A Complete Study on Wearable Smart System for Visually Impaired People

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Abstract. Vision loss significantly influences both machine vision and spatial cognition. Blind individuals face several challenges in their jobs, schools, and even during ordinary outdoor walking due to their visual impairments. In recent years, there has been a lot of attention given to the visual impairments of blind individuals. Wearable gadgets can be utilized to assist these visually challenged people. With the advancement of electronic technology, the use of wearable gadgets has increased. Wearable technologies provide information about the surroundings and help blind people navigate with minimal effort. Based on voice recognition, the primary control chip collaborates with multiple functional modules to perform traffic signal recognition, obstacle avoidance, and navigation capabilities. At the same time, WiFi and GSM (Global System for Mobile Communication) modules will be used instead of Bluetooth to reduce reliance on smartphones.

Keywords: IoT, machine learning, cloud computing, visually impaired, obstacle avoidance, object recognition, navigation, wearable gadgets, assistive technology.

1 Introduction

According to the World Health Organization (WHO), there were 285 million Visually Impaired Persons (VIPs) worldwide in 2012, with 246 million having poor vision and 39 million being blind. 90% of blind people reside in developing nations. Worldwide, on average, 3.4 persons have low vision. Research has calculated the proportion of blindness and visual impairment in the Indian population, revealing that more than one-fourth of persons aged 50 and over in India are visually impaired, with the percentage of blindness reaching 1.99%.

The study found that females had a higher frequency than men, while individuals living in rural areas had a higher incidence of blindness than those living in urban areas. The study also found that illiterate people had roughly six times the risk of going blind than educated ones. The reasons for visual impairment can be due to age, gender, and geography. Visual impairment may create difficulty with typical everyday tasks such as reading and walking.

In the absence of treatments such as correctable eyeglasses, assistive devices, and medical treatment are widely used by VIPs. The Internet of Things (IoT) integrated with machine learning (ML) and cloud computing helps in building these assistive devices. Wearable gadgets such as white canes, glasses, gloves, and shoes are also used as outdoor walking solutions for the blind. Obstacle detection, object recognition, navigation, or calling for help encountered by the blind while walking outdoors can be made possible by using wearable gadgets.

A system with various characteristics that allows VIPs to move safely and independently while maintaining communication with their relatives and caregivers, who can follow their location. The system uses sensors to identify objects at a distance in front of the user, to inform the user's family and caregivers when the user trips, and to alert the user's family, caregivers, and surrounding persons when the user needs assistance.

1.1 Problem Definition

According to the literature reviewed, numerous researchers worldwide have made significant efforts towards developing wearable smart systems for visually impaired individuals. This study aims to identify the key IoT characteristics in wearable smart systems, explore the different applications of these systems, and review the state-of-the-art methodologies offered by wearable smart systems that could be leveraged for decision-making by visually impaired individuals. The proposed study organizes and analyzes the existing research work based on the defined research objectives and selected keywords for the search process. By reviewing the current research in this field, this study aims to provide visually impaired individuals and their caregivers with reliable information that can help them make more informed decisions, ultimately leading to greater freedom of movement and improved navigation capabilities

1.2 Research Contribution

This analysis of the existing research work will assist visually impaired people and their guardians in making more authentic judgements, which will eventually assist in using the study as evidence for walking freely and navigating correctly.

RQ1) What is the Role of IoT in the wearable gadget for the visually impaired

RQ2) What is the Role of cloud computing in making wearable devices for visually challenged individuals?

RQ3) What is the Role of machine learning in the wearable gadget for the visually impaired

RQ4) State-of-the-art techniques developed in the wearable smart system for visually impaired persons from 2015-2022?

2 Related Work

The related work is mentioned below for around 30 papers and also Table 1 describes the research gap for the same 30 papers.

Xia et al. developed a wearable smart system, called IBGS, to assist visually challenged individuals. The system uses computer vision algorithms to detect obstacles and recognize text and provides haptic feedback to the user through vibration motors. The authors evaluated their system's performance in detecting obstacles and reading text and compared it with existing assistive devices.

Singh et al. proposed an end-to-end Indian paper currency recognition framework (IPCRF) for blind and visually impaired people. The authors used a deep convolutional neural network

(CNN) to recognize Indian currency notes, which are often challenging to recognize due to their intricate design and texture. The authors evaluated the performance of their system on a dataset of real currency notes and compared it with existing currency recognition systems.

Lei et al. conducted a survey on pedestrian lane detection algorithms for assistive navigation of vision-impaired people. The authors reviewed various lane detection algorithms and evaluated their performance on different datasets. They also proposed an adaptive lane detection algorithm that uses a combination of edge detection and line fitting techniques and evaluated its performance on a dataset of real-world scenarios.

Ashiq et al. proposed a CNN-based object recognition and tracking system to assist visually impaired people. The authors used a pre-trained CNN to detect and recognize objects in real-time and tracked their movement using a Kalman filter. The authors evaluated their system's performance on a dataset of real-world scenarios and compared it with existing object recognition systems.

Aher et al. proposed a real-time dynamic obstacle detection system for visually impaired persons. The authors used a depth sensor and a camera to detect obstacles in the user's path and provided haptic feedback to the user through a vibrating motor. The authors evaluated their system's performance on a dataset of real-world scenarios and compared it with existing obstacle detection systems.

Yogesh conducted a comprehensive survey on smart sticks for visually impaired people. The author reviewed various smart stick designs and their components, such as obstacle detection sensors, GPS modules, and voice assistants. The author also discussed the challenges and limitations of existing smart stick designs and proposed future research directions.

Apprey et al. designed and implemented a solar-powered navigation technology for visually impaired people. The authors used a combination of GPS and inertial measurement sensors to provide navigation assistance to the user. The authors evaluated their system's performance on a dataset of real-world scenarios and compared it with existing navigation systems.

Suman et al. proposed a vision navigator system for smart and intelligent obstacle recognition for visually impaired users. The authors used a combination of object detection algorithms and machine learning techniques to recognize obstacles and provide haptic feedback to the user through a vibrating motor. The authors evaluated their system's performance on a dataset of real-world scenarios and compared it with existing obstacle detection systems.

Hussan et al. proposed an object detection and recognition system in real-time using deep learning for visually impaired people. The authors used a YOLOv3 object detection algorithm to recognize objects in real-time, and provided audio feedback to the user through a speaker. The authors evaluated their system's performance on a dataset of real-world scenarios and compared it with existing object recognition systems.

Deshmukh et al. proposed a shopping assistant and navigation system for visually impaired people, called SANIP. The authors used a combination of RFID tags and Bluetooth beacons to provide navigation assistance to the user in a shopping mall. The authors also developed a mobile application that provides voice-based instructions and information about the user's location.

Dhage et al. propose a visually assisted stick for people with visual impairment based on the Internet of Things (IoT). The stick incorporates various sensors, including ultrasonic and infrared sensors, to detect obstacles and communicate the information to the user through auditory feedback.

Ramesh et al. present an E-stick designed for people with visual impairment using IoT technology. The E-stick incorporates ultrasonic sensors and GPS to detect obstacles and provide location information to the user through a mobile application.

Abdul-Ameer et al. develop smart eyeglasses for people with visual impairment based on the You Only Look Once (YOLO) algorithm. The glasses incorporate a camera and microcontroller to detect objects and provide auditory feedback to the user.

Pardeshia and Yannawar propose using an Optimized Convolutional Neural Network (OCNN) for object detection. The authors claim that OCNN can improve the accuracy and speed of object detection compared to other algorithms.

Busaeed et al. introduce LidSonic V2.0, an assistive edge device that enhances mobility for people with visual impairment using LiDAR and deep learning technologies. The device uses a small, wearable sensor that detects obstacles and communicates the information to the user through auditory feedback.

Busaeed et al. also present LidSonic for visually impaired individuals, which is a pair of smart glasses that incorporates machine learning algorithms and an Arduino microcontroller to detect obstacles and provide auditory feedback to the user.

Salem et al. propose a non-invasive data acquisition and IoT solution for monitoring human vital signs. Although the paper does not focus on visual impairment, the authors suggest that the technology could be used to monitor the health of people with visual impairment.

Hudec and Smutny develop an ambient intelligence system that allows people with visual impairment to develop and control electrotechnical components. The system includes a wearable device that communicates with a smartphone application to provide auditory feedback.

Rajendran et al. introduces a cognitive IoT vision system that uses a weighted guided Harris corner feature detector to assist people with visual impairment. The system incorporates a camera and microcontroller that detect objects and provide auditory feedback to the user.

Tanabe et al. propose a training system for the white cane technique that uses illusory pulling cues induced by asymmetric vibrations. Although the paper does not focus on IoT or machine learning, the authors suggest that the training system could be integrated with IoT devices to provide additional feedback to the user.

Farooq et al. (2022) developed an IoT-enabled intelligent stick that uses ultrasonic sensors to detect obstacles in the path of visually impaired people. The system is equipped with a camera that captures images of the obstacles and sends them to a remote server for processing using machine learning algorithms. The system then provides real-time feedback to the user through an audio-based interface.

Dhou et al. (2022) developed an IoT-based mobile sensors unit for visually impaired people that uses machine learning algorithms to identify and classify obstacles. The system uses a combination of sensors, including ultrasonic sensors, cameras, and gyroscopes, to provide a more accurate and reliable detection system. The system provides real-time feedback to the user through a mobile app.

Durgadevi et al. (2022) developed an IoT-based assistive system for visually impaired and aged people. The system uses a combination of sensors, including ultrasonic sensors, to detect obstacles and provide real-time feedback to the user through a mobile app. The system also includes a fall detection mechanism that alerts caregivers in case of a fall.

Hu et al. (2022) developed a wearable target location system called StereoPilot that uses spatial audio rendering to provide real-time feedback to the user about the location of obstacles. The system uses a combination of sensors, including a camera and a microphone array, to provide a more accurate and reliable detection system.

Chang et al. (2020) developed an artificial intelligence edge computing-based assistive system for visually impaired pedestrian safety at zebra crossings. The system uses a combination of sensors, including cameras and depth sensors, to detect pedestrians and vehicles and provide real-time feedback to the user through a mobile app.

Hsieh et al. (2021) developed a CNN-based wearable assistive system for visually impaired people walking outdoors. The system uses a combination of sensors, including cameras and gyroscopes, to detect obstacles and provide real-time feedback to the user through a mobile app.

Chang et al. (2020) developed an intelligent assistive system for visually impaired people for aerial obstacle avoidance and fall detection. The system uses a combination of sensors, including a camera and an accelerometer, to detect obstacles and falls and provide real-time feedback to the user through a mobile app.

Jiang et al. (2018) developed a wearable vision assistance system based on binocular sensors for visually impaired users. The system uses a combination of cameras and depth sensors to detect obstacles and provide real-time feedback to the user through a haptic interface.

Sun et al. (2019) developed an obstacle detection and navigation system for mobile users through their mobile service. The system uses a combination of sensors, including a camera and a gyroscope, to detect obstacles and provide real-time feedback to the user through a mobile app.

Kanwal et al. (2015) developed a navigation system for the visually impaired that uses a combination of vision and depth sensors to detect obstacles and provide real-time feedback to the user through a haptic interface.

Sabry et al. (2022) reviewed the use of machine learning in healthcare wearable devices. The authors discussed various machine learning algorithms used in wearable devices for health monitoring, disease diagnosis, and treatment. They also highlighted the potential of machine learning in improving the accuracy and reliability of wearable devices.

Table 1. Representation of the work done in the area of the wearable smart system for VIPs from the year 2015-2022

Citation	Author Name	Research Gap
[1]	Xia, K., Li, X., Liu, H., Zhou, M. and Zhu, K.	Lack of assessment with visually impaired persons: Although the study explains the system design and execution, it does not include any experimental data or evaluation with visually impaired individuals to establish its efficacy and usability. The system depends on a pre-trained object identification model to recognise barriers and other objects, which may not be appropriate for all sorts of surroundings or obstacles. A more robust and adaptive method to object detection might improve the system's capacity to recognise a broader range of items and barriers.
[2]	Singh, M., Chauhan, J., Kanroo, M.S., Verma, S. and Goyal, P.,	Limited research on paper currency recognition specifically designed for Indian currency notes: Although methods for recognising cash exist, they are not intended especially for Indian currency notes. The study presents an end-to-end methodology for recognising Indian paper money, filling a substantial research vacuum in the literature. Lack of study on end-to-end solutions for visually challenged monetary recognition: Although several research has explored solutions for visually impaired people to recognise currencies, they frequently rely on third-party software or hardware. The suggested IPCRF architecture provides an end-to-end solution for visually challenged Indian paper money recognition, which can assist bridge this research gap.
[3]	Lei, Y., Phung, S.L., Bouzerdoum, A., Le, H.T. and Luu, K.,	There has been little study on pedestrian lane detection, particularly for assisted navigation of vision-impaired persons, with the majority of previous studies focused on generic pedestrian detection and tracking. There is a lack of rigorous assessment of existing pedestrian lane identification technologies in terms of performance and applicability for assisted navigation of individuals with low vision.

[4]	Ashiq, F., Asif, M., Ahmad, M.B., Zafar, S., Masood, K., Mahmood, T., Mahmood, M.T. and Lee,	Inadequate assessment on a bigger dataset: The authors examined their system on a relatively limited dataset, which may not offer an accurate picture of its performance. To examine the system's generalisation capabilities, it would be useful to evaluate it on a bigger and more diverse dataset. The suggested system was assessed in a controlled environment, and its performance may not be directly applicable in real-world circumstances, where illumination and environmental variables may vary dramatically. More study is required to assess the system's performance in real-world circumstances.
[5]	Aher, T.H., Karvande, G., Aher, T.U., Jadhav, A. and Gumaste, S.V.	The GPS locator could have been introduced and also the model doesn't run in darkness.
[6]	Yogesh, S.	A detailed assessment on the usage of smart sticks for visually impaired individuals in literature is lacking. Inadequate review and comparison of existing smart stick options for visually challenged persons in terms of efficacy, usability, and affordability.
[7]	Apprey, M.W., Agbevanu, K.T., Gasper, G.K. and Akoi, P.O.,	Inadequate assessment: While the article describes the design and deployment of solar-powered navigation system in depth, there is no complete evaluation of its performance and efficacy. Future research might include user tests to assess the system's usefulness and satisfaction in real-world circumstances. Limited scalability: The paper's solar-powered navigation system is built for a specific setting and may not be scalable to other conditions or scenarios. Future study might look into methods to make the system more adaptive and scalable to various contexts and user requirements.
[8]	Suman, S., Mishra, S., Sahoo, K.S. and Nayyar, A.	There is a lack of a comprehensive obstacle detection and identification system for visually impaired users that includes several sensors and machine learning approaches. The requirement for a real-time obstacle detection and identification system that is low-cost, energy-efficient, and readily incorporated into a wearable device for the convenience of visually impaired users.
[9]	Hussan, M.T., Saidulu, D., Anitha, P.T., Manikandan, A. and Naresh, P.,	There is a scarcity of deep learning-based real-time object detection and recognition systems for visually impaired persons. The accuracy and speed of present object detection and identification systems for visually impaired persons must be improved in order to increase their freedom and safety.
[10]	Deshmukh, S., Fernandes, F., Chavan, A., Ahire,	It can be implemented on an application using TensorFlow models.

	M., Borse, D. and Madake, J.,	
[11]	Dhage, A., Wadekar, S., Shinde, N. and Kale, M.S	GSM could have been installed in the system.
[12]	Ramesh, G., Mustare, N.B. and Kumar, K.U.C.P.,	The study is primarily concerned with the design and implementation of an E-stick for visually impaired people utilising IoT. However, the study does not go into detail on the design issues, limits, or performance evaluation of the system. Future study might look at these elements to have a better understanding of the system's efficacy and usefulness. The study does not compare the proposed system to other current systems, making it difficult for readers to comprehend the system's potential contribution and benefits over other systems. A comparison study with other similar systems can help researchers and designers discover the system's strengths and flaws and enhance the system's performance accordingly.
[13]	Abdul-Ameer, H.S., Hassan, H.J. and Abdullah, S.H	Lack of evaluation: While the paper describes the creation of a smart eyewear system for visually challenged persons, there is no assessment of the system's performance and usability with end users. The paper employs the YOLO technique for object detection, although there is no comparison to other object detection systems. It will be fascinating to observe how the system compares to other cutting-edge object identification methods.
[14]	Pardeshia, S. and Yannawar, P.,	Can be used for multiple object detection in an unconstrained environment.
[15]	Busaeed, S., Katib, I., Albeshri, A., Corchado, J.M., Yigitcanlar, T. and Mehmood, R	Inadequate examination of the system's performance in real-world settings with varying illumination and obstacle densities. There has been little investigation on the device's usage and acceptance by visually impaired users and their carers in everyday life.
[16]	Busaeed, S., Mehmood, R., Katib, I. and Corchado, J.M.,	The research focuses primarily on the design and implementation of smart glasses for the visually challenged, although there is no practical testing of the proposed system in real-world circumstances. The use of machine learning techniques is mentioned in the study, but no information on the specific methods employed, their performance, or how they were taught are provided. More details on the machine learning part of the proposed solution might boost its credibility.
[17]	Salem, M., Elkaseer, A., El-Maddah, I.A., Youssef, K.Y., Scholz, S.G. and Mohamed, H.K.	There is no discussion of how the suggested non-invasive data collecting and IoT system may be customised to address the specific demands and problems of visually impaired people. The report makes no mention of the accessibility challenges that visually impaired people may have

		while utilising IoT solutions, such as the necessity for audio-based feedback and voice control.
[18]	Hudec, M. and Smutny, Z.	The study focuses on the creation of an ambient intelligence system enabling blind people to learn about and construct electrotechnical components and drivers. However, there is no information in the research about how this system is accepted and used by visually impaired people. As a result, more study is needed to understand the system's effectiveness and usability in real-world contexts. The study concentrates on the technical features of the ambient intelligence system but does not go into great detail about the system's human-computer interface. As a result, there is a knowledge gap in knowing how visually impaired people engage with the system and their experiences with it.
[19]	Rajendran, M., Stephan, P., Stephan, T., Agarwal, S. and Kim, H.	The authors have not specifically explored or compared the suggested vision system's performance in real-world circumstances. The authors did not explore the ethical implications or privacy problems of using IoT devices and computer vision technologies for visually impaired people.
[20]	Tanabe, T., Nunokawa, K., Doi, K. and Ino, S.	The research focuses on teaching people how to utilise a white cane using false pulling cues caused by asymmetric vibrations. It is unknown, however, if this training approach is more effective than traditional methods such as physical direction from an instructor or input from a cane with built-in sensors. The research solely evaluates the training system's efficacy in a laboratory context. Further study might look at the system's real-world usefulness and how it could be integrated into existing white cane training programmes.
[21]	Farooq, M.S., Shafi, I., Khan, H., Díez, I.D.L.T., Breñosa, J., Espinosa, J.C.M. and Ashraf, I.	The research focuses on obstacle detection for visually impaired persons, however it does not include a full review of the suggested system's accuracy and efficacy in real-world circumstances. The report makes no comparisons between the proposed system and current systems in terms of performance, cost-effectiveness, and usability, which might give helpful insights for future research and development in this field.
[22]	Dhou, S., Alnabulsi, A., Al-Ali, A.R., Arshi, M., Darwish, F., Almaazmi, S. and Al-ameeri, R.	The lack of a comparison investigation of the suggested mobile sensors unit with other current solutions for visually impaired persons limits the paper's utility in identifying the benefits and shortcomings of the proposed strategy. The research does not include a full evaluation of the accuracy and efficacy of the machine learning-based algorithms utilised in the proposed system, raising concerns about the solution's dependability and feasibility.

[23]	Durgadevi, S., Komathi, C., Thirupurusundari, K., Haresh, S.S. and Harishanker, A.K.R.	The report fails to address the existing research deficit in the field of assistive technology for the visually impaired and the elderly. The suggested IoT-based assistive system and its usefulness in enhancing the quality of life of the targeted population are not empirically evaluated in the article.
[24]	Hu, X., Song, A., Wei, Z. and Zeng, H.	While StereoPilot uses spatial audio rendering to assist visually impaired persons in locating and navigating towards locations, its performance in real-world circumstances with bigger sample numbers is needed to demonstrate its potential advantages. The study analyses the constraints of relying just on auditory cues for navigation and proposes using additional sensory modalities to increase system accuracy and user enjoyment. However, the practicality and impact of such a multimodal strategy in real-world settings require additional investigation.
[25]	Chang, W.J., Chen, L.B., Sie, C.Y. and Yang, C.H.	Lack of emphasis on pedestrian safety: The document exclusively addresses the safety problems of visually impaired pedestrians during zebra crossings, rather than other sorts of pedestrian crossings. confined assessment: The suggested system's evaluation is confined to a small number of visually challenged participants and experiments, limiting the generalizability of the results.
[26]	Hsieh, I., Cheng, H.C., Ke, H.H., Chen, H.C. and Wang, W.J.	A full examination of the suggested system's performance, including accuracy, precision, and recall rates, is missing from the research. The study did not compare the suggested system's performance to that of other cutting-edge assistive devices for visually impaired persons going outside.
[27]	Chang, W.J., Chen, L.B., Chen, M.C., Su, J.P., Sie, C.Y. and Yang, C.H.	The study focuses on the design and implementation of an intelligent assistive system for visually impaired persons to avoid airborne obstacles and detect falls. However, evaluation of the system's performance and effectiveness is limited, and further research is needed to confirm its efficacy. The study makes no mention of the system's cost or suitability for real-world application. It is critical to assess the system's practicality in terms of cost, use, and acceptability by visually impaired people.
[28]	Jiang, B., Yang, J., Lv, Z. and Song, H.	The work focuses mostly on interior conditions, and there has been little investigation into the implementation of the suggested wearable visual aid system in outdoor settings. More research is needed to assess the system's performance in various situations. The influence of the device's form factor on user comfort and wearability was not considered in the article, which might restrict the device's adoption among visually impaired users. Future study might look into

		how to make the gadget more user-friendly and less obtrusive.
[29]	Sun, M., Ding, P., Song, J., Song, M. and Wang, L.	The study solely addresses obstacle detection and navigation for mobile users via their mobile service, but not the needs of visually impaired persons. There is no discussion of the suggested solution's limits or the difficulties in adopting it in real-world circumstances.
[30]	Kanwal, N., Bostanci, E., Currie, K. and Clark, A.F.	The research is primarily concerned with the creation of a navigation system based on vision and depth sensors. However, there has been no examination of the system's usability and efficacy in real-world circumstances with visually impaired people. The study's navigation system provides information to the user through a head-mounted display, however the influence of wearing a head-mounted display on the user's mobility and comfort is not explored.

2.1 Research Definition

The primary purpose of the study is to undertake a thorough examination of the literature on wearable smart devices for visually challenged persons that are already available. In-depth understanding involves researching wearable smart systems. The extensive literature evaluation used in this work aims to assist visually challenged persons in detecting objects, obstacles, and traffic signals, as well as navigating securely to their destination. The current system uses WiFi, but it may be modified to include a module that can function without WiFi.

2.2 Study Selection

The papers were selected based on the domain – IoT and some search keys like- cloud computing, handicapped aids, wearable assistive technology, obstacle detection, and visually impaired persons.

Total papers identified based on the search key =135

Inclusion criteria = 54

1. papers with good content to the specific domain
2. papers offer knowledge of the research questions
3. articles are chosen from the year 2015-2022
4. articles which are written in the English language

Exclusion criteria =80

1. Some studies were irrelevant to the subject
2. Some studies were incomplete
3. Some studies were on surveys and conference papers.
4. Some studies were in other languages.

2.3 Study Selection Process

Fig. 1 shows the count of papers selected against the year and the 2022 papers are widely selected for the literature review.

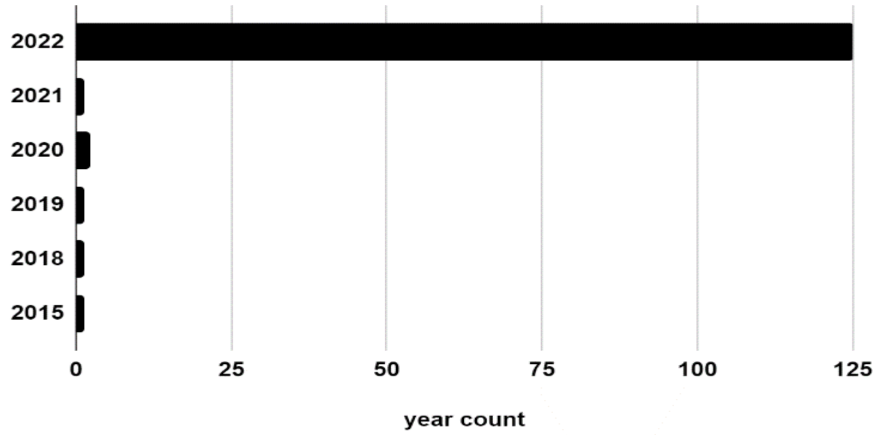

Fig. 1. Count of selected papers against the year in which they are published.

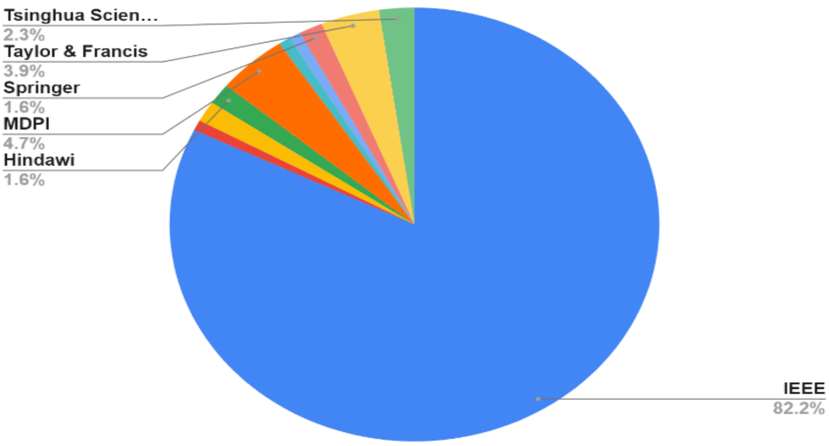

Fig. 2. The percentage of publishers selected

As shown in Fig. 2 82% of IEEE-published papers are selected and other publishers are less than this for literature review.

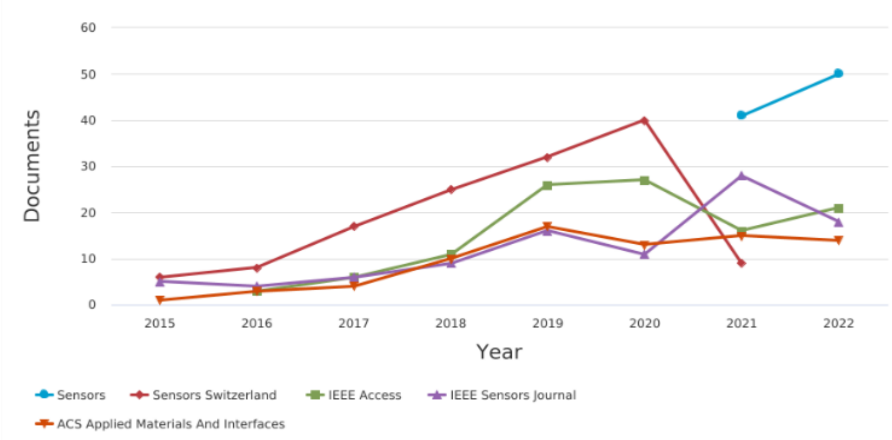

Fig. 3. Document per year by source

As shown in Fig. 3, sensors Switzerland has published a lot of papers until 2020 whereas IEEE Access has continued publishing papers has been consistent on this topic (wearable smart systems for visually impaired people).

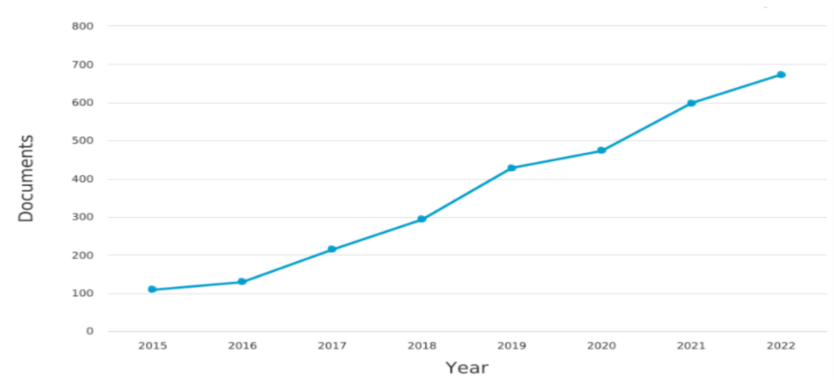

Fig. 4. Document by year

As shown in Fig. 4, in the year 2022 nearly 700 papers are published on this topic.

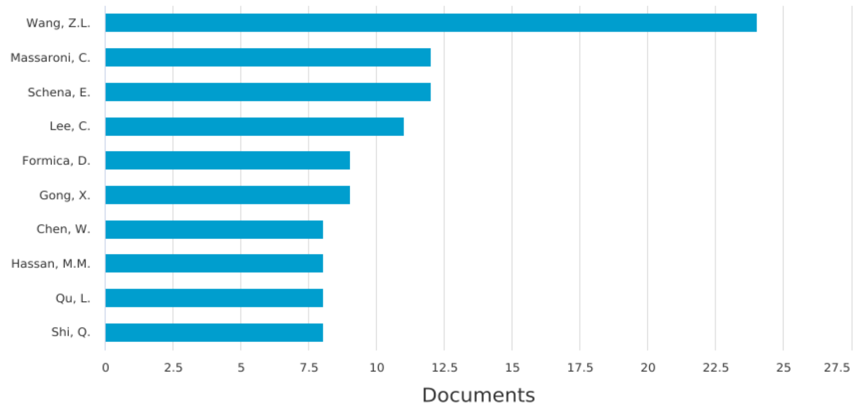

Fig. 5. Document by the author

As shown in Fig. 5, the author Wang, Z.L. has published nearly 24 papers this year on this particular title.

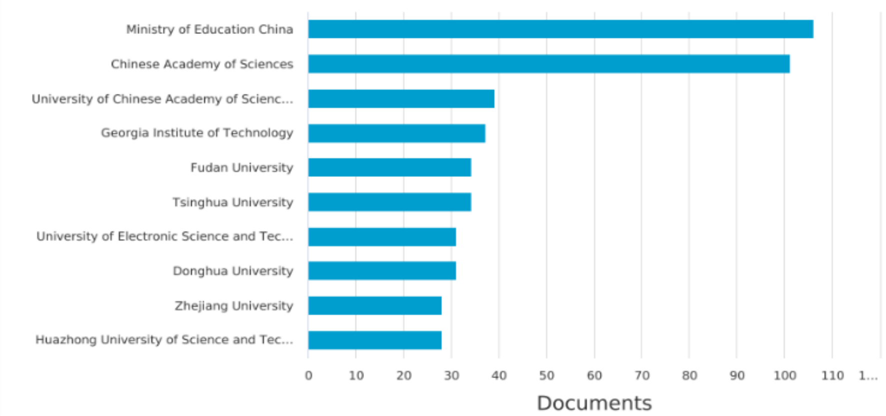

Fig. 6. Document by affiliation

By seeing Fig. 6, we can say that Chinese institutions have published and worked on this topic more than any other institutes around the world. The Ministry of China has published nearly 25 papers on this topic.

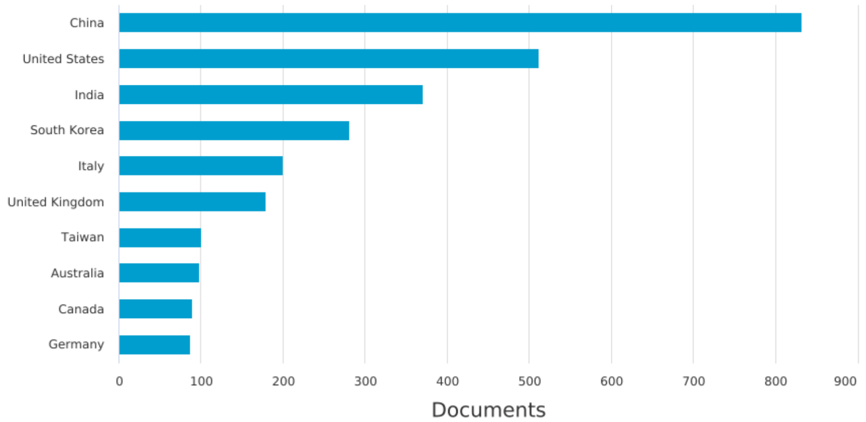

Fig. 7. Documents by country or territory

As shown in Fig. 7, India has published around 350+ papers on this topic placing third on world charts as per statistics. Whereas China is first on a chart published around 800+ and the USA is second on a chart published around 700+.

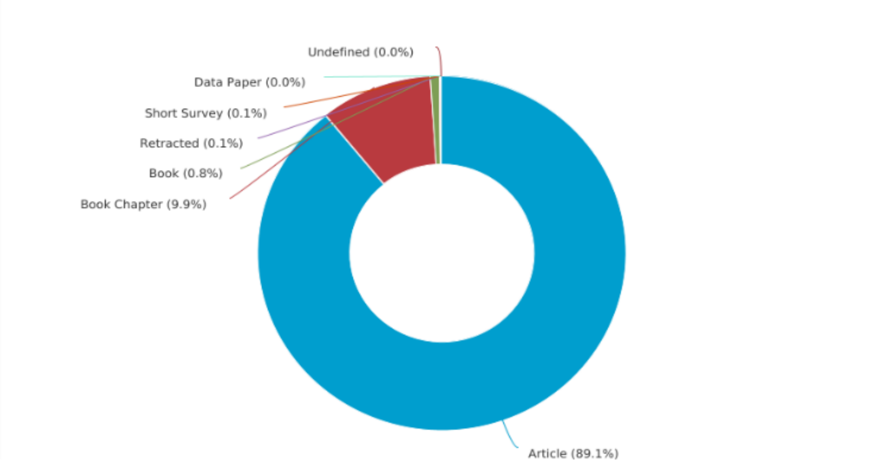

Fig. 8. Document by type

As shown in Fig. 8, the document type which is published more is articles than book chapters and so on.

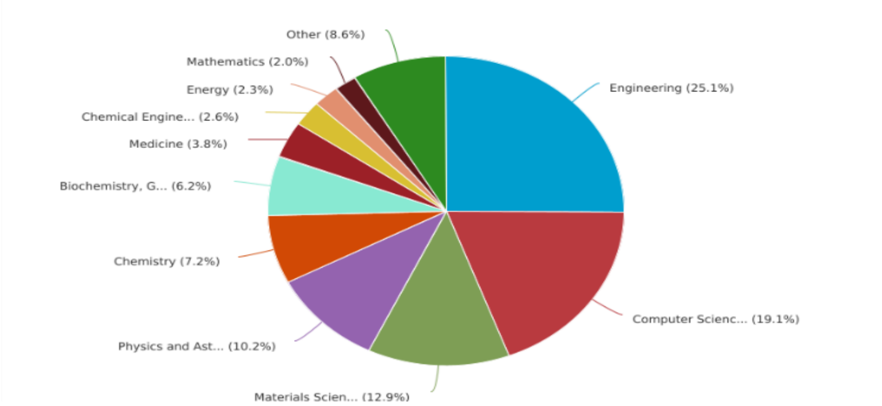

Fig. 9. Document by subject area

As shown in Fig. 9, a large portion of the documents are published in the engineering subject area and then in computer science, and material sciences respectively.

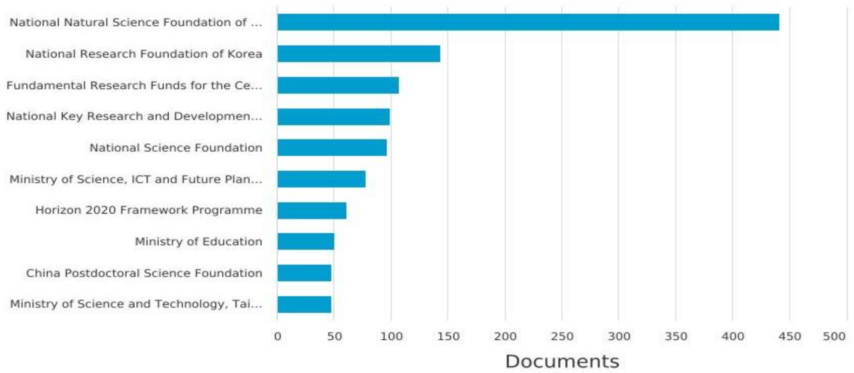

Fig. 10. Documents by funding sponsors

As shown in Fig. 10, the National Natural Science Foundation of China has funded around 450 documents and next who has funded the most is National Research Foundation of Korea respectively.

Abbreviations:
WHO-World Health Organization
VIP-Visually Impaired People
IoT- Internet of Things
ML-Machine Learning
GPS- Global Positioning System
GSM- Global System for Mobile Communication
WIFI- also known as Wireless Local Area Network (WLAN)
CNN- Convolutional Neural Network
YOLO- You Only Look Once

2.4 Research Question

1. What is the Role of IoT in the wearable gadget for the VIPs

The role of IoT (Internet of Things) in wearable gadgets for visually impaired individuals is significant. IoT technology enables these gadgets to connect to the internet and other devices such as smartphones and computers. This connection allows for real-time data transfer and analysis, making the devices more intelligent and efficient.

IoT-based wearable gadgets for visually impaired individuals can use sensors and cameras to detect and identify obstacles, and then provide feedback to the user through haptic or audio cues. The gadgets can also use GPS and other location technologies to provide navigation assistance, giving users the ability to navigate new or unfamiliar environments with greater ease and independence.

IoT technology can also help to make wearable gadgets for visually impaired individuals more adaptable to the individual user's needs. By analyzing data from sensors and other sources, the devices can learn about the user's preferences and patterns of use, and adjust their functionality accordingly.

Overall, IoT technology plays a crucial role in enhancing the functionality and usability of wearable gadgets for visually impaired individuals, enabling them to navigate their environments with greater independence and confidence. Table 2 shows the different sensors used by the different researchers in making the wearable smart system for VIPs.

Table 2. shows IoT sensors and in which they were cited.

Sensos	Description	Citations
Camera	Take pictures and videos	[1-2],[4],[5], [8-12],[19], [21-22],[24],[25]
Raspberry Pi	The utilisation of a microcontroller to process data, Wi-Fi to communicate data to the cloud, and the integration of actuators for control reasons.	[4],[12],[19],[21],[22]
Arduino Uno	The Arduino Uno microcontroller can perceive its surroundings by receiving data from several sensors.	[6-7],[11],[14],[16],[23]
Push buttons	Only by pressing a push button can we energise the circuit or create a specific connection.	[11],[22],[30]
accelerometer	An accelerometer uses an electromechanical sensor to measure either static or dynamic acceleration.	[22]
Gyro meter	A gyroscope sensor is a device that can measure and maintain an object's orientation and angular velocity.	[22],[24]
Ultrasonic sensors	Used to determine distance. It is essentially a proximity sensor.	[1],[6],[7],[8],[11],[13],[14],[16], [21-22],[23],[27]
Image module	Picture field types are defined, and image modification tools are provided.	[1],[19],[24]
Solar power	Sunlight is converted into energy by a panel of absorbent solar cells.	[7]
Speech module	This module turns human language text into audio that sounds like human voice.	[1], [4-5],[8],[14],[22],[24]
Water detection sensors	The sensor may be used to detect rain, water level, and even liquid leaks.	[7],[8],[11],[19]
Temperature sensors	Temperature sensors are used to monitor a variety of settings and machines, including power plants and industries.	[17]
GPS	The Global Positioning System (GPS) is a satellite navigation system. It transmits time and position data to a GPS receiver placed anywhere on or above ground.	[1],[4],[13],[17],[21],[22],[27]

BLE sensors	BLE allows data to be sent between devices using radio waves.	[7],[14],[16],[17],[25],[27]
Buzzers	A buzzer is a tiny yet effective component for adding sound effects.	[6],[7],[11],[14],[16]
RF transmitter and receiver	A radio frequency transmitter and receiver is a (typically) tiny electrical device that transmits and/or receives radio signals between two devices.	[6],[11],[17]
WIFI module	A module is a gadget that sends WIFI signals to smart devices like laptops and phones.	[1],[13],[17]
LIDAR	It is a method of determining distances that involves using a laser to target an object or a surface and counting the duration it takes for the reflectivity to return to the receiver.	[14],[16]
LDR	When detecting the presence or absence of light or measuring the intensity of light is necessary.	[6]
MEMS sensors	MEMS is a Micro Electro Mechanical System that primarily consists of a pair of capacitive plates with extra mass in between them. When force or tension is exerted on this detector, the extra mass causes an electric potential difference, which is indicated by a change in the circuit.	[23]
PIR sensors	Passive infrared sensors are mostly used to detect the motion of an item, animal, or human. The motion will be detected whenever a human or animal moves over a specific range of the sensor.	[23]
Piezo Electric sensors	A piezoelectric sensor is a device that converts pressure, acceleration, temperature, strain, or force to an electrical charge via the piezoelectric effect.	[23]
Binocular sensors	The binocular vision sensor first identifies the spatial position of the target before delivering measurement data to the main controller through the vision control computer.	[28]

2. What is the role of cloud computing in making wearable devices for the visually impaired?

Cloud computing plays a vital role in making wearable devices for the visually impaired. With the help of cloud computing, wearable devices can leverage the computational power of remote servers and access data from various sources to enhance the functionality of the device.

One of the main advantages of using cloud computing in wearable devices for the visually impaired is the ability to store and process large amounts of data. Wearable devices generate a vast amount of data, including sensor data and user data, which can be used to improve the accuracy of the device. Cloud computing provides the necessary storage and processing power to manage this data efficiently.

Another advantage of using cloud computing is the ability to access data from various sources. For instance, wearable devices can be integrated with various data sources such as maps, traffic, and weather data to provide users with accurate and real-time information. This data can be accessed through cloud-based APIs, which allow for seamless integration with wearable devices.

Moreover, cloud computing allows wearable devices to be more intelligent and adaptive. Machine learning algorithms can be trained on large datasets to improve the accuracy of the device. The machine learning models can be hosted on the cloud, and the wearable device can leverage these models to improve its performance.

Cloud computing also plays a significant role in providing remote monitoring and management of wearable devices. Cloud-based management systems can be used to monitor the health of the device, update firmware and software, and remotely manage the device. This is especially beneficial for visually impaired users who may find it challenging to manage the device themselves.

In conclusion, cloud computing plays a vital role in making wearable devices for the visually impaired. It provides the necessary storage and processing power to manage vast amounts of data generated by wearable devices. It also enables seamless integration with various data sources and allows for intelligent and adaptive devices. Additionally, cloud computing allows for remote monitoring and management of wearable devices, which is especially beneficial for visually impaired users.

3. What is the Role of machine learning in the wearable gadget for the VIPs

Machine learning plays a significant role in the development of wearable gadgets for the visually impaired. With the help of machine learning algorithms, wearable devices can detect and interpret information from the environment, and provide real-time assistance to visually impaired users. Some of the ways machine learning is used in wearable gadgets for the visually impaired are:

Object Recognition: Machine learning algorithms can be used to train a wearable device to recognize and identify different objects in the environment. For example, a wearable device can use object recognition algorithms to identify a chair, a door, or a staircase.

Image Processing: Machine learning algorithms can be used to process and analyze images captured by wearable devices. For example, a wearable device equipped with a camera can capture images of the environment, and machine learning algorithms can be used to analyze the images and provide real-time feedback to the user.

Voice Recognition: Machine learning algorithms can be used to train a wearable device to recognize and respond to voice commands. For example, a visually impaired user can use voice commands to navigate through the environment, such as "turn left," "go straight," or "stop."

Navigation: Machine learning algorithms can be used to create maps and provide navigation assistance to visually impaired users. For example, a wearable device can use machine learning algorithms to analyze the environment, create a map, and provide real-time navigation assistance to the user.

Gesture Recognition: Machine learning algorithms can be used to train a wearable device to recognize and interpret gestures made by the user. For example, a visually impaired user can use hand gestures to control the wearable device, such as "swipe left" or "swipe right."

Overall, machine learning plays a crucial role in the development of wearable gadgets for the visually impaired, enabling these devices to provide real-time assistance to users, recognize and interpret information from the environment, and provide a more accessible and independent lifestyle for the visually impaired.

4. State-of-the-art techniques developed in the wearable smart system for visually impaired persons during the census 2015-2022?

This research topic focuses on summarising how many innovative-based techniques for visually impaired people are produced. Researchers all around the world have proposed a variety of ways for a wearable electronic system for a visually impaired individual, including assuring security and danger, storage needs, and many more. Table 2 displays the work reported from 2015 to 2022.

Over the past decade, there have been significant developments in wearable smart systems for visually impaired individuals. These systems leverage various technologies, including sensors, IoT, machine learning, and cloud computing, to assist the visually impaired in their daily activities and enhance their quality of life. Some of the state-of-the-art techniques developed in the wearable smart system for visually impaired persons during the census 2015-2022 are:

Computer Vision: Wearable systems are increasingly using computer vision to help visually impaired individuals navigate their surroundings. Computer vision algorithms analyze video data from wearable cameras to identify objects, people, and obstacles, which is then communicated to the wearer through an audio or haptic feedback system.

IoT-Enabled Systems: IoT-based wearable systems have become popular as they provide a cost-effective way to develop wearable devices. These systems allow for real-time data exchange between the wearable device and other IoT-enabled devices, such as smartphones or smart home devices.

Machine Learning: Machine learning algorithms are increasingly being used in wearable smart systems for visually impaired individuals. These algorithms learn from the user's data and provide personalized assistance. For example, machine learning can be used to improve the accuracy of object recognition algorithms, allowing for more accurate feedback to the wearer.

Cloud Computing: Cloud computing plays a critical role in wearable smart systems for visually impaired individuals. By leveraging the power of cloud computing, wearable devices can offload processing and storage requirements, which can be expensive for the device itself. Cloud computing also allows for data to be analyzed in real-time, providing immediate feedback to the wearer.

Spatial Audio: Wearable devices are increasingly incorporating spatial audio technology, which allows for the wearer to perceive the direction and distance of objects, people, and obstacles in their surroundings. Spatial audio can be used to create a 3D soundscape, which is more immersive and realistic than traditional audio feedback.

Wearable Sensors: Wearable devices are increasingly incorporating various sensors, including GPS, accelerometers, and gyroscopes, to provide context-aware feedback to the wearer. For example, GPS sensors can provide location information, which can be used to provide turn-by-turn navigation, while accelerometers and gyroscopes can detect changes in the wearer's orientation, providing feedback on their position and movement.

Overall, the combination of these technologies has led to significant advancements in the development of wearable smart systems for visually impaired individuals. These systems have the potential to significantly enhance the quality of life of visually impaired individuals by providing them with more independence and mobility.

Table 3 shows the proposed system of the papers considered for the literature review.

Table 3. Summary Table

Citation	IoT	ML	CC	Feed-back	GSM unit	GPS unit	LIDAR	Spatial Audio Render-ing
Hu et al. [2022]	Y	Y	N	Y	N	N	N	Y
K Xia et al. [2022]	Y	Y	Y	Y	N	Y	N	N
M. Singh et al. [2022]	N	Y	N	N	N	N	N	N
Y. Lei et al. [2022]	N	Y	N	N	N	N	N	N
F. Ashiq et al. [2022]	Y	Y	Y	Y	Y	Y	N	N
Aher, Tejas Hari, et	Y	Y	N	Y	N	N	N	N

Citation	IoT	ML	CC	Feed-back	GSM unit	GPS unit	LIDAR	Spatial Audio Render-ing
al. [2022]								
Yogesh S [2022]	Y	N	N	Y	N	N	N	N
M. W. Ap-prey et al [2022]	Y	N	Y	Y	Y	Y	N	N
Su-man, Shub-ham, et al. [2022]	Y	Y	N	Y	N	N	N	N
Hussan, MI Thariq, et al. [2022]	Y	Y	N	Y	N	N	N	N
Deshmukh, Shub-ham, et al. [2022]	N	Y	N	Y	N	N	N	N
Dhage, Aarti, et al. [2022]	Y	N	N	Y	N	N	N	N
Ab-dul-Ameer, Hassan Salam, Hassan Jaleel Hassan, and	Y	Y	N	Y	N	N	N	N

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Citation	IoT	ML	CC	Feed-back	GSM unit	GPS unit	LIDAR	Spatial Audio Render-ing
Salma Hameedi Abdul-lah [2022]								
Ramesh GO, Mustare NB, Kumar KU.[2022]	Y	N	Y	Y	N	N	N	N
Busaeed, Sahar, et al. [2022]	Y	Y	Y	Y	N	N	Y	N
Pardeshia, Suraj, and Pravin Yanna-wara. [2022]	N	Y	N	Y	N	N	N	N
Busaeed, Sahar, et al. [2022]	Y	Y	Y	Y	N	N	Y	N
Sa-lem, Mahmoud, et al. [2022]	Y	Y	Y	Y	N	N	N	N
Ra-jendran, Mano-ran-jitham,	Y	Y	N	Y	N	N	N	N

Citation	IoT	ML	CC	Feed-back	GSM unit	GPS unit	LIDAR	Spatial Audio Render-ing
et al. [2022]								
Farooq, Muhammad Siddique, et al. [2022]	Y	Y	Y	Y	Y	Y	N	N
Dhou, Salam, et al. [2022]	Y	Y	Y	Y	N	Y	N	N
Durgadevi, S., et al. [2022]	Y	N	N	N	N	N	N	N

3 Proposed System

A smart system that can assist visually impaired people to move independently. The visually impaired people can wear glasses and cross the road efficiently. As shown in Fig 12 the proposed system consists of a main control chip, GPS, GSM module, WiFi module, image processing unit, speech processing unit, and ranging module, and for the traffic light recognition the CNN is used.

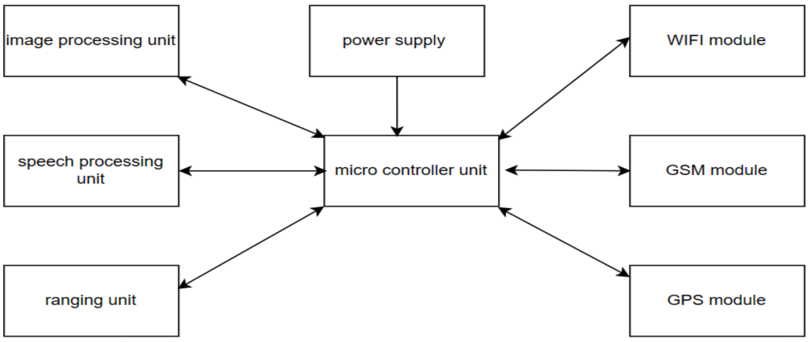

Fig. 11. Block diagram

Table 4, shows the time complexity of the sensors used in the making of the wearable smart system which will assist the programmer in understanding the time required by each of the sensors to run.

Table 4. The time complexity of the components used in a wearable smart system

Components of a wearable smart system	Time complexity	Description
Image processing module	O(N) to O(N^3)	Where n is the number of pixels in the image.
Speech processing module	O(N) to O(N^3)	Where n is the number of frames or samples in the audio signal.
Ranging unit	O (1)	For ultrasonic ranging sensor.
WIFI module	O(N) to O(N^2)	For negotiating parameters, authentication and encryption
GSM module	O (1)	For sending an SMS message
GPS module	O(N^3)	By using the least squares algorithm

4 Research Gaps and Issues

The more the visually impaired person becomes accustomed to assistive technology, the more valuable it is to create an assistive model.

- Since the model is tested in a controlled setting, performance can be one of the issues.
- Challenges such as sensor weight, power consumption, battery lifespan, and calibration arise when undertaking IoT projects.
- Some papers have not used any communication technology to send an alert message to the caregiver of the VIPs when they are in danger.

- Additionally, a few studies haven't used any cloud technology to store the data from the sensors.

5 Conclusion and Future Scope

The literature review on wearable smart systems for visually impaired persons using IoT and cloud technology highlights the potential of this field to significantly improve the efficiency, accuracy, and scalability of these systems. The review found that the integration of IoT, ML, and cloud technology in wearable smart systems allows for real-time monitoring, data analysis, and response to obstacles and dangers. The use of cloud-based storage and computing enables efficient data management and the integration of advanced analytics and ML algorithms to enhance the performance of these systems. Overall, the literature review suggests that the integration of IoT, machine learning, and cloud technology has the potential to revolutionize the way we detect obstacles, provide feedback to guides about VIPs, and navigate, ensuring the safety and security of visually impaired persons. The use of both WIFI signals and the GSM module can be used simultaneously to send warnings to VIPs, guardians, and surrounding people.

Compliance with Ethical Standards

The authors declare that they have no conflicts of interest related to this research.
The studies reviewed in this paper were conducted in accordance with ethical guidelines and regulations.
As the paper is not directly involving or collecting data from individuals informed consent is not necessarily taken.

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