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A Comprehensive Review of Smart Blind Stick: Enhancing Independence and Safety for the Visually Impaired

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Abstract: Vision is a beautiful gift of God. With the vision, we can see this beautiful world. The significant challenge faced by individuals with visual impairments is accurately discerning their location in unfamiliar environments. With the recent surge in the population of the visually impaired, there has been a demand to focus on developing blind sticks for their ease of life. Blind sticks are equipped with a multitude of features aimed at improving the movement and security of individuals with visual impairments. Sensor technology forms the foundation of these devices, incorporating sensors like ultrasonic, infrared, or LiDAR to identify obstacles and offer immediate feedback to the user. Haptic feedback mechanisms employ vibrations or tactile signals to alert users of nearby obstacles or changes in terrain, further enhancing their awareness of the surroundings. The foldable design of blind sticks allows for convenient storage and portability when not in use, while their lightweight construction ensures ease of handling and minimizes strain on the user. The adjustable length feature enables customization to accommodate the height and preferences of each user. Constructed from durable materials, these sticks are designed to withstand regular use in various environments, ensuring longevity and reliability. With an ergonomic handle for comfortable grip during extended use, blind sticks also offer integrated audio feedback, providing auditory cues or voice prompts to aid in navigation and obstacle detection. Some models even offer connectivity options such as Bluetooth or GPS capabilities, expanding their functionality. Thanks to its enduring battery life, users can depend on their blind sticks for prolonged durations without the necessity for frequent recharging. These combined features make blind sticks essential aids for people with visual impairments, encouraging them to move through their surroundings with greater confidence and autonomy.

Keywords: *blind people, infrared sensor, obstacle detection, smart blind stick, visually impaired, water sensor*

1. Introduction

As per the global vision report by the WHO, over 220 crore people worldwide are affected by vision impairment. Vision, being the primary sense, profoundly influences every aspect of our lives. All nations must collaborate in preventing eye conditions and addressing vision impairment more efficiently [1]. According to The Lancet Global Health Commission, vision impairment resulted in a loss of economic productivity totalling $410.7 billion, though the true cost is likely higher than this estimate [2]. Cataracts continue to pose a substantial burden on global health, especially with the ageing population and population growth. To tackle this escalating burden, global initiatives must focus on improving cataract surgery rates and quality, especially in areas with reduced socioeconomic status. Prioritizing efforts to improve access to high-quality cataract surgery is essential to effectively address this challenge [3].

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According to the Laser Eye Surgery Hub UK, while there is a consistent decline in the percentage of people affected by visual impairment, significant efforts are still needed to address the approximately 1 billion cases of preventable visual impairment. The continual expansion of the global population alongside increased life expectancy, combined with restricted healthcare access in specific low-income nations, results in a continuous rise in the overall count of blind and visually impaired individuals. Addressing this challenge requires comprehensive efforts to improve healthcare access, prevent blindness interventions, and promote eye health education on a global scale.

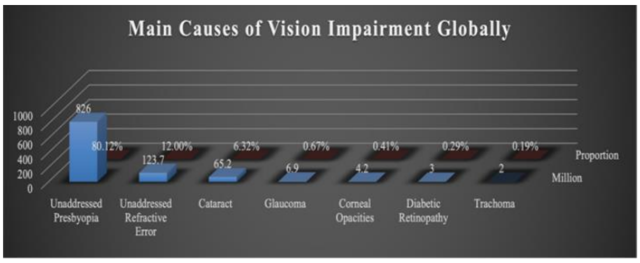

Fig. 1. Main Causes of Vision Impairment Globally (Data by IAPD Visio Atlas)

The increase in life expectancy and the aging population resulted in a 35% rise in affected individuals. However, over the 25 years until 2015, the percentage of the impacted population reduced by 37%, attributed to factors like reduced poverty, lower incidence rates of specific conditions, delayed onset, improved public health initiatives, and advancements in eye healthcare services. The estimation for the prevalence of vision loss by 2050 anticipates an increase in the global population from 7.8 billion in 2020 to 9.7 billion in 2050. The frequency of visual impairments is significantly concentrated in 20 countries, encompassing over three-quarters of cases, despite comprising only 69% of the global population. The occurrence of visual impairment in areas with a substantial elderly demographic is noteworthy. India and China collectively represent 45% of the total instances of blindness and moderate to severe visual impairment (MSVI), despite constituting only 36% of the global population. The accompanying chart delineates the ratio of individuals with visual impairments in each country, showcasing a pronounced correlation between prevalence and income level. This underscores the disparity in visual impairment distribution across different regions and income levels.

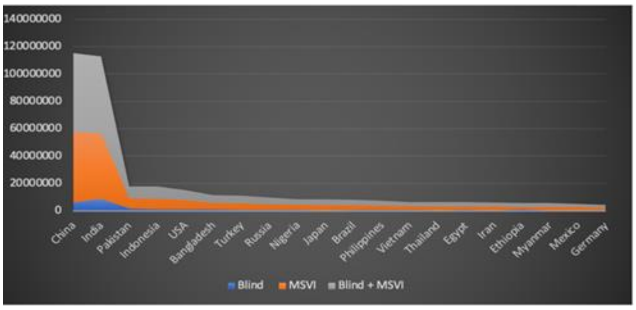

Fig. 2. Highest number of people with blindness and MSVI (Data by IAPD Vision Atlas)

There exists a distinct correlation between the average income of a country and the frequency of visual impairment. Among the 20 countries categorized as low-income, there is a pronounced concentration of visual impairment cases. In Sub-Saharan Africa, more than 70% of individuals experience near-vision impairment as a result of uncorrected Presbyopia. A straightforward solution like providing spectacles could address each case effectively. Despite challenges, strides are being made. Between 1990 and 2015, approximately 90 million people received treatment or were spared from blindness or moderate to severe vision impairment [4].

Smart sticks are crafted to expand the cognitive framework of visually impaired individuals by serving as an integral component of their engagement with their surroundings, augmenting both self-awareness and mobility [5]. Smart sticks employ infrared sensor technology for detecting obstacles within a two-meter range, providing a lightweight, economical, and user-friendly solution characterized by swift response times and minimal power consumption [6]. Guide sticks enhanced with intelligent ultrasound sensors and microcontrollers can effectively mimic and track paths, enabling the comparison of real and simulated routes to enhance navigation [7]. Smart sticks utilize various sensors, including ultrasonic, infrared, and laser, to detect obstacles and communicate information to users through vibrations or auditory signals, reducing the need for human assistance [8] [10] [11].

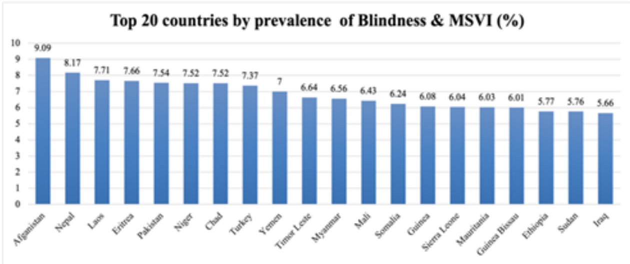

Fig. 3. Top 20 countries by prevalence (Data by IAPD Vision Atlas)

A comprehensive smart stick system prioritizes utilizing ultrasonic sensors for detecting obstacles and providing feedback to aid in navigation and obstacle avoidance. [9]. Incorporating Raspberry Pi and GPS modules into smart sticks facilitates real-time assistance and object detection, with feedback delivered through audio and text-to-speech technology to enhance artificial vision capabilities [12]. Artificial intelligence is incorporated into smart sticks to facilitate object detection and classification, relaying information to the user via speech, thus reducing human effort and providing a better understanding of surroundings [13]. Intelligent sticks based on artificial intelligence can inform users about the size and distance of obstacles, offering direction recommendations for safer navigation [14]. The incidence of vision loss due to URE (uncorrected refractive) is anticipated to escalate, with projections suggesting an increase to 127.7 million people experiencing moderate or severe vision impairment and 8.7 million individuals becoming blind by 2020 [15].

Visual Impaired person can move with the help of a stick so it is easy to define a stick with the functions for the betterment of their life. The Blind Stick, fueled by Artificial Intelligence (AI), stands as a pioneering advancement in assistive technologies crafted to improve mobility and independence. The integration of advanced technology into blind sticks represents a significant leap forward in improving the self-sufficiency, security, and overall well-being of blind persons. Through the inclusion of features such as GPS, GSM, IoT connectivity, ultrasonic sensors, and haptic feedback mechanisms, these technologically advanced blind sticks offer real-time navigation assistance, obstacle detection, and environmental awareness. The use of such sophisticated technology not only enables the person to navigate their environment with increased confidence and autonomy but also facilitates seamless integration into society. As research in this field continues to evolve, it holds the promise of further innovation and refinement, ultimately transforming how visually impaired individuals perceive and engage with their surroundings.

1.1. Abbreviations and Acronyms

Considering the common occurrence of abbreviations in scientific literature, Table 1-2 outlines the abbreviations employed in this study, categorized under Blind Stick Components and Methodologies.

Table 1. Abbreviations for Blind Stick Hardware Component

Abbreviation	Component/Methodology
STM32	32-bit microcontroller integrated circuits by STMicroelectronics
MSP 430	mixed-signal microcontroller family from Texas Instruments
GSM	Global system for mobile communications
PIC microcontrollers	Peripheral Interface Controller – Microcontrollers
SSD	Solid State Drive
GPS	Global Positioning System
LiDAR	Light Detection and Ranging
GPRS	General Packet Radio Service

Table 2. General Abbreviations

Abbreviation	Component/Methodology
SAVIS	Smart Assisting Visually Impaired Stick
KNN	K-nearest neighbour
NLP	Natural Language Processing
R-CNN	Region-Based Convolutional Neural Network
Masked R-CNN	Mask Region-Based Convolutional Neural Network
Fast R-CNN	Faster Region-Convolutional Neural Network
CNN	Convolutional Neural Network
PIC	Peripheral Interface Controller
SOS	Save our Souls
RFID	Radio Frequency Identification
UWB	Ultra Wide Band
RNN	Recurrent neural network
AI	Artificial Intelligence

2. Background

Individuals with visual impairments encounter numerous obstacles when navigating their surroundings autonomously, frequently depending on assistance from others or conventional mobility aids such as white canes. These intelligent blind sticks integrate ultrasonic sensors, infrared sensors, or laser rangefinders to identify obstacles and environmental hazards nearby. These sensors detect objects within a defined range and relay feedback to the user via vibrations, auditory signals, or haptic feedback, facilitating safe navigation around obstacles. Moreover, smart blind sticks can include supplementary functionalities like GPS navigation, voice commands, and integration with mobile devices, enabling users to access location-based information, receive navigation guidance, and even request assistance when necessary. The emergence of smart blind sticks signifies a substantial progression in assistive technology, providing increased independence, safety, and confidence in mobility. Nevertheless, ongoing research in this domain persists in seeking avenues to enhance the precision, dependability, and user-friendliness of these devices, guaranteeing they cater to the diverse requirements of visually impaired individuals across different environments and circumstances.

The intelligent blind stick employs various technologies, such as sensors and connectivity capabilities, to aid navigation and detect obstacles for individuals with visual impairments. [16]. The main objective is to enable or give power to blind individuals by equipping them with a dependable tool for safely and efficiently navigating their surroundings. Additionally, various technologies are integrated into these devices to bolster navigation, obstacle detection, and user safety. The overarching aim is to develop walking assistance solutions that improve the ability to move around and the self-sufficiency of individuals with visual impairments, thereby facilitating their daily activities and social integration [17]. Furthermore, the incorporation of innovative technologies like sensors, connectivity options, and potentially machine learning algorithms within the smart blind stick [18]. This emphasis is on furnishing an effective and trustworthy tool to augment the mobility and autonomy of blind and visually impaired individuals. Through analysis, they evaluate the real-world effectiveness and performance of the smart blind stick, providing valuable insights into its usability and potential advantages for individuals with visual impairments [19].

Its overarching objective is to furnish visually challenged individuals with an effective and dependable tool that enhances their mobility and independence [20]. Researchers provided integration of technologies like sensors, possibly incorporating ultrasonic or infrared sensors, along with connectivity options to offer navigation assistance, obstacle detection, and user safety. The objective here is to improve the movement and autonomy of individuals with visual impairments by furnishing them with a dependable tool for safely and efficiently navigating their surroundings [21]. The examination of a new walking stick's capability to detect drop-offs and prevent falls, possibly by integrating sensors, seeks to evaluate its efficacy in enhancing the safety and movement of individuals navigating environments containing hazards like drop-offs [22]. The SAVIS likely incorporates advanced technologies such as sensors, connectivity options, and possibly intelligent algorithms to aid in navigation and obstacle detection, with the ultimate aim of enhancing the ability to move freely and self-sufficiency of people with visual impairments [23]. The device combines sensors, connectivity choices, and potentially advanced algorithms to assist individuals with visual impairments in navigating and identifying obstacles. Its goal is to offer a modern and effective tool that enhances the mobility and safety of blind individuals, thereby boosting their independence and overall quality of life [24].

The Blind Stick incorporates a range of features including sensors, connectivity options, and potentially intelligent algorithms to support navigation, obstacle detection, and other essential activities for people with visual impairments. Its objective is to furnish a versatile tool that amplifies the ability to move freely and self-sufficiency of individuals who are blind across diverse situations and environments [25]. Another perspective may delve into how the stick leverages advanced technologies like sensors, connectivity options, and potentially intelligent algorithms to facilitate navigation, obstacle detection, and other pertinent tasks for visually impaired individuals. The aim here is to offer an innovative and efficient tool that enhances the ability to move and the self-sufficiency of individuals with visual impairments [26]. Moreover, the integration of diverse technologies such as sensors, connectivity options, and possibly intelligent algorithms in the stick aims to assist in navigating and detecting obstacles. The ultimate objective is to offer an advanced and efficient tool that improves the mobility and safety of blind individuals, thereby fostering their independence and overall quality of life [27]. Additionally, an electronic walking stick design equipped with sensors and intelligent features focuses on aiding visually impaired individuals in their daily activities [28]. Lastly, the stick integrates various sensors and technologies to offer comprehensive environmental awareness, enabling visually impaired users to navigate their surroundings effectively [29].

Integrating a panic button into a cane for the blind provides users with an added layer of security and confidence in their capability to request help or assistance when necessary. This feature promotes independence and mobility, enhancing safety for visually impaired individuals [30].

Ultrasonic sensors are employed to identify obstacles and offer instantaneous feedback to the user, facilitating navigation and obstacle avoidance. The aim is to provide visually impaired individuals with a reliable and effective tool to enhance their mobility and safety in their daily activities [31]. The system employs object detection and classification algorithms to recognize obstacles in the surroundings and offer immediate feedback to the user. The aim is to improve the mobility and safety of blind persons by assisting them in navigating their environment more effectively [32]. Gablind is a glasses accessory incorporated with electronic components and synchronized with a smart cell application called the Gablind app. This accessory is capable of recognizing obstacles in the user's environment and providing navigation guidance via the smartphone application. It focuses on improving the speed of obstacle detection by the Max sonar sensor in the Gablind app. The glasses incorporate Max sonar sensors to perceive the surroundings ahead of the visually impaired individual. The Gablind App, available on Android smartphones, provides audio feedback and a navigation aid for visually impaired persons [33]. It may detail how ultrasonic sensors are utilized to detect obstacles and provide feedback to visually impaired users, aiding in navigation and obstacle avoidance. The objective of the intelligent blind stick is to enhance the mobility and security of persons by providing them with an efficient tool for independently navigating their surroundings [34].

The integration of IR sensors into blind sticks signifies a notable advancement. These sensors serve a vital function in detecting obstacles and delivering immediate feedback to the user, thereby enhancing navigation and promoting safety. Infrared microcontroller-based blind guidance system to aid visually impaired individuals. It is anticipated that the system will incorporate infrared sensors and a microcontroller to detect obstacles and offer real-time guidance to users. This technological solution holds promise in enhancing both mobility and safety for individuals with visual impairments as they move through their environment [35]. The technology is crafted to assist users in navigating through their surroundings by detecting barriers along the way and offering real-time guidance. The implementation and efficacy of infrared sensors within the smart stick, with the overarching aim of bolstering mobility and independence among blind individuals [36].

The utilization of GPS technology for location tracking and route planning, alongside GSM for communication and guidance purposes. The overarching objective of the system is likely geared towards furnishing visually impaired individuals with real-time navigation assistance, thereby enabling them to navigate unfamiliar environments with heightened ease and independence [37]. Another possibility is to elucidate how the stick harnesses various technologies to detect obstacles, offer navigation aid, and ensure user security. The goal is to improve the mobility and safety of visually impaired individuals by providing them with an effective tool for navigation and detecting obstacles [38]. Alternatively, it might delineate the utilization of GPS for location tracking and route guidance, coupled with GSM for communication functionalities. The system is presumably engineered to deliver cost-effective and accessible navigation assistance to individuals with visual impairments who are empowered to navigate their surroundings with increased independence and confidence [39].

It could involve an assessment of the effectiveness of these technologies in accurately detecting and relaying the user's location, taking into account factors such as reliability, accuracy, and cost-effectiveness. The research is likely driven by the objective of identifying the most suitable communication module for integration with blind canes, to enhance navigation and safety for visually impaired individuals [40]. A system geared towards augmenting the safety of blind stick users through the integration of an emergency button feature. This feature is anticipated to be coupled with location-aware technology, allowing visually impaired individuals to transmit distress signals along with their precise whereabouts during emergencies. It may delve into the intricacies of the feature's design, implementation, and subsequent evaluation, with the overarching goal of furnishing an efficacious solution to mitigate the safety apprehensions of blind stick users [41]. Furthermore, by incorporating GPS technology into the walking stick, the system purportedly furnishes real-time location information to the user, thereby facilitating navigation in outdoor environments with heightened confidence and independence. The study likely undertakes an exploration of the design, functionality, and usability aspects of the GPS-enabled walking stick, with the ultimate objective of enriching mobility and safety measures for individuals with visual impairments [42].

The potential of Arduino and Raspberry Pi technology lies in providing real-time guidance by detecting obstacles and offering auditory or haptic feedback to the user, thus enhancing their mobility and independence. The development, deployment, and assessment of this innovative assistive device aim to improve the everyday experiences of those with visual impairments individuals [43]. How haptic feedback mechanisms are integrated into the stick to provide tactile cues to users, assisting in navigating and detecting obstacles. The goal is to offer assistance to individuals with visual impairments with a dependable and user-friendly tool to improve mobility and safety while navigating [44]. The potential research entails integrating Arduino microcontrollers and diverse sensors to create a tailored intelligent assistive device for blind persons. The Smart Stick might incorporate functionalities like obstacle detection, navigation assistance, and potential connectivity options to augment its capabilities. This innovative solution aims to improve mobility and independence by providing them with immediate feedback and assistance during navigation [45].

PIC technology is employed in various applications across industries, offering versatility and reliability. Integrated into electronic devices, PIC microcontrollers serve as the central processing unit, managing tasks efficiently. By integrating PIC microcontrollers, these devices can process sensor data in real time, enabling features such as obstacle detection and navigation assistance. PIC technology enhances its functionality, possibly by integrating sensors or other components To assist individuals with visual impairments in traversing their environment. The development process and the stick's characteristics aim to improve mobility. and safety of individuals who are blind by furnishing them with an efficient tool for navigating their surroundings [46]. The development and functionality of the smart walking stick, detailing how a microcontroller is harnessed to amalgamate various features into the walking stick, including obstacle detection and feedback mechanisms. These features are designed to assist visually impaired users in safely and independently navigating their surroundings. The smart walking stick endeavours to enhance The freedom of movement and self-sufficiency of individuals with visual impairments, furnishing them with a dependable device for daily navigation. [47].

A wearable smart locator band, based on the Android platform, tailored for individuals managing autism, dementia, and Alzheimer's disease. This wearable gadget is expected to integrate GPS technology and additional sensors to monitor the real-time location of the wearer. Moreover, it may encompass functionalities like emergency alerts and caregiver notifications enhancing the safety and well-being of individuals with cognitive impairments by providing a wearable solution proficient in tracking and monitoring them in various environments [48].

Using an integrated SOS navigation system, the device is anticipated to incorporate a range of technologies, including sensors, GPS, and wireless communication, to assist in navigation and emergencies for visually impaired individuals. The SOS navigation system likely empowers users to summon aid or navigate to safety when confronted with the exigencies and features of the intelligent walking cane, with the overarching goal of augmenting the mobility and safety of blind individuals through the provision of an efficient navigation aid [49]. The conception and deployment of this innovative device, leverages sensors to detect obstacles and Aid individuals with visual impairments in navigating through their environment. By integrating sensors into the walking cane, the device strives to Enhance the safety and mobility of individuals with visual impairment by offering immediate feedback and aid in navigating their environment. [50].

Integration of IoT technology revolutionizes navigation for visually impaired individuals using blind sticks. These sticks are equipped with sensors to gather real-time data on obstacles and changes in terrain. Utilizing onboard processing or connected devices, the collected data identifies hazards along the user's path. With wireless connectivity, the sticks transmit data for analysis and provide navigation assistance through GPS technology. They also offer voice feedback and alerts on surroundings, facilitating remote monitoring by caregivers for swift assistance during emergencies. Additionally, data logging and analysis improve stick performance and usability over time. Overall, the integration of IoT technology enhances the functionality and user experience of these blind sticks [51][52].

The proposal suggests an integrated framework that utilizes IoT technology to improve the efficiency and effectiveness of healthcare systems. This framework is expected to include various IoT devices and sensors for real-time data collection, enabling remote monitoring, diagnostics, and personalized healthcare services. The benefits of this IoT-driven approach in improving patient care, optimizing resource allocation, and enhancing the overall performance of healthcare systems [53]. Alternatively, the system may integrate IoT technology to augment the functionality of electronic sticks utilized by visually impaired individuals. By employing sensors and connectivity, it could furnish real-time environmental data, navigation aids, and safety alerts. This IoT-centric approach enhances the mobility and autonomy of blind individuals through improved navigation capabilities and enhanced safety while navigating their environment [54].

These systems likely harness IoT technology to empower visually impaired individuals with a suite of functionalities aimed at enhancing their independence and accessibility. They may encompass features like real-time navigation guidance, object detection, and remote assistance facilitated by mobile applications connected to IoT devices. This likely delves into the potential advantages of these IoT solutions in enriching the daily lives and mobility of visually impaired users, fostering their integration into society [55]. These e-sticks may offer features such as obstacle detection, real-time navigation aid, and remote monitoring capabilities, contributing to improved mobility and safety for the visually impaired [56]. Furthermore, an IoT-enabled smart blind stick engineered to detect obstacles and aid visually impaired individuals, likely elucidating on the incorporation of IoT technology to enhance its capabilities. Leveraging sensors and connectivity for real-time obstacle detection and navigation assistance, this IoT-based solution is poised to enhance mobility and safety by facilitating independent navigation for visually impaired individuals [57].

The integration of echolocation and image-processing techniques to detect obstacles and offer navigation assistance to visually impaired individuals. This innovative approach is aimed at bolstering the mobility and independence of blind users by furnishing them with a dependable and self-sufficient navigation aid capable of perceiving and reacting to their surroundings in real-time [58]. Alternatively, it might encompass discussions on obstacle detection, route planning, and the implementation of real-time feedback mechanisms facilitated by deep learning models. The primary objective is to harness advanced AI methodologies to improve the mobility and autonomy of people with visual impairments, providing them with a trustworthy tool for safely and efficiently navigating their environment [59]. The smart walking stick utilizes sensors and AI algorithms to detect obstacles, analyze terrain conditions, and provide real-time feedback to the user. Traditional walking sticks incorporate AI capabilities to assist users in navigating their surroundings more effectively and independently. The main focus is to illuminate the potential of machine learning in augmenting the effectiveness and adaptability of blind sticks, ultimately fostering the mobility and independence of visually impaired users [60].

Utilizing Random Forest classifiers for indoor localization within a hospital setting offers insights into machine learning-based localization techniques applicable to assistive devices [61]. Another suggests an integrated wearable sensor system for recognizing posture and localizing indoors, potentially informing the development of advanced positioning technologies for assistive devices, although not specifically designed for blind stick localization [62]. Concentrating on accurate detection and localization of falls in elderly individuals using neural networks and energy-efficient wireless sensor networks could offer insights into localization techniques suitable for wearable assistive devices used by elderly or visually impaired individuals, though not directly related to blind sticks [63]. Deep learning enhances blind sticks by training algorithms to recognize objects through camera images, enabling real-time detection of obstacles, pedestrians, and more. These models accurately locate objects within the camera's view, guiding users with precise alerts about obstacles along their path. Semantic segmentation further enhances navigation by distinguishing elements like sidewalks and roads. Customizable algorithms adapt to users' needs, improving performance over time-based on interactions. Real-time auditory or haptic feedback alerts users to hazards, enhancing situational awareness and safety [64].

A critical patient localization algorithm utilizing sparse representation for mixed signals in emergency healthcare systems, potentially offering insights into localization techniques adaptable for blind stick navigation in dynamic environments [65][66]. Localization systems within the Internet of Things (IoT) framework provide perspectives on

IoT-based localization technologies that could apply to assistive devices like blind sticks [67]. Indoor localization system using wireless technology and Type-2 Fuzzy Logic, customized for aiding visually impaired navigation within buildings, potentially offering a specialized solution for blind stick localization in indoor environments [68]. Localization for blind navigation within indoor environments on a building scale, utilizing smartphones, offers potential insights into navigation techniques assisted by smartphones that could be incorporated into blind stick technologies [69]. The system probably integrates RFID technology with sensor networks to achieve precise indoor positioning, which could be useful for guiding visually impaired individuals indoors [70]. The updated method for localization based on received signal strength, specifically designed for healthcare applications, might offer valuable insights into enhancing localization algorithms for assistive devices utilized in healthcare environments [71]. RFID tags are strategically placed indoors to create a network that helps users navigate through various spaces. The system likely includes a handheld device or smartphone application that communicates with the RFID tags to provide real-time navigation guidance. This technology aims to enhance independence and mobility for visually impaired and elderly individuals within indoor environments [72]. This system likely utilizes sensors and possibly RFID technology to provide real-time navigation guidance in indoor environments. The development process involves both the hardware and software elements to evaluate the effectiveness and ease of use of the system. The main aim is to improve the mobility and independence of the visually impaired by offering reliable indoor navigation assistance [73].

In summary, the fusion of AI and assistive technologies offers a promising avenue for developing blind sticks that excel not only in navigating complex environments but also in tackling the distinctive and personalized requirements of individuals with visual impairments. By integrating these technologies, the main goal is to enhance the confidence, independence and safety of individuals as they navigate their surroundings.

3. Design of Blind Stick

The gadgets' innovative design aims to like, ease the daily struggles of those with visual impairments, making their lives more manageable and convenient. It's, like, a game-changer for sure! Here's a concise summary outlining the usual design and constituent elements found in a Smart Blind Stick.

3.1. Usable Component

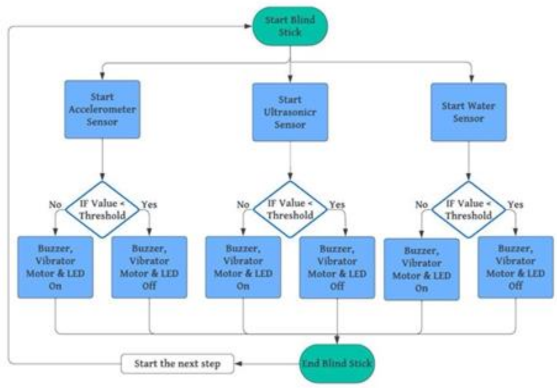

Fig. 4. Flowchart for smart blind stick

In the realm of assistive technology designed for individuals with visual impairments, sensors are pivotal in influencing the design and operational functionalities of blind sticks. These sensors serve as the eyes and ears of the blind stick, empowering it to perceive the surrounding environment and furnish valuable information to the user. From ultrasonic sensors that detect obstacles to GPS modules that offer location tracking, each sensor serves a specific purpose in enhancing navigation and safety. Infrared sensors aid in detecting objects nearby, while gyroscopes and accelerometers help in determining the orientation and movement of the stick. By integrating a combination of sensors, blind sticks can offer comprehensive assistance to users, allowing them to move with increased assurance and autonomy. These components are widely used in the research paper we have reviewed and also it is heavily usable for commercial use in the business market.

3.1.1. Ultrasonic Sensors

Ultrasonic sensors play a crucial role in blind stick technology, facilitating obstacle detection and navigation for visually impaired individuals by emitting high-frequency sound waves that bounce off nearby objects. These sensors measure the return time of these signals, accurately calculating obstacle distance. Continuously scanning the environment, they detect obstacles such as walls or furniture and trigger haptic or auditory alerts when detected within a set range, enabling safe navigation. Ultrasonic sensors demonstrate exceptional performance in various conditions, including low light, offering versatility and reliability. Their compact, lightweight, and energy-efficient nature makes them ideal for inclusion in portable assistive devices. Ultimately, ultrasonic sensors empower individuals with visual impairments to confidently and safely navigate their surroundings, providing real-time feedback every step of the way. This sensor is commonly employed in blind sticks available on the market [74].

Fig. 5. Ultrasonic Sensor

3.1.2. Infrared Sensors

In the realm of blind stick technology, infrared sensors play a pivotal role in assisting individuals with visual impairments with navigation and obstacle detection. These sensors emit infrared light pulses and precisely measure their reflections to gauge the distance to nearby objects. Continuously emitting pulses and analysing their return time allows infrared sensors to calculate obstacle distances in real time. When obstacles are detected within a predefined range, these sensors activate feedback mechanisms, providing haptic or auditory alerts to users. Known for their effectiveness in diverse lighting conditions, infrared sensors ensure reliable assistance in navigating various environments, ultimately bolstering security and autonomy for individuals facing visual impairments. This sensor is additionally valuable for the blind stick [75].

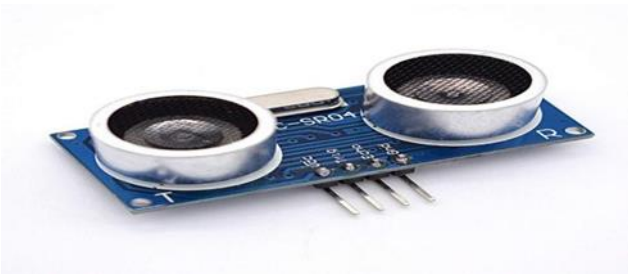

Fig. 6. Infrared Sensor

3.1.3. Water Sensors

Water sensors are integral in blind stick technology, enhancing safety and usability for visually impaired individuals, especially in adverse weather. They detect moisture levels on surfaces like sidewalks or floors, identifying wet areas caused by rain or spills. Upon detection, water sensors trigger feedback mechanisms, alerting users through haptic or auditory signals to prevent slips and falls. By providing real-time assistance in adverse weather, blind sticks equipped with water sensors enable independent navigation even in inclement conditions [76].

Fig. 7. Water Sensor

3.1.4. Accelerometer Sensor

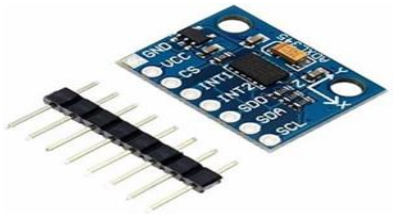

Fig. 8. Accelerometer Sensor

Accelerometer sensors play a pivotal role in enhancing navigation assistance for visually impaired individuals through blind stick technology. They detect motion and orientation by measuring acceleration forces acting on the stick, aiding in determining its movement and positioning. The data collected from accelerometer sensors is analyzed to interpret movement patterns, assisting in discerning the user's intended direction and speed. Utilizing this analysis, blind sticks provide feedback to users via haptic or auditory signals, signalling changes in direction, proximity to obstacles, or required path adjustments. By offering real-time feedback, accelerometer sensors empower visually impaired individuals to move securely and autonomously across different surroundings, including crowded spaces or unfamiliar terrain [77].

3.1.5. Haptic Feedback

Haptic feedback, an integral aspect of blind stick technology, aids visually impaired individuals in navigation assistance. It is triggered upon encountering obstacles, varying in intensity or pattern to alert users to their presence. Additionally, haptic feedback offers directional guidance, indicating changes in direction or the presence of pathways. Different vibration patterns convey information about terrain types, while user customisation allows for personalised feedback settings. Furthermore, haptic feedback serves as confirmation for executed actions, enhancing user interaction with the blind stick [78].

3.1.6. LiDAR

LiDAR, employing laser pulses for distance measurement, isn't typically integrated into blind sticks but holds the potential for aiding visually impaired individuals. LiDAR accurately detects obstacles, relaying data through haptic feedback, auditory cues, or vibration alerts on the stick for real-time obstacle avoidance. Detailed mapping of surroundings, including streets and landmarks, assists users in navigating unfamiliar environments confidently. LiDAR detects moving objects like pedestrians or vehicles, enabling the blind stick to alert users and adjust navigation to avoid collisions. LiDAR data enables dynamic navigation route generation, adapting to environmental changes such as construction zones, and providing alternative routes for safe passage. LiDAR extends to indoor navigation, facilitating guidance within complex environments like malls or airports, and aiding in locating specific points of interest [79].

3.1.7. Microcontroller

It comprises a compact integrated circuit housing a core processor, memory and i/o peripherals, and serves specific functions within electronic systems. In blind stick technology, microcontrollers play vital roles. Microcontrollers act as central processing units, interfacing with sensors like ultrasonic, infrared, or LiDAR to collect data. Microcontrollers analyse sensor data to interpret the environment, identifying obstacles and potential hazards. Microcontrollers generate feedback signals, conveyed through haptic, auditory, or visual cues, to alert users about detected obstacles. Microcontrollers regulate various components, such as motors and actuators, ensuring optimal performance and energy efficiency. Microcontrollers offer programmable flexibility, allowing developers to tailor blind sticks to user preferences and environmental conditions [80].

3.1.8. Buzzer

Fig. 9. Buzzer

A buzzer is a vital component in blind stick technology, offering auditory cues to aid visually impaired individuals in navigation. Buzzers alert users to obstacles by emitting sounds when encountered, providing proximity feedback. Varying tones or frequencies indicate different obstacle distances, enhancing spatial awareness. Buzzers offer directional cues, guiding users towards open pathways and away from obstacles. Audible cues confirm successful actions, ensuring user confidence during interaction. Distinct alarm sounds signal emergencies, attracting attention and facilitating assistance. Users can adjust volume, pitch, or patterns to suit personal preferences and needs. Buzzer modules are energy-efficient, optimizing battery life in blind stick devices [81].

3.1.9. GPS Module

Fig. 10. GPS Module

The GPS module is pivotal, providing advanced navigation aids for visually impaired individuals. It receives signals from satellites, updating the real-time location of the user. This data enables route planning, guiding users with turn-by-turn directions to their destinations. Auditory feedback is delivered, offering instructions, distances to landmarks, and intersection guidance, ensuring safe travel. GPS combines with other sensors for obstacle detection, issuing warnings and suggesting alternative paths. Location-based services grant access to nearby points of interest, public transportation, and emergency assistance, enhancing situational awareness. In emergencies, the GPS can send distress signals, ensuring prompt aid. Designed for efficiency, GPS modules conserve power, ensuring prolonged functionality. Customization options allow users to tailor settings to their preferences, enhancing usability and personalization [82].

3.1.10. GSM-GPRS Module

This module enables wireless connectivity for blind stick technology, enabling various functionalities. It allows blind sticks to communicate with remote servers or caregivers, updating them on the user's location and any encountered obstacles or hazards. Users can activate the module to send distress signals or request aid from predefined contacts or emergency services. Caregivers can remotely monitor the user's movements and receive alerts for unusual activity or deviations from the usual route. The module enables accurate location tracking, aiding users in navigation to specific destinations and assisting in locating them if needed. Blind sticks equipped with GSM GPRS modules can convert text messages into speech, facilitating communication for visually impaired users. Supporting voice commands and auditory feedback, the module ensures intuitive operation for users. It can log user movements, encountered obstacles, and environmental conditions, offering insights for further optimization of blind stick functionality [83].

Fig. 11. GSM-GPRS Module

3.1.11. Motor Driver

Motor drivers play a vital role in blind stick technology, it regulates the movement of retractable mechanisms and other motorized components. They enable adaptive features like retractable canes and sensors, ensuring optimal navigation. Motor drivers also control actuators for feedback, such as vibrators, enhancing user awareness of obstacles. They ensure smooth, precise movement, instilling confidence in navigation. Additionally, motor drivers optimize energy usage, prolong battery life, and offer customizable functionality for tailored user experiences [84].

3.1.12. Vibrator Motor

Vibration motors in blind sticks aid obstacle detection, distance perception, directional guidance, feedback confirmation, and emergency alerts through tactile vibrations. Users can customize vibration intensity and duration, and these motors are designed for low power consumption, extending battery life [85].

Fig. 12. Vibrator Motor

3.1.13. Raspberry Pi

It is a small single-board computer that finds extensive application across diverse fields. It is equipped with a camera module and programmed with computer vision algorithms, it facilitates real-time detection of obstacles and objects, providing users with immediate feedback on their surroundings. Raspberry Pi executes machine learning models adept at recognizing common obstacles or hazards encountered by visually impaired individuals, with the capability for continual refinement to enhance accuracy. Utilizing data from onboard sensors such as ultrasonic or infrared sensors, Raspberry Pi processes information to identify obstacles and measure distances, offering contextual insights to users. Integration with GPS modules enables Raspberry Pi to furnish navigation assistance, aiding blind individuals in route planning and destination guidance. Leveraging built-in audio capabilities or external speakers, Raspberry Pi delivers auditory feedback, comprising spoken instructions hereby enriching user interaction. Raspberry Pi supports diverse connectivity options like Wi-Fi and Bluetooth, facilitating communication between blind sticks and external devices or online services, and expanding functionality and utility [86].

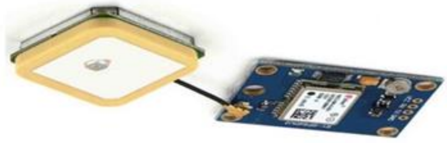

Fig. 13. Raspberry Pi

3.1.14. Arduino UNO

It is a widely used microcontroller board, it seamlessly integrates with an array of sensors including ultrasonic, infrared, and moisture sensors facilitate obstacle detection, terrain changes, and environmental conditions. Arduino UNO processes sensor data in real-time, analysing inputs to identify obstacles, measure distances, and evaluate terrain features, ensuring prompt feedback to the user. It facilitates diverse feedback mechanisms such as haptic vibrations, auditory alerts, or visual cues based on sensor readings, effectively notifying users of surrounding obstacles or alterations. Arduino UNO permits extensive customization of blind stick functionality, empowering developers to fine-tune parameters like sensitivity, feedback intensity, or navigation algorithms to meet specific user preferences and requirements. By controlling motorized components or actuators, Arduino UNO enables essential functions such as retractable mechanisms, obstacle avoidance, and directional guidance, optimizing user experience. With its energy-efficient design, Arduino UNO conserves power consumption, prolonging the blind stick's battery life and enhancing user dependability while minimizing recharging intervals. Moreover, Arduino UNO benefits from a vibrant open-source community, providing abundant resources, libraries, and tutorials, fostering rapid innovation and development in the realm of blind stick technology [87].

Fig. 14. Arduino

3.1.15. NodeMCU

NodeMCU, based on the ESP8266 Wi-Fi module, offers multifaceted functionalities for developers. It interfaces seamlessly with various sensors like ultrasonic, infrared, or moisture sensors, enabling comprehensive obstacle detection and environmental monitoring. Processing sensor data in real-time, NodeMCU swiftly

analyses inputs to provide instant feedback to users, crucial for safe navigation. Its Wi-Fi connectivity empowers blind sticks to communicate with other devices, enhancing functionality such as GPS navigation or remote assistance. Developers can customize features like sensitivity and feedback intensity, tailoring blind sticks to individual user needs. With efficient power management, NodeMCU extends the battery life of blind sticks, ensuring prolonged reliability. Its compatibility with Arduino IDE and Lua scripting expedites prototyping, facilitating swift iteration and testing. Offering a cost-effective solution, NodeMCU democratizes the development of blind stick technology, fostering innovation and accessibility. Supported by a vibrant open-source community, NodeMCU enthusiasts benefit from collaborative resources, libraries, and tutorials, enriching the blind stick development landscape [88].

Fig. 15. NodeMCU

3.1.16. Switch

Switches serve as essential components in blind stick technology, enhancing functionality and usability for visually impaired individuals. Initially, switches enable easy activation, granting users convenient control over the stick's operation. They also aid in mode selection, allowing toggling between different functionalities like obstacle detection or navigation assistance. Moreover, switches regulate feedback mechanisms, adjusting signals' intensity or frequency, such as vibrations or auditory cues. Sensitivity adjustment is facilitated by switches, customizing obstacle detection to suit various environments or user preferences. Additionally, switches can allocate to auxiliary functions like GPS navigation or emergency alerts, ensuring quick access. Their ergonomic design ensures optimal placement and ease of access, contributing to user comfort. Engineered for durability, switches withstand repeated use and environmental conditions, ensuring long-term reliability. As vital elements of the user interface, switches facilitate seamless interaction and control over the stick's functionalities. Lastly, designed with tactile or auditory cues, switches ensure accessibility, empowering visually impaired users to operate with confidence [89].

3.1.17. Battery

Batteries are vital for powering blind stick technology, supplying energy for its operation. Batteries are the primary power source, fuelling components like sensors, microcontrollers, motors, and feedback mechanisms. Battery-powered blind sticks offer mobility, allowing users to carry them conveniently for use in various environments. These batteries provide sufficient capacity for prolonged usage without frequent recharging, ensuring continuous assistance. Battery management systems optimize energy usage, prolonging operational time between recharges or replacements. Many blind sticks use rechargeable batteries, allowing users to replenish energy from wall outlets or portable chargers, reducing waste. Some sticks feature indicators or monitoring systems for real-time battery status, ensuring uninterrupted functionality. Batteries undergo selection for safety and reliability, with safeguards against hazards like overcharging or short circuits [90].

3.2. Traditional Blind Stick Features

For a long period, blind sticks played a crucial role in assisting individuals with visual impairments in mobility and navigation. Using it, the person can happily move around. Through this review, we can define some of the valuable features as given below.

3.2.1. Long and Lightweight Shaft

Traditional blind sticks are typically constructed from lightweight materials such as aluminium or fibreglass. The shaft is long enough to extend from the ground to approximately the waist height of the user. This length allows for effective sweeping motions to detect obstacles and changes in terrain.

3.2.2. Tapered or Rounded Tip

At the end of the shaft, traditional blind sticks feature a tapered or rounded tip. This tip is designed to glide smoothly across surfaces and detect variations in terrain, such as curbs, steps, or uneven ground. It is typically made of rubber or another durable material to provide traction and durability.

3.2.3. Grip Handle

Near the top of the stick, there is usually a grip handle designed for comfortable and secure holding. The handle may be ergonomically shaped to fit the user's hand and may feature grooves or texture to enhance grip, especially in wet or slippery conditions.

3.2.4. Contrasting Colour

Many traditional blind sticks are painted or coated in a contrasting colour, such as white or red, to increase visibility and ensure they are easily recognizable as mobility aids. This contrast helps other pedestrians and motorists identify individuals with visual impairments and provide appropriate assistance or accommodation.

3.2.5. Folding or Collapsible Design

Some traditional blind sticks feature a folding or collapsible design, allowing them to be easily stored and transported when not in use. This feature adds convenience for users who may need to carry the stick with them throughout the day.

3.2.6. Tactile Wrist Strap

A tactile wrist strap or loop is often attached to the handle of the blind stick. This strap allows users to secure the stick to their wrist, preventing accidental drops or loss while in use. It also offers a practical method for suspending the stick when it is not being used.

3.2.7. Symbol of Disability

In addition to their functional purpose, traditional blind sticks serve as symbols of disability and identification for individuals with visual impairments. Carrying a white cane signals to others that the individual may have difficulty seeing and may require assistance or accommodation.

While traditional blind sticks remain indispensable tools for many individuals with visual impairments, advancements in technology, such as digital blind sticks enhanced with sensors and artificial intelligence, are continually expanding the possibilities for improving mobility and independence in navigating the world.

3.3. The importance of blind sticks

Blind sticks, especially those enriched with artificial intelligence (AI) technologies and the latest technology, hold immense importance due to their potential to greatly influence the mobility, independence, and safety of individuals with visual impairments. Below are several key points highlighting the significance of blind sticks.

3.3.1. Enhanced Navigation Abilities

Blind sticks enhanced with AI technologies offer users advanced navigation functionalities, empowering them to detect obstacles, recognize pathways, and traverse intricate environments more confidently and effectively. This increased navigation capability can greatly enhance the autonomy of individuals with visual impairments, facilitating seamless navigation through unfamiliar surroundings.

3.3.2. Real-Time Feedback

While traditional white canes offer tactile feedback, they cannot provide real-time information about the surrounding environment. In contrast, blind sticks can leverage AI algorithms to offer immediate feedback using auditory or haptic cues, notifying users of obstacles and hazards as they navigate their surroundings. So, it will be an easy navigation for them.

3.3.3. Improved Safety

Utilizing AI-driven sensors and algorithms, blind sticks can swiftly identify obstacles and hazards, improving safety for individuals with visual impairments through the provision of real-time alerts. This proactive approach can effectively reduce the risk of accidents and collisions, especially in bustling or changing environments where conventional tactile feedback may fall short.

3.3.4. Personalization and Adaptation

AI technologies empower blind sticks to customize the navigation experience according to user preferences and behaviour. Through machine learning algorithms, the device can assimilate user interactions and adjust its functionality to meet individual requirements, delivering a personalized experience that improves usability and efficiency. AI will play a game-changer role in this field of study and research.

3.3.5. Accessibility and Inclusivity

Blind sticks signify a significant stride forward in accessibility technology, addressing the disparity between the capabilities of visually impaired individuals and the hurdles they encounter in navigating their surroundings. Through their enhanced navigation features, these devices foster inclusivity and autonomy for people with visual impairments.

3.3.6. Technological Innovation

The evolution of blind sticks exemplifies the capacity of AI and sensor technologies to tackle real-world obstacles and enhance the well-being of individuals with disabilities. By using technological advancement, these devices actively contribute to the continuous progress and exploration within the realm of assistive technologies. Sticks enhanced with AI technologies yield substantial advantages in navigation, safety, customization, accessibility, and technological advancement.

3.4. Limitations

There are several limitations in this review. Initially, the detection rate of potholes was minimal. Additionally, none of the studies accounted for traffic data beyond the immediate environment. When considering the implementation of traditional blind sticks, it's crucial to acknowledge their inherent limitations, as these can impact the ability to move freely and independently for individuals with visual impairments. Future research endeavors should integrate both pothole detection and comprehensive traffic data to enhance precision. Furthermore, inconsistencies were noted in defining and measuring relevant variables, as well as in the screening techniques and reference periods utilized between screening visits and questionnaire assessments across the studies. Understanding these constraints is essential for identifying suitable alternatives and offering enhanced support to the visually impaired community.

3.5. Analysis of learning

Analyzing the learning from a research paper on blind stick technology for visually impaired individuals involves several key aspects, which are described below:

3.5.1 Technological Innovation

Assess the level of innovation presented in the research paper. This includes the integration of advanced sensors, such as ultrasonic, infrared, or LiDAR, along with AI algorithms and machine learning models to enhance obstacle detection and navigation assistance.

3.5.2 Effectiveness of Solutions

Evaluate the effectiveness of the blind stick solution. Need to consider how well the technology addresses the needs of individuals with visual impairment in terms of mobility, safety, and independence.

3.5.3 Usability and Accessibility

Examine how user-friendly and accessible the blind stick technology is for visually impaired users. This includes factors such as ease of use, customization options, and the presence of accessible interfaces like auditory or haptic feedback.

3.5.4 Real-World Applications

Consider the practical applications of the blind stick technology proposed in the research paper. Assess its potential effect on the everyday experiences of individuals with visual impairments and its suitability for various environments, including both indoor and outdoor environments.

3.5.5 Evaluation of Results

Examine any experimental findings or user studies carried out to evaluate the efficacy of the technology employed in the blind stick. Analyse the results to ascertain the efficacy and dependability of the proposed solutions in practical situations.

3.5.6 Challenges and Limitations

Identify any challenges or limitations associated with the blind stick technology discussed in the research paper. This may include technical limitations, usability issues, or constraints related to cost and accessibility.

3.5.7 Future Directions

Explore potential avenues for future Research and Development based on the findings outlined in the research paper. This exploration could encompass avenues for enhancement, including refining sensor precision, streamlining algorithms, investigating emerging technologies for better enhancement and diminishing overall costs to propel the evolution of blind stick technology for individuals with visual impairments.

4. Literature Survey

A Literature Survey has been given based on the major parameters.

Table 3. Literature Survey

Author and Reference	Practical Insights	Technology Used	Limitations
A. Anwar et. al. [16]	Keep alarming on dangerous thing, GPS for navigation, Obstacle detection efficiently up to 2 meter	Ultrasonic Sensor, Infrared Sensor, Water Sensor, Heat Sensor, Light Dependent Resistor (LDR), Microcontroller, Buzzer, Vibrator	No pot hole detection accurately

M. M. Kamal et al. [17]	Object Detection, Surface smoothness detection, Taking, sending and processing images	Embedded microcontroller LPC1768, LinkSprite JPEG Color Camera, Bluetooth Module RN-42-I/RM, Microcontroller PIC12F683, LV MaxSonar EZ0, Mini Vibration Motor	Multiple device carry for better performance.
M. P. Agrawal et al. [18]	Object detection like pebbles, pitc, rocks etc…, water detection, location tracing, panic button for emergency, traffic detector	Moisture and Ultrasonic Sensor, GPS-GSM Module, Radio Frequency (RF) Module, Microcontroller, Battery, Buzzer	battery life, accuracy of obstacle detection, or reliability in various environmental conditions
Z. M. Yusof et al. [19]	Front hole, low and high height hole detection, obstacle detection, pit hole detection	Ultrasonic Low Sensor-100.285 cm, Ultrasonic High Sensor-596.632 cm, Laser Sensor, Microcontroller, Buzzer, Vibrator, motor driver (L293D)	GPS based navigation system and GSM based sms alerting system in emergency
N. Sahoo, et al. [21]	Obstacle detection in conical shape up to 45 degree, Realtime location, helpful in panic situation, Height detection with different sensors	Obstacle detecting/Hybrid ETAs, Raspberry Pi, Arduino, BeagleBone, and PCDuino, GPS, PIC Microcontroller, Ultrasonic Sensor, Vibration Motor, Buzzer and Power supply	Dangerous situation avoidance
M.M. Billah, et al. [22]	Lower height/distance and higher height/distance detection, Hole detection in night and day	Ultrasonic Sensor, Vibration motor, Power bank, 9V battery, Laser sensor, Buzzer, Motor Driver, Genuino UNO, Laser Sensor	Unable to discern the height of obstacles, identify frontal gaps, or distinguish between day and night.
Lim Tim Choong et al. [23]	Object detection is more than 70%,	Raspberry Pi 3 B+ Model, Motor driver, Earphone, GPS, 5V/2.1A	Time response for each functionality is little bit low , Auto navigation for destination
S. Budilaksono et al. [24]	Detect the presence of obstacle, detect the presence of water, anti-theft	Ultrasonic Sensor, Rain Sensor, IR Sensor, LCD, GSM, Buzzer, Speaker, Panic	Charging is required for functioning, Pit hole detection is

	protection, detect light or darkness in the room	Switch, Arduino UNO,	not there, traffic control
V. Kunta et al. [25]	Detect obstacles of diverse shapes and sizes, provide vibratory alerts for wet surfaces, incorporate a GPS locator, and enable SMS notifications.	Ultrasonic, Infrared and Soil Moisture Sensor, RF Module, GSM-GPS Module, Buzzer and Vibration Motor, Push Button, Speaker, Microcontroller, Switch, Power Supply	Costly, Ineffective and unreliable, Offering limited features and usability
R. Bhavani et al. [26]	Detect various size obstacles	Ultrasonic Sensor Module, Water Circuit, Atmega 328 Microcontroller, RF Module, Buzzer and Vibrator, Arduino UNO	GPS, SMS is not included, pit hole detection is not there
M. H. Mahmud et al. [28]	The system is capable of recognizing obstacles and gaps, detecting damp, muddy, or slippery terrain, and delivering GPS-based voice guidance.	Microcontroller PIC 16F877A, Sonar Sensors, GH-311 Ultrasonic Sensor	GH-311 sensor is too small to reflect enough sound back to the sensor.
Amjed S. Al-Fahoum et al. [35]	It can scan areas to the left-right and in front of the blind person, regardless of variations in depth or height.	Microcontroller PIC 16F877A,	Amjed S. Al-Fahoum et al. [35]
U. K. Alam et al. [42]	Obstacle detection and GPS positioning.	The GPS antenna and module, electromechanical buzzer, IR sensor and battery, Arduino UNO	Obstacles detection zone is very small, GPS gives different-different values for the same location.
Anuj Parikh et al. [46]	Obstacle Detection (3cm-4m), Pothole Detection	Ultrasonic Sensor, Microcontroller, Buzzer, Battery, Motor, PIC 16F877A, Accelerometer Sensor	The stick needs to be on the pothole for detection of the pothole accurately.

Ch Sudhakar et al. [54]	Obstacle detection efficiently in range of 2cm-120cm, Low outline time, Low power consumption, Voice recognition	Ultrasonic Sensor, SD Card, Battery, Arduino Microcontroller, Headphones	Water sensor and pit hole detection can be improved.
Hussein Abdel-Jaber et al. [55]	Obstacle detection, GPS location, SMS service	IoT, Ultrasonic Sensor, GPS, Arduino	Dangerous obstacle detection, Voice assistant
Gopisetty Ramesh et al. [56]	A voice alert system for obstacles, emergency positioning, low energy usage, and a resilient navigation solution with a noticeable quick response time.	ATMEGA328P, Node-MCU, ultrasonic sensor, IoT blynk cloud, SMS and GPS	No pit hole detection, No traffic control detection, No moisture detection
Sangam Malla et al. [57]	Detects obstacles and moisture,	Ultrasonic Sensor, Infrared Sensor, Arduino UNO R3, Light Sensor, Moisture Sensor, RF transmitter and receiver, Water sensor (Robodo REL_35)	Voice assistant, GPS and SMS, Pit hole detection
Akhilesh Krishnan et al. [58]	Identifying direction, detecting obstacles, recognizing paths, and navigating using GPS and Maps.	Assistor, Echolocation, Image Sensor, Ultrasonic Sensor, Microprocessor and Bluetooth Module	Charging, Object recognition, dynamic image recognition
Muhammad Sulaman et al. [59]	Face recognition and object recognition	Raspbian, Ultrasonic Sensor, dlib library, Raspberry Pi3,	Obstacle detection upto 60cm, GPS Location, Emergency button, air quality monitoring

A S Romadhon et al. [64]	Object detection in range of 200 cm, Wet surface detection, SMS, Location tracking	Ultrasonic Sensor HC-SR04, GPS UBLOX NEO-6M, Module SIM8001, Pulse Heart Sensor, GSM SIM800L Module, MP3 Module, Emergency Button, Water Sensor	Connecting the NEO-6M GPS module to a satellite typically takes approximately 5 minutes, while the stability of a pulse heart sensor is relatively lower. Sending an SMS typically requires between 6 to 10 seconds.
Masayuki Murata et al. [69]	Minimize localization error, Better navigation, Continuous user location monitor, Sensory information, Identify initial pose for starting track	Particle Filter, Motion model, Observation model, Initial pose estimation, Localization integration monitoring, Adaptive Signal Calibration, Probability motion state detection, Floor Transition Control, Time sensitive observation modelling	The classification of the user's motion state is inaccurate when the user walks at much slow pace or steps onto soft flooring.
ZhAng Dian et al. [70]	Indoor precise localization	RFID, RSSI, SA-LANDMARC algorithm, Maximal dynamic algorithm, Intersection algorithm, RSSI Vector Euclidean distance Algorithm, COCKTAIL Algorithm	Time interval of RFID tags, Latency
Charalampos Tsirmpas et al. [72]	Localization of the user and self-navigation	Bluetooth, UWB, Wi-Fi, or RFID (RFID), along with Dead Reckoning, are technologies used for various tracking and communication purposes.	Betterment required for outdoor environment, positioning accuracy

Alejandro Santos Martinez-Sala et al. [73]	Locating the user and guide them to reach destination with high accuracy due to UWB positioning.	SUGAR System, UWB Sensors, Server, UWB Tag,	Works efficiently in indoor environment only

5. Conclusion

This paper examining a range of recent methodologies, experiments and research endeavors in this domain. Our analysis identifies several potential improvements, including the utilization of Raspberry Pi for real-time object detection via machine learning, the implementation of a single ultrasonic sensor on a servo motor for comprehensive sensing, and the integration of Arduino Uno with GPS and GSM functionalities. Moreover, we propose replacing traditional buzzers with voice module playback, featuring pre-recorded messages for object detection alerts. By harnessing deep learning algorithms, these smart devices can promptly recognize and categorize environmental objects and obstacles, thereby aiding users in navigation and obstacle avoidance. CNNs and RNNs undergo training on vast datasets comprising images and sensor data to recognize patterns and features pertinent to various objects and environmental contexts. Once trained, these models can be deployed on the smart blind stick device to process inputs from onboard sensors, such as cameras and ultrasonic sensors, and furnish users with pertinent feedback. The rate of decrease in avoidable vision impairment isn't keeping up with the rapid demographic shifts in the global population, warranting greater attention to this issue than it has received thus far.

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Conflicts of interest

The authors declare no conflicts of interest.

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