International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Implementation of Smart Glove for Visually Impaired People

Logulakshmi T[1], Shivani P[2], Srimathi G[3], Nandhini S[4]

[1,2,3]Student, Sri Manakula Vinayagar Engineering College, Puducherry, India.

ABSTRACT-

The visually handicapped have a difficult time locating things of everyday use because of their impairment. With the use of Deep Neural Networks (DNN) and Yolo version 5, the purpose of this study is to develop a smart glove with the intention of directing the hand of a person who is vision impaired to the desired object while the individual is inside. The micro-vibrating motors included within the smart glove are designed to direct the user's hand. The palm of the glove has a camera that connects to a Universal Serial Bus (USB), and this camera sends real-time footage to the system so it can be processed. Additionally, it includes a camera and a microphone integrated right into it. The user issues spoken commands to the system, telling it to identify the item of their choosing. After that, the camera employs DNN in order to detect the item. The process of tracking the object will start after it has been tagged. The micro-vibrating motors vibrate in a manner that is proportional to the relative location of the camera in relation to the object in order to steer the user's hand in the desired direction. The ability to differentiate between identical items based on colour is an extra capability that has been introduced.

Keywords: Deep Neural Network of Open CV, Micro-Vibrating Motors, Smart Glove, Visually Impaired, yolo version 5

I. INTRODUCTION

The human capacity for seeing was a primary consideration in the formation of the structure of the world as we know it. This is because seeing things is the most significant means of acquiring information from the environment around you, and seeing things is the most crucial approach. As a direct consequence of this, a visually impaired person requires assistance in order to carry out the responsibilities associated with day-to-day life. Blind people are unable to differentiate between known and new landmarks, which makes it incredibly challenging for them to navigate unfamiliar situations. Therefore, an easy task such as recognising and reaching the thing that is needed, which just involves fundamental motions of the arm, requires the blind person to grope around in order to reach the required object. This is because the blind person lacks vision. Recent improvements in technology have made it simpler for visually impaired individuals to navigate unfamiliar environments, such as the vast outdoors. On the other hand, things are considerably different once you inside the building. There hasn't been a lot of work done on the inside of buildings to increase blind people's ability to traverse the world and discover items that they need on a daily basis. Those who are blind or have some other form of visual impairment must be able to recall the positions of objects inside an interior space in order to operate normally. It is vital that stationary things such as tables, chairs, and other pieces of furniture not be moved about without prior warning in order to reduce the likelihood of accidents occurring. This will help keep everyone safe. It is of the utmost importance that everything be placed in the specific locations for which it was designed, and that all of the walkways be maintained clean. Regarding this matter, each and every member of the family is responsible for exercising the utmost prudence. With the aid of the technology that has been built, the person who is blind is able to navigate about an interior space. Blind people who employ traditional techniques, such as the white cane, are only able to become aware that something is around; nevertheless, they are unable to use this awareness to identify the item that is nearby. They cannot get an accurate comprehension of what it is until they physically interact with it by touching it with their hands. The only thing need to do in order to use the smart glove is to provide directions to the glove. The micro-vibrating motor that is housed within the glove gives the wearer the ability to locate whatever it is that they are looking for and guides them to it. The use of voice input and output technologies is common in assistive devices developed for people who are blind or visually impaired. In this context, the procedure of keyword extraction is of significant importance. It is vital to do an analysis of the flat-type vibration motor in order to establish how advantageous these motors will be in the actual building of the glove. This may be done by asking questions such as "What are the benefits of using these motors?" One of the disadvantages of using a white cane is that it makes it impossible to recognise some items. This is one of the negatives. Deep Neural Networks are used, and a large number of items are individually identified, in order to accomplish this goal (DNN). Object tracking becomes an absolute necessity as a result of the fact that the glove is always moving, and a framework to support this necessity has been devised. In the past, several navigational aids f+or persons who are visually impaired have been employed, but the main objective of these aids was to assist individuals in avoiding hazards. In yet another idea, in addition to enabling input via touch and sound, SONAR and a camera are incorporated into the design in order to facilitate navigation around obstacles. Previous assistive devices for the blind have made use of image processing and ultrasonic sensors, but their primary function was to help blind people navigate around obstacles. There is no navigational aid that is user-friendly and that can put the user in the direction of the thing that they are looking for. Even the intelligent gloves that were used in early iterations of the system act as collision avoidance devices in later iterations of the system. The difficulty of recognising and navigating to items inside an indoor environment may be alleviated with the suggested implementation of the functionality of this prototype, which is exactly what we intend to accomplish with our glove. This is made possible by the utilisation of a micro-vibrating motor that is included within the glove itself. People who are visually impaired now have the ability, thanks to the "smart glove's" micro-vibrating motor and Speaker, to locate and navigate to the item of their choosing. This is in contrast to the assistive technologies that have been developed in the past, which have only been used for avoiding obstacles..

II. RELATED WORKS

It is impossible to understate the significance of the literature review since it occurs at such a pivotal time in the life cycle of the project. The information gathered through websites is appropriately assessed so that the needs may be comprehended in their entirety. This literature review has been conducted with the intention of deriving a new solution by gaining an awareness of the failings and deficiencies of the existing system. During the preliminary phases of the project, the survey is conducted, and it is assessed whether or not this application is necessary. This chapter offers an analysis of a variety of earlier technologies, as well as the benefits and drawbacks of those earlier technologies. This chapter includes not only a comparison of the technology that existed before and the technology that was used in the work, but also a comparison of the designs that existed before and the design that was suggested. "Summarization of spontaneous speech using speech-to-text and voice-to-speech technologies" In this study, a strategy that is based on the extraction and concatenation of speech units is presented. In the first scenario, an investigation is being conducted into a two-stage approach of summarising that includes the processes of important sentence extraction and word-based sentence compression. This approach is used to summarise the unrestricted-domain spontaneous presentation, and it is analysed using both objective and subjective measurements. It has been demonstrated that the proposed strategies are successful in capturing the essence of spontaneous speech[1]. "Smart Cane for Blinds" In this study, an intelligent shared control system that has been implemented to a smart cane is presented. The "smart cane" is a mobile platform that assists individuals who are visually impaired in navigating through environments that contain obstacles. It is made up of two wheels that may rotate in their own axis and respond differently to different control instructions. The intelligent shared control system is made up of three fundamental control modules as well as a decision maker that chooses which action should be carried out. The first fundamental module is a continuous fuzzy controller, and its purpose is to move the cane from its beginning position to its destination point. The second fundamental one is a discrete event controller, which uses the data collected by the sensor to guide the robot away from potential hazards as it walks. The third fundamental module is the discrete commend from the user, which is when the user gives instructions such as "Go Straight," "Turn Left," "Turn Right," and "Stop." A little joystick, which may be pressed in any of the aforementioned four directions, is the means by which the human interacts with the cane. All of these modules are connected to the decision-maker module, which allows for the selection of a single action at any given moment in real time [2]. "Smart Gloves for Blinds" This study presents a smart glove with the purpose of assisting blind persons in walking and judging the distance between themselves and obstacles. The ultrasonic sensor had a high degree of sensitivity and would react more quickly when it detected obstructions. The ultrasonic sensor that was utilised in this project only has the ability to identify obstacles; it cannot depict the geometry of such objects. This was a limitation of the project. Ultrasonic sensors will be utilised as a sensor to detect impediments at the front of the device, and it will transmit signal to Arduino UNO, which will operate as the microcontroller for the device. After then, the microcontroller will evaluate the data and transmit the signal to the servo motor, which will direct it by the feedback it receives from its vibrations. When it comes to the software, the design of the circuit is created with the help of the Fritzing software, and the programming will be created with the help of the Arduino software, which will be installed with the help of the Arduino library [3]. An investigation on the flat-type vibration motor used in mobile phones We have created a novel way of calculating the torque of the flat-type vibration motor by employing a two-dimensional finite element model in order to replicate the motion transient characteristics. In doing so, we hope to be able to better understand the motion itself. We have taken a measurement of the load torque that the vibration motor requires in order to function properly for the motion transient analysis. A comparison is made between the computed vibration characteristic and the experimental value [4]. "High-tech cane for those who are blind or visually impaired" People who are blind or visually impaired typically make use of a white cane, which is a mobility device with extremely restricted use, to assist them with their movement outside. It is necessary to have a smart gadget in order to increase the level of awareness that visually impaired users have of their surroundings when they are travelling in outside situations. This will help to keep them safer. A high-tech walking cane designed for those who are blind or visually impaired is described in this article. The user's path can be scanned for potential hazards, including changes in the landscape, using the suggested gadget. The primary structure of the device is comprised of a regular walking cane, upon which ultrasonic sensors have been installed in strategic positions in order to identify potential hazards, such as steps, pits, and other obstructions, in the way of the user. The user's path may be hazardous due to the existence of puddles and surfaces that are slippery, and the gadget has a provision that alerts them to these hazards. The presence of these impediments is communicated to the user either by speech recordings that are played in their earbuds or through haptic feedback, which is delivered by vibration motors that are positioned on the hand support of the stick. Both of these methods can be utilised simultaneously. The smart walking cane also has GPS and GSM modules, both of which, when triggered with the push of a button, can be used to send a distress signal to the user's relatives along with the user's current position. The gadget is easy to carry around and is powered by a battery that can be recharged. The general architecture of the gadget assures that it is accurate, uses very little energy, and can be easily transported [5]. "Multiple object detection on an embedded device using OpenCV." The diverse range of applications that make use of object detection has contributed to a surge in interest in the field in recent years. The rise of available processing power in software and hardware has been a driving force behind the development of object detection technologies. In this work, we demonstrate an application that was designed for the purpose of detecting numerous objects at once using OpenCV libraries. It is presented here the complexity-related elements that were taken into consideration in the object recognition process utilising cascade classifier. In addition to this, we go over the process of profiling the programme and porting it into an embedded platform, then we compare the outcomes of this process to those of the standard platform. The application that is being offered deals with the development of real-time systems, and the findings provide an indication of the areas in which the cases of object detection applications may be more difficult and the areas in which it may be easier [6]. "A research paper on the framework of Deep Neural Networks" Deep neural networks, often known as DNN, are an essential component of machine learning and have found applications in a variety of domains. In contrast to shallow neural networks (NN), deep neural networks (DNN) possess superior feature expression as well as the capacity to accommodate complicated mapping. In this paper, we first discuss the historical context of the development of the DNN. We then introduce several typical DNN models, such as deep belief networks (DBN), stacked autoencoder (SAE), and deep convolution neural networks (DCNN). Finally, we investigate the applications of the DNN from three different perspectives and discuss the future of the DNN. [7] "A low-cost intelligent glove for the mobility of persons with vision impairments." A decline in a person's visual system makes it more difficult for them to move around, especially if they rely only on their sense of touch and hearing. The purpose of this study is to describe the prototype of a low-cost intelligent glove designed to assist the mobility of persons who are visually impaired. Through the use of vibration motors, the range finders in the glove are able to offer a vibro-tactile feedback on the location of the nearest obstacles in range. This allows the wearer to investigate their surroundings. The dependability of this time-honored instrument is improved thanks to the fact that the system is intended to work in conjunction with the white cane [8]. The article "Shared Control Framework: Applied to a Robotic Aid for the Blind" demonstrates how the shared discrete event control system can be applied to the Robotic Cane, which is a device that helps people who are blind or visually impaired navigate through environments that contain a lot of obstacles. It is also demonstrated how the control framework functions to navigate around obstacles, with or without the involvement of human operators. During the course of the experiment, the cane provided the user with significant assistance when navigating in an indoor setting. The user would need some practise, but eventually they would be able to follow the cane in the direction it pointed. This demonstrates that the control mapping was specified in an accurate manner. The only command that might be considered difficult to understand was the left and brake order, which was used whenever there was just a moderate amount of dispute. However, in order to achieve the appropriate turning and braking, a separate kinematic solution for the cane would need to be implemented. In situations when there was a significant discrepancy between the input from the user and the command from the autonomous control system, the human stayed in charge. The user was successfully alerted by the audible notice that played whenever a disagreement occurred [9]. "SMART CANE FOR THE VISUALLY IMPAIRED: DESIGN AND CONTROLLED FIELD TESTING OF AN AFFORDABLE OBSTACLE DETECTION SYSTEM" ["SMART CANE FOR THE VISUALLY IMPAIRED: DESIGN AND TESTING OF AN AFFORDABLE OBSTACLE DETEC People who are visually impaired often have a tough time moving around independently and often rely on a white cane as a mobility aid to help them identify nearby hazards that are on the ground. Nevertheless, the cane suffers from two significant drawbacks. Its detection range is limited to about above the knee level. As a result, the user is unable to identify higher impediments such as elevated bars, which results in numerous collisions with these barriers. The cane is only able to identify obstacles that are less than one metre away from the user. In addition, hazards such as moving automobiles are difficult to spot until they are perilously near to the individual. Nearly all of the world's blind population is concentrated in developing nations, where the vast majority of them live in abject poverty. Current gadgets offered worldwide are unaffordable. In this work, we discuss the findings from controlled field testing as well as explain the design and usability aspects of a low-cost knee-above obstacle detection system. Approach The cane's horizontal and vertical ranges are improved by the utilisation of directional ultrasonic ranging technology. A user-friendly and low-cost system developed with convenience in mind. Controlled tests with a total of 28 users were carried out in order to evaluate the effectiveness of the device in lowering the risk of collisions and improving users' personal safety. System Design A lightweight, detachable equipment that consists of an ultrasonic ranger and vibrator has been created. This unit has a range that has been improved to 3 metres and can detect objects that are higher than knee level. The user receives information on the distance between obstacles using vibratory patterns that change gradually in response to the progression of the obstacle's distance. The estimated price of the gadget is less than 35 US Dollars, making it feasible for consumers in underdeveloped nations to purchase it. An earlier paper covered both the development of the original prototype as well as the design. Field Experiments In randomised controlled trials, 28 people were given training on how to use the gadget, and then they had to navigate four obstacle courses. Two of the courses involved using the device, while the other two involved using a white cane. Research was conducted on the following metrics: I Obstruction Awareness; (ii) Collision rate; and (iii) Distance at which each obstacle is recognised. The use of a Smart Cane raised the user's awareness of obstacles by 57%, lowered the rate at which they collided with obstacles by 91%, and increased the mean distance at which they detected obstacles by 260%, which resulted in an improvement in the user's ability to move about safely. Two users who tested the gadget over the course of three months claimed that it accurately detected railings, raised bars, raised sides of vehicles, as well as the existence of a gate, people, trees, and other objects. Conclusions For those who are visually impaired, we have developed a low-cost obstacle detection device that will increase their ability to move around independently. Positive user feedback gleaned from field trials indicates that the proposed solution might be used in actual life situations [10]. "Smart Cane Indicates a Safe and Free Path to People Who Are Blind Using Ultrasonic Sensor" People who are blind or visually challenged typically make use of the traditional white cane. There are a variety of electronic aids for the visually impaired that are now in prototype and commercial states. The issue area that spurred the study is presented, as well as an alternate solution, in this section of the article. In this study, we offer A Safe Free Path to Visually Impaired Person using PIC16 and ultrasonic sensors to turn the cane into a smart device. The system that we provide can identify the nearby Obstacle and provide the user with feedback in the form of vibro-tactile sensations to let them know where the obstacle is located. The purpose of the system is to improve the mobility of persons who are visually impaired by providing a new cane that is both low-cost and suitable for use both inside and outdoors, and which is able to alert the user at any moment if an impediment is in his way [11].

III. PROPOSED WORK

In the system that has been proposed, the message "object name" is transmitted to the micro controller whenever a blind person says it. When an item is detected by the input, the vibrating motor is adjusted to vibrate in the direction of the object. Help the blind folks find their way to the object by guiding them. This high-tech glove can guide a blind person to the location of whatever it is that they are looking for. The entirety of the system is capable of operating as a single, self-contained entity. Since the system is being powered by a battery, it undergoes a comprehensive analysis to determine how it can use the least amount of electricity possible. The micro controller, which has a Universal Serial Bus (USB) camera that also has a built-in microphone, is the component that makes up the standalone device. The user first verbally communicates with the system about the item that is being searched for before any further steps can be taken to implement the recommended solution. The "yolo version5" – voice to text module for python is used to translate the audio input from the user that is received by the microphone that is linked to the microcontroller. This conversion takes place in real time. Using a process known as keyword extraction, the user's vocal command is parsed in order to determine the name of the item the user requires. This extracted keyword is then sent to the object detection method that DNN employs. The Caffe framework is utilised in the implementation of the DNN that is employed for the smart glove. The real-time video is processed by the DNN that is running on the microcontroller, which then locates the item of interest and tags it. The object tracking algorithm then takes over to boost the frame rate when it has been activated. When it has been found, the object must always remain in the middle of the picture when seen in relation to the glove. The micro-vibrating motor will lead the user to move his hand in such a manner that the object may be brought back to the centre of the frame if it moves away from the centre owing to the motion of the glove.

Fig 1. Object Detection

The micro vibrating motor will continue to vibrate to assist the user ahead as long as the object being moved remains in the centre of the device. A connection has been made between the microcontroller and the micro-vibrating motors. Microcontroller Model B is put to use in the process of object detection by way of the DNN module of Yolo version 5. There is a category of machine learning algorithms known as DNN. It makes use of a hierarchy of stacked non-linear processing units in many levels.

Fig 2: Glove object

The output of the preceding layer is used as an input for each subsequent layer. It is possible to record high-definition video using the camera module for the system. Image categorization and pattern recognition are two possible applications for it. The fact that this single-board computer features wireless LAN makes it the best option for use in applications that require a lot of processing power. Processing, such as speech recognition, object detection, object tracking, and control of the micro-vibrating motors, takes place in the microcontroller. Other processing tasks include object tracking and object detection. Any regular power bank or Li-Po (Lithium Polymer) batteries with a power rating that is sufficient for the microcontroller can be used to provide power for the complete system.

BLOCK DAIGRAM:

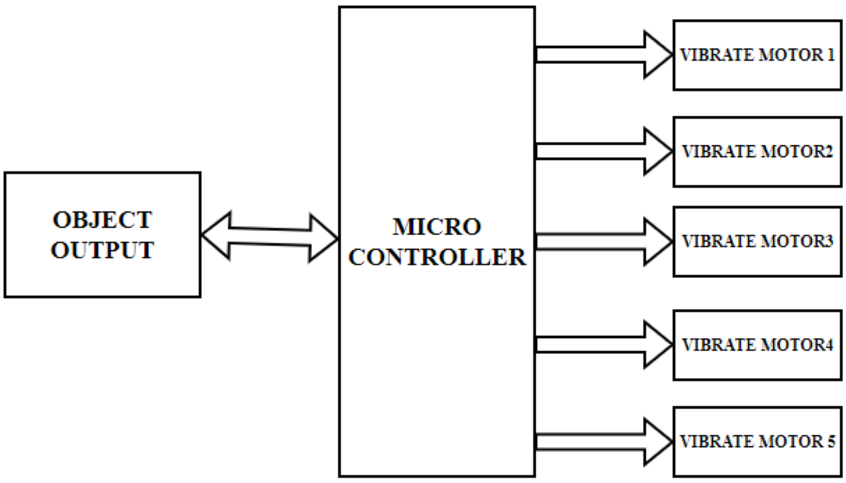

Fig 3: Block diagram of the proposed system

IV. SYSTEM DESIGN

I. Data Glove

The data glove is just a standard hand glove that has two movable sensors attached to it along the length of the fingers and thumb. Data collection and transmission are both possible with its help. These sensors are attached to the glove by being strung along the fingers and thumb of the glove. This is how they are connected together.

Fig 4: Data Gloves

II. Arduino UNO

ARDUINO is a piece of computer hardware and software that is freely available to the public. organisation, user community, and user-driven initiative that designs and specialises in the production of microcontroller-based kits for the creation of digital gadgets and interactive items that are able to perceive and manipulate the environment around them world that can be touched. A family of microcontrollers serves as the foundation for this project. designs for boards that are mostly made in Italy by Smart Projects, as well as by a number of other sellers, utilising a selection of 8-bit Atmel AVR processors based on the 32-bit Atmel ARM architecture or microcontrollers. These different systems provide combinations of digital and analogue input and output ports that may be connected to a number of different circuits and extension boards (sometimes called "shields"). The planks/boards include serial communications ports, including Universal Serial Bus support. On some versions, the Universal Serial Bus (USB) allows for the loading of applications from personal computers.

Fig 5: Arduino UNO

III. Flex Sensors

The flex sensor is a type of analogue device, and the technology behind it is protected by a patent. It uses resistive carbon thick components. They are analogue sensors in the form of a changeable printed resistor, and the Flex Sensor achieves a wonderful form factor on a thin flexible substrate. When the substrate is bent, the sensor generates a resistance output that is associated to the bend radius, despite the fact that the relationship between the resistance and the bend radius is the opposite of what is expected. In most cases, a needle and thread are utilised to sew the flex sensors onto the glove. They need an input of 5 volts and an output that is between 0 and 5 volts, with the resistivity changing depending on the degree to which the sensor is bent and the voltage output adjusting appropriately. Connectors with three pins allow the sensors to communicate with the device (ground, live, and output).

Fig 6: Flex sensors

IV. Voice record

The APR33A3 has eight channels that are used to capture the audio that is associated with each gesture. The address that is associated with each channel is transmitted to the Speaker when the gesture that is associated with that channel is detected. The APR33A series is a highly effective audio processor that also includes high-performance audio analog-to-digital converters (ADCs) and digital-to-analog converters (DACs). The APR33A series is a completely integrated solution that provides analogue input, digital processing, and analogue output functions. It offers excellent performance and exceptional integration with all of these features. The APR33A series combines all of the capability necessary to successfully carry out difficult audio/voice applications in its products. Because of its integrated analogue data converters and full suite of quality-enhancing features such as sample-rate convertor, the APR33A series allows for the implementation of high-quality audio and voice systems at lower bill-of-material costs. This is possible thanks to the series's sample-rate convertor.

Fig 7: voice record

V. RESULT AND DISCUSSION

Fig 8: Glove object

The output of the preceding layer is used as an input for each subsequent layer. It is possible to record high-definition video using the camera module for the system. Image categorization and pattern recognition are two possible applications for it. The fact that this single-board computer features wireless LAN makes it the best option for use in applications that require a lot of processing power. Processing, such as speech recognition, object detection, object tracking, and control of the micro-vibrating motors, takes place in the microcontroller. Other processing tasks include object tracking and object detection. Any regular power bank or Li-Po (Lithium Polymer) batteries with a power rating that is sufficient for the microcontroller can be used to provide power for the complete system.

VI. CONCLUSION

In this project, we have presented the design of the smart glove, which is helpful in directing the blind to the thing that is needed in an interior setting. Specifically, this project focuses on indoor environments. The user will have access to a solution that is more dependable, efficient, user-friendly, and lightweight as a result. People who are blind or visually challenged will have their lives given new purpose as a result of this. It is possible that in the future work will involve combining the smart glove with the smart cane so that it can also avoid obstacles. Additionally, bespoke models can be trained to recognise additional things of interest. It is possible to employ micro-controllers or processors that have a Graphics Processing Unit (GPU) that is capable of high performance in order to enable the DNN to process video frames effectively. In addition to this, the distance to the object that is needed may be measured with the use of a camera that has a depth sensor.

VII. REFERENCES

1. Furui, S., Kikuchi, T., Shinnaka, Y., & Hori, C. (2004). "Speech-to-text and speech-to-speech summarization of spontaneous speech". IEEE Transactions on Speech and Audio Processing, 12(4), 401-408.

2. Gharieb, W., & Nagib, G. (2016). "Smart Cane for Blinds". In Proc. 9th Int. Conf. on AI Applications (pp. 253-262).

3. Arsh.A.Ghate,Vishal.G.Chavan2(2017)."Smart Gloves for Blind". International Research Journal of Engineering and Technology, (Vol.04).

4. Won, S. H., & Lee, J. (2005). "Analysis of flat-type vibration motor for mobile phone". IEEE transactions on magnetics, 41(10), 4018-4020.

5. Murali, S., Shrivatsan, R., Sreenivas, V., Vijjappu, S., Gladwin, S. J., & Rajavel, R. (2016, December). "Smart walking cane for the visually challenged". In Humanitarian Technology Conference (R10-HTC), 2016 IEEE Region 10 (pp. 1-4). IEEE.

6. Guennouni, S., Ahaitouf, A., & Mansouri, A. (2014, October). "Multiple object detection using OpenCV on an embedded platform". In Information Science and Technology (CIST), 2014 Third IEEE International Colloquium in (pp. 374-377). IEEE.

7. Huang Yi, Duan Xiusheng, Chen Zhigang, Sun Shiyu. "A study on Deep Neural Networks framework". In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 770-778).

8. Bernieri, G., Faramondi, L., & Pascucci, F. (2015, June). "A low-cost smart glove for visually impaired people mobility". In Control and Automation (MED), 2015 23rd Mediterranean Conference on (pp. 130-135). IEEE.

9. Peter H. Aigrer and Brenan J. McCarragher, "Shared Control Framework: Applied to a Robotic Aid for the Blind", IEEE Journal Control Systems, Vol.19, no2, pp.40-46, April 1999.

10. S. Vaibhav et al., "'Smart' Cane for the Visually Impaired; Design and Controlled Field Testing of an Affordable Obstacle Detection System", *TRANSED 2010; 12th InternationalConference on Mobility and Transport for Elderly and Disabled Persons*, 2010

11. A. G. Gaikwad and H. K. Waghmare, "Smart Cane Indicating a Safe free Path to Blind People Using Ultrasonic Sensor", *International Journal on Recent and Innovation Trends in Computing and Communication*, vol. 4, no. 2, pp. 179-183, Feb. 2016.

12. J. Sakhardande, P. Pattanayak and M. Bhowmick, "Smart Cane Assisted Mobility for the Visually Impaired", *International Journal of Computer Electrical Automation Control and Information Engineering*, vol. 6, no. 10, pp. 1262-1265, 2012.

13. M. H. Wahab, A. A. Talib, H. A. Kadir, A. Johari, A. Noraziah, R. M. Sidek, et al., "Smart Cane; Assistive Cane for Visually-impaired People", *IJCSI International Journal of Computer ScienceIssues*, vol. 8, no. 4, pp. 21-27, Jul. 2011

14. A. Agarwal, D. Kumar and A. Bhardwaj, "Ultrasonic Stick for Blind", *International Journal Of Engineering And Computer Science*, vol. 4, no. 4, pp. 11375-11378, Apr. 2015.