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Blind Assistance Technology (B.A.T)

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Abstract: **A significant challenge that visually impaired people face is finding their belongings when they need them. Most of the object detection methods and algorithms used are too resource hungry to be used on low end hardware. Here, an innovative contour based tagging system has been developed by the authors. The information obtained from these tags is provided in a meaningful and non-intrusive manner. Bone conduction and sound spatialization is used for finding the exact location of objects. Speech recognition is used to accept voice commands from the user. Alongside this is an ultrasonic glove is used to detect obstacles in his path. The glove provides haptic feedback so the user can estimate the distance from the object intuitively.**

Keywords: **visual impairment, computer vision, haptics, bone conduction, accessibility**

I. INTRODUCTION

An estimated 285 million people worldwide are visually impaired: 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired live in low-income settings. Approximately 90% of visually impaired people live in developing countries. An estimated 19 million children are visually impaired. Of these 1.4 million are irreversibly blind for the rest of their lives and need visual rehabilitation interventions for a full psychological and personal development. [1]

Aids such as walking sticks and guide dogs are still used by the blind today. Advancements in technology have enabled different types of electronic aids to be developed to help the visually impaired. Most of these aids use ultrasound. Mowat-Sensor [2] and Sonic Pathfinder [3] are obstacle detectors. These devices have a very narrow directivity. NavBelt[4] and Sonic-Guide are environment sensors having wide directivity enabling it to search for several obstacles at the same time. The problem with them is their large size.

The idea of the project was not to become a complete solution to a lot of problems. Our aim was to help them in one particular aspect of their life. In addition, to help blind or visually impaired travellers to navigate safely and quickly among obstacles, an obstacle detection system using ultrasonic sensors and vibrators has been added to this aid. The proposed obstacle detection system consists then in sensing the surrounding environment via sonar sensors and sending vibro-tactile [5-8] feedback to the user of the position of the closest obstacles in range.

II. LITERATURE SURVEY

Bar codes or QR codes involve the use of patterns to code information into them. These codes have evolved to include a variety of symbols like dots, polygons etc. Bar codes enable significant amount of information to be encoded into an extremely small space. The data can be decoded by suitable readers. Even though they have been in use for object identification, they have limited use in enabling the blind to recognise objects since they often need to be near the camera or the reader. Moreover, processing complexity increases as the plane of the code changes. It also encodes a large amount of information which is redundant in this case.

RFID or Radio Frequency Identification makes use of electromagnetic waves to transfer data over short distances. One method of object identification is to attach RFID tags, each with a unique ID to everyday object that the blind person might use. The person carriers a portable RFID reader and hence can distinguish between various objects. It can also be used for navigation purposes where the tag is attached to the person and multiple readers are used to triangulate his/her position. Passive RFID tags are inexpensive, need no external power source but has severe range limitations. This can be overcome by the use of active tags but these tags need external power source and is expensive which makes it uneconomical since a large number of tags are needed to map an indoor environment.

Ultrasonic sensors are low-cost, reliable sensors which are popular when it comes to finding the distance to a target object. The sensor emits pulses of ultrasonic frequency and the time taken for the wave to bounce back to the sensor from the obstacle is used to calculate the distance to the object since the speed of the wave is known. These sensors are favourites for obstacle detection due to the low cost, less interference from external sources and easy processing of signals. Image processing and computer vision algorithms can be used to detect obstacles and compute the distance to them. It often helps to map a large area and hence a real time information about the obstacles and environment can be provided to the user. However, large computational complexity is involved in detecting obstacles using computer vision. Moreover, various parameters like non-uniform lighting can result in large errors. A large number of field tests need to be performed before such a system can be deployed for mass use.

III. OBJECT IDENTIFICATION

The first step in the process is to identify the object. This might seem a routine step in image processing. But to implement it with a minimum footprint on a low power embedded system is a challenge. We tried three different approaches and will be comparing the results of the three approaches.

A. Colour Tags

The first approach we thought of was using colour tags. Different colour tags can be used in combinations so that different tags can be made. In our approach, we chose 7 standard colours. Each with adequate intensity variations from the others. When arranged as a streak of colours, a total of 7! combinations of tags are possible. But, we realized that if tag turned upside down it is identified as another object. So only 7!=2 colour combinations were possible. The results were not satisfactory and considerable computation was required to distinguish between the colours. Another problem we facedwas that in different lighting conditions, there colour intensities detected by the camera varied and hence were inaccurate. So, some tags identified as another or remained unidentified. Hence, we sought another approach.

B. QR Code

The second choice was the use of QR codes. We came to this as less preprocessing will be required because black and white objects have the maximum contrast hence edge detection is a lot easier. QR codes are widely used and development was a lot easier as there are a wide range of open source software available for decoding QR codes. Though we were positive about the use of QR codes, upon real life implementation, we had a few problems. QR codes work efficiently only for short ranges. It is difficult to extract information contained in a QR code from a distance away. A high quality camera and it will become more computationally intensive.

C. Contour Tags

Contour tags have by far been the most robust method used so far. It has very little effect on it due to changing lighting conditions. Contour tags have all the advantages of QR codes but without its drawbacks. Contour tags are nested contour tags that we developed to make object detection easier and less computationally expensive. A contour tag can be assigned to an object and the object can be detected using the tag. It has more than thousand combinations as different patterns can be used. Some contour tags are shown in Fig. 1 alongside. All objects in a frame have contours or boundaries but nested contours occur rarely in an image. In this work, we use this simple assumption as the basis of our tagging system The tag consists of three consecutive contours of pre-defined shapes nested with their centres aligned. In real time, the tags are not parallel to the plane of the camera. Hence, in traditional systems a transformation needs to be performed before further processing is possible. Usually, the perspective projection of images are captured and then further processing is done. This causes additional and unnecessary computation. To avoid this unnecessary computation, we have introduced a simple mathematical method. Instead of finding out the perspective projections of our images, we use the fact that the ratio of areas of multiple objects always remains the same even if the image lies in an inclined plane. We used a contour detection algorithm or border tracing algorithm to find the contours of the tags. In the OpenCV implementation, the contours are saved in a hierarchical order. If A1, A2 and A3 are the areas of these contours, then

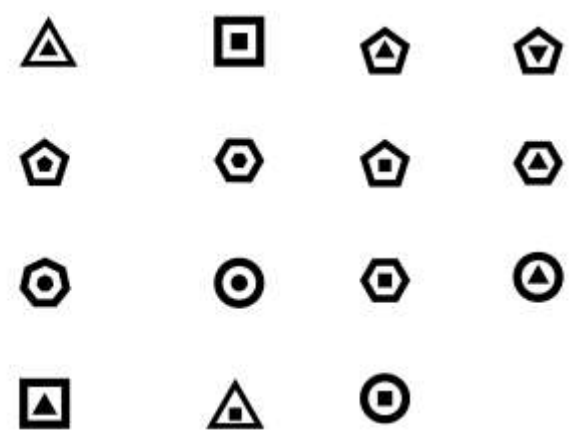

Fig. 1: Contour tags

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Fig. 2: Flowchart of system working

their ratio will always be the same. This ensures that if any unwanted nested contours are obtained in the first step, it is effectively filtered out. To distinguish between our tags, we first calculate the vertices of each contour. For example, a circle inside a square which inside a triangle will be saved as f0; 4; 3g. For different combinations of shapes, different combinations are produced. Hence, an infinite number of unique tags can be used.

IV. OBSTACLE DETECTION

Searching for and retrieving lost objects was the first part of the project. Apart from being able to detect objects and retrieve them, our system also helps them avoid obstacles by using ultrasonic sensors and tactile feedback. Most of the ultrasonic aids are incorporated into long canes. The biggest disadvantage of this is that one hand of the person is always in use and in effect the usefulness of one hand is lost. We came up with an innovative way to tackle this problem. Instead of using a long cane, we incorporated the ultrasonic sensors onto a glove so that the person will still be able to use his hand with scanning for objects in his path. This increases his work rate by a huge margin enabling him to work on other things. The problem with ultrasonic sensors is that it has very less directivity. We overcame this shortcoming by using an array of ultrasonic sensors that can cover a wider range. The advantage of having a wider coverage area is that the person need not move his hand in all directions to detect objects around him. When an obstacle is detected a beep sound would be produced. Ultrasonic sensors were the obvious choice as they have good range, are widely used and hence are easier to work with.

V. FEEDBACK

After testing the setup so far we found that the results were satisfactory but there was still room for improvement. The visually impaired have a very powerful sense of touch and hearing. So, to improve on the results obtained, we wanted to optimize the feedback given to the person. Feedback would be given for the two parts of the project: haptic feedback for the ultrasonic glove and sound spatialization effects for object retrieval.

A. Haptic Feedback

Humans experience a sense of touch because when we touch something we apply a small force and a relative force is reflected back to us. Similar techniques are used in robotics and computer vision applications. Here a feedback is created using haptics. This has made remote sensing a reality. A haptic feedback is created using a rumble motor which produces a vibration due to the off center load mounted on it. This technique is extensively used in mobile phones to create the sensation of touch. Thus, haptic feedback was chosen as an effective method for providing the blind with a more intuitive feedback. Here the distance of an obstacle is calculated using ultrasound and the distance calculated is used to drive the motor. The feedback is relative in nature, which means as the distance varies the intensity of the vibration will also vary accordingly thus providing a more natural user experience.

B. Sound Spatialization

Custom designed hardware for the blind are either expensive or are available only with significant limitation. Existing technologies depend on audio instructions to provide information regarding distance, direction and type of location around the user. This makes the whole system highly intrusive or distracting, thus people are reluctant to use it continuously. 3D virtualization of sound involves techniques that manipulate human hearing in such a way that a user perceives a sound to be coming from a particular direction using ordinary headphones. This has many applications in high end games to increase user interaction. The same techniques can be used to help blind find objects. If the position of an object is known along x,y or z direction, a virtual sound can be created from that position and the user can easily navigate without being obtrusive to the user. Thus sound spatialization bridges the gap between visual and auditory perception. All the code for this project was done in C++ using OpenCV, SFML and OpenAL libraries.

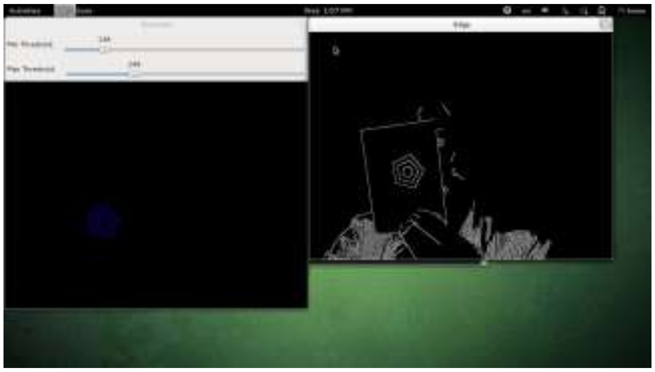

Fig. 3: Nested pentagon tag detected

Fig. 4: Nested triangle tag detected

VI. RESULTS

The results of the proposed approach can be observed in the figure. This shows that such contours can be easily determined even with low resolution web cams. Even when all the edgesare not visible nested contours can easily be detected. Sound specialization could be achieved at relatively low computation but can be significantly improved upon to make sound sources more 3 dimensional. It was observed that if the correct Head Related Transfer Function (HRTF) [9] value for a particular user is provided then better spatialization can be achieved and the results can be further improved. Ultrasound sensors where calibrated to detect obstacles within 1 m range and the use of three sensors increased the radius of the system. The haptic sensor provided reliable feedback to the user which could be operated with a small external battery. The whole system was designed as a wearable unit. The detected contour tags are shown in Fig.2 and Fig.3. Fig. 2 shows a nested pentagon tag. The accuracy of the detection can be seen. Fig. 3 shows a nested triangle tilted at an angle. The tag is still detected with high accuracy

VII. CONCLUSION

We propose a novel algorithm which uses the concept of nested contours and invariance of ratio of area with prescriptive projection. We also developed a system that helps blind to find everyday objects by tagging them. The tagging system used here is optimized for real time applications and it can be easily ported to any device. B.A.T uses 3D sound or sound spatialization for giving the location of the object. The user is prompted for input using voice instructions and guided through the whole system using voice instructions. The user wears a bone conduction earphone hence it doesn't interfere with his everyday activities. Ultrasound gloves are provided to give a hands free experience to the user. The haptic feedback helps to provide reliable feedback to the user. The whole system can be effectively used as a wearable unit which provides small but effective assistance to the user.

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