A Study on the Sound-Imaging Algorithm of Obstacle Information for the Visually Impaired

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Abstract: In this paper. we implemented system to detect obstacle in that develop a guidance robot for the visually impaired and inform the result to the visually impaired through sound. We used ultra sonic sensor to detect obstacle. We supposed the algorithm that classifies distance and direction of obstacle using information that acquired from ultra sonic sensor, and embodied device that produce correct warning negative sign according to direction and distance of obstacle. According to the experiment, a reagent could detect obstacle without sight information.

1. Introduction

Despite interest in welfare by the upgrade of living environment and development of technology recently, welfare facilities for the disabled are unprepared level yet.. There is seldom guidance equipment for The visually impaired except Braillewriter type block of report or walk sound of signal lamp. Therefore, it causes many discomforts as the visually impaired do outdoor activity.

Usually, the visually impaired use white cane or receive guidance of guide dog when they do outdoor walk. However, there are many problems. The white canes weak walk guidance equipment. Because white cane can only detect by contact with the obstacle. Guide dog is superior function of obstacle escaping and walk guidance. But, it is not easy to pervade, because there are many problems in training and administration, Therefore, it is much problem in costs.

It is ETA(Electronic Travel Aids) that is to electronically aid the disabled in travel. It uses various sensors such as ultrasonic sensors, process information and guides the visually impaired. Much researches of ETA are being progressed such as ultra sonic glasses, Japan mallet University's 'Pin Display'[3], Michigan University's 'NavBelt'[6] etc.. Research about RTA (Robotic Travel Aids) that use robot for active walk guidance is gone much. There is many RTA systems such as Michigan college's Guide Cain [1], Japan Yamanashi college's Harunobu [2].
In this paper, we implemented system for necessary obstacle perception and guidance to develop guidance robot for the visually impaired. This system was consisted of part that detect obstacle by using ultra sonic sensor array and part that produce the alarm by sound perception.

2. Basic Concepts

It must use sight principal parts such as sense of hearing or feeler, for guidance the visually impaired that cannot see. These senses cannot substitute sight perfectly. but it can acquire information about obstacle using ETA. Figure 1 is concept about the sound Imaging function.

This system achieves function that information of distance and direction of obstacle to the visually impaired using sound after acquire these using ultra sonic sensor arrays. There is applied sound localization algorithm to inform obstacle information by sound. Sound localization studied to make sound such as actuality. Sound localization distinguishes position and distance of sound source using stereo sound. In this system we replaced obstacle to sound source and expressed by stereo sound in reply[3]. There are Inter-aural Time Difference and Inter-aural Level Difference by two cues for sound localization

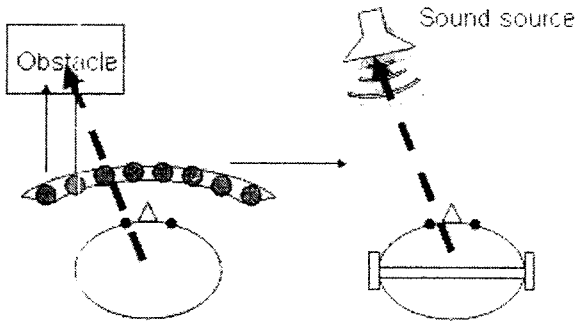


Figure 1. The Concept of Sound Imaging

2.1 Acquisition of obstacle information

In this paper, we used ultra sonic sensor to detect obstacle. Usually, it uses TOF(Time of Flight) method to measure distance with object using ultra sonic sensor.

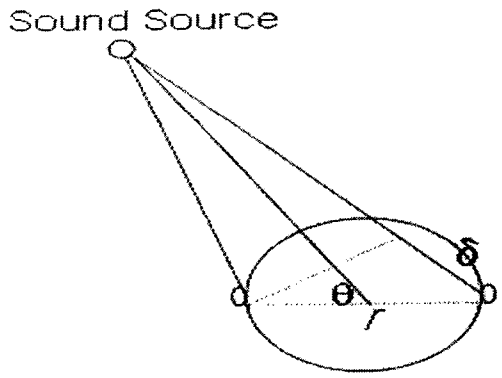


Figure 2 Concept of Inter-aural Time Difference

TOF method calculates distance using transmission of a message and reception's time lag because send a letter ultra sonic using transducer and receive if ultra sonic that is resented is reflected meeting object. (1) Represents distance Z_0 with object when t_0 is time that faction that sound wave is reflected by object being resented signal is received.

$$Z_0 = C\frac{t_0}{2} \qquad (1)$$

C is speed of sound (343m/s).

This system uses eight ultra sonic sensor modules to detect obstacle of 120° front putting angle by 15°.

In case of ultra sonic reflects by right angle, measure of distance is easy, but measure in shape that supersonic dispersion begins with corner is difficult.

2.2 Inter-aural Time Difference(ITD)

Inter-aural Time Difference(ITD) is the one of most important cue at sound localization. Sound wave is passed with about 343m/s speed at normal temperature.

If sound source becomes one-sided, difference of distance between two ears happens and arrival time becomes difference. Therefore, phase difference of sound wave happens.

Figure 2 is ITD Concept. In the case of figure 2, right ear is away with sound source as δ than left ear. Therefore, direction angle θ of sound source can express by distance difference δ and diameter of head r with (2).

$$\theta \approx \sin^{-1}\frac{\delta}{r} \qquad (2)$$

If refer to the speed of sound wave at normal temperature that is C and time lag of status that reach in both ear that is τ, we can present relation with direction θ and time lag τ of status with (3) because is $\delta = \tau/C$.

$$\theta = \sin^{-1}\frac{\tau}{rC} \qquad (3)$$

Usually, ITD is effect in low frequency wide-band less than 1.5 kHz

2.3 Inter-aural Level Difference(ILD)

With ITD, Inter-aural Level Difference(ILD) is important cue of sound localization. ILD is cuing that display distance of sound source as well as direction of sound source.

If distance of sound wave becomes double far from sound source, level decreases 6dB by inverse square rule. If sound that it is level difference between two ears is heard, we can know direction of sound source.

In the case of LF, length of wavelength becomes hard to uses ILD because level difference between two ears does not occur than distance between two ears. ILD can use in frequency more than 1.5kH usually and direction distinction by ILD is easy at more high frequency.

Obstacle warning is sound of high frequency usually, because warning effect is big and used high frequency sound in a practical experiment, ILD could do more effective localization than ITD.

3. System Implementation

3.1 System Organization

Figure 3 is completely schematic diagram of system. Data that sense obstacle using ultra sonic sensor arrays change and displays by audible signal by distance and direction in main processor.

Ultra sonic sensor module that use by obstacle detection is it Devantech SRF04 ultra sonic module of Acroname Inc. This has power supply and trigger input and pulse output fin, in input trigger pulse of TTL level more than 10μ s output that have pulse duration as much as time that is proportional in distance that 40kHz's ultra sonic is radiated and is received is send.

This This system marks left ultra sonic sensor by No.0, and arranged 8 sensor modules by 15° angle to No.7.

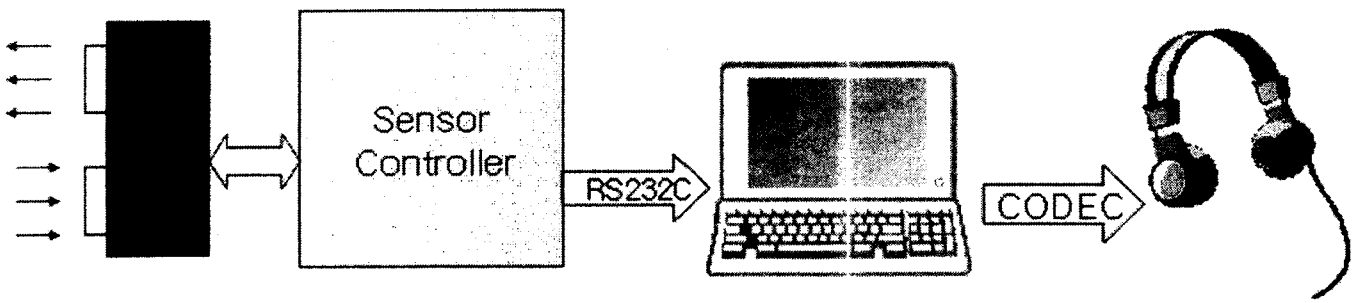


Figure 3. System Diagram

And it used Atmel gratitude 89C51 microcontroller and control sensor.

If do several ultra sonic sensor activate at the same time, extraordinary measure value can appear because receiving in other sensor displaying transmission of a message waveform at the same time. Therefore, do so that may activate one sensor module in 40ms taking into account operating time of sensor module and used method to measure sequentially.

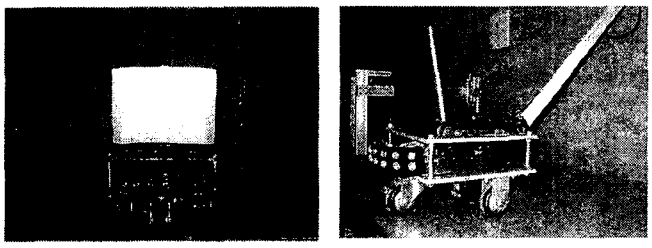
It used RS232C communication interface with 4800baud for distance signal transmission of obstacle that is measured from ultra sonic sensor and system to process transmitted signal made use of notebook PC that thread RAM of 128MHz as Pentium 3 processor 600MHz. Soundcard for output of stereo headphone used SB compatible.

3.2 System Operation

If run system, ultra sonic sensor controller operates and RS232C interface between sensor controller and main system is connected. It needs 320ms' time to get all distance information in eight ultra sonic sensors. Therefore, main system distinguishes position of obstacle using signal of sensor every 320 seconds. Position of obstacle does to specified number of sensor and the distance that acquire shortest distance of measurement distance of each sensor. It recognizes the middle for direction of obstacle that in case sensor more than two that adjoin acquired minimum distances at the same time.

Sensor that this system uses can measure distance to maximum 3m but it is differentiable valid distance 1m this by obstacle actually. It does not display warning sound distinguishing that there is no obstacle when acquire obstacle distance more than 1m. If there is obstacle within 1m, it makes warning sound.

Basis warning sound in 1m used sample rate 21kHz's wave file, in an experiment, it used method to adjust level distance with obstacle is shorted and method to adjust frequency. Method that adjust level made 6 dB decrease in distance of double using inverse square rule according as distance recedes in level of when obstacle approximated maximum. Method that adjust frequency did to increase by 100Hz whenever distance of 1 ㎝ approaches.



(a) Front side (b) left Side

Figure 3. Manufactured system.

4. Experiment and Result

4.1 An obstacle perception experiment that use ultra sonic sensor array

Table 1 shows value that measure after install obstacle in position of each direction 1m front of f right and left 105° . Results of measurements can see that error of right and left 15° can happen maximum error is within ± 2 ㎝. Error increases than this in distance more than 1m and there was change of measure value in suspension situation sometimes. On the contrary, error decreases and did stable measuring in 1m within.

It is within distance 1m that require in this paper. Therefore, error of system does not influence greatly in treatise requirement that see.

Table 1. Measured value in sensor by position of obstacle. Sensor number is clockwise from left. Angle of obstacle left -, right + angle.

	0	1	2	3	4	5	6	7
-52.5	99	100	102	107	0	0	0	0
-37.5	101	100	105	0	0	0	0	0
-22.5	0	100	101	101	0	0	0	0
-7.5	0	0	101	99	0	0	0	0
0	0	0	106	105	102	105	0	0
7.5	0	0	0	103	101	101	103	0
22.5	0	0	0	105	102	101	102	0
37.5	0	0	0	0	0	105	102	102
52.5	0	0	0	0	0	0	102	101

4.2 Obstacle information transmission experiment by sound

As experiment in 4.1, we did to display sound of when is obstacle in position of each direction 1m front of front right and left 105° and catch reagent.

Because wave sound that use in this experiment used warning sound, it was near sound in high frequency. As a result, according to direction, we confirmed that it is more effective that adjust sound level than that adjust sound phase. Actually, reagent could distinguish direction of obstacle regulating sound level without regulating sound phase. When take into account error of sensor and did by obstacle perception success when distinguish direction of obstacle in extent 30° , it showed success ratio average more than passage 90% that experiment to 10 reagents.

By next time, we experimented about change of audible signal when distance of obstacle changes from one direction.

We compared method to do greatly sound pressure distance approaches about audible signal by distance and method to heighten frequency. Reagents responded that methods that heighten frequencies could distinguish more effectively, and frequency rises actually, because

psychological consciousness rises, it is profitable that select method to heighten frequency.

4.3 Traveling Experiment

We manufactured system that reagent can operate directly with figure 4 for this experiment. We require that reagent that hides eye sees using this system, traveled Corridor with obstacle of wastebasket, duplicator, opened door etc. Width of corridor is 3m and distance is 120m.

Reagent did walk with 10cm/s' the speed about and effect of Doppler Effect of ultra sonic sensor by the walk speed did not receive hardly. Reagent could go by boat without being bumped in stumbling block. Therefore, we showed that the visually impaired guidance using this system is available.

Figure 5. Traveling experiment that use this system

5. Conclusion

In this paper, we showed that the visually impaired can detect and avoid obstacle using system that convert from sight information to hearing information at walk. Forward research plans disabled person's life elevation through research that grasp algorithm and own position that can sense several obstacle

In addition, we wish to develop system that achieve more active guidance function applying system that see also to robot.

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