

Design of Obstacle Detection System for Visually Challenged People

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Abstract: This paper describes a obstacle detection system for visually impaired people using Image processing in MATLAB. This system, together with ultra-sonic sensor interfaced with Arduino detects stairs and doors with or without signage and distance of these objects from the user. This information is conveyed to the user through a speaker. The results show satisfactory accuracy in detecting stairs and extracting different signage on doors such as that of washroom, exit, elevator etc.

Keywords : MATLAB; fourier; regionprops(); arduino; ultrasound

I. INTRODUCTION

A significant percentage of the world population suffers from visual impairment and blindness. According to the World Health Organization, globally about 285 million people are visually impaired, and 39 million of them are blind. Independent travel presents significant challenge to visually impaired or blind people. GPS technology and guided electronic way finding devices show a lot of promise in outdoor environment. But, still they face a lot of difficulty in unfamiliar indoor environment such as to find stairs, elevators and doors, rooms in an office or a building. Even in familiar indoor environment such as home, they have to memorize where every- thing is kept. Computer vision technology in principle has the potential to assist blind individuals to independently access, understand, and explore such environments. An obstacle detection system for such problem is proposed by using a web cam to detect and recognize objects using MATLAB and ultrasonic sensors for distance calculation. In an unfamiliar environment, this system can also detect the signage associated with the detected object, like say sign of elevator or washroom is labeled on. Signs play an important role in navigation and way finding for even fully-sighted persons. In order for this system to work accurately, it is assumed that all doors are labeled on with different signage. In case it's not labeled, then the system simply tells the person that a door has been detected without any information about the door. Large number of signs as templates is stored in the database of MATLAB. This system simply compares the sign encountered with all the ones in its database and informs the persons when it gets matched along with its

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II. EASE OF USE

A. Versatility

One of our goals was to make a device which can be used in variety of application. Apart from making the device to help visually impaired people, the algorithm used with little tweaks can also be used in areas such as scene understanding, robot navigation, autonomous systems, etc.

B. Learnability

A transparent system is by definition one that requires little or no learning on the part of the user. While we do not claim that our system will require no learning, we aim to require as little learning as possible. The user should be able to understand how to operate our system within moments of first exposure.

C. Cost Effectiveness

Our device is fairly simple to use and very economical. It has been designed to keep the cost to a minimum, so that everyone could afford it

III. APPARATUS/SOFTWARE USED FOR PROTOTYPING

1. Arduino Development Board,
2. Mp3 shield for Arduino with microSD card slot
3. Ultrasonic sensor



Fig. 1: Arduino Duemilanove(Freeduino)

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Fig. 2: USB Webcam



Fig. 3: Sparkfun MP3 shield for Arduino



Fig. 4: Ultrasonic Sensors

4. A small set of speakers
5. Web Cam
6. Matlab R2011b with Image Processing ToolBox and MATLAB support package for Arduino

IV. IMPLEMENTATION

This particular system which can be used to develop a full fledged steps and rectangular object detection system for the blind has been simulated in the following manner in MATLAB. A standard web- cam was connected to a laptop running MATLAB R2011b. A webcam which can produce an image of resolution greater than or equal to 640X480 and of

the RGB format is required. For the actual recording of the video and analysis, manual triggering was used. Conditions are set in the MATLAB program to process each trigger. With each trigger, a fixed number of frames are recorded. These frames are processed instantaneously, and the results of the first pass are computed. If it is found that the image (the frame extracted) has steps, processing stops. On the other hand, if it is found that the image has a rectangular object, image goes through a second pass, and further processing takes place to extract the label from the frame. This label is compared with a known set of templates to determine the type of the object bearing the label. Once processing is complete, the results from the fixed number of frames processed are collated together and the most frequently occurring observation is said to be the output for that particular batch of frames. Once the frames are matched, output is sent to the attached Arduino microcontroller to activate the ultrasonic sensor to calculate distance. After the distance has been calculated through this method, an appropriate tune is played through the attached speakers.

V. A-FIRST PASS

The image is transformed into the Fourier domain, where after appropriate processing it can be determined if it has strong horizontal or vertical edges. Strong vertical and horizontal edges in the frame map to a single horizontal and/or vertical line in the Fourier domain, its brightness increasing with the strength of edges in the frame. So, if the image has steps, a horizontal line of substantial intensity will be produced in the Fourier spectrum, along with a somewhat dull vertical line. If it contains a rectangular object (like a door), there is majorly a vertical line of substantial intensity in the spectrum with little or no horizontal lines. Once the image has been transformed into its Fourier spectrum, thresholds are set in reference to the intensity of the line and its maximum deviation from perfectly vertical/horizontal position. This differentiates between steps and other rectangular objects.

VI. B-SECOND PASS

It is found the image contains a rectangular object. The image is passed through an unsharp mask and the appropriate R or G or B frame is extracted. The image is then converted to a binary image, and then either dilated and/or eroded with appropriate parameters so that only the label is extracted. This helps in ensuring non detection of other artifacts that might be found on the surface of the door/rectangular object. After segmentation, MATLAB's image processing toolbox's regionprops() function has been used which returns segmented regions in an image along with some of their properties. With appropriate thresholding in the Area, Extent and Length and Width properties a rectangular object(the label) is identified and using its coordinates, the label is extracted from the frame. Using correlation, this label is then compared with a set of templates with a further threshold to determine the best match. Conditions are also inserted for no match. In all cases, the matching is performed by calculating correlation between the extracted image and the templates. MATLAB's corr2() function helps find the correlation between two matrices easily. Maximum correlation corresponds to the maximum match.

VII. C-OUTPUT STAGE

An ultrasonic sensor is attached to the Arduino Development Board. It works on a simple echo principle to calculate the distance taken for a wave to reflect back from the rectangular obstacle. This distance is then relayed back to MATLAB, which further activates a sound message to play through the Arduino's MP3 shield.

VIII. TESTING

For the testing of this simulation, similar sized labels with different symbols on them were stuck on the hostel doors of our college campus. Some of them were stuck on door-like objects like cupboard doors. After this a person carrying the device pointed the webcam one by one at such doors and recorded a fixed number of frames with each trigger. Images of steps and of non-rectangular objects were also recorded. A script was written in MATLAB to display a message box corresponding to the detected image after each computation. We also read in the detected distance to the object from the Arduino using the serial connection.

IX. RESULTS

It was seen that despite doors having a number of artifacts, this detection scheme worked with a good number of positive results. Some sample cases are shown at the end.

Table 1: Detection Accuracies

		Detected	NOT DETECTED
Steps	Present	20 (94.4%)	3(5.6%)
	Not Present	2(20%)	8 (80%)
Doors	Present	41 (82%)	9 (18%)
	Not Present	2 (17%)	10 (83%)

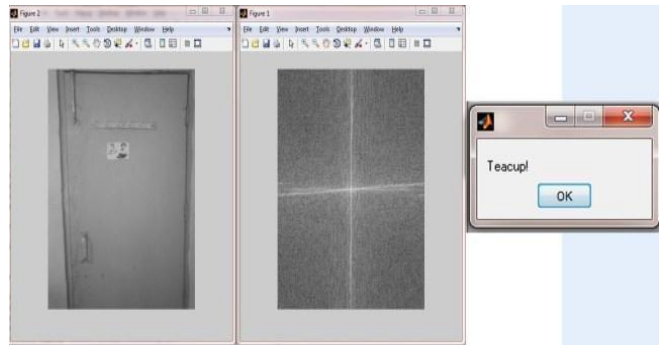


Fig. 7: Recognition of coffeeshop symbol

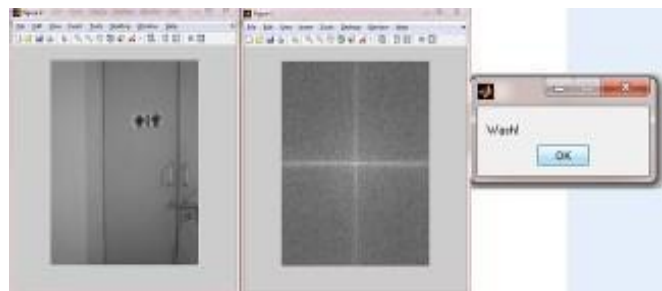


Fig. 7: Recognition of washroom sign

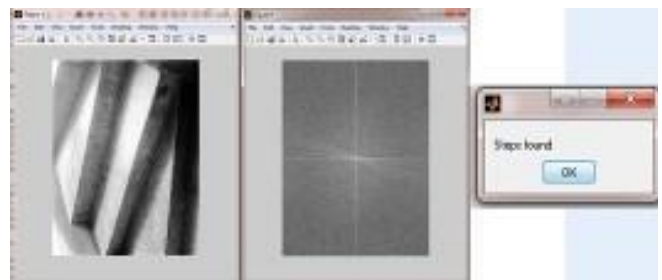


Fig. 8: Recognition of steps

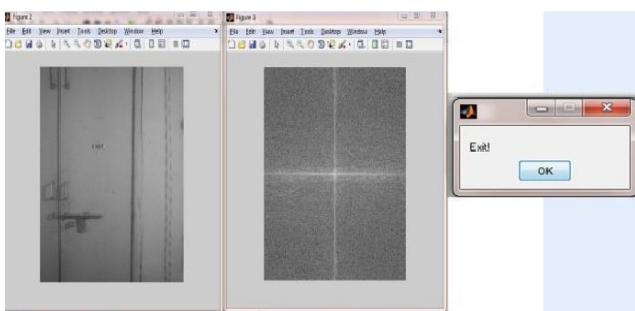


Fig. 5: Recognition of exit sign

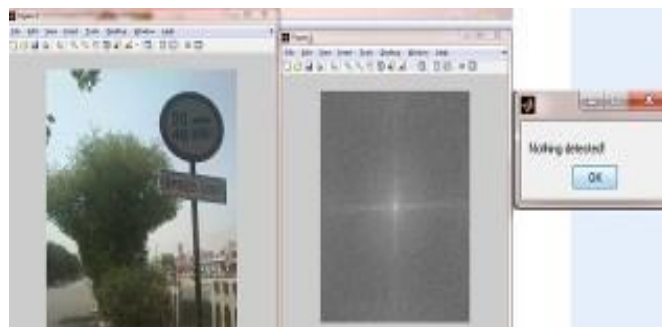


Fig. 9: Random image where nothing is detected

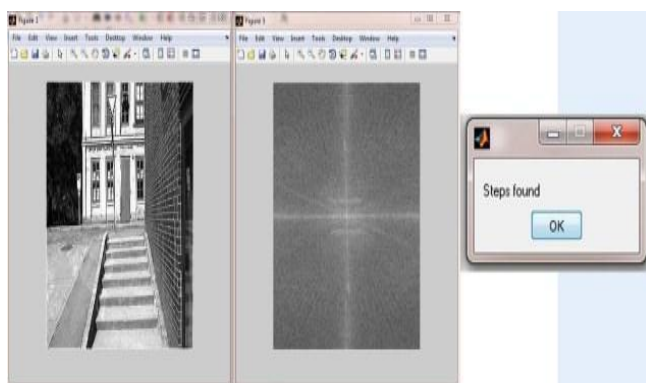


Fig. 6: Recognition of steps

X. FUTURE WORK

The paper covers the detection of only two kinds of obstacles: doors with or without labels, and steps. We are working to improve the variety an range of obstacles that can be detected through this system, while at the same time keeping the cost to a bare minimum and maintaining the computation time. Future work will include detection of tables, chairs and more such common obstacles. Also, we are hoping to simulate it on a DSP board with image processing capabilities, thereby also translating the code to embedded C, which should speed up processing considerable. Also we are trying to achieve the distance calculation through image processing alone by using



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stereo cameras in place of the webcam. This will also help eliminate the cost and power requirements that the excess hardware (Arduino and MP3 shield), entail now.

XI. CONCLUSION

In this paper, we have presented an obstacle detection system for the blind using image processing. We have used techniques such as segmentation and Fourier domain transforms to develop an algorithm for the same. We believe that this system offers a novel solution to the problem domain. As we develop this system further, we believe it will take on a much more polished form and its features will help blind people carry out their day to day tasks with greater ease.

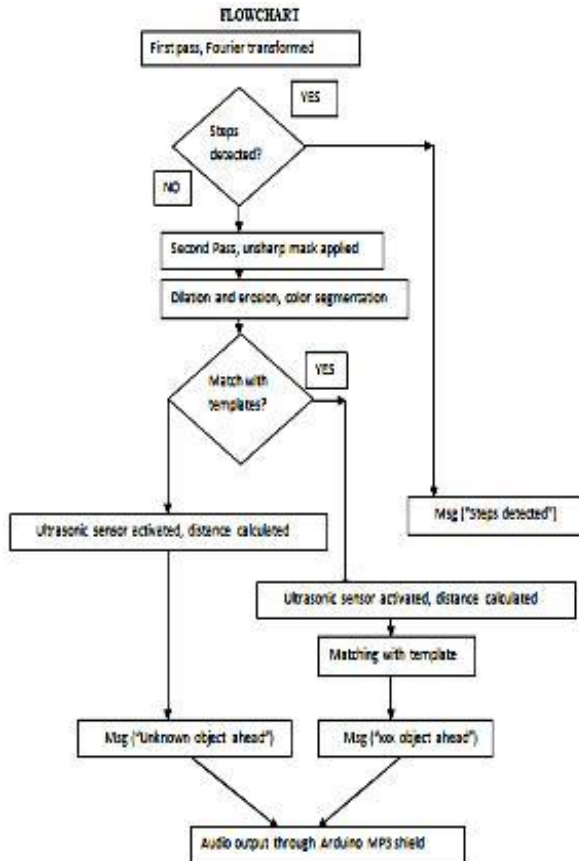


Fig. 10: Flowchart

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AUTHORS PROFILE



Pardhu Thottempudi became a Member (M) of IEEE in 2015. Pardhu was born in Luxettipet village in Adilabad district in Telangana state, India. He completed Bachelor's Degree B.Tech in the stream of Electronics and Communication Engineering in 2011 from MLR Institute of Technology, Hyderabad, India. He has done his Master's Degree M.Tech in Embedded Systems from Vignan's University, Vadlamudi in 2013. He is Pursuing his Ph.D from VIT University, Vellore, Tamil Nadu His major fields of interests include Digital signal processing, RADAR communications, Embedded systems, implementation of signal processing on applications in FPGA. He is working as Assistant Professor of Department of Electronics and Communication Engineering in MLR Institute of Technology, Hyderabad, India since 2016. He also worked as project intern in Research Centre Imarat, Hyderabad. He published 29 research papers on VLSI, Image Processing, Antennas, Signal processing, RADAR Communications in Reputed International Journals and Various IEEE Conferences. Pardhu Thottempudi is the Life member of ISTE, Associate Member of IETE from 2015. He is the member of IEEE signal Processing society, IEEE Industrial Electronics Society