Collision Avoidance Device For Visually Impaired (C.A.D.V.I)

Kiran G Vetteth, Prithvi Ganesh K, Durbha Srikar

Abstract: The white cane is the most successful and widely used travel aid for the blind. This purely mechanical device is used to detect obstacles on the ground, uneven surfaces, holes, steps, and other hazards. The main problem with the white cane is that users must be trained. In addition, this device requires the user to actively scan the small area ahead of him/her, and it cannot detect obstacles beyond its reach of 1 - 2 m. Another drawback of the white cane is that obstacles can be detected only by contact. This can become inconvenient to the user and the people around the user. Guide dogs are very capable guides for the blind, but they require extensive training as well, and are extremely expensive. Collision Avoidance Device for the Visually Impaired is a hands-free and a hassle-free pedestrian navigation system. It integrates several technologies including wearable computers, image processing, audio processing and sound navigation and ranging. This device focuses on bringing about an approach which would make a visually impaired person to walk through busy roads and help identify obstacles without any trouble. The device uses a digital camera to capture the image frames directly in front of the user, and the processor implements image processing to determine the obstacle and a set of vibrational motors warns the user. The system also provides audio response. The sonar sensors detect obstacles in the user's immediate vicinity. Upon detection, the vibrational motors caution him/her regarding the presence of obstacles. Image processing is used to provide the lateral distance between the obstacle and the user, so as to provide distance perception. Being a real time system, it accounts for real time changes by processing on current frames and is reactive by providing instant responses.

Index Terms: C.A.D.V.I, Image Processing, OpenCv, Obstacle-Avoidance, Blind, Visually impaired, Navigation, Wearable system.

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1 Introduction

There are about 15 million visually impaired or blind persons in the India alone. Many of these persons use the white cane. To a certain extent, traditional navigation aids like long canes and guide dogs provide assistance to these people. Even such aids cannot detect all possible obstacles to prevent the accidents occurring to the blind person. Further the biggest hurdle for blind and disabled is to travel distant, unknown or dynamically changing environments. The goal of our work is to provide adaptive navigation support in such environments. C.A.D.V.I augments contextual information to the visually impaired and computes optimized routes to avoid static and dynamic obstacles (e.g. ongoing ground work, pedestrians, road blockade). The system constantly guides the user to navigate based on real time data. Environmental conditions are provided on the fly through detailed explanatory voice cues. Advances in wearable computing, image processing and the processing speeds of the microcontrollers have made possible to address the navigation problem of the visually impaired and disabled. The main motivation behind this navigational system is to eliminate the hardships faced by visually impaired people in dealing with their day to day lives. It is our belief that recent advances in technologies could help and facilitate in the day-to-day operations of visually impaired people. 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.

2 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 traffic and obstacles on the way and things that can easily be seen by people without visual disabilities. The conventional ways of guide dog and long cane only help to avoid obstacles, not to know what they are. Navigation systems usually consist of three parts to help people travel with a greater degree of psychological comfort and independence: sensing the immediate environment for obstacles and hazards, providing information about location and orientation during travel and providing optimal routes towards the desired destination. Sunita Ram and Jennie Sharf [1] designed the "People sensor," which uses pyroelectric and ultrasound sensors to locate and differentiate between animate (human) and inanimate (non-human) obstructions in the detection path. Thus, it reduces the possibility of embarrassment by helping the user avoid inadvertent cane contact with other pedestrians. The system also measures the distance between the user and obstacles. John Zelek's [2] work on a technology, "the logical extension of the walking cane," which provides visually impaired individuals with tactile feedback about their immediate environment. Two small, webcam-sized video cameras wired to a portable computer feed information into a special glove worn by the user. The glove has vibrating buzzers sewn into each finger that send impulses to the user warning of terrain fluctuations up to 30 feet ahead. One major limitation of these systems discussed so far is that they merely deal with navigation service in outdoor or indoor but not in the actual combined traveling environment. Imagine a visually impaired person needs to travel from his home to his office. He has to use at least two systems to guide him while walking indoors and traveling outdoors. His life will be much easier if one single system could guide him all the way to the destination. C.A.D.V.I is such a kind of integrated navigation system that the user can employ while traveling from an outdoor environment to an indoor environment or vice versa.

3 Proposed Methodology

Being a real time system, it accounts for dynamic changes by providing instant responses. The digital camera transmits the image frames to the ARM Cortex A8 controller. The video is processed frame by frame. If an obstacle is detected [3], [4] its distance from the user (estimated in meters) and its relative position in the x-axis of the image frame is calculated. The distance perception for this application is uniquely done using area to distance mapping. The area of the Haar-cascade rectangle [6] formed around the detected human's face in the camera is cleverly mapped to the relative distance of the human from the camera in order to intimate the user of the distance from the approaching obstacle. This avoids the use of two digital cameras for stereoscopic vision. The input video frame is divided in to three segments [5] based on pixel values. Any object appearing in the central segment is considered an obstacle and the presence of the same is conveyed to the user. The width of the central segment is equivalent to the approximate width required by the user to navigate freely. Any objects appearing on the right or left segments are neglected as they are of no consequence to the user. Table 1 shows the pixel segmentation ranges.

Table 1: X- axis pixel segmentation ranges

SEGMENT	PIXEL RANGE START	PIXEL RANGE END
LEFT SEGMENT	0	216
MIDDLE SEGMENT	216	300
RIGHT SEGMENT	300	400

The detection of the obstacle is conveyed to the user via the Earphones along with the distance to the obstacle. Based on the calculated relative position of the obstacle in the 2D image, one of the 3 vibrational motors, placed in his/her belt, vibrates. The vibrational motors are placed from left to right, equidistant to each other and vibrate with reference to the position of the obstacle. The sonar sensors detect obstacles in the immediate path of the user. Upon detection, the center vibrational motor cautions him/her. Being a real time system, it accounts for dynamic changes by providing instant responses. A wireless home automation system is also developed to provide ease of access to electrical appliances, such as fans, radio, music system and alarm systems. The user wears a glove having aluminum contact points at all five finger tips. Based on the contact of the thumb with any of the other four fingers, any 4 appliances can be turned on wirelessly.

3.1 SPECIFIC OBJECTIVES

i. C.A.D.V.I focuses on bringing about an approach which would make a visually impaired person to walk freely through busy roads without any help.

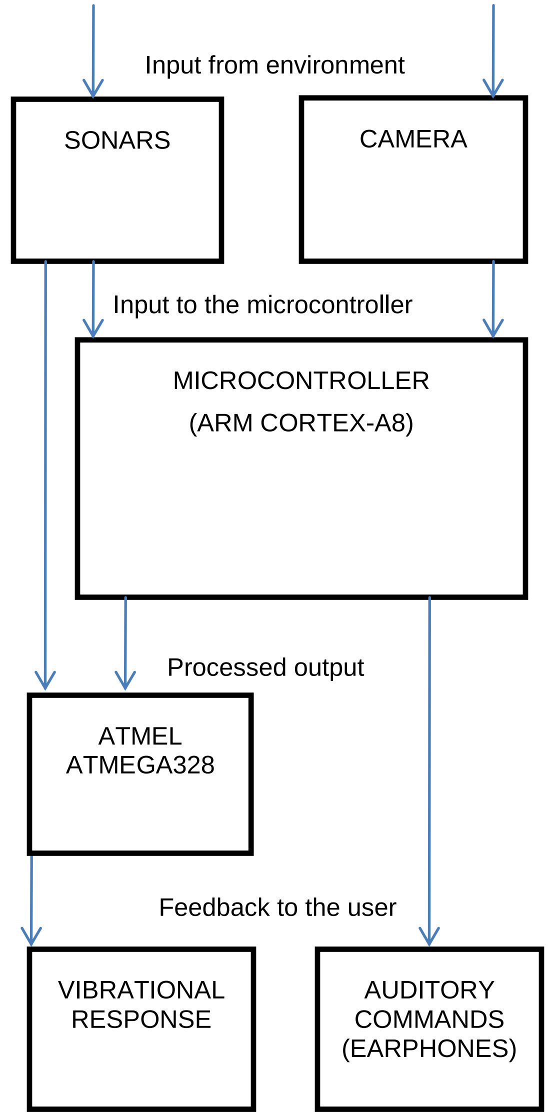
ii. Aids in detecting people and objects and avoids collision by determining the distance to obstacles.

iii. C.A.D.V.I aims to help a visually impaired person to sense his/her surroundings and perceive them almost at par with a person with sight.

iv. Ease of use and practicality in wearing

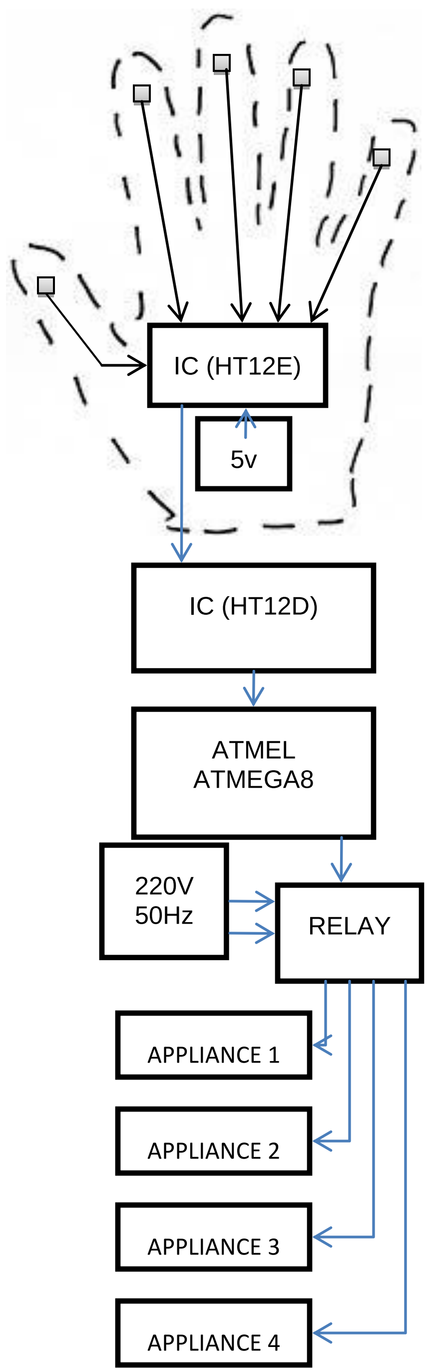
4 SYSTEM DESIGN

4.1 BLOCK DIAGRAM OF THE WEARABLE SYSTEM



The digital camera sends the video frames to the ARM CORTEX A8 microcontroller. Based on the code, the controller processes the frames individually. Upon detection of an obstacle, the distance from the user as well as the 2D spatial distance is computed. The controller then warns the user of an impending obstacle and provides the distance to the obstacle via voice commands. The spatial distance is sent serially to the ATMEGA328 microcontroller. Based on the position of the obstacle as well as the distance from the user, the controller sends PWM signals to the respective vibrational motors. The 3 motors are placed on a belt at the center and on either sides. The vibration of any of the three motors tells the user of the spatial location of the obstacle and the intensity of vibration (inversely proportional to the distance from the obstacle) provides perception of distance from the obstacle. The SONAR, placed at the front center of the belt, scans the immediate path the user is about to traverse in. If an obstacle or a ditch is present it triggers the center motor to vibrate at high amplitude to warn the user to avoid the immediate danger. The non-conductive glove for wireless home automation houses the IC HT12E Encoder, a 9V battery, and an IC 7805 voltage Regulator. As shown in fig 4.2, to each fingertip is attached metal contacts. When the thumb makes contact with either one of the other four fingers, the respective circuit is completed and its respective unique signal is transmitted wirelessly. At the receiver the IC HT12D receives the respective signals and transmits it to the ATMEGA8 microcontroller. Based on the signal, the controller sends an ON/OFF signal to the AC relay, which turns ON/OFF the respective electrical appliance

4.2 BLOCK DIAGRAM OF THE WIRELESS HOME AUTOMATION SYSTEM



4.3 Hardware Components

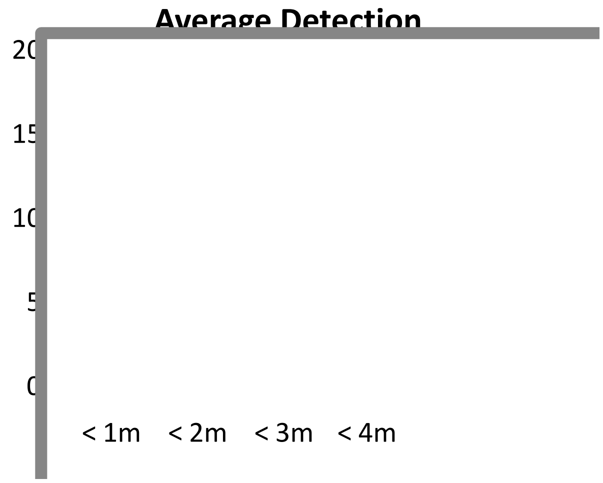
- **i.** MICROCONTROLLERS - ATMEL ATMEGA8, ATMEL ATMEGA328, ARM CORTEX-A8
- **ii.** SENSING ELEMENTS - USB Camera-Logitech C270, SONAR - HC-SR04
- **iii.** OUTPUT DEVICES - 3.5mm Earphone - Phillips, Vibrational Motors
- **iv.** RF TRANCIEVER - Encoder IC (HT12E), Decoder IC (HT12D)
- **v.** VOLTAGE REGULATOR - L7805
- **vi.** TRANSISTOR - SL100
- **vii.** POWER SUPPLY - 9V 400mA Zinc Carbon, 6V 400mA Rechargeable Battery, 220V 50Hz AC Source
- **viii.** AC RELAY - HRS4H-S-DC 12V

4.4 Software Components

- **i.** OPERATING SYSTEM - Ubuntu
- **ii.** C LIBRARIES - OpenCV 2.4.3, - OpenAL 2.1
- **iii.** COMPILER - GNU Compiler Collection(GCC), - Arduino

5 DATA ANALYSIS

We have made many test runs with this integrated System. The accuracy of the camera was tested for various ranges, such as 1m, 2m, 3m. Different locations were chosen for multiple test that were thought to produce the least accurate results, for example, places with dim lighting and crowded places.



The statistics above show the successful face detections (y-axis) out of 20 cases that were conducted for different ranges of obstacles from the user (x-axis) in different environments, favorable and unfavorable. Ultrasound pulses are subject to environmental influences. We did several tests under indoor and outdoor disruptive sound producing activities such as talking, yelling, radios playing, etc.

6 Limitations

The current system has few limitations. Environmental conditions play a major role. The camera may not provide much assistance during the night time and also fails to detect obstacles approaching the user from his/her back. During rainy season it may be difficult to operate the system as it may disrupt the connections. In the case of presence of any bugs the user is helpless in regards to debugging or reprogramming the code.

7 Conclusion and Future Work

We have developed C.A.D.V.I, a wireless pedestrian navigation system for the visually impaired and disabled. Most systems that have been developed so far lack the kind of dynamic interaction and adaptability to changes that our system provides to the user. Our project also incorporates Controlled Home Automation for ease of access to electrical appliances. It is our belief that recent advances in technologies could help and facilitate in the day-to-day operations of visually impaired people. We believe that with the endless applications of Computer Vision, using the robust, platform independent OpenCV libraries, systems can be created which can compensates the visual awareness of a visually impaired person. In future work we intend to incorporate GPS facility to the system to provide step by step voice directions to the blind users to their destinations, while avoiding obstacles based on the current system. By providing user input to the system, the system can be made more robust and user friendly. For instance the incorporation of speech processing or tactile switches will give the user control over system. We would also like to explore the use of sensors to update pedestrian traffic levels to constantly monitor and update our database directly. In the future, GPS and Global Navigation Satellite System (GLONASS Russian equivalent to GPS) receivers can be incorporated to take advantage of expanded satellite coverage. Studies in urban environment have shown very good position fix density by incorporating GLONASS.

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