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Review of Assistive Technology and Applications for Visually Challenged

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ABSTRACT

There are currently 285 million visually impaired people around the globe, which is about 4.25% of the total human population. The world is progressing rapidly with the advent and development of new technologies. These new technologies arebeneficial to provide facilities to the people in need assisting them in their daily living, thus improving their very quality of life. This paper examines the literature available on visually impaired people regarding obstacle detection, especially with respect tothe feedback methods of the system. We consider all type of assistive devices and prototypes that have been designed to help in mobility and navigation.

Keywords

Assistive Technology, Visually Impaired

INTRODUCTION

Visually Impairment is the inability to see, and it has been recognised as a pivotal physical issue in India. According to World Health Organization (WHO), a total of about 8.075 million blind, 54.544 million low vision, and 62.619 millionvisually impaired people were in India as of 2010, and this was total of 20.5%, 22.2%, and 21.9% of total respective categories in the world[1].

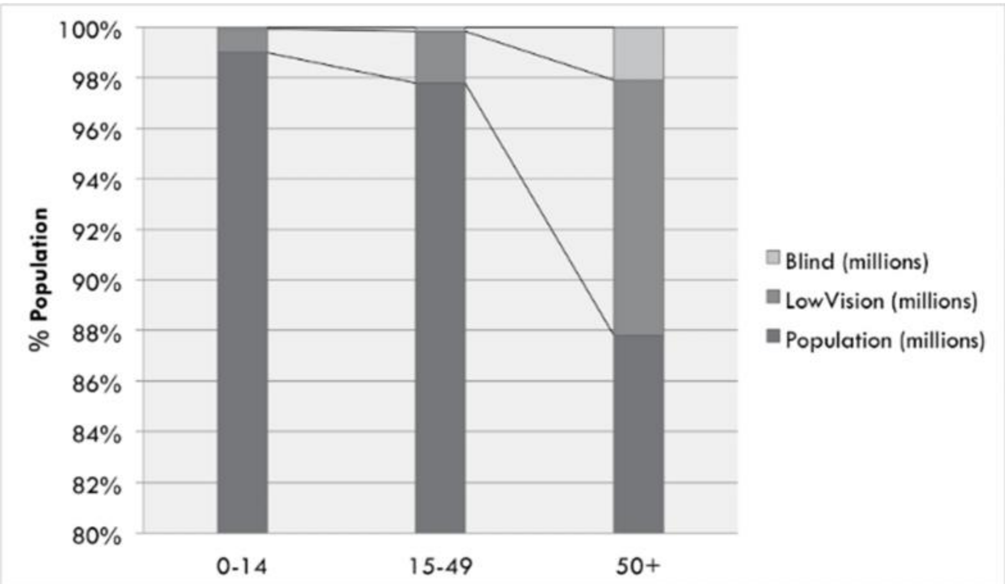

Figure 1. Global estimate of the percentage of people visually impaired by age.

Visually impaired people facesevere difficulties in leading an independent life due to the reduced perception of the environment. Most of them experienceserious difficulties in navigation, especially when they find themselves in a new and unknown environment. It is verychallenging for them to identify an open utility holeon the road, or something hanging on the level of head or chest. How can a visually challenged know as to what kind of road they are walking? Most of the buildings have building maps on display. However, they are useless for the visually impaired. In order to live an independent and qualitylife, visually challenged person depends on some form of aid or equipment. Assistive equipmentsareused to reduce the gap between desires of a disabled person and the capacity of existing infrastructure to fulfil these desires. In order to research, design and develop new technologies for the assistance of the visually challenged, we ought to understand the physical challenges of impairment with respect todiverse situations along with social model challenges.

Recent advances in human-computer interaction have solved many information acquisition problems of the visually impaired. There are several challenges for the visually challenged[2], such as:

1. Mobility,
2. Communication and Information,
3. Cognitive Activities,
4. Daily Living,
5. Education and Employment,
6. Recreational Activities.

There are various solutions in the form of hardware and software available in the market to reduce some of the challenges as stated above. An auditory display in a document speaks the text in addition to displaying it on a screen. These displays also make the digitised reading material available to the blind. Multimodaldisplays allow the blind to comprehend and interact with the complex geometry of web pages and Windows interfaces. However, navigating independently in spaces designed for the sighted people has always remained a big problem for the visually impaired people.

For a visually impaired person, navigation has two main challenges: a global challenge and a local challenge. The global challenge, also known as the"Orientation Problem", is concerned with determining where one is in the absolute terms of the reference. The local challenge,also known as "Mobility Issue", is concerned with determining what is present in one's immediate neighbourhood. Today, there are several different kinds of techniques and training available for the visually impaired to navigate. However, before 1921 there was no standard aid available. In 1921, James Biggs designed a white cane for himself that is recognised as a symbol of blindness till date.

Till the end of World War II, White Cane and guide dogs were the onlychoices available to the visually impaired. After the war, there was a substantial technical advancement in the technology of sensors. With their help, visually impaired people got some electronic travel aid. Much of the early research on obstacle detection focused only on object detection and localisation with different sensors. Most of them were based on laser and ultrasonic sensors.

ETAs are devices that are used to sense the environment using some sensors and provide the feedback with another. Many of them use multiple sensors and multiple feedback systems. GPS, RFID, wireless sensor network(WSN)are some examples that are designed using multi-model ETAs. Tactile, auditory, and vibration-based methods are used for the feedback of sensed data.

ETAs are good in object detection and localisation, but they are not able to identify the object type, their categories and other things. It is essential to identify the type of the object in order to decide the procedure of tackling it. For example, in anindoorenvironment, there may be a stool or a steel bucket with hot water. If travel aid is not able to identify this obstacle on the path, then it is may be tough to cross this.

Computer Vision (CV) is a relatively new field in object detection. It can not only be used for object detection, but also for object identification. They use stereoscopic or depth-based cameras for input data devices. CV has multiple methods and algorithms to extract environmental information from 2D or 3D images. Some researchers design algorithms only and suggest them to use from smart mobile phone[3], [4].

After the success of travel aids, now, it is time to filter some of them, to know which of them is better than the other and how. Some milestones in literature-surveys are available in the field of obstacle detection for visually impaired. However, as the availability of literatureis continuously increasing, it is essentialto review the literature of assistive devices. This survey is focused on navigational aids. The rest of paper is structured in as follows: section 2 provides details of Electronic Travel Aids, section 3 presents vision-based aids and in section 4 hybrid models are presented. The conclusions are drawn in section 4.

ELECTRONIC TRAVEL AIDS (ETAs)

An Electronic Travel Aid is a device that is used to enhance the mobility of a visually impaired person. ETAs are devices that transform information about the environment that would usuallybe relayed through vision into a form that can be conveyedthroughother sensory modalities[5]. ETAs are categorised based on data collection and distribution strategies, i.e. how they gather information from the environment and how the gathered information is presented to the user. ETAs gather environmental information through sensors (e.g. SONARs, LASER-scanners, or cameras), process and interpret it, and then present the result to the individual through other sensory methods(e.g. audition and tactual sensation). The choiceof sensor and the information display are the two primary design considerations in the development of an ETA. This section focuses on the presentation of a summarised survey of ETAs from the perspective of different types of sensing technologies used by them.

A. **Sensors:** A sensor may be defined as "a device, which measures some attribute of the world". All ETAs make use of the sensor(s) to grab the environmental information. The choice of sensor(s) is crucial in the design of an ETA. The sensor used in an ETA should: operate in real time, not interfere with other systems, have low cost and be reliable. According to the sensing technology being used, sensors can be classified into active sensors and passive sensors[6]. As the name indicates, passive sensors detect the reflected, transmitted or emitted electromagnetic radiation provided by natural energy sources. They do not have an energy source to illuminate the scene. On the contrary, active sensors provide their energy for illumination and receive the reflected responses of the respective signals from the objects in the scene.

Active sensors rely on their source of radiation to illuminate the scene. They detect and measure the energy reflected from the obstacles in the scene to perform their localisation. Three different types of active sensors have been majorly used in the development of ETAs: RADAR (Radio Detection And Ranging), LADAR (Laser Detection And Ranging) and SONAR (Sound Navigation and Ranging).RADAR is an active sensor, which emits electromagnetic energy. A radar sensor emits the radiation as a series of pulses from an antenna. When the energy reaches the target, some of it is reflected back. The reflected energy is detected, measured and timed. The time required for the energy to travel to the target and return to the sensor determines the distance or range of the target. An advantage of radar sensors is that they can operate in varied environmental conditions, i.e. different lighting conditions (such as day, twilight, or night) and poor environmental conditions (such as rain, fog or haze). LADAR (Light Detection And Ranging sensor) is another active sensor that transmits a light pulse and measures the reflected light. SONAR works on a similar principle as that of RADAR, with a difference that instead of electromagnetic radio or microwaves, sound waves are transmitted from an antenna. Ultrasonic sensors generate ultrasonic waves, which pass through the environment, strike the target and get reflected back. Based on the time gap between the transmission of ultrasonic waves and detection of transmitted echoes, the distance and speed of the targetare determined. In the Early age of development, a large number of ETAs using active sensors were developed for the visually impaired people.

Passive sensors detect energy that is reflected or absorbed and then remitted by the object or the surrounding area being observed. Visible spectrum cameras and infrared cameras are the two most popular passive vision-based sensors used in the development of ETAs. These sensors are most often called vision-based sensors because they register images. Images captured by cameras working in the visible spectrum are very rich in contents and easy to interpret.

B. **SONAR:**Sonar-based sensors reflect echoes from objects and contain information about geometric shape, size, orientation and surface material properties of the detected object[7].

Many visually Impaired start their daily living life with a white cane. They developed their environment perception with a white cane. They trained themselves with this cane to navigate in surroundings. That iswhy it is very convenient for them to use the devicein the form of a cane. Keep this fact in mind, in early years, many researchers developed cane-based devices for visually impaired. Sonar extends the range of cane to detect an obstacle. The response of the ultrasonic sensor is linear with distance, and it can work both at day and night. However, they are not much effective in an indoor environment because the indoor environment has mostly much smoother surfaces and many objects. Moreover, the strength of echo is affected by the reflectivity of the object and its shape[8], [9]. The amplitude of echo levels is also affected by sound speed and temperature in the medium. Targets of low density,like soft fabrics, foam, cloth, small obstacles, kerbs, and holes may be challenging to sense at long range. Rough, stony ground or long grass can cause unwanted sound echoes.

Examples The Ultracane is a sonar-based cane, which is equipped with dual-range and a narrow beam ultrasound system, one for obstacles on the floor and the other for obstacles above the waist level[10]. The wrist has two buttons. The button near the front of the handle will buzz when the sensor facing forward detects obstacles, and back button will buzz when the sensor facing upwards detects obstacles. The vibrations of buttons increase as user move closer to obstacles. It has two ranges for forwarding direction sensor, 2.1 and 4 meters, and range of 1.6 meters for upwards direction from the handle. It can detect head height obstacles and is available in 10 standard lengths from 105 cm to 150 cm with 5 cm intervals.

Guidecane is an ultrasonic sensor based on mobility aid to detect obstacles, which is attached to a white cane[11], [12]. GuideCane is heavy and has passive wheels. It has 2.5 to 3kg weight with a wheelbase of$43 \times 25 \times 23$ cm. Wheels are embedded with encoders to regulate the relative motion. It can detect obstacles in a 120-degree wide range. To avoid obstacles, it prescribes an alternative direction that clears the obstacle and then resumes in the original direction.

Some devices provide a virtual feel of the white cane. PalmSonar is one of them[13]. It is a small, hand-held device (weight: 40 grams, dimensions: $20 \times 31 \times 77$ mm) thatinspects the area via ultrasound. This device uses vibrations as a feedback method. The different type of vibration patternused to notify the distance of theobject from theuser. It has seven ranges from 0.3 to 4 meters. The width of the ultrasound beam is 60° horizontally and 30° vertically. The manufacturergives another name for their device: "a can of air", due to it has anarrow beam of ultrasound. Small, clipped on a stick. It cannot detect the difference between an open door and wall for range longer than 0.9 and 1.8 meters, respectively.The K-Sonar gathers spatial information about the surrounding environment. In a way similar to a person recognising the texture of different surfaces through their fingertips, sonar echoes, as heard in miniature headphones, carry objects texture information to the brain. It can detect a 40mm object from 5-meter range, and the user can hear echoes from multiple sources.iSonar is an obstacle warning device[14]. iSonarwas designed for Thailand's visually impaired users with specific requirements. It uses an ultrasonic transducer and tactile feedback with different vibration frequencies to detect obstacles at the head and upper body levels. The range of this device is 130 cm in length and 80 cm in width. Easy-Go-Cane is an ultrasound sensor-based ETA which can be attached to a white cane. It has a ring that rotates when an object is detected. It is available in ranges of 2.5 and 4 meters.Sonic Torch produces a sound, after detecting obstacles by which, the user can navigate[15]. It is an audible output presented via an earphone. It transmitsa broad bandwidth of 45-90KHz (three times every second) frequency modulated ultrasonic energy wave,where the reflected signals are converted to the audible region by multiplication with the transmitted signal.

Poloran is a handheld device, having the weight of 270 grams, and$162 \times 275 \times 50$mm form factor [2]. It can detect objects within 1.22, 2.44, or 4.88 meters. It can be worn around the neck, can be hand-held or chest mounted. It uses vibration feedback system, which can be fitted either on the neck or hand.

iGlass is an ultrasonic obstacle detection device developed by RNIB and Ambutech. It is like a regular pair of spectacles. They provide feedback in the form of vibrations when one is near an obstacle at head and chest level. It has been designed to be a secondary mobility device alongside traditional aids. It detects obstacles up to 3 meters. Vibration changes relatively, as user distance to an obstacle decreases. As the distance lessens from 0.7m, the vibrations become continuous. iGlass is quite bulky (weight: 75grams, dimensions: 6.75" × 5.75" × 2"), and still can't be used as a primary device.

Ultra BodyGuard is a vibrating and voice output aid. This device detects obstacles at head and chest level and gives feedback in the form oftactile or audio warnings. It also has a compass to for usersto give directions. It has a range of 1.9 to 3meters. It provides hand-held or chest mounted vibration either on the neck or hand. It cannot detect holes, drop-offs and steps.

Sensory 6 is a head-mounted travel aid that relies on an ultrasonic sensor[16]. It contains three removable parts that are connected by wires:a base unit, stereo headphones, and spectacles. The spectacles contain transducers that convert electrical energy to acoustic energy. The headphones produce tone alerts to warn the user of nearby objects, and as the user approaches an object, the pitch produced becomes higher. The device also differentiates the general location of an obstacle (left, right, orcentre) by producing sound either in the left ear only, the right ear only, or both ears. The base unit contains all other electrical components as well as the battery pack. The device uses the Polaroid ultrasonic ranging system, which detectsapproximatelyupto 3.5 meters at long range and up to 2 meters at short range. It is a hands-free device which can detect head height obstacles, but itmay not provide accurate distance. Nevertheless, the range is relatively narrow.

Pathsounderis designed for cane users as well as wheelchair users[17]. It is chest-mounted sonar designed as a supplementary travel aid for cane users. It provides feedback in the form of speech and vibrations. It can warn users within the range of 6 feet. The frequency of vibrations increases as the distance from the obstacle decreases. Atthe distance of 30 inches, it vibrates on maximum frequency. Size of the device is $2 \times 4 \times 4.5$ inches, and weight is approximately 570 grams.

EyeCane for the visually impaired is used for point-distance information into auditory and tactile cues. It has a range of 5 meters. The size of thedevice is $4 \times 6 \times 12$ centimetres with a weight of 100 grams. It can detect obstacle up towaist-height, pointing downward at a 45° angle for ground-level assessment. The user decodes the distance to the object via sound frequencies and vibration amplitudes.

Blind Guardian is a head-mounted ultrasonic sensor-based device[18]. For feedback, it uses a mobile vibrator, which can hold or cling. This system uses an Arduino UNO and Ultrasonic Ranging Module. It can detect objects within the range of 2cm to 400 cm and at an angle of 30 degrees. Although it can detect up to 400cm, it generateswarning only when the object is less than 90cm away with small vibrations. Another range limit of warning is 50 cm. After this, the vibrator vibrates more vigorously.

INCH is a prototype with tag "An Intelligent Wheelchair"[19]. As the tag says, it is a wheelchair equipped with facilities to fight with visualimpairments. Sometimes a visually challenged person may have a physical weakness or may be facing physical challenges. INCH hasa straightforward concept to detect drop-offs and objects. It has six Polaroid ultrasound transducers and microcomputer. Sonar sensors attached to a chair are directed downward to calculate the distancefrom the surface. When the calculated range is higher than the threshold,a drop-off is expected,and if the range is less thanexpected, then there is an obstacle. It is powered by stepper motors.

Niitsu et al. focused only on detection of dangerous obstacles and places [20]. Compass, tri-axial accelerometer, infrared and ultrasonic sensors are used along with smartphone and headphone for feedback. The author claims that detection percentage of a wide obstacle, crossing persons, approaching persons are 100%,and detection of a thin obstacle is 95%.

C. **Laser-Based:**Some aids use laser sensors to detect objects. It is beneficial for tracking and detects a targeted object at a long distance. It is very precise in measurement, but it has some disadvantages too. Laser noise, stray light, and speckle interference create a problem for the laser beam. Different surfaces have different reflection quality of light that sometimes provide inaccurate measurements.

Examples C5 Laser Cane is equipped with three laser detectors, capable of detecting the obstacles in three directions: Up (for head-height), Down (for drop-offs), Forward (for a range of 1.5 to 3.5 meters from the tip of cane).Kapten Mobility GPS is a small (130 grams, 100 × 55 × 18 mm) mobile navigation system based on GPS. It has voice recognition and a full voice interface with the tactile keypad. KaptenMobility GPS provides some additional smart features while on the move, in particular, location positioning, route guidance, exploration and map reading functions. It has walking, driving and public transportation routes.

Yuan and Manduchidesigned a hand-held range sensing device that is used to scan the surface to detect objects and discontinuity of the surface [21]. This prototype is in the form of cane,and itis based on active triangulation. The device shows laser light,andminiaturised grayscale Firewire camera detects the reflected light with a rate of 15frames/s. This device can detect objects, stairs, and drop-offs within the range of 0.7 to 3 meters.

Milioset al. present a method for three-dimensional space perception by sonification of range information, which is obtainedvia a point laser range sensor [22]. By this prototype, a visually challenged person can scan space by pointing the laser beam in a different direction. It achieves eight range measurements per second. Measurements are mapped to MIDI notes of different frequencies. Although this prototype is not for object detection, it provides a method to scan the environment to know the surrounding things or to give a great sense of spatial perception.

D. RFID Tag Based:

RFID tags provide better location information for objects, and the user does not need to be in a particular direction of the object to search it. They are tiny and easy to attach to an object. RFID tags do not need any power source to work. However, it has some weakness too. It can sense an object only in the case when it is manually attached to that object. RFID tags are low-cost tags but attaching with each object is not feasible. More information from multiple objects is also a severe problem. It increases response time to detect the needed object. It works only in the tagged environment and an object without a tag cannot be identified by this system.

Examples Tactile Acoustical Navigation and Information Assistant (TANIA) is a GPS and RFID based navigation device, which is developed in University of Stuttgart. The TANIA system has a portable touchscreen computing device in front of the user, with a GPS and small movement sensor attachedto the neck strap.The mapis accessedby tapping on the computer's screen. The current position of theuser can be accessed on this map. It works in both indoor and outdoor environment. The map provides detailed data, including guiding grids for open squares or large rooms, and shape-adapted segments for irregular streets or floors.The output of current position, such as building or class/office room numbers, can be presented by theaudioand visual display of computing device. TANIA can be connected to portable Braille displays, anddeaf-blind people can also use it for communication. There is no need for pre-installed infrastructure. The deaf-blind individual can also use TANIA.

Nassih et al. proposed a prototype based on RFID tagging of locality [23]. In this method, a visually challenged person has a stick with RFID tag reader and braille reader on the handle. All the systems of the cane run by mechanical batteries. This system may be useful for a specific area related to visually impaired people but does not look universally feasible. It can be used for identifying addresses, thoughthis can not identify obstacles.Prototype given by Kalbani et al. focuses on Bus Detection System using RFID [24]. It has some useful features like inform users about the next bus details, and the next coming station for the passengers. It also displays the number of visually challenged people to the driver with their required destinations. This prototype is designed in two sub-systems: bus sub-system and station sub-system.

Abdullah et al. also proposed mobility recognition system for bustraveller[25]. Travelling in public transport is a very challenging task for a visually challenged person. A prototype of this paper is a cane device, which uses a GPS for identifying bus stop, a transmitter-transceiver with 433 MHz frequency to detect bus number and route of the bus, and an ultrasonic device to detect the object. This prototype works on three different modes: object detection, bus stand identifier and bus number identifier. For feedback purpose it uses sound. The range of its object detection is 3 to 300cm which is categorised in 251-300cm, 201-250cm and less than 200cm. A transceiver for identifying bus number and accessing the bus database hasarange up to 250ft.

Ivanov proposed java based mobile service that operatesthrough voice augment objects [26]. Thisprototypeis a cloud-based mobile service where client-side application allowed users to record voice or audio-based description of surrounding physical objects and store those recordings in the local cache or the cloud. For tagging objects, RFID technology is used. NFC based smartphonesare used for theinterface.The client-side application has NFC manager, Accelerometer manager, mike, Text-to-Speech module, cloud manager,the file manager. First,we need to tag all objects that VI user want to identify. Accuracy may vary according to changes in illumination, translation and rotation of objects, distance to objects and quality of the camera. After tags are printed, data cannotbe changed. A small object cannot be tagged. The most prominent limitation of this prototype is that It is difficult for VI users themselves to create tags. Nevertheless, if the mobile is busy on another service, then the app loses its focus.

E. Infrared: Infrared Sensor detects thermal energy from both living and non-living objects. These sensors are used to detect objects, but they have several disadvantages. They are not able to distinguish between objects and similar level thermal energy levels. These sensors are very sensitive to sunlight and dark colours.

Lopes et al. proposed a stick with infrared sensors to detect obstacles [27]. This paper proposed an algorithm with thefacility to modify potential field function to tackle detected obstacle and method for automatic and real-time adaption of algorithm's parameters as the situation demands.

Minitact is ahandheld device, which examines thearea with infrared light [28]. It has small form factor $90 \times 30 \times 15$ mm. It uses vibration-based methods as feedback for object detection. Minitact is available in various models where it has either one or two levels of vibration. In the latter case, the fast vibration signals a short distance to the detected object. The detection ranges of thedevice are 6, 4, 2 and 1m.

VISION-BASED SYSTEM

A. 2D Models:

The vision-based systems used visual data and used computer vision methods for object detection/recognition. These systems are developed for 2D as well as 3D cameras. Every system in thevision-based method has its pros and cons. These systems work better in acontrolled environment.

Tactile Vision Substitution System is a project of Tactile Communication and Neurorehabilitation Laboratory (TCNL). It is based on “sensory substitution” systems. These devices have been developed, since the end of the 60's. The first "Tactile Vision Substitution System" (TVSS) converted a visual image in thetactile image of 20×20 array of stimulators. A video camera captures the images. Feedback of system is given on the back, chest or tongue [29].

Lakde and Prasadproposed a prototype of a wearable device in the form of shoes, which is used voice and vibration-based guidance system [30]. This device uses infrared sensors for obstacle detection. These IR sensors are mounted on shoes at its front, left and right side to accurately detect the position of theobstacle. It also uses RGB sensor to detect the colour of objects. An RGB sensor placed in front of shoes. Arduino microcontroller is usedfor processing purpose in this prototype. This prototype is designed for situation identification and object detection. Situations which are identified this system are grass, road, footpath, zebra crossing, up/down stairs. Prototype does not work on head level obstacle detection, so they also propose a cap with thesame system to detect anobstacle.

Tyflos Navigator is a wearable device proposed by Dakopoulos and Bourbakis[31]. This prototype includes various software and hardware components including stereovision system, and high-to-low resolution methodologies using navigation criteria and a 2D tactile array. Thestereovision system is attached to conventional eyeglasses to captures user’s surrounding data and create a disparitymap. After processing, the disparity map is utilised to calculate depth and translated it into words from a tactile vocabulary and then provide feedback by a 2D tactile array. The feedback mechanism is attached to user’s abdomen,and it has 16 elements arranged in order of 4×4. It helps theuser to understand various levels of vibrationsto locate obstacles distance.

Bardella et al. designed a prototype allowing to shift from the paradigm of a very skilled robot,interacting with astandard object, to ordinary robot, interacting with asmart object [32]. This system has two methods: WSN, and visual perception. WSN has three phases: object discovery, object mapping and object recognition. This system uses thestereoscopiccamera and odometer for visual perception. Light sensor and humidity sensor are some other sensors that used in this prototype.

Serrãoet al. design a system using Computer Vision techniques and GIS[33]. It has a system which integrates data in a GIS of building with detection of visual landmarks. They use a camera, portable computer. GIS system presented in this paper is part of Project "Blavigator". The authors claim to detect doors, stairs and signs and many more objects.

Wang et al. prototype focus on signs and doors to identify them [34]. To identify doors and signs, they first extracted attended area by using a saliency Map. Then signage detection is detected in the attended areas by using a bipolar graph matching. This paper shows increase detection chances of signs 57% to 75% by using saliency map.

Capi et al. designed a robotic system for indoor and outdoor environment [35]. It is equipped with avisual sensor, laser range finders, speaker, potentiometer, camera. Detection distance is 20 to 5600mm with accuracy of +/- 30mm on the distance of 60 to 1,000 mm and +/- 3\% for 1,000 to 4,095mm. It has 240° scanning angle. Good for thestable object.

HYBRID MODEL

Hybrid models are the combination of sensor and computer vision-based techniques.The hybrid models are designed to overcome the limitations of ETAs and computer vision-based methods.

Examples NavBeltis primarily based on technology initially developed for mobile robots[36]. The Navbelt consists of a belt, a portable computer, ultrasonic sensors, and stereophonic headphones. The Navbeltis designed for two operational modes; Guidance Mode, and Image Mode. In guidance Mode: the acoustic signals actively guide the user on the way about nearby obstacles. The signals carry information about recommended path and speed and information about the obstacles. In image Mode: this mode presents the user with an acoustic panoramic image of the environment by using stereophonic effects. The direction to an obstacle is indicated by the perceived spatial direction of the signal, and the distance is represented by the relative signal's volume.

Kang et al. proposed a system which is based on ultrasonic to audio signal transformation [37]. It has two sub-systems. One is glass type,and another is cane type. Wide-beam-angle ultrasonic sensors are used. It is built around 16-bit AM188 ES, high performance, 80C188-compatible, 16-bit embedded microcontroller with an 8-bit external data bus and 32 programmable parallel I/O pins. CPU board consists 40MHz clock, 1-Mb ROM, 1-Mb SRAM, three internal and external programmable interval timers and three switches.

Lee et al.develop a navigation device to provide anoptimal path for users for indoor and outdoor environment [38]. After selecting adestination, its identifier detected by thecamera (indoor) or by GPS (outdoor). It uses an array of eight ultrasonic sensors with its direction (10°, 20°, 30°) to avoid anobstacle. Vibrators are used for feedback.

Poddar et al. proposed an obstacle detection method using adaptive saliency-weighted technique [39]. This prototypeadaptively computes weights from spectral residual based saliency map. These weights are utilised in the computation of the obstacle map. This method can be used for theindoor and Outdoor environment with thesuitable database.

CONCLUSION

Object detection to assist visually impaired is still in early stage. This review provides asummary of various ETAs and computer vision-based prototypes. However, these prototypes have several limitations. There is nearly no device available for generic object detection in anindoor environment. Although computer vision has many goodsolutionsfor object detection, localisation and recognition, these solutions need to incorporate with theassistive device of visually impaired.

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