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A Systematic Literature Review on Obstacle Detection for Visually Impaired People

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***Abstract*—** In general humans have five senses, among all vision is the most important and best gift given to the humans by GOD, but it is limited to some of the people due to their Visual Impairment issues. If vision is the problem then GOD will give the capabilities in other senses. The proportion of visually impaired and blind people in the overall world has become a very large. In a survey report given by WHO (World Health Organization) in 2010, they estimated nearly 285.389 million people are suffering with visual impairment problems across the globe. Many equipment's (Ex: Cane, Assistive shoe, Spectacles) are developed by different authors for detection of obstacles by visual impaired people over the time. All these equipment's are developed by using different techniques like IoT enabled smart cane, GPS/GSM based smart cane, Wearable devices like Assistive shoe's and blind vision spectacles which detects the obstacles, Smart Phone based navigation technology , Image processing techniques based smart cane which uses the camera for capturing the images, ETA's (Electronic Travel Aid's), normal Ultrasonic sensor based smart canes, Sensors(Ultrasonic, LDR's, Soil moisture and water detection) used smart cane and the most advanced smart canes which uses the Algorithms of Machine Learning and Deep Learning ANN, CNN, RNN. In this paper, we present a clear survey of the navigation systems of blind/Visual impaired people that are proposed by different authors highlighting various technologies used, designs implemented, working challenges faced and requirements of blind people for their autonomous navigation either in indoor or outdoor environment. Also we aims at presenting several existing literatures which are based on object detection by blind people. Due to the advancement in techniques and technology, study, analysis and evaluation of all these proposals by different authors will play a vital role. Hence this survey will concentrate on analyzing the process involved in detection of obstacles with different techniques.3

Keywords— Visual Impairment, IoT, Ultrasonic sensor, wearable devices, Image processing, smart phone, LDR (Light Dependent Resistor), Machine Learning, Deep Learning.

I. INTRODUCTION

The World Health Organization estimates the world blind population at 39 million persons, which roughly corresponds to 0.56% of the total world population. More precisely this represents an incidence ranging from 0.5% to 1.4% in the developing countries and of 0.3% in the whole of the industrialized countries. As for low-income countries, in nearly 90% of the cases a blind individual can no longer work and his/her life expectancy drops down to 1/3 that of a matched peer, in age and health **[1]**. People with visual impairments face different challenges in their daily life in this rapidly advancing technological environment. They cannot do their own work and always search for external assistance as the helping hand in their work. Autonomous navigation is of extreme importance for those who suffer from visual impairment problems. So that, they must be provided with some assistive things which helps them to do their work. In the largest survey made in France by Ministry of Health, 59% report troubles in outdoor and almost one-third of the whole visually impaired people confess not being able to travel by themselves **[2]**. As per the current statistics, India contributes to 21% of the total blind population all over the world. In a million, there are around 53 persons are visually impaired, 46 thousand people are having low vision and 6800 people have complete vision loss. One in every 179 people is blind **[3]**. Blindness is a state of lacking the visual perception due to physiological or neurological factors. The partial blindness represents the lack of integration in the growth of the optic nerve or visual centre of the eye, and total blindness is the full absence of the visual light perception. Total blindness is the complete lack of form and visual light perception and is clinically recorded as NLP, an abbreviation for "no light perception" **[4]**.

Table 1 describes the Global estimate of the number of people who faces the Visual Impairment problem by the year 2010.

Table 1. Global estimate of the number of people visually impaired by age, 2010; for all ages in parenthesis the corresponding prevalence (%).

Ages (in years)	Population (millions)	Blind (millions)	Low Vision (millions)	Visually Impaired (millions)
0-14	1,848.50	1.421	17.518	18.939
15-49	3548.2	5.784	74.463	80.248
50 and older	1,340.80	32.16	154.043	186.203
All ages	6,737.50	39.365 (0.58)	246.024 (3.65)	285.389 (4.24)**[5]**

The cause of Visual Impairment for the people may be differed from country to country. It may be depend on their Environmental conditions. Environment conditions will be differed from region to region. In some countries, there may be strict law's regarding the Environment pollution and in some country's they may be not up to the level. In such cases the cause of Visual Impairment may be also due to the pollution made by the Industries and also by the common people. Industries release toxic gases into Environment which are the severe threat for vision. In some cases it may result in complete vision loss for individuals.

1.1 Cause of Visual Impairment in INDIA

The prevalence of blindness as estimated in a national survey conducted by NPCB in the year 2001-02 was 1.1% and in the year 2007 and it reduced to 1%. Cataract is the most important cause of blindness in India accounting for 62% of the total prevalence of blindness. At the same time the geriatric population has also increased significantly in the country. In the year 1991, the 60+ population which was around 56 million that has doubled in the year 2017**[6-8]**. These results will conclude that the population who are affecting for blindness are increasing exponentially. The current goal of NPCB is to reduce the prevalence from 1% to 0.3% by the year 2020. Not only Cataract, there are also some other reasons for the cause of Visual Impairment. That can be visualized by the below representation **[9].**

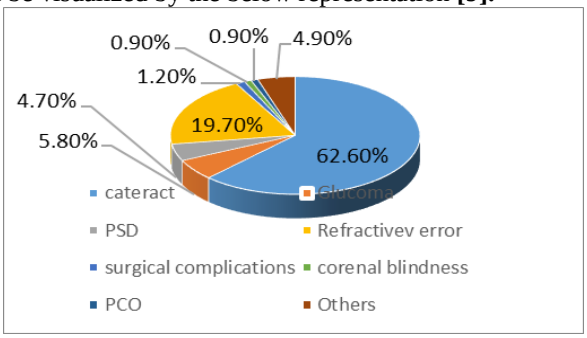

Figure 1 Main Cause of Blindness in India (Courtesy: **[9]**)
Source: Community Eye Health J Indian Supplement 2008, NPCB

Keeping in view such circumstances in country The Government of India produced some objectives to overcome such conditions in country. They are:

a) To reduce the backlog of avoidable blindness through identification and treatment of curable blind at primary, secondary and tertiary levels, based on assessment of the overall burden of visual impairment in the country;
b) Develop and strengthen the strategy of NPCB for "Eye Health for All" and prevention of visual impairment; through provision of comprehensive universal eye-care services and quality service delivery;
c) Strengthening and up-gradation of Regional Institutes of Ophthalmology (RIOs) to become centre of excellence in various sub-specialities of ophthalmology and also other partners like Medical College, District Hospitals, Sub-district Hospitals, Vision Centres, NGO Eye Hospitals;
d) Strengthening the existing infrastructure facilities and developing additional human resources for providing high quality comprehensive Eye Care in all Districts of the country;
e) To enhance community awareness on eye care and lay stress on preventive measures;
f) Increase and expand research for prevention of blindness and visual impairment;
g) To secure participation of Voluntary Organizations/Private Practitioners in delivering eye care **[9]**. This issue is also included in Five Year plans of India **[10]**.

Vision centre as a strategy to provide eye care services to understand populations a survey was conducted by government in a district of Madhya Pradesh named Satna in between April 2007 and March 2008 by placing 5 vision centres **[11]**. The results are:

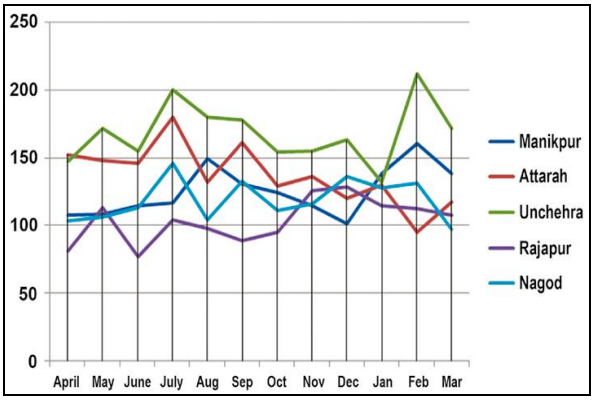

Figure 2: Persons screened at Vision Centres by month and place.

And meanwhile these vision centre's provided the spectacles to the people around their vision centre's campaigns. Later again they conducted the survey on the people. The results are:

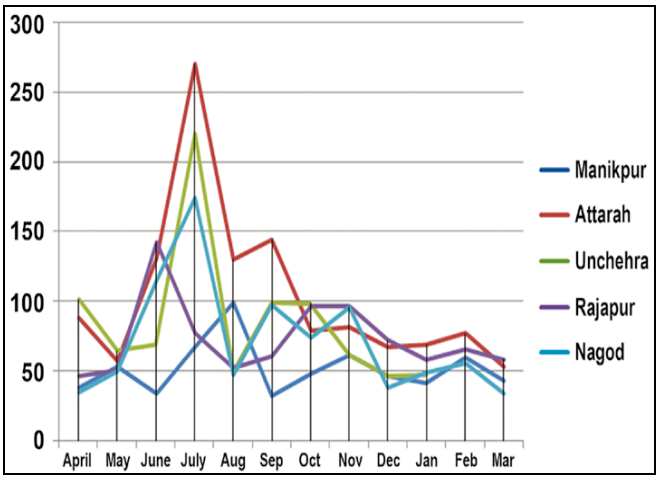

Figure 3: Spectacles dispensed at Vision Centres by month and place (Courtesy: **[11]**)

1.2 Targets and achievements during last 3 Years and Current Year

Table 2: No. of Cataract Operations

Year	Target	No. of Cataract operations performed	% surgery with IOL
2014-15	66,00,000	64,19,933	95
2015-16	66,00,000	63,04,177	95
2016-17	66,00,000	64,81,435	95
2017-18*	66,00,000	15,91,977	

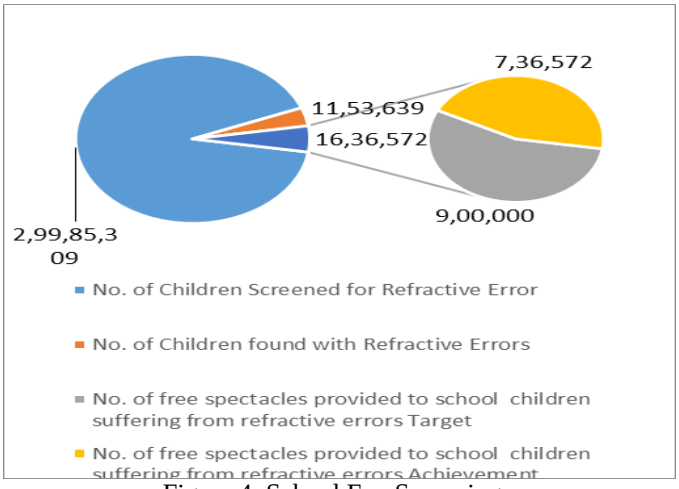

Figure 4: School Eye Screening

Source: DIRECTORATE GENERAL OF HEALTH SERVICES (Courtesy: **[12]**)Ministry of Health &Family Welfare Government of India

II. LITERATURE SURVEY

A literature search on Visual Impairment identified totally more than 1000 publications out of which they are shortlisted to a count of 353. This work is carried basing on majorly the Obstacle Detection by Visual Impaired people. Among 353 there are 50 National and International Conferences, 139 National and International Journal's, 40 Thesis produced by Research Scholar's and Master of Degree graduate's from across the world and 100 other publications which are published by graduates, post graduates and other Research Scholars of standards world's top University's on the Obstacle Detection by Visual Impaired people in between 2004 to 2018* and some other papers from reputed forums. Figure 4 depicts no. of papers collected under different categories.

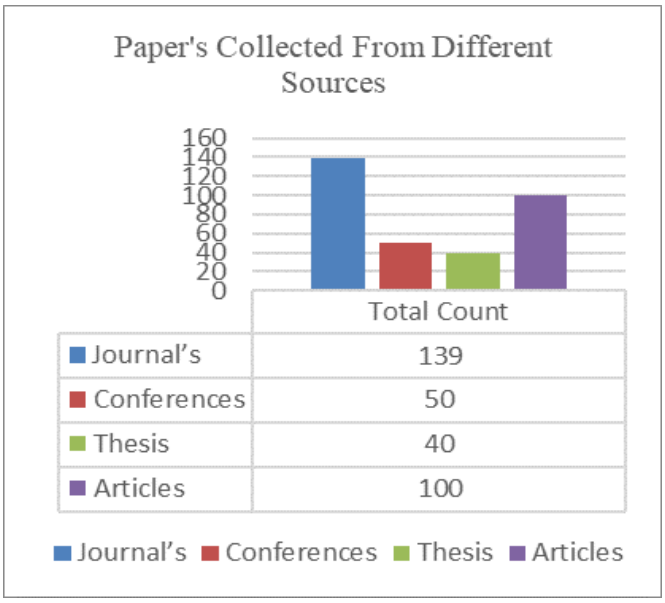

Figure 5: No. of papers collected from different sources

In the year's between 1990 to 2010 the work and research on the Obstacle Detection System (ODS) for the Visually Impaired people is quite less but later on in further years the research on ODS is drastically increased. It may be due to ease of using techniques of Machine Learning, Deep Learning, ANN, CNN and other useful technologies. This can be clearly depicted by Figure 6 where the no of publications are exponentially increased after 2010.

Table 3: Different categories of papers collected according to keywords

Category	No. of Articles	Author
Ultrasonic Sensor	21 of 69	ShrutiDambhare,A.Sakhare.(2011) Jayant,Mita Bhowmick(2012) V.S.M.Madulika, M.S.Madhan (2013) BenLeduc-Mills,Halley Profita(2013) Sonda,Imene(2013) Marut Tripathi,Manish(2014) Olakanmi O. Oladayo(2014) NHemalatha,S Dhivya(2014) Shashank,K.V.N. Kavitha(2014) PoojaSharma, Arun ,H. K. Waghmare(2015) Shubham Adhe,Sachin(2015) Parth Dhall, Pankaj(2016) Sudhanthiradevi.M, Palanisamy, Arunkumar(2017) Dr.B.Paulchamy, K.Anandhasundaram(2018) Tony Jose, Misab P. V(2018) A.Aruna, Y.Bibisha(2018)**[16]**
Sonification	3 of 15	SofiaCavaco, J. Tomás(2013) Rebekk, Hoffmanna(2018)
Pedestrians	2 of 20	Shirin E. Hassan(2012) Sergio Mascetti, Lorenzo(2015)

Initially our work is segregated basing on the keywords that are provided by the authors of the respective Journal's. Majorly the keywords found are Ultrasonic sensor, Visual Impairment, GPS, Sonification, Pedestrians, Path Assisting, Obstacle Detection, Haptic Based, Infrared, Wi-Fi, Mobile Application, Image Processing. Apart from these there are some other keywords but which are less frequent. In this survey paper it is predominantly focused in the area of Ultrasonic Sensor's and the way they detect the Obstacle's in helping the Visually Impaired people in their daily life. There are different number of papers available with these keywords and all they are tabled below which gives the details of Author's and the category they fall under. There are nearly 100 publications based on Ultrasonic sensors, 20 publications on sonification, nearly 30 publication's on keyword pedestrians, nearly 70 publications based on Visual Impairment, nearly 60 publications based on GPS, 60 publications on keyword obstacle detection, 30 publications on Mobile based applications and nearly 30 publications on image processing techniques based journals. Figure 6 shows the graph of no. of articles under different keywords.

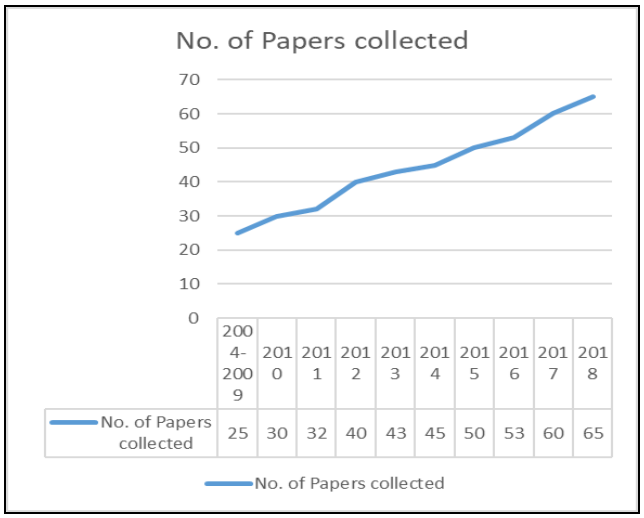

Figure 6: Number of Paper's collected according to Year's

In the above table, the details of the authors basing on the keyword are provided through which it can be clearly depicted that most of authors are published based on Ultrasonic, Visual Impairment and based on GPS.

Table 4

Category	No. of Articles	Author
Path Assisting	2 of 20	Pereira,Nunes(2010) José,Miguel(2011)
Wi-Fi	3 of 26	Ernesto Cividanes(2010) Nektarios Paisios(2012) Vignesh, Madheswari(2017)
Haptic Feedback	7 of 17	Ramirez,Renato(2012) Chinh Nguyen(2014) Huang, Hunter(2014) Megalingam, Aparna(2014) Gilson,Sagar(2015) Eoghan Martin(2016) van Erp, Liselotte(2017)
Image Processing	5 of 11	Karen Soares(2014) Swati Singhal(2015) Chaitrali S., Dabhade(2015) Swathi,Raja(2017) Hana Majerova(2017)
CNN	4 of 26	Ernesto Cividanes(2010) Nektarios Paisios(2012) Karen Soares(2014) Ashish Patankar(2016)

Category	No. of Articles	Author
GPS	31 of 41	Ernesto Cividanes(2010) Shruti Dambhare, A.Sakhare(2011) Ljupko Šimunović, Velimir(2012) Rodríguez, Luis(2012) Somnath koley, Ravi Mishra(2012) V.S.M.Madulika,M.S.Madhan(2013) Chary, B Santosh(2014) Huang, Hunter(2014) Bhambare, Akshay(2014) Swati Singhal(2015) Gilson,Sagar(2015) Deekshith B N,Shwetha(2015) Sangami, M.Kavithra(2015) Lakde, Dr. Prakash(2015) Rimmon Saffoury,Peter(2016) Lokesh.A,Manjunath(2016) Ramamohan.C,Dr.Vishnu(2016) Ramesh Satpute, Mohsin(2016) Radhika R,Payal(2016) Sunaina,Vyshnavi(2016) NIMRAN KAUR, AYUSH(2017) Bhavana sharma,Aukif(2017) Harshal Shimpi, Shubham(2017) Vini Pashiney,Nishant (2017) Tony Jose, Misab(2018) Ajitkumar R, SivasuryanM(2018) A.Tekade, M.Sonekar(2018) Matteo Poggi,Stefano(2018) Kalpana Singh, Mansi(2018)
Infrared	10 of 20	Ernesto Cividanes(2010) Šimunović,Velimir(2012) Venkateswar, Ninad(2012) Vigneshwar ,Vimala(2013) Chaurasia,Kavitha(2014) Chinh Nguyen(2014) Pooja, Shimi (2015) Kher, Dabhade(2015) Abeer, Altegany(2016) Prof. Wankhade,Bichukale
Mobile Applications	12 of 29	Shin, Cheol(2007) Nektarios Paisios(2012) Hakobyan ,Jo Lumsden (2012) Daniel Koester(2013) Madulika S, M.S.Madhan(2013) Abdel Nour Alshbatat(2013) Leduc-Mills,Halley(2013) Satyajit Pokale, Sujeet(2015) Van-Nam Hoang,Thanh(2016) Prof.Wankhade, Bichukale(2017) Priyanka Kumari, Sayani(2018) Shubham Jain,Marco(2017)

Category	No. of Articles	Author
Visual Impairment	23 of 59	Ömer ,Eralp Altuna(2010) Senem KURSUN(2010) Emerson,Koorosh(2011) S.T. Brassai, L. Bako(2011) Wahab, Amirul(2011) Rodrıguez, J. Javier(2012) Ramirez,Renato(2012) Jayant,Pratik(2012) Pooja,Hemant(2013) E. Shobhana(2014) Swati Singhal(2015) Adhe, Sachin(2016) Hannu Seppälä(2017) Onwuka,Olushina(2017) Evan Justin Taylor(2017) Junaid Rayini(2017) Wafa,Khaled(2017) Arti Soni, Sonal(2018) Dimitra P. Marini(2018) Ali Hojjat(2018) Ramchandani P, Maheshwari K. (2018) Grijalva, Medardo(2018) Shirin E. Hassan(2012)
Obstacle Detection	26	Shin ,Cheol(2007) Pereira,Nunes(2010) Mohajeri, Roozbeh(2011) Rodrıguez, J. Javier(2012) MISHRA, RAJ(2012) Gundewar, Hemant(2013) Sachin Lalar(2013) Shehabi, Mustahsan(2014) E. Shobhana(2014) Priyadarshana, Wimalaratne(2014) Khenkar, Hanan(2016) BAHARUDDIN MUSTAPHA(2016) Soni,Sonal(2018)

		Dimitra P. Marini(2018) Jafri and Marwa(2018)

A total of nearly 15 keywords are frequently used and basing on that itself remaining are segregated.

2.1 Papers based on the keyword 'Ultrasonic Sensors'

Shruti Dambhare, A.Sakhare (2011) **[13]** proposed "Smart stick for Blind: Obstacle Detection, Artificial vision and Real-time assistance via GPS". In this paper they have given the solution as the replacement for the oldest mobility aid white cane by providing the new system architecture and model explanation of Electronic Travel Aid (ETA The proposed combination of various working units makes a real-time system that monitors position of the user and provides dual feedback making navigation more safe and secure. And algorithms used for implementing the model are scene segmentation, depth map processing and bounding box estimation. Dada Emmanuel Gbenga, Arhyel Ibrahim Shani, et al. (2017) **[14]** proposed "Smart Walking Stick for Visually Impaired People Using Ultrasonic Sensors and Arduino". In this paper a modified cane with some electronics components and sensors, the electronic aiding devices is designed to solve such issues. The Ultrasonic sensor is used to detect all kinds of obstacle. Water sensor is used to detect if there is water in path of the user. The cane is accomplished to identify the obstacles and humidity in the pathway. Therefore, a better device can be constructed using ultrasonic sensors, Arduino Uno and other devices that employ audio commands to alert the user of what is in his path of movement

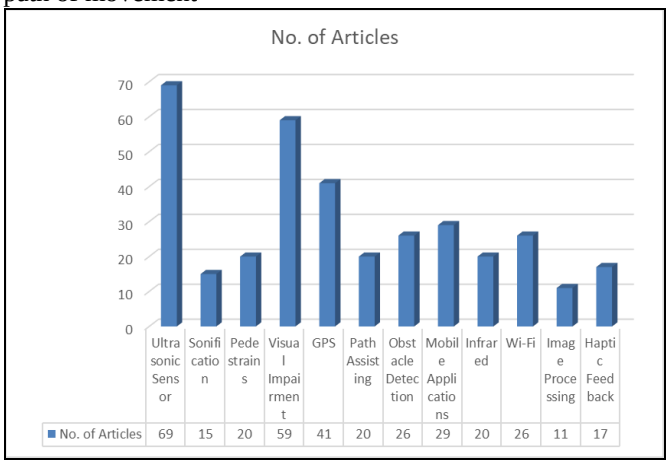

Figure 7: No. of articles collected according to the keywords

O. O. Olakanmi (2014) **[15]** proposed "A Multidimensional Walking Aid for Visually Impaired Using Ultrasonic Sensors Network with Voice Guidance", is capable of detecting the direction and position of obstacle. The performance and functionality are also improved by the addition of alert light, and voice guidance signal which is connected to a miniature headset. The voice module guides the user. This multidimensional walking cane was able to detect obstacles within the range of 0m to 1m at the left, right and front of the stick with an appropriate voice alert. For easy movement in both familiar and unfamiliar environments, there are various methods devices to aid visually impaired individuals, like the use of walking canes, use of guide dogs which assist in navigation or by the help of another human with perfect sight.

2.2 Waist Belt and Shoes mode of Obstacle Detection

Parth Dhall, Pankaj Sharma et al. (2016) **[16]** proposed "A Review Paper on Assistive Shoe & Cane for Visually Impaired People". In this paper to provide a talkative assistance for a visually impaired person they provided the system architecture and the block diagram of the assistive shoe. In this they implemented the entire work as two modules, one the shoe module, in which a Bluetooth chip, PIC microcontroller along with three IR Sensors are used.

Suryavanshi, Mayuri et al. (2016) **[17]** proposed "Assistance for visually impaired people". In this they have given the system architecture for the shoe which detects the obstacles. This shoe model is implemented by using the Arduino uno board on which all the circuit components is deployed on to. And for the obstacle detection they used the ultrasonic sensors and other hardware components they used are Micro SDHC Card Series and Bluetooth. N. Rama Murthy, N. Sudha (2016) **[18]** proposed "Smart Navigation System for Visually Challenged People". In this provided the system architecture of waist belt and shoe through which obstacles are detected by the visual impaired people. In this working is done in such a way that it uses 2 sensors at spectacles, 3 sensors at waist belt which are separated by 12cm from each other and 2 sensors in shoe one facing the front and one facing the down.

2.3 Papers basing on GPS/GSM Technology

R. Radhika, P.G. Pai, S. Rakshitha and R. Srinath **[19]** proposed "Implementation of smart stick for obstacle detection and navigation". This paper refers to the obstacle detection with the help of ultrasonic sensor and IR sensor connected to Arduino ATMega 328P which has 14 digital input/output pins Ultrasonic sensor detects the range of 3m and IR sensor detects small objects at a range of 50cm, angle +/- 245 degrees upwards and downwards. Arduino is the microcontroller used. By Ljupko Šimunović, Velimir Anđelić, Ivan Pavlinušić (2012) **[20]**, Alberto Rodríguez, Luis M. Bergasa et al. (2012) **[21]**, in this paper they used the stereo camera for capturing the pictures of the location further which are processed by using the image processing technique namely Dense Disparity Map. In which it processes in such a way that it detects the edges of the captured pictures for easy detection of the obstacles. By

using those pictures it is made easy to track the user by equipping the GPS module to the user

Somnath koley, Ravi Mishra (2012) **[22]**, S. Madulika, S. Mohan et al. (2013) **[23],** Vishwa Rupa, B Santosh (2014) **[24],** these authors introduced the usage of Braille capacitive touch keypad on the controller board. It is very helpful for the blind users because they are unable to see the digit buttons. For that as interface for them they used the Braille language. And they equipped the canes with different sensors like Ultrasonic, LDR, Soil moisture sensor, temperature sensor and the major part GPS module through which the location tracking of the user is done. Due to this facility the caretaker of the blind person can know the live location of the person.

2.4 Papers basing on Mobile Applications

Lilit Hakobyan, Jo Lumsden et al. (2012) **[25**], Nektarios Paisios (2012) **[26],** Adbel Iiah Nour (2013) **[27],** in this they discussed the innovative assistive applications designed for the visually impaired by using the current technologies that are either delivered via mainstream devices and can be used while in motion (e.g., mobile phones) or embedded within an environment that may be in motion (e.g., public transport) or within which the user may be in motion. Ben Leduc-Mills, Halley Profita et al. (2013) **[28],** Aswathy, Dilraj et al. (2015) **[29],** proposed a mobile application in which it has two screens namely the main screen and the settings screen. It can be switched from one another just by pressing the provided button. The main screen shows the readings from the 3 ultrasonic sensors in real-time and has a single button for entering the settings screen. A pilot study testing the performance of the ioCane with blind cane users showed a 47.3% improvement in obstacle avoidance. Karen Soares (2014) **[30],** in these thesis papers author proposed a cane for assisting the blind or visual impaired person in shopping activities. And for tracking the location of the user the cane is connected to Wi-Fi through which the location based on the GPS and GSM is transmitted to the person who is care taking and in other thesis author designed the android application basing on SVM and for supporting the SVM they used Open CV android SDK. And they the results of pilot study which given the accuracy approximated to 82.5%.

III. OBSTACLE DETECTION BY USING IMAGE PROCESSING TECHNIQUES

Anik Hasan, Nasrat Sharif (2010) **[31],** Niclas Zeller (2013) **[32],** in the proposed paper they chosen the Android Application as the medium of communication between the user and the device. The mobile captures the pictures and on the images Image Processing techniques are applied and also by using the Kinect depth image processing techniques are applied. For coding these things MATLAB is used. Pooja, Hemant (2013) **[33],** Ian Austen (2004) **[34]** presented a survey paper on the Obstacle Detection while they are in Navigation either in Indoor or in Outdoor environment. And also by using the camera, surrounding environments images are captured later they are processed by using the software where it works basing on the color Sonificaton.

Qing Lin, Hernsoo et al. (2013) **[35]**, N. Sachin, G. Anil et al. (2016) **[36]**, these authors used the web camera as there equipment for capturing the pictures and later on the captured pictures by using different Image processing techniques like Harr classification, edge detection and dense disparity map they make the system to recognize the obstacle. Byeong-Seok, Cheol-Su (2007) **[37]** and other authors used the technique of Morphology filters which enhances the edges of obstacles as the edge blobs. These are represented using a directional ellipse as a new model for obstacle classification. And for voice commands they used the Fuzzy logic. K.Swathi, Dr.R.Subhashin et al. (2017) **[38],** implemented a cane which is completed based on IoT. In that they used different sensors for different functionality like water and moisture sensor, LDR and US sensors. And for capturing the pictures they equipped the camera to the stick further which are processed using different Image Processing techniques.

3.1 Haptic based sensing of obstacles

Alejandro, Renato et al. (2012) **[39],** Chinh Nguyen (2014) **[40],** and other authors proposed the way of detecting the obstacles based on haptic sensing. These haptic obstacle detectors uses the Infrared sensors, Ultrasonic sensors and also for maintaining the time gap they implemented the function avoid tiredness. Haptic sensing can be well accomplished by knowing the surroundings well. By knowing the surrounding environment it will help a lot from avoiding the obstacles and to choose other way for reaching the desired destination. For the accuracy they tested the cane practically with visual impaired people and got good accuracy in sensing the obstacles.

3.2 Trending technologies used in building Smart cane and wearable devices for Visual Impaired people

Fernando, Gerardo et al., (2017) **[41],** Dawid, Karolina et al., (2017) **[42]** these authors proposed a concept by using the SCANeR software and Matlab/Simulink. The cyber-physical system is designed and implemented in SCANeR. And three specific artificial intelligence-based methods for obstacle recognition libraries are also designed and applied using a sensory information database provided by SCANeR. And other authors tried to interpreting a reality-based real-time environment evaluation for informing the user about impending obstacles They implemented an algorithm for object detection as a regression problem to object bounding box masks. Roshan, Dinesh et al., (2018) **[43],** they processed the captured images by using libraries like Open CV and Google Cloud Vision API. And for comparison of

the images captured they used COCO dataset. Several test sequences are conducted for results on indoor and outdoor for estimating the effectiveness of the proposed method.

V. SELECTION PROCESS OF PAPERS

Initially our search process is started basing on selection of different key terms like blind person helping sticks, visual impairment aid's, smart canes, wearable devices for blind person, assistive canes for blind persons, guiding systems for blind people and many more and basing on this search results we got the best publications on visual impairment from different reputed Journals, conferences, articles and thesis from standard Universities. Fig 6 depicts the number of journals, thesis and articles collected from different sources like IEEE, Science Direct, Elsevier and International Journal of Scientific & Engineering Research and other. Many journals are available in the website, from them we downloaded a few papers which are close to our problem statement.

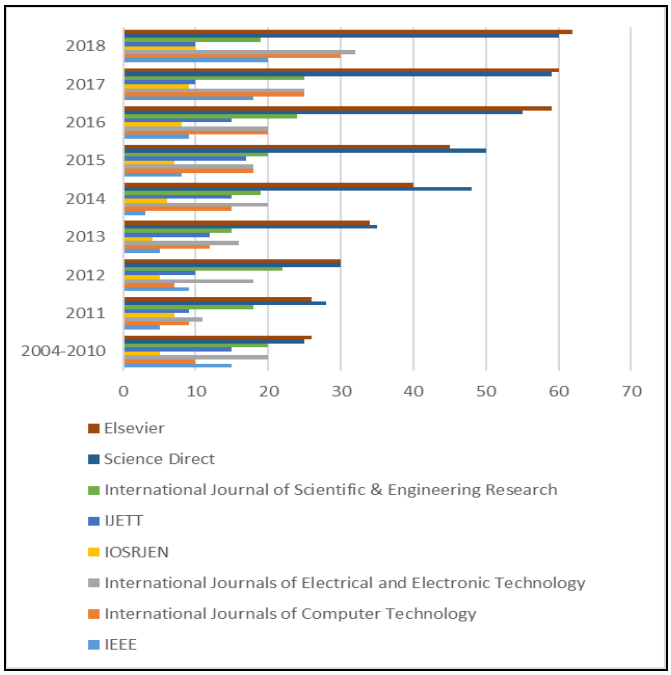

Figure 8: No. of Papers collected from different sources.

Many of the authors explained their terms, concepts and views in detection of obstacle by visually impaired/blind people very similarly. The author -author mapping is also matched that is mainly based on the technique they used i.e., like Ultrasonic, Mobile based navigation, haptic based sensing, IoT based sticks and many more. Of all them we mapped some of the authors who are more similar in their ideas related to obstacle detection by visually impaired people. Figure 9 depicts the Author names who are very close in their ideas. At the end we kept a meter ranging from 0 to 5. In that 0 refers that the context of those authors are close enough, one represents a minute less relative idea and in order of five the ideas of the authors are mapped.

Figure 9 depicts the relativeness among the authors and their views. Mapping of the authors is done according to the keywords provided in their articles, journals, thesis, conference papers and in any their publication. Here mapping is done basing on keywords like Ultrasonic sensor, IoT, 3D vision, Wearable devices, Haptics based detection, Voice based output canes, Microcontroller based stick and GPS based tracking canes. The systematic survey mainly aims to present a better approach in navigation for visually impaired people that is provided by different authors in their publications. Either it is smart cane or spectacles or assistive shoes or any mobile based navigation, the reason behind taking up the survey is to provide a better source for navigation for blind/visually impaired people.

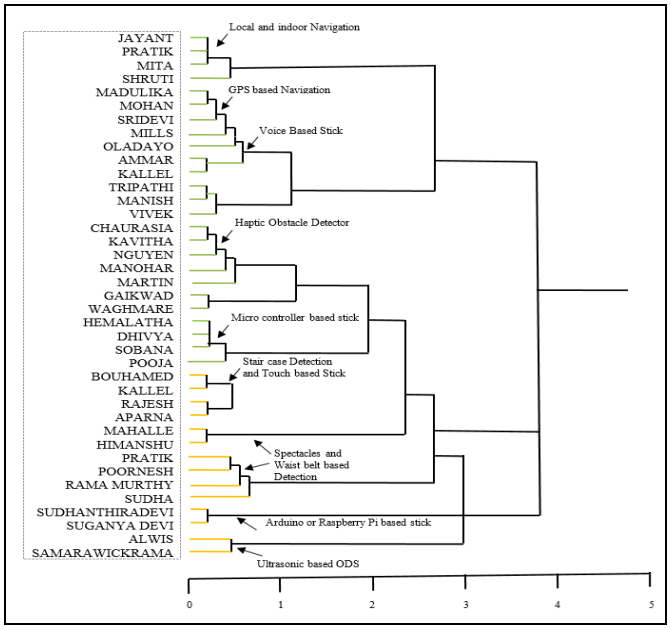

Figure 9: Cluster analysis of seminal authors for Obstacle Detection for Visually Impaired people using Wards method

VI. CONCLUSION

A systematic survey on obstacle detection by visually impaired people is presented in this paper and explained functionalities and techniques applied on each system. Majorly these obstacle detection systems can be like Electronic Travel Aid, wearable obstacle detection systems, handheld obstacle detection systems and many other sensor based devices. In this paper these obstacle detection systems are majorly classified on the basis of Ultrasonic Sensor based smart cane, GPS/GSM based navigation, wearable devices which detects the obstacles, Mobile based navigation aid for visually impaired people, Image processing technique based detection of obstacle and the advanced technologies like

Machine Learning, Deep Learning and Artificial Intelligence learning algorithms based obstacle detection systems. The survey performed in this paper shows the important development carried out during these previous decades within the field of Travel Aids for visually impaired people, mentioning the evolution of assistive devices with very less features to modern devices with more features in which user can easily interact with the system. From the survey conducted to our knowledge it seems usage of algorithms from advanced technologies like Machine Leaning, Deep Learning and Artificial Intelligence from all of the proposed approaches will provide the better navigation aid for the Visually Impaired people.

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