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VISUAL AID SYSTEM BASED ON IMAGE MATCHING AND ULTRASOUND SENSOR PRINCIPLES FOR BLIND PERSONS

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VISUAL AID SYSTEM BASED ON IMAGE MATCHING AND ULTRASOUND SENSOR PRINCIPLES FOR BLIND PERSONS

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Abstract- Navigation systems have been used for quite a long to support human perception of surrounding environment beyond reach of eyes. The same concept has also been applied to aid the people who are limited with the vision. Many electronics gadgets are developed to improve the vision perception of blind people. The electronic devices available for the aid of blinds are often complex, needs training sessions and come at much higher cost. This research aims at finding a reliable and easy to implement solution for visually challenged persons at a very small cost. This paper is an effort to report a comprehensive method to design, characterize and test electronics system based on image matching, radar and ultrasound sensor principles for the aid of blind persons. The simulation results showed good accuracy for identifying objects. Simulations were carried out in MATLAB and images of test objects were acquired by using NI-LabVIEW platform. The main objectives were to acquire an image of obstacle, identify it, measure a distance from current location and finally convert text into synthesized voice. Finding is expected to be supportive to the vision affected people.

***Keywords** - ultrasound sensors; radar; speech conversion; LabVIEW; MATLAB; image matching*

I. INTRODUCTION

There are millions who suffer from vision impairment in one or other degree. Vision is one of the very essential human senses and it plays the most important role in human perception about surrounding environment. People who suffer with blindness or in other words who are affected by visual impairment, face quite difficulties while in movement apart from many other constraints. This condition leads the concerned person to be handicapped and need guidance or assistance for every action. Many researchers have proposed devices for improving blind person's life quality [1]-[2]. Human vision abilities are extraordinary to realized images with the imbibed images in the brain, but these are also having some limitations like being tired, slow, and not so accurate because of some disease [3]. These limitations may be rectified by using the principles of computer vision system which definitely improves the blind life quality [4]. Few researchers have proposed outdoor navigation devices for vision affected person [5].

The main tool used is LabVIEW. It is a CAD based system design platform and development environment for a visual programming language [6]. Visual block coding is very easy to use in designing systems. An image processing mechanism was used to identify the presence of object in the way of a visually impaired person and images were captured using smart camera. Vision assistant tool of LabVIEW was used for image processing and further coding had been done to match the patterns present in images. This program helped to identify the object and spells the name of the object detected by the system. The text was converted into synthesized speech which enabled the blind person to hear about the surrounding objects for identification purpose.

The other important parameter is the distance of object form current location of a person. It is necessary to know the distance of an object to help affected person to be guided towards it or away from it. The distance was measured using ultra sound sensors and radar signals [7]-[8]. Distance measurement simulation tests were carried out using MATLAB.

Capturing of objects' images was achieved by using Image Acquisition (IMAQ) tool in available with LabVIEW. Images were taken by using USB cameras, both web and industrial cameras for comparison analysis purpose.

II. LITERATURE REVIEW

Published literature shows that there are many researchers who are engaged in research work in the field of developing various aids to blind persons. Many solutions were evolved for enhancing comfort in movements of a blind person.

Jaime Sánchez and Tiago Hassler designed Audio Multi User Dungeon (MUD) by using spoken text to describe the environment, navigation and interaction [1]. They had also introduced some collaborative features into the interaction among blind users. The core of a multiuser MUD game consists of a networked textual virtual environment. The authors developed AudioMUD by adding additional collaborative features to the basic idea of a MUD and integrated a simulated virtual environment with human body.

B. Ando [2], designed, a new multisensory architecture, which helped blind people to perform routine tasks with improved ease. The device was based on a multisensory system with use of smart signal processing techniques. The technique proved to be quite useful for vision affected ones.

Gaurav Sharma, Sonali Sood, Gurjot Singh Gaba, Nancy Gupta [3] recognized two images through the process of geometric comparison. The geometric comparison was performed by comparing the image with a template through the processes of edge detection, scaling, contour matching and RGB to grayscale conversion. It was a simple and less complicated for implementation purpose apart from being cost effective. Accuracy and speed of the response was reasonably good.

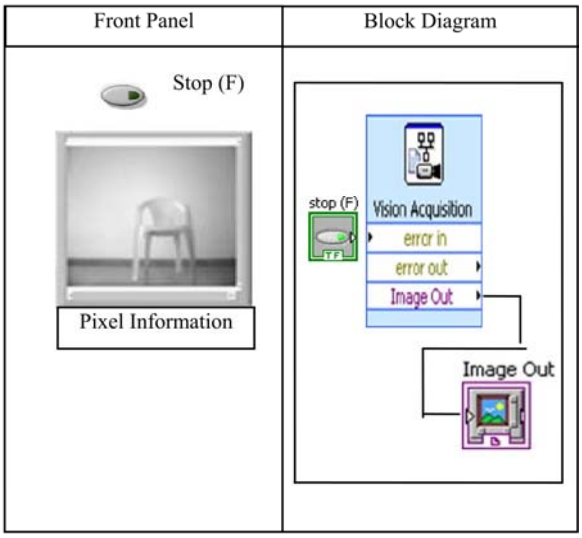

Figure 1. Representative block diagram for image acquisition GUI build in LabVIEW Platform

The research in this field has shown that an aid for blinds can be designed using a smart camera or a normal camera by embedding with application software built on MATLAB and LabVIEW based software. The implementation consists of object identification, classification, and object understanding. An ultrasonic sensor array may be used for the determination of object distance. The image matching circuits, output generators and the ultrasonic sensor array are integrated on a common board. The output signals were used to actuate relevant speech messages stored in an auxiliary memory in voiced form.

III. SIMULATION ENVIRONMENT

Parametric information about an imaging environment is a critical step for imaging application. Before acquiring images, there are fundamental principles to be applied in proper context. These may include resolution, field of view, working distance, sensor size and depth of field. A typical resolution may be defined as the smallest amount of object detail that can be reproduced by any imaging system. It should be chosen in such a manner so that the imaging system can distinguish a smallest feature size on the object. Field of view is the area of inspection that the camera can acquire. Working distance is defined as the distance from the camera lens to the object under inspection. The size of a sensor's active area is called as sensor size. The depth of field of a lens is the ability to keep in focus objects of varying heights or objects located at various distances from the camera.

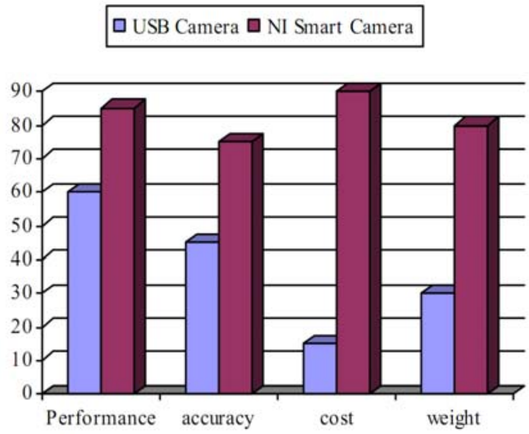

Figure 2. Graphical comparisons between USB and NI-smart camera

Acquired images may be having poor lighting condition, which can cause lack of good results in terms of image matching. The cameras should be selected in such a way that these can acquire images at even poor lighting condition. This can improve the results of matching the images of object to be identified. Mainly, there are two types of cameras available in the market. These may be analog and digital. Digital cameras have several advantages over analog cameras. Analog videos are more susceptible towards noise compare to digital videos. Images acquired for moving or dynamic objects may appear blurry. Progressive scan cameras acquire a full frame at a time which eliminates blur resulting due to motion [9]. Another method for eliminating blur from the images of motional objects is to use a strobe light with a progressive scan camera.

For this system, the authors have used NI 1762 smart camera with resolution 640 x 480 pixels and web camera for training session. Fig.1 shows a representative block diagram of graphic user interface (GUI) built on LabVIEW platform. Objects' images were acquired by vision acquisition software.

Fig. 2 shows the comparison analysis between normal USB camera and NI-Smart camera in respect of different performance parameters. NI-smart camera is costly and bulky but more accurate and has better performance results compared to USB camera. NI-smart camera is normally used for real time surveillance systems to monitor processes online whereas USB camera is considered to be good for offline still image capturing and subsequently analyzing.

IV. IMPLEMENTATION METHODOLOGY

A. Experimental Setup

Over the time, many navigational aids such as canes and guided dogs were used by visually impaired person to reduce their mobility constraints [10]. In the development of modern technology, many different types of tools, which are known as electronic travel tools (ETA), designed to assist the visually impaired ones. Easy controlling mechanism of these tools is important for blind persons. These devices should have characteristics of being small in size, lighter, simple to control, more reliable and portable [4].

Fig. 3 shows the flow chart, which describes the connectivity and working principle of modules. Algorithm block, as shown in Fig. 4, is main functional sub-system.

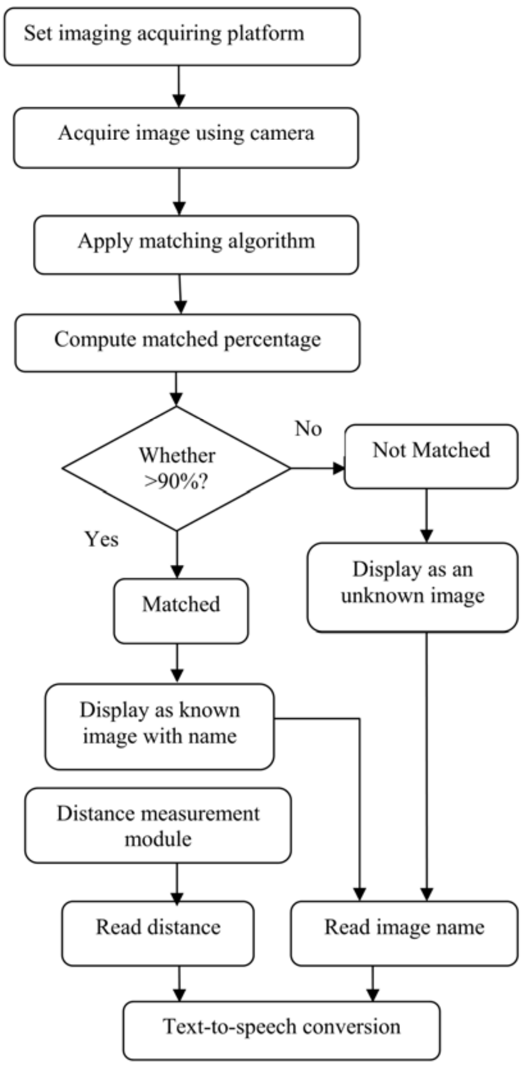

Figure 3. Flow chart of the visual aid system for blind persons

The main objective of the research was focused on enhancing the blind person's life quality. For this research work, an image matching technique based on comparison principle was used. Firstly, images were acquired and converted into an array format. Secondly, the images in array format were compared for further processing.

This system contained three modules namely image matching module, distance measuring module and text to speech conversion module. Image matching and distance measurement tasks are performed parallel. Image matching module consists of acquiring, loading, comparing, edge detection and object identification. Distance measurement module consists of radar circuitry and ultrasound sensors. The third module is related to text to speech conversion software and microphone.

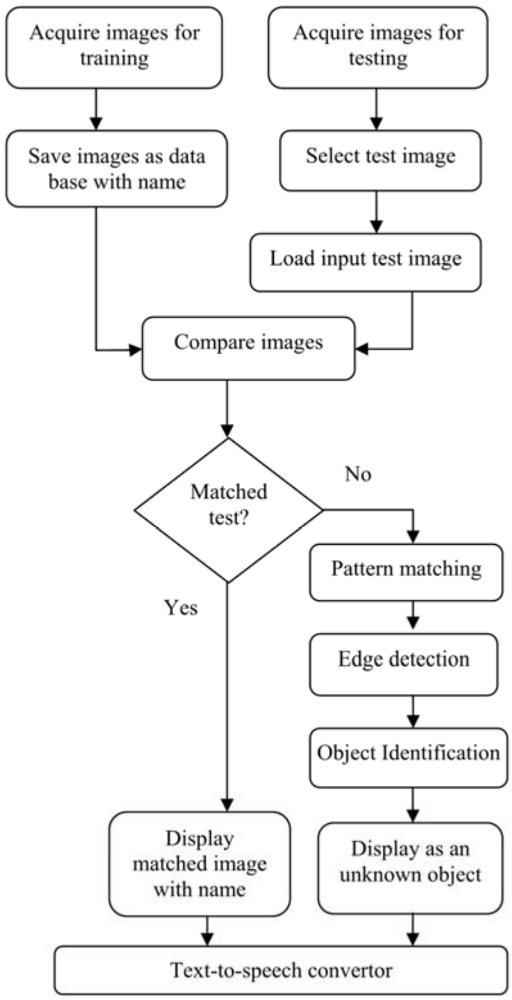

Figure 4. Flow chart for image matching algorithm

B. Algorithm Flow Steps

After the imaging environment has been configured as per requirements, the images acquired by using web and smart cameras were stored in folder with name tag. These stored images were used for training the intelligent system. These images could be that of the living or non-living objects. Images were taken with variable directions and lightings to take into account of varying conditions of real time environment. For example lighting of environment is different at day time than evening time or at night time.

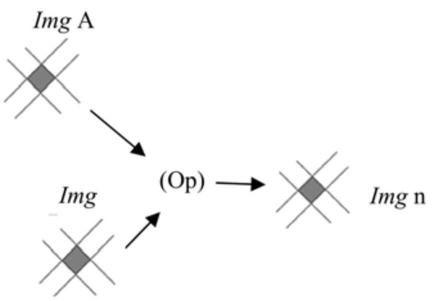

Figure 5. Operator principle for comparing images

In the next step the testing images were acquired and compare with the previously stored database images using IMAQ operators. Threshold limit is fixed as 90% for matching. If matching percentage will be more than 90% then is considered as matched. If the matching percent is less than 90% then it is considering as an unknown object. In case matching is less than 90%, then it will perform certain operations such as edge detection etc. This feature may be used for estimating the size of the unknown objects in terms of height and width. Fig. 4 shows the flow chart execution sequence of matching algorithm.

IMAQ operators' principle is depicted in Fig.5 as shown above. If A is an image with a resolution XY, B is an image with a resolution XY, and Op is the operator, then the image n resulting from the combination of A and B through the operator Op is such that each pixel P of the resulting image n is assigned the value

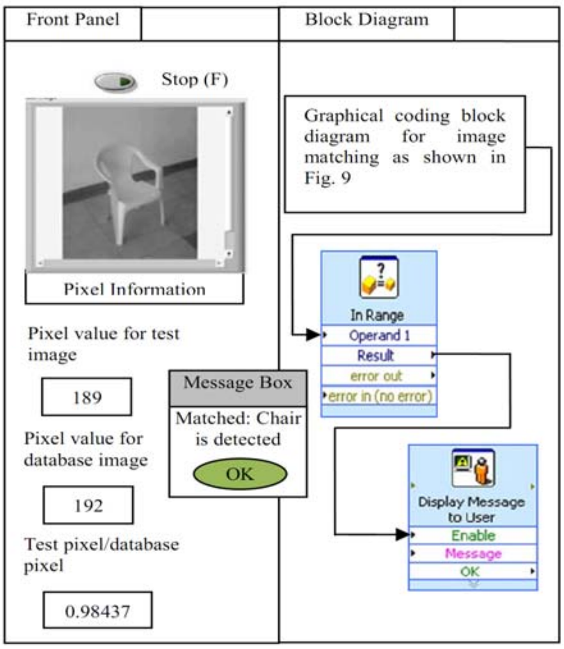

Figure 6. A Typical LabVIEW GUI designed for identification of the objects by image matching technique

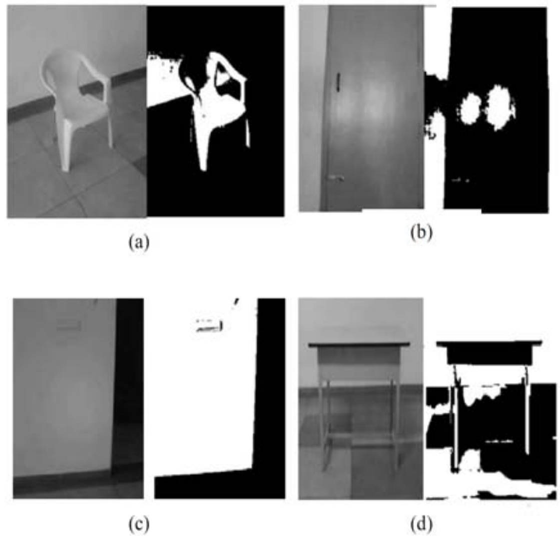

Figure 7. Left side represents grayscale image and right side represents threshold image of test samples: (a) chair, (b) door, (c) wall and (d) Table

$$\text{Img n} = (\text{img A})\ (\text{Op})\ (\text{img B})$$

Where img A is the value of pixel P in image A and Img B is the value of pixel P in image B.

Fig.6 shows the partial output generated by virtual instrument (VI), which is developed by using IMAQ palettes. In this paper, two techniques were used. In the first technique, grayscale image pixels were converted into an array and in second technique local threshold method was applied on grayscale image for background clearing and then it converted into an array.

After converting image into array, the array elements are summed up and comparison was performed between test image array value and database image array value. Fig.7 shows the pair of grayscale image and threshold image. Applying local threshold method resulted in increased accuracy of image matching results. Fig.8 shows front panel VI and Fig.9 shows the block diagram VI.

As explained above, if newly acquired test image did not match with image in the system, then it underwent further testing like pattern matching, object identification etc. Pattern matching [11]-[12] determined main feature of an image of target object such as chairs and tables. The software removed blurring, noise and performed shifting and rotation of image. IMAQ vision used new technique requiring less amount of information needed for characterizing an image or pattern which in term speeded up the searching process. Also, extracting useful information from image and removing noise provided a faster search. If image matching process failed to generate appropriate results, then system checked the image by describing it as an unknown object with some possible descriptions such as size or height as explained earlier. This helped to some extent a blind person.

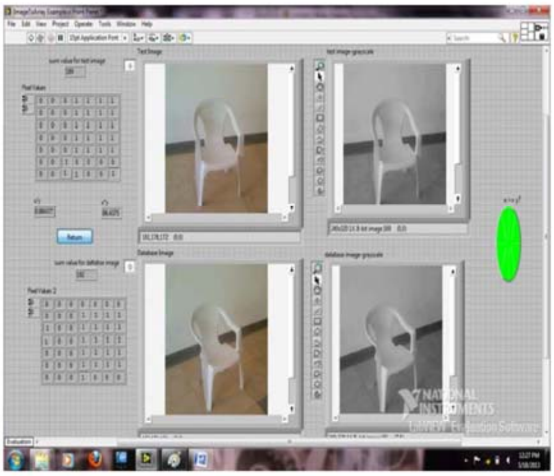

Figure 8. A typical Front Panel of LabVIEW for image matching results

Edge detection finds the outline of the object in the image before performing the comparison. The position and orientation of the moving object provides textual message to the blind person. The outline of the object was marked if an edge occurs. Additional distance measurement finds the correct location of the object. It can specify the minimum strength by using the contrast parameter in the software.

TABLE 1. IMAGE MATCHING SYSTEM TESTING STATISTICS

Objects	Sample size	True mismatch		False mismatch		Correct match	
		BT	AT	BT	AT	BT	AT
chair	25	03	02	02	02	20	25
table	30	01	01	02	01	26	29
walls	20	00	01	01	00	17	20
doors	10	03	01	01	00	07	07
Total	85	8.2%	5.8%	7.1%	3.5%	82%	95%

*BT = Before Threshold, AT = After Threshold

Vision assistant tool was used for pattern matching and edge detection. It is also used for prototyping and testing image processing applications. For this work a prototype was developed for identification of image of moving object on normal road conditions and stationary objects in an office environment. The scripting feature records every step of the processing algorithm. After completing the algorithm execution, tests were conducted for other images to check that it functioned as was desired. In this project, an image processing application based on LabVIEW VI was created, which performs as a vision assistant prototype as well as IMAQ GUI.

The results were generated in the form of correct match, true mismatch and false mismatch, which are listed as shown in Table 1. This sample is only for indoor objects. In the similar manner, the tests were conducted for moving objects also. Fig. 10 shows the comparison result between two methods which were explained above.

C. Distance Measurement by Ultrasound Sensor

To enable a visually impaired person to move on, it is important to identify the object at its current location with approximate distance of object from moving person.

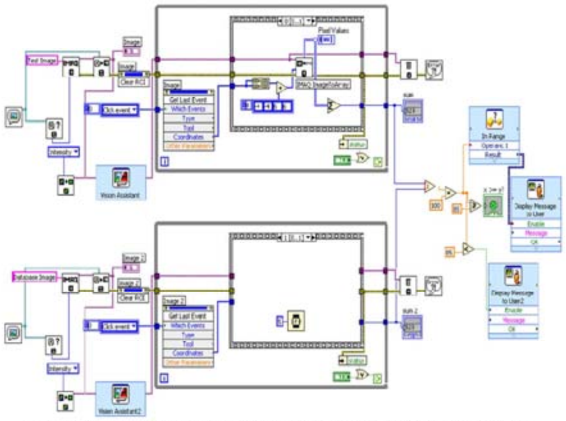

Figure 9. Block diagram representing graphical coding for image matching designed using NI Vision on LabVIEW platform

With this information blind person can navigate more safely for indoor as well as outdoor movements. Distance analysis was carried out by using two techniques based on radar principle ultrasound sensors. The long range distance was measured using radar principles for the range of 35 m to 3 km.

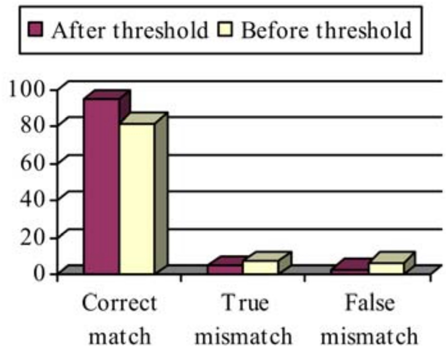

Figure 10. Graphical representation of comparison performance for image matching accuracy

The authors had used ultrasonic sensors for measuring short range target objects. Ultrasonic sensors work on the principles similar to radar which evaluates attributes of a target by interpreting the echoes of sound waves received. It converts energy into ultrasonic waves higher than the normal range of human audible frequency. Ultrasonic sensors generated waves and the echo received was evaluated. Sensor provided basis for determining the time duration between transmitted sound and received echo to compute the distance of an object. It can refer to piezoelectric transducers that convert electric energy into sound. Piezoelectric crystals vibrate if a voltage is applying across it. Piezoelectric crystals can be used as an ultrasonic detector because it generates voltage when force is applied on it. The authors used T40-16 and R40-16 ultrasonic sensors.

In Fig.11, block diagram shows the working principle of ultrasonic sensors along with 8051 based microcontroller. It required less memory. A 20 pin 8051 based microcontroller was used for triggering the circuit and convert hex value to decimal and then into ASCII, so that distance value can be displayed on LCD and at the same time this ASCII values was used by text to speech converter to spell it out. Triggering circuit works as a signal generator in on time and off time with the help of timer IC. Short distance test results are shown in Table 2. Distance measured closely matches with true distance.

For long distance, a monostatic pulse radar was used to estimate the object distance. A technique based on the standing wave microwave or millimeter wave principles and an adoptive non-coherent detection scheme were used [13].

TABLE 2. DATA FOR SHORT RANGE DISTANCE MEASUREMENT

S. No.	Objects	True distance	Distance measured
1	Chair1	35cm	33cm
2	Chair2	16cm	14cm
3	Door	36cm	37cm
4	Table1	19cm	22cm
5	Chair3	14cm	13cm

The monostatic radar contains transmitter and receiver at same end. The transmitter generates a signal which detects an object called target and then reflects signal. The reflected echo signals are then received. Once echoes' location has been measured in respect to time then range of target can be determined by different signal processing techniques. The block diagram as shown in Fig.12 illustrates steps of distance determination. Distance computation was performed using programming codes and simulated the same on MATLAB. A methodology was designed and tested for determining a threshold value for probability of false alarm (pfa).

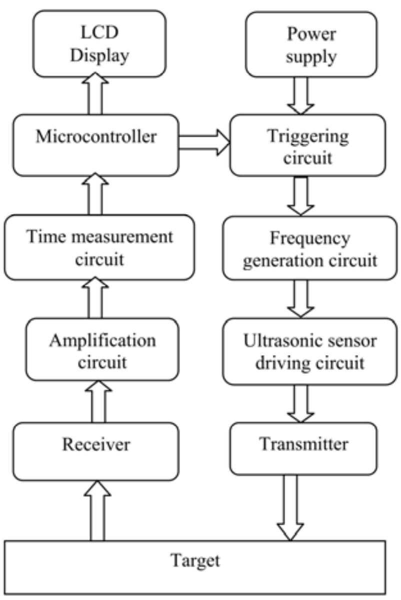

Figure 11. Block diagram for distance measurement using technique of ultrasonic sensors

The design goal of the radar based system was to detect non-fluctuating targets with at least a distance up to 3 km. Rectangular wave pulses were chosen as transmitting signals. The peak power of transmitter and SNR are important factors determined by radar equation. SNR value was determined by MATLAB based Albersheim's equation. Pulse integration technique can make radar system easier to be implemented. The receiver compared the signal power with given threshold value which was chosen in such a way that the pfa was below the selected level. The noise was assumed as a white Gaussian. Next the SNR was improved using matched filters prior to pulse integration and threshold detection operations.

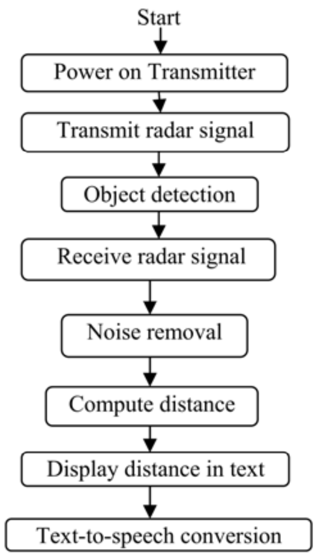

Figure 12. Flow chart for long range distance measurement

The matched filter generates an intrinsic filter delay for compensation. It moves the output of the matched filter forward and pads the zeros at the end. Because of filter processing gain threshold was increased and for further improvement of SNR was observed. Next, video integration technique was performed on received signals. As shown in the Fig.13, three echoes were received from the target objects when echoes crossed the level of threshold which is shown by a doted horizontal line at -120 dB.

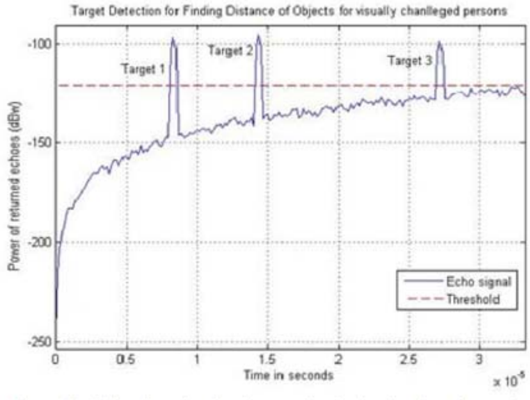

Figure 13. Object detection based on received echo-signal on time scale

Next, threshold detection was performed over the integrated pulses. The detector found peak of the signal and later it was translated into position values in terms of distance range. Range was determined by using the following equation.

$$range\ of\ target = (c \times t) \div 2$$

Where c = speed of light, 3×10^8 m/s and t = time taken by the wave to reach target and return to the receiver. The simulations were performed for measuring long range target objects by MATLAB. The summary of observed results is listed in Table 3 as shown below.

TABLE 3. DATA FOR LONG RANGE DISTANCE MEASUREMENT

S. No.	True distance	Estimated distance
1.	257m	260m
2.	35m	36m
3.	2675m	2669m
4.	1453m	1445m
5.	75m	72m

D. Text to Speech Conversion using Open Source Software

The text generated by other two modules i.e. image matching module and distance measurement module were stored in a folder. The speech maker spells the text from this folder and outputs the same form of a voiced signal. Blind person can hear this output through microphone.

The authors used speech synthesizer technology to produces artificial human look-like speech. A computer system used for this purpose is known as speech synthesizer and it can be implemented in software and hardware both. The quality of speech synthesizer is judged by its similarity with human voice and its clarity to be understood. An intelligible text-to-speech program allows people with visual impairments or reading disability to listen to written works [14]-[16]. The Fig.14 illustrates step by step flow chart for text to speech conversion. Input text is taken from the folder where image matching result and computed distance value were stored. These results were in the form of text was converted into voiced signals.

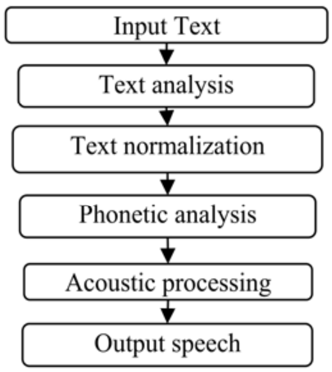

Figure 14. Flow chart for conversion of Text into Speech Conversion

Text analysis is a method where input text is organized into a list of words. Text normalization transforms text to pronounceable form. Phonetic analysis converts symbols into phonological ones by using phonetic alphabet. Phoneme is a basic smallest unit of sound and it can be represented by shapes similar to sound waves. Finally acoustic processing spells the text into an audible voiced form.

V. RESULTS AND DISCUSSIONS

This system has been implemented with different type of images. Firstly, the color images were captured by USB cameras. For matching purpose, the images were converted into grayscale since the images are easy to match with the system stored database images.

By using NI camera, the real time images were matched successfully. Matching has been done successfully with static objects but for dynamic objects partial results had only been achieved. By using ultrasonic sensors calculation of short range distances was done successfully. For long range distance MATLAB simulation was done. As shown in Table 1, the correct matching of the object images varied from a minimum of 82% to about 95%. Apart from this two other statistics were used. These were true mismatch and false mismatch. True mismatch was actually failure of object identification when it was supposed to be identified. False mismatch was related to the wrong identification of objects in terms of other objects which otherwise not supposed to do. The mismatches were very small and didn't affected system mostly. Further some improvement may make system very reliable and robust. The same system can be further refined to improve upon its accuracy and reliability. This research work was mainly focused on to find that the fundamental principles apply and that the approximate solutions are obtained. The continued work will further improve the results and observations.

VI. CONCLUSION AND FUTURE SCOPE

This paper has been focused on mainly three tasks of image matching, distance measurement and text to speech conversion. Considering the results of the system, it had been observed that, images acquired by using web camera and NI-smart cameras had been classified most of the time correctly. Grayscale images are easier for matching purpose. It makes system to function faster. This helps in identification of objects as well as scans the entire instances for the presence of number of objects in the path of the blind person. Matching percentage has to be nearly all the time correct as there no chance for correction for a blind person if it is to be trusted and reliable one. The authors utilized the principles of monopulse radar for determining long range target objects and ultrasonic sensors for short range target objects. By analyzing results it can be concluded that both the methods of radar based as well ultrasound sensors based are well suited for computing the distance of target objects located in indoor and outdoor environment. The further research may be done to build a more intelligent system with the same concept presented here. The other scope may include a new concept of optimum and safe path detection based on neural networks for a blind person.

REFERENCES

[1] Jaime Sánchez and Tiago Hassler, "AudioMUD: A Multiuser Virtual Environment for Blind People," IEEE Trans. on neural systems and rehabilitation engineering, vol. 15, no. 1, march 2007.

[2] B. Andò, "A smart multisensor approach to assist blind people In specific urban navigation tasks" IEEE Trans. on neural systems and rehabilitation engineering, vol. 16, no. 6, December 2008.

[3] Gaurav Sharma, Sonali Sood, Gurjot Singh Gaba, Nancy Gupta "Image Recognition System using Geometric Matching and Contour Detection" International Journal of Computer Applications (0975 – 8887) vol. 51, no.17, August 2012.

[4] Amit Kumar, Rusha Patra, M. Mahadevappa, J. Mukhopadhyay and A. K. Majumdar, "An embedded system for aiding navigation of visually impaired persons" current science, vol. 104, no. 3, 10 February 2013.

[5] Somnath koley, Ravi Mishra, "Voice operated outdoor navigation system for visually impaired persons", International Journal of Engineering Trends and Technology- vol.3, issue2- 2012.

[6] Thomas Klinger, Image Processing with LabVIEW and IMAQ Vision, Prentice Hall, 2003.

[7] Hyongsuk Kim, Chun-Shin Lin, Jaehong Song, and Heesung Chae, "Distance Measurement Using a Single Camera with a Rotating Mirror" International Journal of Control, Automation, and Systems, vol. 3, no. 4, pp. 542-551, December 2005.

[8] Youngpo Lee, Junhwan Kim, Dahae Chong, and Seokho Yoon, "An Enhanced Distance Measuring Scheme for DS-UWB Radar Systems", The Fourth International Conference on Communication Theory, Reliability, and Quality of Service, CTRQ 2011.

[9] Antonio Torralba, "How many pixels make an image?" visual neuroscience, vol.26, pp.123–131., 2009.

[10] S. Bharathi, A. Ramesh, S. Vivek, J. Vinoth Kumar, "Effective Navigation for Visually Impaired by Wearable Obstacle Avoidance System", International Journal of Power Control Signal and Computation (IJPCSC), vol3. no1. Jan-Mar 2012.

[11] Cong wang and david j. Hill, "deterministic learning and rapid dynamical pattern recognition" IEEE Trans. on neural networks, vol. 18, no. 3, May 2007

[12] Anil k. Jain, robert p.w. Duin, and jianchang mao, "statistical pattern recognition: a review" IEEE Trans. on pattern analysis and machine intelligence, vol. 22, no. 1, January 2000.

[13] T. Kitagawa, T. Uebo, T. Iritani, "Short Range Radar Utilizing Standing Wave of Microwave or Millimeter Wave", Proceedings of the IEEE Intelligent Vehicles Symposium 2001.

[14] Dey S.; Kedia M.; Basu A., "Architectural Optimizations for Text to Speech Synthesis in Embedded Systems," Design Automation Conference, Asia and South Pacific , vol., no., pp.298-303, 23-26 Jan. 2007

[15] Douglas B. Loyd, Anna C. Phalangas, and Kenneth E. Barner, "An Audio- and Speech-Based Interface for Computer-Controlled Scientific Instruments", IEEE Trans. on rehabilitation engineering, vol. 7, no. 2, June 1999

[16] D. Sasirekha, E. Chandra, "text to speech: a simple tutorial" International Journal of Soft Computing and Engineering (IJSCE), vol.-2, issue-1, March 2012.

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