Aids for Visually Impaired Persons for Obstacle Acknowledgment: A Study and Proposed New Framework

Preetjot Kaur
M.Tech Student
Department of ComputerEngineering
Punjabi University, Patiala, India.

Sumandeep Kaur
Assistant Professor
Department of Computer Engineering
Punjabi University, Patiala, India.

ABSTRACT
From the gift of current innovations, particularly in the versatile innovative world of computer vision and so forth, the blind/vision weakened individuals' lives are getting to be vivid. They are presently pondering themselves differently on account of these helpful devices that are going to be as a general rule which were once just in heart's craving. A great deal of techniques and applications has been made by some extraordinary analysts. In this paper, computer vision strategies to bolster visually impaired or vision hindered individuals are referred to and several techniques of different specialists are talked about. Their merits and demerits are addressed and comparative analysis is made among them based on several parameters such as Recognition Rate, Time, efficiency etc.

Keywords
Obstacle detection, object recognition, comparative analysis, computer vision, visually impaired/ blinds

1. INTRODUCTION
Visual disability is regularly mistaken for the term visual blindness. In this way, before going into discourse around a few computer vision based systems, it's critical to know the difference between two. A man is said to be outwardly debilitated, when he is confronting issues while reading, driving, strolling, working, and so on... Furthermore, these issues are not settled using Glasses. Now, when a man has vision of 20/70 to 20/1000, then he's considered to be apparently disabled. Then again, when a man loses his capacity to see totally, or sees just dull area around, he's alluded to as visually impaired. Similarly as our history is thought of it as, obviously demonstrates that visually impaired people have been all that much underestimated by our general public. Individuals regularly think of them as subordinate roles in their general public, supposing they are unfit for lead roles. In 2010, the amount of people outwardly weakened was assessed to be 285 million, of whom 39 million were visually impaired. This is a diminishing in the amount of people as of now assessed as being outwardly hindered in 2004. This can be a direct result of better data, moreover in view of efforts of science which have decreased the amount of people with avoidable visual shortcomings. [1].

The American Foundation for the Blind estimates that 85% of all persons with eye disorders have some remaining sight; only about 15% are totally blind[2]. There have been several non-computer-vision based techniques such as White Cane & the use of guide dogs. The white cane has been the only tool that is widely accepted even now.

Guide Dogs make it simpler to get around, bringing about the individual making them more comfortable & bring some sort of independence among them. These benefit even more when one is in an unfamiliar environment.

Moreover, we know that most of the visually impaired population lies in the developing countries; therefore cost becomes important factor while designing tools for them.

Keeping all the challenges (like not accepting new tools or refusing to wear aids at public places) into notice, we will propose a technique in which user may not have to wear heavy electronic gadgets around him & can walk with free hands. In this paper, we will give a review about various computer vision based techniques.

The remaining paper is organized as: Section – 1 discusses about various obstacle detection aids based on computer vision. Section-2 gives comparatives analysis of these techniques. Section- 3 mentions performance measurement parameters, section -4 gives proposed new system & section – 5 concludes.

2. OBSTACLE DETECTION AIDS BASED ON COMPUTER VISION.

2.1 An aid modeled from echolocation of bats (1991)
T. Ifukube in [3] from Japan designed a model which uses microprocessor & ultrasonic devices. In this model, a downswept frequency modulated ultrasound signals are transmitted by an array in order to detect obstacles. The frequency is measured from the emitted ultrasound so as to match it with the characteristics of the bat echolocation. These audio waves are then transmitted to the user through earphones. The results showed that downswept ultrasound was better than other ultrasounds. Blinds could detect several obstacles at the same time & make discrimination among them too. Good for small obstacles detection. But not fit for large obstacles.

2.2 Stereo based vision-aid (1997)
N.Molton [4] from University of Oxford, Oxford, U.K has used navigation techniques to detect obstacles in the way of blind persons. The ASMONC (Autonomous System for Mobility, Orientation, Navigation and Communication) is a navigation system which uses Sonar for detection of high obstacles.

The ASMONC project uses a wearable backpack. It uses T1 C40 processor & two Sony NDP-40BY/E cameras, one on each shoulder. The sensors are present on the chest & belt. The GPOD (Ground Plane Obstacle Detection) algorithm is

used for ground obstacle detection, which is more stable towards changes in contrast & lightning. However noise, being a stochastic (random variable) cannot be detected through geometry, therefore, probabilistic approach is followed for this.

The above algorithm is extended to DGPR (Dynamic Ground Plane Recalibration) for including recalibration of the ground images. The Kalman filter was used to improve the accuracy of movement estimations. It is used for ground obstacle detection. But it doesn't provide detection of small obstacles. DGPR does not run with C40 Processor, which is very old & slow & doesn't accurately detect noise.

2.3 Obstacle detection by creating virtual acoustic space (1999)

Gonzalez-Mora [5] From department of Physiology, La Laguna has developed a prototype which allows blind users to become familiar with the environment by perceiving the spatial characteristics of the environment. The author considers the fact that not only light, but sound can also be used for carrying spatial information to the brain. This makes the user who cannot visualize the environment through his eyes to perceive its details through sound.

In this process, the sounds produced from objects are simulated, & are allowed to create a 3D perception about objects. The system also uses other parameters such as color, texture, etc. so as to translate these into binaural sonic parameters, which would allocate sound source to them at every position. Letting user knows about the room orientation. For this, the user wears spectacles which are having two cameras attached to them. The results obtained were unbelievably accurate for blind persons than those from control sighted ones. The cons were like System becomes impractical when difficult to distinguish real sounds from virtual ones. System focuses only on object orientation rather than obstacle detection.

2.4 NAVI (2003)

Farrah Wong [6] From School of Engineering and Information Technology University Malaysia Sabah, worked on the technique NAVI ("Navigation Aid for Visually Impaired"). According to him, the earlier versions of NAVI (NAVI-01 & NAVI-02), with single camera were limited in providing depth information about objects. This prompted him to extend the system using stereo vision.

In this system, two video cameras are used with space apart from each other and fixed onto head gear. The system uses fuzzy-based segmentation procedure for the pre-processing of images. The framework produces a two-level sound. First, an organized stereo sound shows the size of the object & other verbal sound, to indicate the distance.

After computing disparity, the distance is computed. Then the respective sound is generated. The images are output in the form of black & white. Good approach for detection of obstacle, its size, location & distance from the user. The nearest object is considered prior to all for user's safety. The system needs learning. The object which is nearest to user will be considered prior to all.

2.5 Speeded Up Robust Features (2008)

Herbert Bay in [7] From Switzerland has presented new detector & descriptor, namely SURF. SURF is invariant to features such as scale & rotation. It computes & compares functions such as repeatability, robustness & distinctiveness much faster than other techniques.

SURF is an efficient technique for object finding. It is based on the Hessian matrix. It has been concluded that Hessian based detectors are repeatable & more stable than Harris based detectors. Another reason behind the speed gain is due to the use of integral images. It is an efficient technique. Performs computations faster & is invariant to scale & rotation. It gives approximate results i.e. not accurate.

2.6 Robot vision – Based on SLAM (2010)

VivekPardeep[8] from University of Southern California, USA makes the use of visual odometry& SLAM (simultaneous localization and mapping) i.e. an advanced computer vision technique into their vision based system. It uses Bumblebee2 stereo camera. The system consists of head-mounted design which enables users in scanning the scenes by standing.

It utilizes camera posture estimates with 3D information obtained from stereo triangulation & builds surrounding map of user. This map is then used to analyze the obstacles in the path of a user. This system provides better orientation of the surrounding. It has more mobility. This system might not work if there is an obstacle down the path. The Bumblebee2 stereo camera is additionally exceptionally bulky to be used. A fastened fire wire association forces requirements amid portability tests.

2.7 Wearable Obstacle Avoidance ETA (2010)

DimitriousDakopoulosin [9] presents a comparative survey among several wearable obstacle detection systems. This paper justifies the difference between how the information is gathered & then transferred to the user.

The Data can be assembled with sonars, laser scanners, or cameras and the user can be educated through the sound-related and/or material sense. The ears are set free. It generates the sense of comfort in users. Although, every techniques has something special over the other one, None of the systems discussed in the paper have succeeded in fulfilling all the demands & challenges being faced by the Visually Impaired users.

2.8 Modified SURF Descriptor (2010)

Hui Huang [10] from National Digital Switching System Engineering & Technology Research Center, China has proposed a new detector, namely OCT & modified version of SURF descriptor as I-SURF.

The integral images are used here. Response is calculated at every pixel by OCT. I-SURF is different from SURF in a way that it considers the boundary effect of sub-regions & speeds up the machine by introducing index vector in it.

It provided better performance in terms of accuracy in wall sequence than those of SIFT & SURF. It weakens the boundary effect. It is 3 times faster than SURF. OCT performed worst in boat sequence than SIFT & SURF.

2.9 Finding Objects based on SURF features (2011)

Ricardo Chincha&YingLiTian [11] from City college of New York has proposed an object recognition technique based on SURF (Speeded Up Robust Features) to assist blind persons in finding objects.

The object identification is done by matching query image with images in the reference sample. System was found to be 84% accurate. The system is invariant to the basic operations

like rotation, scaling, translation, etc. The system failed under extreme conditions.

2.10 Blind shopping (2011)

Diego López[12] from University of Deusto, Spain started a project based on shopping for visually impaired persons. Its work is based on following components. These are as such: first, a white cane having a user navigation system on its tip. Then, product recognition component is used to detect QR codes. The android phone camera is used. The author keeps into notice about the joy of visually impaired in doing shopping of new products i.e. other than that of planned shopping. But at the same time, recommend user to carry white cane along in order to ensure safety. Thus the proposed system yields reliable, cheaper and easily deployable solution for blind persons.

2.11 Way finding aid for blinds to access unfamiliar environments (2011)

YingLiTian[13] proposes a new system for blind persons to access unfamiliar environments. In his system, he tries to locate the doors for blinds/ VI. He also tries to distinguish the different classes of doors, for example, bathroom doors, office door, etc.

The technique is based on the detection of edges & doors. First, image is pre-processed to eliminate noise. Then canny edge detection smoothens the image by down sampling it. Then after extracting contours, corners are extracted. The audio display is provided by Microsoft Speech Software development kit (SDK).This paper also justifies how relative position of a door is affected with respect to user. It can handle both open & closed doors. Algorithm achieved 92.3% accuracy without protruding objects & 89.5% with protruding objects. Motion blur occurs when sudden movements take place. This detection of doors can also be done using cane or guide dogs, making system irrelevant.

2.12 Finding lost objects (2012)

Schauerte [14] from Karlsruhe Institute of Technology developed a system that helps the blind persons —find their lost objects by combining color & SIFT-based object detection using sonification. The user is allowed to effectively make use of his senses i.e. the system does not interfere with the user's senses.

The system is first trained by holding an object in front of camera & taking its snapshots. Then while searching an object, SIFT identifies them by matching features & performing classification. To find any colored object, color attributes are used. The sonification is done using sound properties – Pan & Pitch. Lower sound is produced when objects are located close to bottom of image frame & vice-versa.

Two scenarios were considered. First, when object is placed randomly & other where an area is restricted i.e. object is placed randomly somewhere on desk. The system not only helps in detecting features, but also colors. The results showed that in the second case, search time was greater using system. Users need to be trained for using this system.

2.13 Using Visual Tags (2013)

RabiaJafri in [15] from department of information technology, King Saud University, Saudi Arabia provides several techniques based on visual tags. The author considers the fact that almost every user owns a very basic device such as mobiles, etc. Badge3D uses 1D barcode with black rectangular boundary. Tags are located by system making use of Canny Edge Detector.

Shoptalk and ShopMobile allows visually impaired to do shopping independently. It's another version, namely ShopMobile reduces hardware complexities & port the whole software into user's mobile.

Trinetra was developed to help users in grocery stores. LookTel is a very famous Smartphone application, which is using 1.5" or 3" restickable vinyl stickers with printed imagesTalkingTagTMLV was proposed to scan 2D barcodes. The iPhone touch screen is used as an interface.

These systems are financially savvy, compact, instinctive and convincing to urgent issue. Occupy less storage & power computation. Certain products from stores are already having bar codes attached to them, thus do not need any external tags & are economic. Tags must be carefully placed on objects. These must be carefully placed in front of camera for being detected. If any system is having lot of tags, it becomes inefficient.

2.14 Combination of SIFT + SURF (2013)

Chucai Yi [16] from The City University of New York proposes a new prototype based on camera network & feature matching. The two famous techniques of SIFT & SURF are combined to perform object detection for blind persons.

In this system, a reference sample is created, in which multiple pictures of a same object are captured & stored. Whenever, the user sends a query, it is first checked within the reference sample. SURF & SIFT based feature extraction is used for matching objects. Search becomes successful if a match is found & otherwise, not. The system is good for finding indoor objects. Simple cascading of two descriptors was not very significant as SURF was good in terms of efficiency, while SIFT in terms of accuracy. The system needs to be trained.

2.15 White cane + Obstacle detector (2013)

Cheng-Lung Lee in [17] from Chaoyang University of Technology, Taichung developed a prototype which is light-weight, cheap and portable. There are three modules for detecting obstacles. These are as: sensing module which is used to sense the presence of obstacle. For this there are 3 sensors attached; one on user's body and the other two are kept in bag. The processing module is to control the host. For warning user about obstacle, warning buzzer is provided. In concluding part, the user recommends this prototype in order to attain user's satisfaction and safety.

2.16 Depth finding (2013)

R.Gnana Praveen [18] from IIT Guwahati, Assam proposed technique for estimation of depth from a single image on the basis of local depth hypothesis, which doesn't require any interference. The approach works as like a camera captures the picture of any close depth which is ahead of user, then the image is resized for making it computationally efficient. The depth is calculated based on local depth hypothesis following edge detection procedures on the obstacles in the image. The estimated depth is matched with the reference depth map & is used in obtaining information about the obstacle which is ahead of user.

The pros include that the system does not require any prior information about user like his height, etc. no learning required to work with it. System is compatible in real time applications. But like other, it is also not free from cons like it

may fail to detect depth in obstacle, between sub segments which are joined.

2.17 For Navigational Assistance (2014)

Navya Amin[19] from University of Applied Sciences, Germany collects all the techniques for detection and classification of objects in his paper. The techniquesare summarized into 3 methods, which further categorizes into several techniques based on their class. He collected computer vision techniques. Then another class is based on SVM which comprises of techniques such as SIFT/SURF. Then the last method is Computer stereo vision-based, which is based on the distance calculation. Then these methods were tested by their success rate, which is calculated using Recall Rate (RR) & Precision Rate (PR). After analyzing, it was found that CSV- based method was better than the other two in terms of accuracy and performance.

2.18 Darshan: a navigation system (2014)

MarutTripathiin [20] from National Institute of Electronics & Information Technology, Aurangabad proposes a new electronics guidance for VI namely, Darshan, which is an electronic guidance system used for blind persons to navigate safely & quickly.

In this system, ultrasonic sensors & USB camera are used. The obstacles are identified & then informed to the user through earphones in the form of beep sound. The images of obstacles are captured by USB Webcam connected with Raspberry Pi Embedded board. The 92% Accuracy, minimum physical interface, lesser training time&Human being detectionare making it real time. But lot of hard wires with sensors & others make it cumbersome. The system does not detect ground level obstacles & color detection.

2.19 Electronic Guide Cane (2015)

B.MohanSitaramaiah [21] from Nalanda institute of technology, Guntur, A.P, implemented a new technique for blind persons by making the guide cane to be an electronic aid & removing the drawbacks of existing cane.

In this system, the data from the ultrasonic sensors will be investigated by the microcontroller incorporated in it and as indicated by the output obtained, the microcontroller controls the vibrating engine and voice playback module. A GSM modem associated with the microcontroller gives the crisis salvage by making a message on the relating guardians of that individual's networks are available even in a small village. It is less costly than internet. The system provides better results in traffic & busy areas, thereby ensuring safety. Two ultrasonic sensors are used.

2.20 Using smart technologies (2015)

Mohammad L. Mekhalfi [22] from University of Trento, Italy developed a system, overcoming the shortcomings of techniques which are only meant for either navigation or obstacle avoidance. The system has two complemtary units. One is Guidance system – which is working online & guiding user about his path. Other is Recognition system – which recognizes obstacles but works only on demand. The computer vision based tool is designed especially for indoor systems. The hardware used is camera, which is mounted on chest, IMU (Inertial Movement Sensor) and laser sensors. The feedback is provided in form of audio & is fast. The piece-wise curves, if obtained needs to be smoothened further. Laptop can be replaced by tablet or Smartphone camera. Verbal guidance can be replaced with haptic technology.

3. COMPARATIVE ANALYSIS OF EXISTING TECHNIQUES – A DISCUSSION

No.	Author (Year)	Work proposed	Hardware/ technique used	Remarks
1.	T. Ifukube& T.S (1991)	Aid after echolocation of bats	Model uses microprocessor and ultrasonic devices.	• It can detect multiple obstacles at a time. • It is good for small obstacle detection but not fit for large obstacle detection.
2.	N.Molton(1997)	Stereo based vision aid for navigation purposes (ASMONC).	It uses T1 C40 processor & two Sony NDP-40BY/E cameras, one on each shoulder & sensors on chest & belt.	• Kalman filter improved the accuracy of the system. But does not work with C-40 processor, which is very old & slow. • Used for ground obstacle detection, but does not detect small obstacles. • Does not detect noise too.
3.	Gonzalez Mora (1999)	Prototype built on spatial characteristics of the environment & uses sound for knowing about surroundings.	Sounds are simulated & allowed to create 3D perception about objects.	• Accurate results. • System becomes difficult when difficult to distinguish the real sounds from virtual ones.
4.	Farrah Wong (2003)	NAVI - Navigation Aid for Visually Impaired.	System uses two cameras. Uses fuzzy segmentation for preprocessing of image. Two kinds of sounds are used here & output comes in the form	• Good approach for detection of obstacle, its size, location & distance from the user. • Gives priority to user's safety. • But the system needs learning.

			of black –white.	
5.	Herbert Bay (2008)	SURF – Speeded Up Robust Features	A new feature detector & descriptor which is invariant to scale & rotation.	• Efficient & faster technique. • But does not yield accurate results.
6.	VivekPardeep (2010)	Robot vision Based on SLAM - Simultaneous localization and mapping	It utilizes camera posture estimates with 3D information obtained from stereo triangulation & builds surrounding map of user. The micro vibration motors signals obstacle.	• The system provides better orientation about surroundings, but does not work for ground level obstacles. • The Bumblebee2 stereo camera is additionally exceptionally bulky to be used.
7.	D. Dakupoulos (2010)	Conducts a survey among several wearable obstacle detection systems.	The systems usually takes input through sensors, laser scanners, cameras, etc& output in the form of sound.	• Although, every techniques has something special over the other one, None of the systems discussed have succeeded in fulfilling all the demands & challenges being faced by the blind users.
8.	Hui Huang (2010)	Proposed new detector, namely OCT & modified version of SURF descriptor as I-SURF.	Response is calculated at every pixel by OCT & it considers boundary effect of sub-regions & speeds up the machine by introducing index vector.	• It weakens the boundary effect & is 3 times faster than SURF. • OCT performed best in wall sequence but worst in boat sequence than SIFT & SURF.
9.	Ricardo Chincha (2011)	Object finding based on SURF	The object identification is done by matching query image with images in the reference sample.	• The system is accurate, invariant to rotation, scaling & translation. But failed under extreme conditions.
10.	Diego López(2011)	Proposed a project based on shopping for visually impaired persons.	There are two components. Navigation component in which white cane shaving sensor on its tip. Recognition component to detect QR Codes.	• The user can safely enjoy shopping. • The proposed system is reliable, cheaper and easily deployable solution for blind persons.
11.	YingLiTian (2011)	system for blind persons to access unfamiliar environments	The technique is based on the detection of edges & doors. The image is pre-processed, smoothened & then contours are extracted for corner detection.	• It can handle both open & closed doors. • Accurate but Motion blur occurs when sudden movements take place. • This detection of doors can also be done using cane or dogs, making it irrelevant.
12.	Schauerte (2012)	Proposed system for letting blind persons find their lost objects.	SIFT is used for identification & matching of features. To find any colored object, color attributes are used. sonification is done using sound properties – Pan & Pitch.	• The system not only helps in detecting features, but also colors. • Several times, the search time was greater & users also need to be trained.
13.	RabiaJafri (2013)	Comparative analysis of systems based on visual tags.	Badge3D, Shoptalk and ShopMobile, Trinetra, LookTel, TalkingTag^{TM}were some of the systems that were discussed here.The iPhone	• These systems are financially savvy, compact, and instinctive & occupy less storage & power computation. But Tags must be carefully placed on objects. • If any system is having lot of

			touch screen is used as an interface.	tags, it becomes inefficient.
14.	Chucai Yi (2013)	Proposed prototype based on camera network & feature matching.	The system uses cascading of two techniques as SIFT & SURF.	• System is good for finding indoor objects, but it needs to be trained.
15.	Cheng-Lung Lee (2013)	White cane + Obstacle detector	There are 3 modules in this system. These are sensing module, processing module and warning buzzer.	• System attains user satisfaction and ensures safety.
16.	R.Gnana Praveen (2013)	Proposed technique for estimation of depth from a single image on the basis of local depth hypothesis.	The camera captured image is resized. The depth is calculated based on local depth hypothesis following edge detection procedures on the obstacles in the image.	• No training is requires to use the system & the system performs computationally well in real time applications. But it may fail to detect depth in obstacle, where sub segments are joined.
17.	Navya Amin (2014)	For Navigational Assistance	He summarized the techniques into 3 methods, which further categorizes into several techniques based on their class. & were analyzed on the basis of precision rates & recall rates.	• It was found that CSV- based method was better than the other two in terms of accuracy and performance.
18.	MarutTripathi (2014)	Proposes a new electronics guidance, namely Darshan	In this system, ultrasonic sensors & USB camera are used. User is informed through earphones. The images are captured by USB Webcam connected with Raspberry Pi board.	• Accurate,minimum physical interface & lesser training time. • Lot of hard wires with sensors & others make it cumbersome & the system does not detect ground level obstacles & color detection.
19.	B.Mohan Sitaramaiah (2015)	Developed Electronic Guide Cane.	The microcontrollers attached examine the data from sensors & controls vibrating engine & voice playback module, which gives output. A GSM modem informs the user's guardians during emergency.	• GSM networks are available even in a small village & are less costly than internet. It makes use of two ultrasonic sensors.
20.	Mohammad L. Mekhalfi (2015)	Proposed a system that provides navigation as well as recognition capabilities using smart technologies.	The system has two complemtary units. One is Guidance system – which is working online & guiding user about his path. Other is Recognition system for object recognition with an audio feedback.	• Fast but the piece-wise curves, if obtained needs to be smoothened further. • Laptop can be replaced by tablet or Smartphone camera. • Verbal guidance can be replaced with haptic technology.

4. PERFORMANCE MEASUREMENT PARAMETERS

4.1 Why do we need performance measures?

In order to ensure that:

4.1.1 How well the system meets our goals.

41.2 in the event that we are meeting our objectives.

4.1.3 If our clients are satisfied with our system.

4.1.4 If our procedures are in measurable control.

4.1.5 If and where enhancements are important.

4.2 What are parameters?

The parameters on which evaluation is done are as:

4.2.1 Recognition rate (RR)

It is the measurement of accurate results out of total procedures applied over an image [23].

$$RR = 100\,\frac{n_c - n_r - n_e}{n_c}$$

Where n_e the number of committed errors is, n_c is the number of all characters in the text & where n_r is the number of rejections.

4.2.2 False positive rate

It is the extent of absent events that yield positive test results, i.e., the restrictive likelihood of a positive test outcome given a missing occasion.

$$P = 100\,\frac{FP}{FP+TN}$$

Where FP is false positives & TN is total negatives.

4.2.3 False negative rate

It is that point of events that are being tried for which yield negative test results with the test, i.e., the restrictive likelihood of a negative test outcome given that the occasion being searched for has occurred.

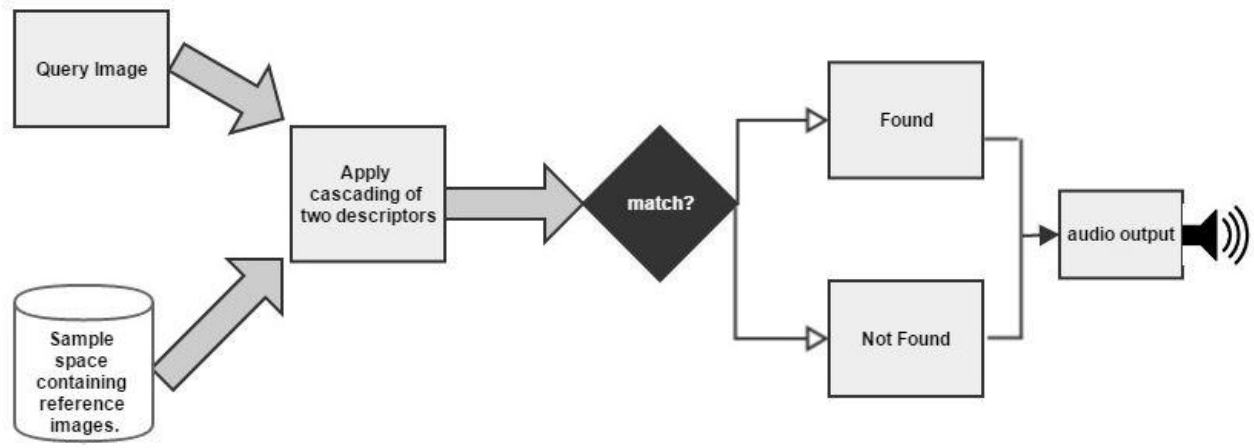
$$FN = 100\,\frac{FN}{FN+TN}$$ where FN is false negative rate.

4.2.4 Time

This is the time taken by certain technique or system to execute.

5. PROPOSED WORK

In the future, the proposed strategy is to combine two descriptors & make a new technique out of it as shown in Flowchart 1 below:



Flowchart 1: Above flowchart describes the mechanism of the proposed algorithm.

6. CONCLUSION & PURPOSE

According to [24], WHO aims to reduce visual impairment by 2019 by about 25%. As one can analyze from the above table that most of the work done is hardware based. Therefore, there need of a cost- effective, portable, reliable and using less computational power system demands that much is yet to be done in the field of computer vision for blind persons. The purpose of this paper is to help research scholars in doing their research by reading about several existing techniques & algorithms. All the above techniques are helpful in their very own ways, but none of them yields very impressive results as one can judge this through the comparison's made in the table. Thus there is a need of a complete package, which is more effective for real-time environment, is cost-effective & would fulfill their needs altogether.

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