Smart stick for Blind: Obstacle Detection, Artificial vision and Real-time assistance via GPS

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ABSTRACT
The paper presents a theoretical model and a system concept to provide a smart electronic aid for blind people. The system is intended to provide overall measures – Artificial vision and object detection ,real-time assistance via global positioning system(GPS).The system consist of proximity sensors, ultrasonic sensors , gps module, stereo cameras and dual feedback system- auditory as well as vibratory circuit. The aim of the overall system is to provide a low cost and efficient navigation aid for blind which gives a sense of artificial vision by providing information about the environmental scenario of static and dynamic objects around them.

Keywords
The GPS, Ultrasonic sensors, Artificial Vision

1. INTRODUCTION
Vision is the most important part of human physiology as 83% of information human being gets from the environment is via sight. The 2011 statistics by the World Health Organization (WHO) estimates that there are 285 billion people in world with visual impairment , 39 billion of which are blind and 246 with low vision . The traditional and oldest mobility aids for persons with visual impairments are the walking cane (also called white cane or stick) and guide dogs. The most important drawbacks of these aids are necessary skills and training phase, range of motion and very little information conveyed. With the rapid advances of modern technology, both in hardware and software front has brought potential to provide intelligent navigation capabilities. Recently there has been a lot of Electronic Travel Aids (ETA) [1] designed and devised to help the blind navigate independently and safely. Also high-end technological solutions have been introduced recently to help blind persons navigate independently. To identify the position and orientation and location of the blind person any of those solutions rely on Global Positioning System (GPS) technology While such systems are suitable for outdoor navigation, due to the need for line of sight access to satellites, they still need additional components to improve on the resolution and proximity detection to prevent collision of the blind persons with other objects and hence subject his/her life to danger. However in comparison to other technologies many blind guidance systems use ultrasound because of its immunity to the environmental noise. Another reason why ultrasonic is popular is that the technology is relatively inexpensive, and also ultrasound emitters and detectors are small enough to be carried without the need for complex
circuitry.
Apart from the conventional navigation systems , a blind aid systems can be provided a new dimension of Real-time assistance and Artificial vision alongwith dedicated obstacle detection circuitry. This different units are discussed to implement the design of a 'Smart stick' for blind.

2. SYSTEM DESIGN
The proposed design for smart stick distintly consists of three units:

- The GPS Unit.
- The Obstacle Detection Unit.
- The Artificial Vision System.

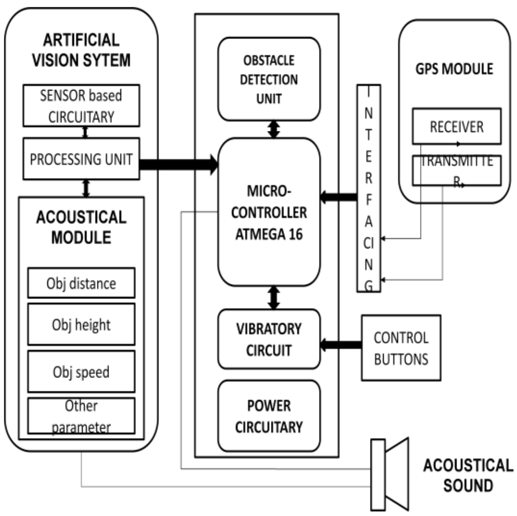

Fig 1. Proposed Smart Stick System

The figure above depicts the proposed design of an embedded smart stick. The system elements consist of various subsystems . The sensor based circuitry consisting of sensors such as proximity sensors, TSOP1738 sensor array, ultrasonic sensors, Led sensors. Vibratory circuitry consist of an array of mobile vibrators with logic designed to obtain different vibratory patterns . The feedback systems is dual with an additional auditory interface. The GPS system, microcontroller, control buttons and power circuitry (preferably battery-based) are the crucial systems.
The proposed system can be designed to take of form of an detachable and portable device ,which can be unconditionally mounted on a simple white cane or blind stick . This requires a clear vision of the desired system goals. Various sytem parameters are thus needed to be evaluated based on the design to be practically implementable.

NO	PARAMETERS	GOALS
1	SIZE	Compact & Robust.
2	WEIGHT	Less than 3 kg.
3	SPEED (d+a)	0 to 0.5m/s.
4	HANDLING	Maximum support force & forces in X and Y directions for stability and guidance
5	BATTERY CHARGING	About 8 hrs between charges at duty cycle.
6	ON-BOARD COMPUTING	Sufficient for planning, control, health monitoring and communication
7	SENSORS AID FOR NAVIGATION	GPS n Passive signposts acceptable for localization. Infrared (Ultrasonic)sensors acceptable for obstacle avoidance
8	INPUTS	Handle forces and voice commands
9	COSTS	Target production cost less than 30000 INR

Table 1. System Design Goals

The table above discussed in brief the various parameters which are to be kept under consideration prior to design implementation. The most important parameters being cost .As 90% of the blind population of the World lives in the developing countries. So an affordable and convincing desgn has to be put forth for world-wide acceptance.

3. THE GPS UNIT

The GPS Based blind device with userinput interfacing get alert the blind person when reaches his destination by voice .This consists of microcontroller and GPS and one voice module to generate the voice.pic The Micro controller is the heart of the device. It stores the data of the current location which it receives from the GPS system. So that it can make use of the data stored to compare with the destination location of the user. By this it can trace out the distance from the destination and produce an alarm to alert the user in advance.

The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

The Global Positioning System (GPS) [2]is a U.S. space-based radio navigation system that provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis -- freely available to all. For anyone with a GPS receiver, the system will provide location with time. GPS provides accurate location and time information for an unlimited number of people in all weather, day and night, anywhere in the world. The accurate timing provided by GPS facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids. Farmers, surveyors, geologists and countless others perform their work more efficiently, safely, economically, and accurately using the free and open GPS signals.

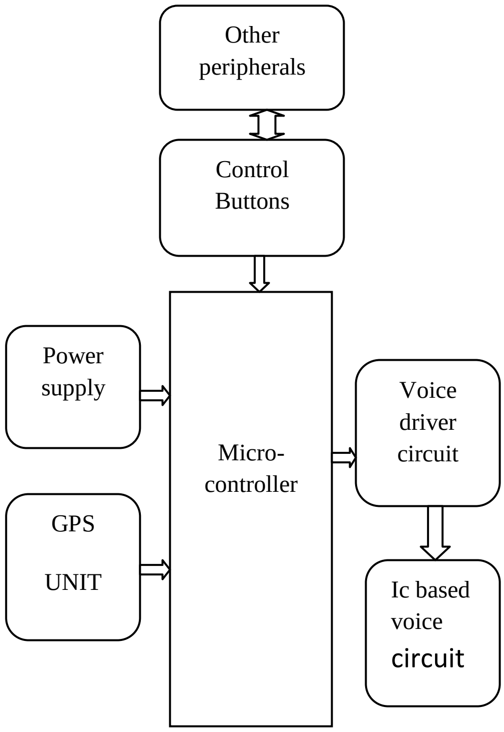

Fig 2. The Gps Unit Block Diagram

The figure above depicts a block diagram of the GPS Unit . It consist of the following blocks:

- Microcontroller:
- APR (Voice circuitry).
- Control Buttons.

3.1 Microcontroller

The microcontroller used in GPS based blind man device with user input interface can be preferably a PIC 16F877A. It is a 8-bit micro controller having 40 pins. In which 2 pins are used for vcc,2 pins for ground,2 pins for crystal oscillator,1 pin for reset and all other pins are used as i/o pins. This micro controller is having 5 ports .

3.2 APR (Voice Circuitry)
APR 9600 is a low cost, high performance sound record/replay IC, incorporating flash analogue storage technique. The device offers true single chip voice recording and play back capability for 40 to 60 seconds. The IC is non-volatile; recorded sound is retained even after the power supply is removed from the module. The device offers true single chip voice recording and play back capability for 40 to 60 seconds. The replayed sound exhibits high quality with the low noise level. Sample rates are user selectable which allows the designers to customize their design for unique quality and storage time needs.

3.2 Control Buttons
These are used to record the voice and play the voice.

4. OBSTACLE DETECTION UNIT
Electronic Travel Aids (ETA) [1],[3] have been classified in three classes:

- Obstacle detectors or clear-path indicators,
- Environmental sensors and
- Navigation systems.

The first class is based on sensory or artificial vision systems. The sensory systems emit ultrasonic or laser beams to the environment, which are reflected by the object; the system calculates the distance from the object according to the time difference between the emitted and received beam. The stereo-vision systems use the object tracking algorithms and calculate the distance by using grayscale method (vOICe). The best known object detectors systems are the Lindsay Russell Pathsounder, Laser Cane, Mowat Sensor, Nothingam Detector, Sonicguide, Polaron, Sonic Torch etc.
The proposed system uses an array of ultrasonic sensors [6],[7]which basically works on the principle of the ultrasonic sound generation and alert mechanism. The system is however having a dual feedback mechanism i.e it has an additional vibratory feedback mechanism . This enhances the overall feedback received by the blind user who receives the outputs generated in different formats of vibration i.e high, low, medium and strong vibrations.

5. ARTIFICIAL VISION UNIT
This Unit provides the overall edge to the proposed work so far. With the variety of obstacle detection devices available and GPS emerging as a commonly preferred technology in blind navigation kit there is a need for providing overall assistance to the blind about the environmental information to make navigation more safe and secure. The unit comprises of getting the data from the environment , assembling the information and extracting the required information required by the blind user. This incorporates extracting data about the environment and providing information about the: static and dynamic objects around the blind user. The system can make use of stereo camera and processing unit , which process the data. Environmental information acquisition and image processing algorithms represent the artificial vision system. The hardware of the system is based on a pair of stereo cameras mounted on a helmet connected via connectors to a portable computer. The system speed achieves 25 frames per second due to the special Express card which allows external power supply. Actually, it runs at a rate of around 6 frames per second, working on 320x240images, when dealing with onlya single dominant object. The artificial vision system [4] is able to detect the objects which have a major importance, such as humans, cars, buildings, threes, animals and free spaces covering a range of 64º at a distance between 1 and 15m. However, the primary aim of the artificial vision system is to identify objects moving independently in the scene and to extract sufficient information from it for the cognitive feature, which will later judge if the detected object poses any danger for the visually impaired user. The objective can be achieved by implementing a series of key points: algorithms of scene segmentation, object detection, depth map and Bounding Box estimation.

All this algorithms are needed to be studied and analyzed to be practically implementable with the system. Image capturing, data analyzing and generating proper feedback are the core set of actions which are expected to be executed by this system.

6. CONCLUSION
The paper proposed the design and architecture ,of a new concept of Smart Electronic Travel Stick for blind people. The advantage of the system lies in the fact that it can prove to be very low cost solution to millions of blind person worldwide. 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.

7. REFERENCES
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