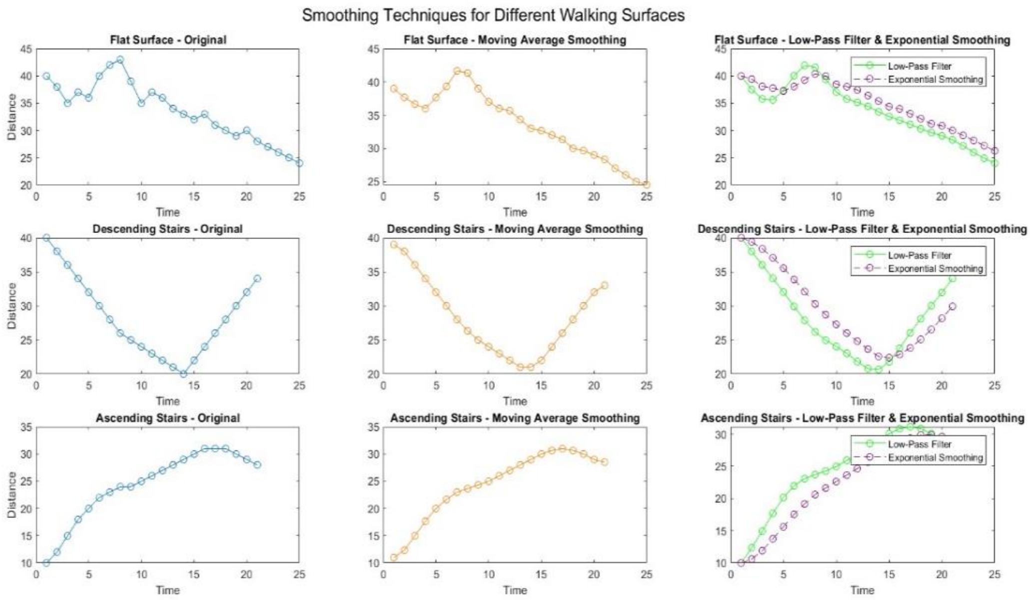

Figure VIII. Smoothing technique results in enhancing the readability of ultrasonic signals for flat surfaces, ascending stairs, and descending stairs.

After smoothing, extract key features to differentiate between flat surfaces, ascending stairs, and descending stairs. These features can include Mean and Standard Deviation as given in Table I:

Flat Surface	Moving Average: Mean = 33.59	Std Dev = 5.13
Flat Surface	Low-Pass Filter: Mean = 33.59,	Std Dev = 5.24
Flat Surface	Exponential Smoothing: Mean = 34.88,	Std Dev = 4.40
Descending Stairs	Moving Average: Mean = 28.30	Std Dev = 5.60
Descending Stairs	Low-Pass Filter: Mean = 28.33	Std Dev = 5.81
Descending Stairs -	Exponential Smoothing: Mean = 29.45	Std Dev = 5.86
Ascending Stairs	Moving Average: Mean = 24.45	Std Dev = 6.14
Ascending Stairs	Low-Pass Filter: Mean = 24.44	Std Dev = 6.26
Ascending Stairs	Exponential Smoothing: Mean = 22.30	Std Dev = 6.79

Table I: Mean and standard deviation for three cases.

The mean and standard deviation values extracted from each smoothed dataset provide insight into the overall trend and variability of the signals for different types of surfaces.
The floor flat surface Mean values around 33-35 show that the signal is relatively high. This is expected, as flat surfaces usually have a steady level without significant upward or downward trends. In the Descending Stairs case the mean is lower at around 28-29. This reflects the downward trend in the signal due to descending steps, which bring the values lower on average. The mean for the ascending stairs case is even lower, around 22-24, especially in the exponential smoothing case. This indicates an upward trend that starts lower but gradually increases, consistent with going upstairs.

The standard deviation reflects the spread or variability of the signal values. A higher standard deviation indicates more fluctuations, while a lower standard deviation suggests a more stable, consistent signal. In the flat Surface case, the standard deviation is generally lower (around 4.4 to 5.3), indicating that flat surfaces are more consistent and less variable, with fewer abrupt changes. while in the descending stairs case, The standard deviation is slightly higher (around 5.6 to 5.9), showing increased variability as the signal moves downward with each step. However, in the ascending stairs, the standard deviation is the highest (around 6.1 to 6.8), suggesting greater variability, likely due to the upward movement that tends to vary more in amplitude compared to descending stairs or flat surfaces.

Finally, Pattern Recognition with Thresholding to identify distinct surface types: Set a threshold range for standard deviation values. If the distance variations fall within this range with no clear upward or downward trend, classify the surface as a flat floor if it identifies a consistent downward trend in the distance values. Apply a threshold on the gradient (negative values) to trigger an ascending stair detection. and a sudden increase in the distance values after a period of stability, indicating a possible stair edge. A positive gradient exceeding a certain threshold can signal the start of a descending stair. The following table 02 shows the classification results after applying thresholding on the data set for the three cases.

Mean	Standard Deviation	Classified as
33.59	5.13	Flat Surface
28.30	5.60	Descending Stairs
24.45	6.14	Ascending Stairs

Table II: Classification Results using Extracted Features.

6. Conclusion. - Blind and visually impaired people require assistance to engage with their surroundings with greater security. As a result, a multi-sensor system that analyzes floor surfaces for the presence of stairs, obstacles, fire, darkness, and water was created.

In this research, we offer a unique electronic instrument with two ultrasonic sensors designed to assist the visually impaired. Only one ultrasonic sensor is utilized to detect and identify three different floor states: even floor, ascending staircase, and descending staircase. To this goal, we devised a method for detecting floor states. Such performances are challenging because no prior techniques have proposed detecting stairs.

The experimental results demonstrate that mean and standard deviation values extracted from smoothed signals are powerful features for differentiating between flat surfaces, ascending stairs, and descending stairs. By implementing a threshold-based pattern recognition system using these features, one can achieve accurate and efficient surface-type classification. The findings provide a foundation for developing real-time applications in health, fitness, and navigation. Future work can explore refining thresholds, incorporating additional features, and testing in dynamic environments to enhance the robustness and versatility of this approach.

Future research in surface classification holds significant potential for enhancing navigation, mobility assistance, and health monitoring. By leveraging advanced sensors, machine learning, and augmented reality, these systems can provide more accurate, adaptable, and user-friendly solutions. Such advancements could lead to more personalized, real-time assistance for various applications, ultimately improving safety, engagement, and independence for diverse user groups.

References

[1] M. S. Nowak and J. Smigielski, "The Prevalence and Causes of Visual Impairment and Blindness among Older Adults in the City of Lodz, Poland." Medicine, vol 94, number 5, pp. e505, February 2015 doi:10.1097/MD.0000000000000505

[2] G. Gayathri, M. Vishnupriya, R. Nandhini and M. Banupriya "Smart Walking Stick for Visually Impaired." International Journal of Engineering and Computer Science, vol. 3, number 3, pp. 4057-4061, 2014.

[3] R. Radhika, P.G. Pai, S. Rakshitha and R. Srinath "Implementation of Smart Stick for Obstacle Detection and Navigation." International Journal of Latest Research in Engineering and Technology, vol. 2, number 5, pp. 45-50, 2016.

[4] M.H. Mahmud, R. Saha and S. Islam "Smart Walking Stick – An Electronic Approach to Assist Visually Disabled Persons." International Journal of Scientific and Engineering Research, vol. 4, number 10, pp. 111-114, 2013.

[5] A. Jose, G. George, M.R. Nair, M. J. Shilpa and M. B. Mathai "Voice Enabled Smart Walking Stick for Visually Impaired." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 5, pp. 80-85, 2016.

[6] R. Sheth, S. Rajandekar, S. Laddha and R. Chaudhari "Smart White Cane – An Elegant and Economic Walking Aid." American Journal of Engineering Research. Vol. 3, number 10, pp. 84-89, 2014.

[7] C.S. Kher, Y.A. Dabhade, S.K Kadam., S.D. Dhamdhere and A.V. Deshpande "An Intelligent Walking Stick for the Blind." International Journal of Engineering Research and General Science, vol. 3, number 1, pp. 1057-1062, 2015.

[8] B.G. Roopashree, B.S. Patil and B.R. Shruthi "Smart Electronic Stick for Visually Impaired." International Journal of Innovative Research in Science, Engineering and Technology, vol. 4, number 7, pp. 6389-6395, 2015.

[9] O. O. Olakanmi, "A Multidimensional Walking Aid for Visually Impaired Using Ultrasonic Sensors Network with Voice Guidance", International Journal of Intelligent Systems and Applications (IJISA), vol. 6, number 8, pp. 53-59, 2014. DOI: 10.5815/ijisa.2014.08.06

[10] E. J. Chukwunazo and G. M. Onengiye "Design and Implementation of Microcontroller Based Mobility Aid for Visually Impaired People." International Journal of Science and Research. Vol. 5, issue 6, pp. 680-686, 2015. Available at http://dx.doi.org/10.21275/v5i6.NOV164233.

[11] G. Prasanthi and P. Tejaswitha "Sensor Assisted Stick for the Blind People." Transactions on Engineering and Sciences, vol. 3, number 1, pp. 12-16, 2015.

[12] Shahid Karim, Muhammad Shakir, Ali Sheikh, Shahzor Memon, Halar Mustafa, Vishal Kumar "A Novel Eye-Tracking Device Designed with a Head Gesture Control Modul" Big Data fusion and Intelligent Information Integration, October 2021

[13] Muhammad Shakir, Shahid Karim, Muhammad Imran Saeed, Halar Mustafa, Shahzor Memon, S. Abbad Kazmi "IOT Based Real-time clinical healthcare system for aging and unprivileged areas" Int. J. Computational vision and robotics, January 2022

[14] Wasiq Khan, Abir Hussain, Bilal Muhammad Khan, Keeley Crockett, "Outdoor mobility aid for people with visual impairment: Obstacle detection and responsive framework for the scene perception during the outdoor mobility of people with visual impairment", Expert Systems with Applications, Volume 228, 2023, 120464, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2023.120464.

[15] Cardona Mesa AA, Vasquez Salazar RD. "Mobility aids for visually impaired persons: Journals reviewed. Wearable Technology" 2021; 2(1): 73–81.

[16] Ricardo Yauri, Kevin Alvarez, Junior Cotaquispe, Jordy Ynquilla, Oscar Llerena "Guidance device for visually impaired people based on ultrasonic signals and open hardware" International Journal of Reconfigurable and Embedded Systems (IJRES)Vol. 13, No. 3, November 2024, pp. 520~527 ISSN: 2089-4864, DOI: 10.11591/ijres.v13.i3.pp520-527.

[17] Arshad, Khan., Gerard, Deepak. (2024). Voice-Based Navigation System for Visually Impaired Using Ultrasonic and Moisture Sensor via Bluetooth and GPS Tracker. Deleted Journal, 2(1):20-28. doi: 10.48001/jocevd.2024.2120-28.

[18] J, S, Raghul., Durga, Devi, K., M., Sreya., S, Maithreye. (2024). Mobility Stick with Haptic Feedback for People with Vision Impairments. 1-6. doi: 10.1109/iconscept61884.2024.10627855.

[19] A, Harini., C, Buvana., M, Harshini., S., Keerthana., Dr.Ramkumar, prabhu., S., K., UmaMaheswaran. (2024). Iot Based Smart Assistant Cane For The Visually Impaired. doi: 10.1109/ic3iot60841.2024.10550222.

Author contribution:

1. Conception and design of the study
2. Data acquisition
3. Data analysis
4. Discussion of the results
5. Writing of the manuscript
6. Approval of the last version of the manuscript

SM has contributed to: 1, 2, 3, 4, 5 and 6.

MMA has contributed to: 1, 2, 3, 4, 5 and 6.

SUR has contributed to: 1, 2, 3, 4, 5 and 6.

HM has contributed to: 1, 2, 3, 4, 5 and 6.

MSS has contributed to: 1, 2, 3, 4, 5 and 6.

Acceptance Note: This article was approved by the journal editors Dr. Rafael Sotelo and Mag. Ing. Fernando A. Hernández Gobertti.