Review of Designs for Smart Walking Stick used by Visually Disabled

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Abstract - Technology is providing every individual the comfort & ease that is desired by them. Presently evolved sensors have limited human senses pretty well. In the view of this, efforts are undergoing to build up a helping mechanism for those individuals who are visually disabled. A Smart Walking stick based on various sensors may help an individual to perform daily activities easily. Many research activities are undergoing to develop a full-fledged version for it. In this paper, we will try to look into the constraints occurring in building smart stick. Then, we will realise camera based image processing as an effective solution, allowing texture recognition, face recognition & text recognition.

Index Terms -- *Obstacle reading, Pit sensor, Buzzer Alarm, Vibration Alert, Image Processing*

I. INTRODUCTION

Blindness or visual impairment is a condition that affects many people around the world. This makes basic movement of individual difficult. The condition affects transportation, working, searching activities of any person. The usage of the blind navigation system is very less as it is not efficient. The blind traveller is dependent on conventional devices like cane, support assistant, trained dogs etc. A walking stick is the majorly used guiding mechanism for a visually impaired person, and gets basic information about the surrounding as they waves their stick and finds the obstacle by striking the obstacles in his way.

Technology has successfully developed sensors based on biological stimulus. Majority of biological superpowers are now possible by sensing devices. The power to see & under the environment around is one the most advanced sensing mechanism developed by Mother Nature. Electronic systems used in navigation can be grouped into three categories:

- Electronic traveling aids
- Electronic orientation aid
- Electronic Position Detectors

Based on the ideas of working of sensors and recent research activities undergoing, we will try to explore the feasibility, scope and constraints in building a Smart Walking Stick, based on which possible solution will be traced out to make this technology a near reality.

II. LITERATURE SURVEY

Assistive Technology is a generic term incorporating technology, equipment, devices, appliances, services, systems, processes and environmental change used by people with disabilities or older people to overcome social, infrastructural barriers, to actively participate in society and to perform activities easily and safely. Many research activity have been conducted across the world to find a working solution for the visually impaired. The major focus thought about during designing a blind navigation system was put into obstacle detection system, staircase detection system, pit detection, etc. The basic understanding of a stick based navigation system can be understood by using a White Stick. It basically operates through human touch sense and the orientation is achieved through performed navigation experiments or experience of environment in human memory. The development of a sensor based walking stick can be traced to Smart Cane, a system basically working on the basis of environment as sensed by electronic sensors.

A work at University of Paris, developed a stick based system that detects obstacles or objects in front. It uses sensors for obstacle detection mounted on stick like ultrasound emitter/detector and laser. An audio feedback of intensity, inversely proportional to the distance to the nearest obstacle is provided by the stick. TOF (Time-of-Fly) between sensor and a nearest obstacle pointed by the user, gives the distance. The shape of the whole obstacle is detected by manual scanning [1] A work at University of Leeds, Ultra-Cane, it was designed to offers only an assistance to the walking with overhanging obstacle detection using an ultrasonic obstacle detector. Ultra-Cane transforms this information into vibrations which activate a thumb stimulating by buttons in the handle. [2] A work at Canterbury University, K-Sonar, uses ultrasonic sensor for obstacle point-wised detection but it provides an audio feedback. The whole obstacle is “reconstructed” by the end-user from these sonificated points. K-Sonar does not provide assistance to orientation function. [3]

The Guide-Cane, a robotised stick, is designed to to detect ground located specific obstacles such as upward stairs. The set of ultrasonic sensors located on a distal end of the smart stick transform acquired data into a vibrating feedback stimulating the end-user palm. [4] The Smart-Cane, made at Indian Institute of Technology, detects knee-above obstacles using Ultrasonic sensor. It does not provide assistance to orientation.[5] The Intelligent Cane ”iCane” built at the

National Taiwan University, partly assists in walking and the orientation. It works on data exchanges between the standard white cane, equipped with an RFID, and RFID tags embedded in the environment. The orientation is assisted by providing the optimal path to reach the targeted location with respect to the end-user current location and a database of maps. It stimulus is an audio signal for hearing input to end user. [6] Central Michigan University developed an electronic cane for blind people that would provide contextual information on the environment around the user. They used RFID chips which are implanted into street signs, store fronts, similar locations, and the cane reads those and feeds the information back to the user. The device also features an ultrasound sensor. A speaker is placed to provide voice alerts when an obstacle is detected and also directs the user to move in different direction. [7]

Many visual aids where designed with Camera as sensor. These systems are more advanced, & needs an advanced reading, & controlling system. One of the design named as Tyflos, was published in 2001. [8] In the year 2007, another camera based design was published, which was working on fuzzy based control system to detect & guide the user. [9] Also, another device uses sound based guidance system, named Audio-Man, which has pre-recorded voice commands, for each type of obstacle. [10] These systems provides information not only about obstacles along the travelled path. Assists the user in selecting the preferred travel path. It can capture whole environment information.[11] It can use advanced image processing algorithm to complex data. Also, Acoustic Visual Reality, works on the frequency of sound wave that gets reflected from the obstacle. The analysis of sound-wave pattern results in identification of type of object as obstacle. [12]

It is very clear from the above summary that the medium of understanding the environment for blind is limited to obstacles and objects available in the medium.

III. OBJECTIVE FOR SMART STICK

In order to achieve a perfect blind navigation system, many detection aspects needs to think on. The feasibility is dependent on the sensors available. The stick needs an overall controller to process the data received from individual sensors. The following possibilities needs to be made available in the stick.

a) Object/Obstacle Detection- as seen in most of the previous work, the idea was to make the user aware of the obstacles available around the environment.

b) Surface Detection- another requirement that needs to be fulfilled is the idea about surface i.e. smooth, uneven, sandy etc.

c) Staircase Detection- to design a stick for indoors or office, the stick should detect presence of staircase and distance from user.

d) Hanging Object Detection- one important objective is to detect hanging objects like tree branches, hanging ropes or wires, rods etc, which can become dangerous for blinds.

e) Object Identification- an aspect of object detection can be improved to object identification like bikes, cars, home to help identify things as much as possible.

f) Liquid/Water Detection- an important aspect that can be incorporated in stick is the presence of water or water bodies in front of user. This can avoid muddy pits, watery mud holes, pools etc.

g) Face detection - an advance feature that can be built in a stick is to detect and identify faces using camera.

IV. SENSORS & THEIR USES

A Smart stick is as smart as the sensors. The capabilities added to a stick is dependent on the performance and capacities of the sensor used. The following sensors are available for use along with the stick:

a) Ultrasonic Sensor- Ultrasonic ranging module HC - SR04 provides 2cm-400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

- Using IO trigger for min. 10us high level signal.
- It automatically sends eight 40 kHz wave and detect whether there is a pulse signal back.
- IF the signal comes back, the time of high output is the time from sending ultrasonic to returning.

b) User Position Sensor - The position of the user on map can be established by placing a Global Positioning System, GPS transmitter on the rod. Using internet facility, it can detect user position, and provide voice guidance while on roads

c) Infrared (IR) Transmitter- electronic remote device mainly consists of IR transmitter and receiver. A remote control patterns, a flash of invisible light which is turned into an instruction and is received by the receiver module. The IR signal is modulated during transmission. [8]

d) Light Dependent Resistors (LDR) - LDR are the resistors whose resistance varies with the intensity of light incident on it. The resistance is typically very high when no light is incident and it begins to reduce as light is incident on it. It is used for material type detection.

e) Distance Sensor- it can be based on Light or Sound transmission (IR or Ultrasound Signal). The time taken by signal to travel across the user-object distance is twice the actual time. So based on signal speed, distance is calculated.

f) Camera- an ophthalmic device which captures the light signals in RYB category to capture all the colours signals from objects in front of us. Even face detection can be done through camera.

g) RFID Tags - Radio Frequency identification tags are used to mark identity of an object. The transmitter uses Ultra High Frequency (UHF) signal, and is set at suitable locations.

When the stick approaches the proximity of tag, an information about location can be achieved.

V. SCOPE & CONSTRAINTS

The smartness of the cane is dependent on the amount of sensing abilities installed in the device. The scope of sensor usage can be seen in previously developed smart sticks also. While going through all the sensing devices and their area of application, the following scope can be observed:

- Ultrasonic signal based obstacle sensor is the predominant sensor that is must in a smart cane, as it gives you the idea of distance.
- User Position sensor using GPS is useful for outdoor usage of stick, as it gives guidance about roads & turns.
- IR Transmitter or RFID is a useful tagging system for marking important destination. The receiver reads identification signal, informing the user about it.
- Camera based guidance system seems to be the best in class mechanism if the processor reading the images can be trained to work effectively for image processing.

Along with the scope of sensors, it can be seen while looking into the working of each sensor, that all sensor works in a particular constraint or operation zone. The following is summarized below:

- Ultrasonic Obstacle sensor cannot estimate the size of obstacle, e.g. Obstacle can be Truck or Scooter, both will give equal magnitude signal.
- GPS Position sensor with map is highly dependent on internet. This can become a problem it network fails to provide suitable information.
- Identification Tags based on IR or RFID is constrained by range issue, e.g. RFID is efficient, but range is 100m.
- Camera passes most of the constraints faced by other sensors, but its dependency on program reading the image may require constant updating of the software database.

VI. EFFECTIVE GUIDANCE SYSTEM DESIGN

After having a look on the objectives required to be persuaded for designing an effective smart stick system, and sensors available for achieving the objectives, we will discuss the design of an effective smart stick system.

A blind pedestrian should be guided about the environment around him, which can range to about 1.5 m radius, considering an average walking speed of 1m/s. The sensor needs to be placed to detect obstacle as well as deep gradient, pot holes or downward staircase. To achieve this, ultrasonic sensors are used positioned at around waist height, approximately 1m from ground.

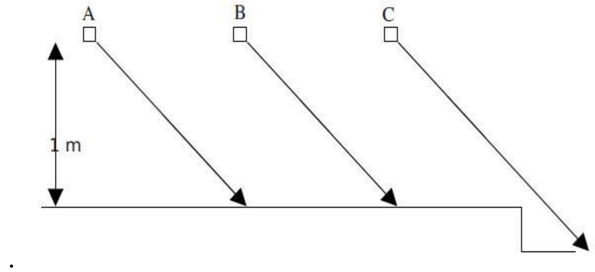

Fig 1 - Downward Staircase / Pothole Detection Scheme

The accuracy of the system is dependent on the controller that controls the pulse discharge and interim calculations. Also, a slope gradient should not be marked as a pothole. An RFID tagging system can be used for marking important regularly used areas like Shops, Gardens, Stations, Building entrance to provide accurate identification. The RFID reader reads the information, and gives voice commands through an earpiece.

Along with these, a camera can be placed in the guidance system, which will record live real time images of what eyes actually see. The processor needs to install with a high level image processing module that will decode the image for necessary inputs to the user. Image/video processing consists of simple to high level thresholding operations, for image simplification techniques which is generally based on denoising and contours segmentation. Region segmentation is used for allowing region filling with predefined textures, colour, or contour etc. Specific image processing techniques like contrast enhancement, image magnification, image remapping are used for low-vision aids. [9]

There is now a clear trend to use the most recent scene analysis techniques for static images and videos. Object recognition, video data interpretation are performed in order to be able to describe the semantic content of a scene, and is delivered to the user as voice commands. This can be used for detecting objects on the path, water zones like rivers, ponds or oceans in front. If programmed properly, it may detect hanging or suspended objects.

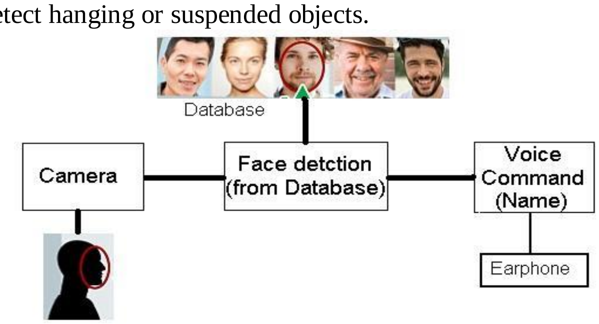

Fig 2- Face Detection & recognition for Blind

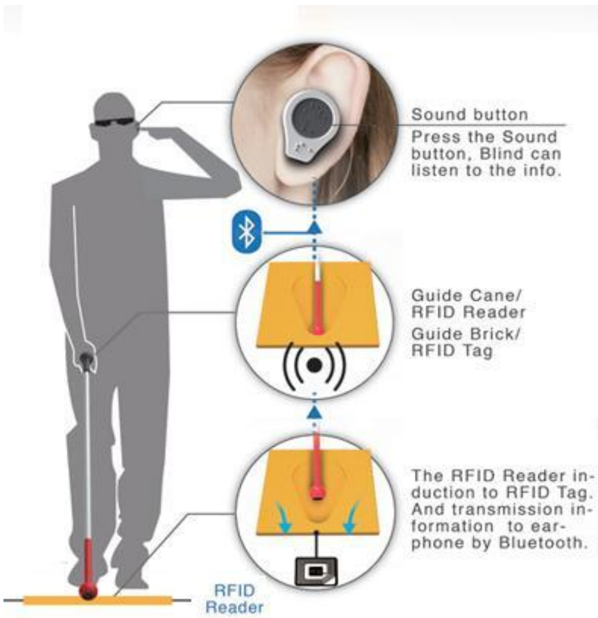

Fig 3 - RFID tag for Location detection

Another fundamental use of camera imaging can be used for face detection. Based on in-build database, the processor can accurately detect the face, and give names as voice command to the user.

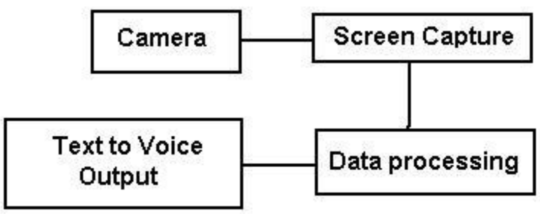

Fig 4 - Camera based Assistive Text Reading

Another dimension that can be installed in blind guidance system is the ability to read through camera. Based on image of text received, the image processor reads out the text through earphone. This can help users to read printed letters, labels on products. So, to develop an effective blind guidance system that counters most of the shortfalls in stick systems, we need to install few ultrasonic sensor for obstacle sensing at various directions, RFID transmitter-receiver for tagging important locations, and a good quality face Camera for image processing. The data collected from sensors needs to be processed by a powerful processor for quick detection & imaging.

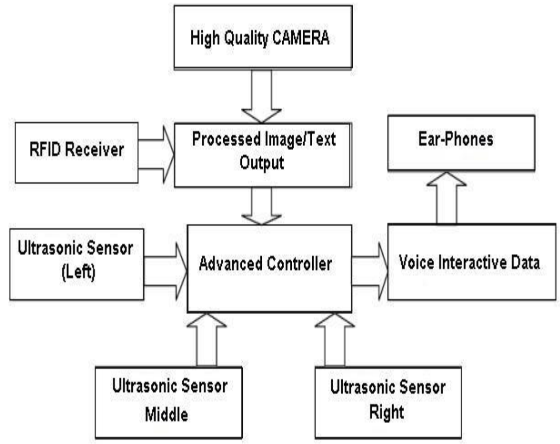

Fig 5- Hardware Interfacing for system

VII. CONCLUSION

The Blind Guidance System developed with combined power of obstacle detection through ultrasonic detector, and camera based image processing gives enormous possibilities to allow user to visualise their environment through voice alerts. The ultrasonic detector senses the objects, direction of its approach and surface contour changes like stairs. The camera system can detect environment texture like lakes / hills, read out literature through text recognition, identify person through face detection and can figure out suspended or hanging objects.

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