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Indoor Navigation Approach for the Visually Impaired

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ABSTRACT

Navigation in indoor environments is difficult for the person who suffers from visual impairment, especially in spaces visited for the first time. Several solutions have been proposed to deal with this challenge. Although some of them have shown to be useful in real scenarios, they involve an exorbitant cost or use artifacts that are not natural for blind users. According to WHO survey about 90% of the worlds visually impaired live in developing countries. Thus our work aims to develop an inexpensive visual assistance prototype which detects an obstacle and gives auditory response. We propose a solution which holds image processing methodology & low cost hardware for obstacle detection. Here in a vision assistance prototype a camera captures the image frames directly in front of the user and it is fed to MATLAB for the processing. Processing unit processes the captured image and enhances the significant vision data. Also a connection between ARM7 and PC is made using USB to RS232 connector to use stored procedures of audio annotations. Upon detection of obstacle the person gets auditory feedback to his/her ears.

Keywords: Audio annotation, Image Processing, MATLAB, Obstacle-Avoidance, Visually impaired, ARM 7

INTRODUCTION

There are 285 million people are estimated to be visually impaired globally: 39 million are blind & 246 have low vision [15]. India is home to the world's largest number of blind people. Of the 39 million people across the globe who are blind, over 15 million are from India. Also about 90% of the world’s visually impaired live in developing countries. Navigation of blind people is very arduous because they wields white cane for obstacle detection while following the front sides of houses and shops, meanwhile memorizing all vicinity they are becoming familiar with. Several ―everyday objects that are present in most built environments become real obstacles for blind people, even putting at risk their physical integrity. Simple objects such as chairs, tables and stairs, hinder their movements and can often cause serious mishap. In a place visited for first time it is very difficult to memorize & they tend to depend on a nearby people. The goal of our work is to develop an inexpensive embedded system that utilizes image processing mode to detect obstacles in indoor environments & pass the information in auditory form to the blind person’s ears.

The system will constantly guide the user to navigate based on real time data. The focus of this project is navigation aid for the blind which will be a supplementary to other navigational aids such as canes, guide dogs and wheel chairs.

RELATED WORK

Blind and visually impaired people are at a disadvantage when they travel because they do not receive enough information about their location and orientation with respect to obstacles on the way and things that can easily be seen by people without visual disabilities. Conventional navigational systems

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in the indoor environment are expensive & its manufacturing is time consuming. Many costly devices exist to assist visually impaired people for navigation. Number of software companies and research institutes are working on solutions to the problems of determining appropriate navigational information for visually impaired people. Most of the research that has been completed in this field makes use of GPS, sensors & RFID to detect obstacles. Also few approaches of using digital video cameras as vision sensors are implemented in some visual aid. Different navigation systems for visually impaired can be categorized on the basis of technology they employ for localization.

RFID

Systems which use RFID [1, 2, 3] installations in the building cannot provide path-based guidance. The user has to roughly estimate the position of an RFID tag which is difficult of visually impaired, while our system provides real time obstacle guidance and the user does not require any prior knowledge of the surroundings. Also another RFID-based mobile indoor navigation application [4] has been developed. Application combines the capabilities of modern mobile phones like electronic compass & accelerometer with near field communication. Currently there are no NFC based mobile phones with accelerometers & electronic compass. Thus most of the rfid based works are expensive because use of various technologies and difficult to implement because of their usability.

SENSOR

Guide Cane [4] is a computerized travel aid for blind pedestrians. It consists of a long handle attached to a sensor unit on a small, lightweight and steerable device with two wheels. While walking, the user holds the handle and pushes the Guide Cane in front. Ultrasonic sensors detect obstacle and steer the device around them. The user feels the steering direction through the handle and can follow the device easily and without conscious effort. CASBliP or Cognitive Aid System for Blind People [6] was a European Union-funded project. The main aim was to develop a system capable of interpreting and managing real-world information from different sources in order to improve autonomous mobility. Environmental information from various sensors is acquired and transformed into enhanced images for visually impaired users or into acoustic maps via headphones for blind users. System developed using gyroscopic compass & Sensors [7,8,9] provide precision metric localization which may not be required for mobility of a visually impaired individual. Distance are typically short in indoor scenario be placed. Therefore, dependence on metric localization can be reduced.

GPS

Drishti [10] is an in- and outdoor navigation system. Outdoor it uses DGPS localization to keep the user as close as possible to the central line of sidewalks. It provides the user with an optimal route by means of its dynamic routing facility. The user can switch the system from out- to indoor operation with a simple vocal command which activates a precise ultrasound positioning system. In both cases the user gets vocal prompts which alert to possible obstacles and which provide guidance while walking about. Another existing commercial navigation systems based on GPS(eg. Street Talk [11], Sendero [12]) have made navigation a lot easier in outdoor environments. But their major shortcoming is that they can only identify very specific landmarks encountered by the user and typically do not work in the indoor setting.

CAMERA

Tyflos-Navigator is a system which consists of dark glasses with two cameras, a portable computer, microphone, earphones and a 2D vibration array [13]. It captures stereo images and converts them into a 3D representation. The latter is used to generate vibration patterns on the user's chest, conveying distances of the user's head to obstacles in the vicinity.

Apart from all these techniques amalgam of techniques have also been used like SWAN or System for Wearable Audio Navigation is a project of the sonification Lab at Georgia Institute of Technology [14]. The core system is a wearable computer with a variety of location- and orientation-tracking technologies, including GPS, inertial sensors, pedometer, RFID tags, RF sensors and a compass. Sophisticated sensor fusion is used to determine the best estimate of the user's actual location and orientation. From the overview presented above we can conclude that technologically there are many possibilities which can be exploited. Some are very sophisticated, but also very complex and likely too expensive for most blind persons who, in addition to having to deal with their handicap, must make both ends meet financially.

Thus keeping in mind expensive nature of existing technologies this paper presents a prototype of obstacle detection system that helps the visually impaired to move within indoor environments. Our system uses low cost camera that processes the image & apply obstacle detection algorithm implemented in MATLAB. The results are processed in auditory form to visually impaired person's ears, so that he/her can traverse in safe direction.

PROPOSED METHODOLOGY

The methodology aims to extract information from the video stream output of a camera in order to create a map of the traversable and non-traversable areas in real-time. The main challenge is the creation of an algorithm that is detects inert objects in internal environment by utilizing possible computational resource that would facilitate execution on a low-cost processing unit. Since the video is processed frame by frame, first of all we describe the noise-filtering approach that is applied prior to segmentation in order to eliminate shadows, reflections and water prints. Then images segmentation is apply to enhance properties of image. Finally edge detection algorithm is applied to image to detect edges of obstacles. An edge in an image may point in a variety of directions, so this algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image.

SYSTEM DESIGN

In this section we describe hardware & software architecture of proposed system. Since we are developing a prototype of our system, modules need to be cost effective It also shows how different blocks communicate with each other

Hardware Description

The hardware board consists of Power supply IC LM7805, LPC2148 ARM 7 processor, ultrasonic sensor, 16 X 2LCD display and APR 9600 Voice IC. The Camera module used here can be a portable or a webcam interfaced through a USB to serial prolific adapter. It provides connectivity for a camera capable of capturing still images or video recordings. The APR9600 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The system gives output to speaker in form of auditory command which is interfaced to Voice IC.

The response of edge detection algorithm applied for the obstacles detection can be seen on a command window display.

Embedded Software Description

Here ARM 7 Programming is done using keil u vision3.The µVision3 IDE is a Windows-based software development platform that combines a robust editor, project manager, and makes facility. µVision3 integrates all tools including the C compiler, macro assembler, linker/locator, and HEX file generator which gives us a procedure to interface with other modules as well as helps in generating in audio response.

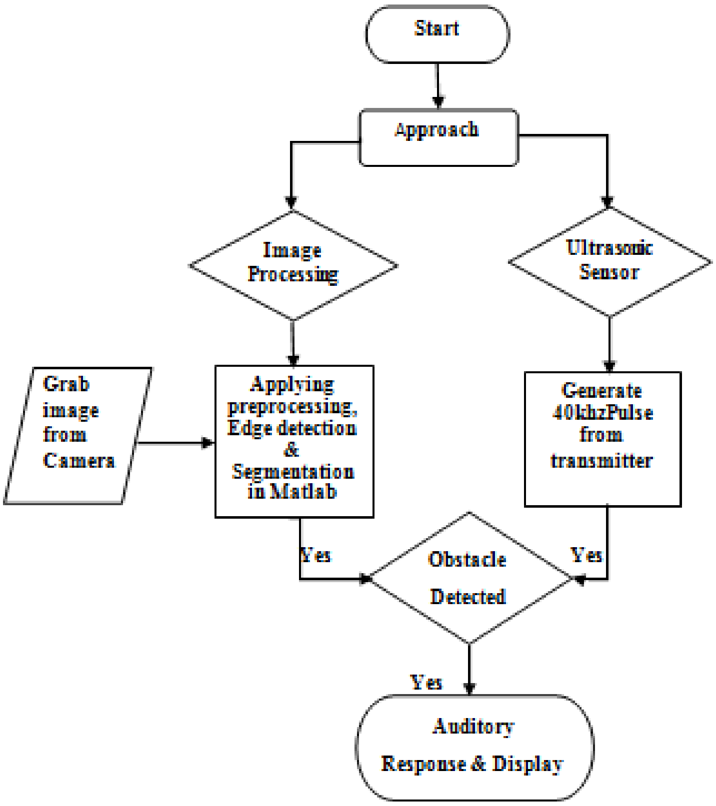

Figure1. *The embedded software flowchart overview*

The software modules communicate with camera device driver. Through Matlab we generate image processing algorithm which detects obstacle and pass this information to ARM module using serial communication.

RESULTS

Experimentations are done to evaluate the proposed methodology. The set of experiments were conducted to evaluate the image processing procedure using simulated images.

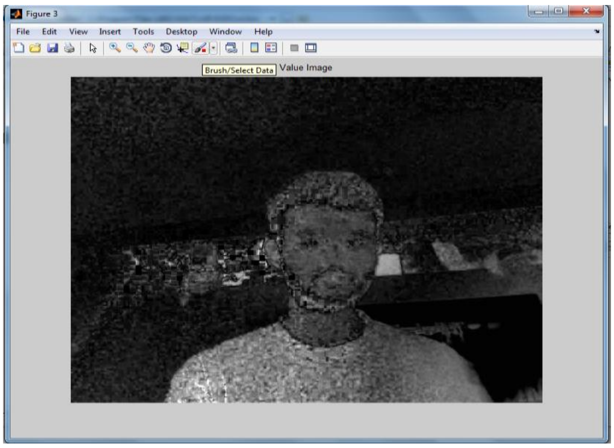

Figure2. *Grayscale image*

The obstacle in front of camera is made to go through different phases of algorithm. First of all we describe the noise-filtering approach that is applied prior to segmentation in order to eliminate shadows, reflections and water prints. This is achieved by Saturation. By converting the RGB color-space to HSL, the saturation channel is extracted and further resized to a coarse 64 X 48 saturation intensity map by Gaussian pyramid decomposition of the 320 X 240 input image.

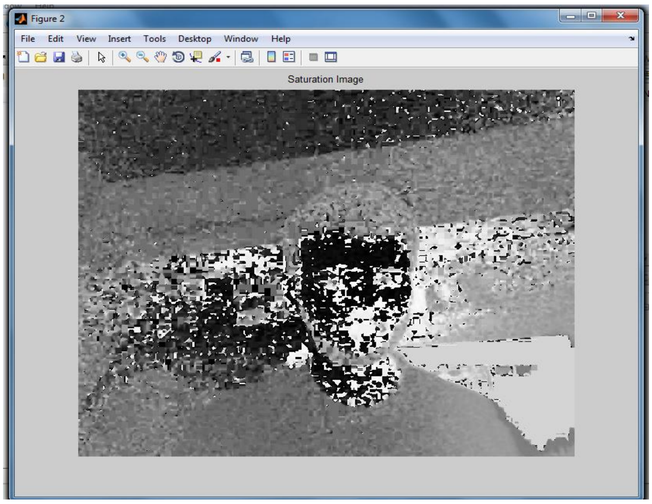

Figure3. *Saturated image*

Image segmentation makes extensive use of the Gaussian and Laplacian pyramids. In this method, one builds an image pyramid and then associates to it a system of parent–child relations between pixels at level Gi+1 and the corresponding reduced pixel at level Gi. Image segmentation makes extensive use of the Gaussian and Laplacian pyramids. In this method, one builds an image pyramid and then associates to it a system of parent–child relations between pixels at level Gi+1 and the corresponding reduced pixel at level Gi.

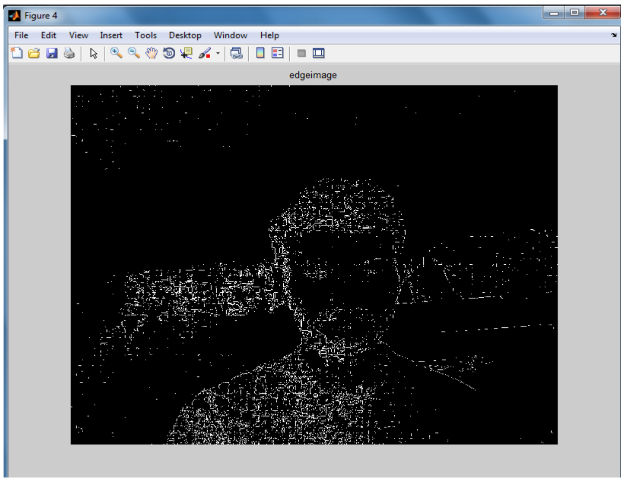

Figure4. *Edge Detection*

In this method we use the output of segmentation process to extract the accurate path and obstacles. Due to the different saturation of color-spaces generated from previous steps, the edges are detected accurately by edge detection method. An edge in an image may point in a variety of directions, so this algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator returns a value for the first derivative in the horizontal direction (Gx) and the vertical direction (Gy).From this edge gradient and direction can be determined:

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2}$$

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The edge direction angle is rounded to one of four angles representing vertical, horizontal and two diagonals (0, 45, 90, 135 degrees for example).

Finally the important step in which we identify the obstacle by comparison it to "safe" window near the bottom of the image. The current approach also adopts this idea since the "safe" window can always be validated by low-cost active short range sensors such as ultrasonic or infrared. The safe window identifies the particular obstacle for the traversal.

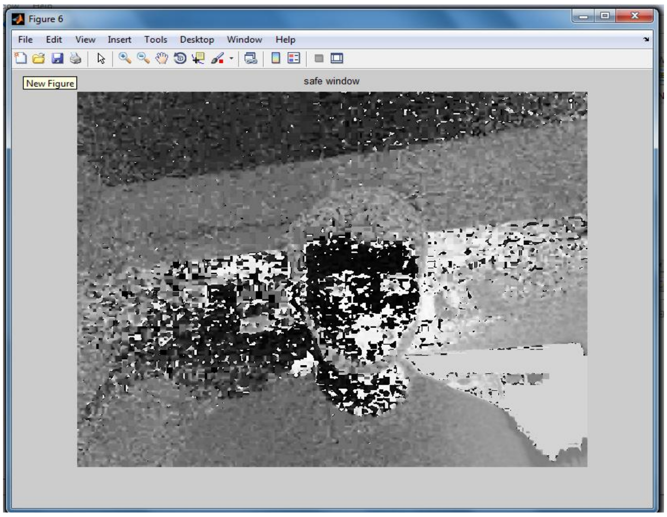

Figure5. *Final Image*

CONCLUSION

This paper categories different techniques of obstacle detection for visually impaired in indoor environment. A new approach to design an inexpensive visual aided system that solely uses camera & image processing methodology is proposed prototype. Our main concerns are the cost of devices, size of devices, processing time and accuracy. These concerns are improvised by applying several combinations of algorithms to discriminate shadow and actual objects.

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