

Development of orientation strategy and guidance tool for visually impaired people

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Abstracts

In this paper a new method and an instrument has been developed to recognize object's location, orientation and size. The basic idea is the application of sense of locality of bats. Applying Doppler effect an image will be developed about the object in question but the people with the lack of power of vision will not be able to see this. The second step of this project is to make the image audible. Applying a special transformation all pixel of an image will be adequate with a respective sound effect.

Keywords

Doppler effect, image process, sense of locality

1. Introduction

Target

My target is to develop a virtual imaging method based on sonic reflection and to create a device which is able to generate images using ultrasonic technology.

Background

In the world of animals some mammals use ultrasonic orientation, however there are some „night vision” techniques used by warriors of certain tribes centuries before the invention of electronics. As well known the bat use ultrasound for exploring its prey and for orientation. Dijkgraaf (1949) Matsuda et. al. (2013) This technique is called „echolocation” which means ultrasonic navigation. Bats' echolocation is discovered by Donald Griffin and Robert Galambos in 1938. Griffin (1958) It seemed to be obvious, that animals, Jones (2005), and even humans can use this method for orientation in darkness. Let's use this technique extended by electronics for virtual imaging!

2. „Echolocation”

Principle of operation

If we compare the technical practice with the echolocation technology, the simplest analogy is the active sonar. The meaning of SONAR is Sound

Navigation And Ranging Operation is the following: Jones (2005) The animal or the location equipment emits a sound impulse which reflects from surfaces and gets back to the emitter. The „emitter” calculates the distance from the elapsed time between emitting and receiving the pulse. The horizontal azimuth is calculated from the loudness and time difference between the signals received by two sensors or ears. The navigation method inspired by animals patented by an English meteorologist, Lewis Richardson in 1913. Hill 1962

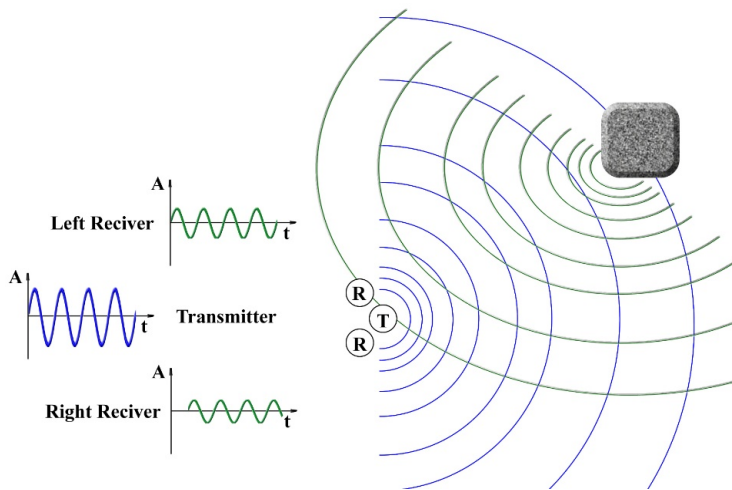


Figure 1. Working principle of „echolocation”

According to Suga et. al. (1975) the emitted sound can be examined from several points of view.

– **Frequency**

- Frequency modulation (FM): during the FM ping the modulated search sound's frequency changes in a wide range.
- The sweeping starts from higher frequencies. Constant frequency (CF): During a CF search the frequency range is narrow; the search sound's frequency can be considered as constant.

- **Intensity** in the world of animals the search sound's intensity varies between 60 and 140dB. The amplitude is reduced in small distances, because the reflected sound's pressure could damage the bat's ear.

- **Pulse time** Bats change the interval of the search sound between 0,2 and 100 ms, depending the distance to be measured. When hunting pings are more frequent, this results in a better image resolution of their environment. Shorter pulses are used measuring smaller distances.

FM sweep

The biggest advantage of wide-range-sweeping ultrasound is the possibility of precision distance measurement. In J.A Simmons'(1975) experiment, bats were

able to detect 0,5 mm difference between two surfaces using FM sweep. The emitted sound sweeps in a wide frequency range which helps them to detect the reflection time more precisely, and has a better cross-correlation. The accuracy can be improved if the search sound has harmonics. The disadvantage of FM method is the limited range of operation. It works with small distances only Suga et. al. (1975).

CF sweep

The biggest advantage of CF is the bigger range, and the capability to measure speed from the Doppler's effect.

As the bat search for moving prey, and the red shifts, and the blue shifts from Doppler's effect help him to sense the target moving direction, Suga et.al. (1975).

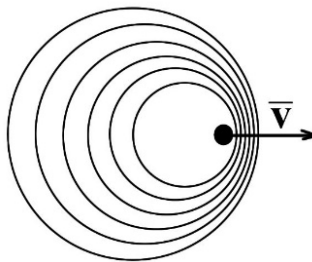


Figure 2. Doppler effect

$$f = \left(\frac{c + v_r}{c + v_s} \right)$$

Where:

f: frequency of the reflected sound

c: speed of sound

v_r : the bat speed relative to the medium

v_s : speed of the reflector (prey) relative to the medium

f_0 : the frequency of the emitted sound

Neurological mechanism in the brain

As the bats find their way with their sound, their ear and the part of their brain which is responsible for hearing are modified specifically. The human basically orientates himself with his vision. The experiences prove that the brain section, which is responsible for hearing – the temporal lobe –, is much more supplied with blood if the human is blind. Also the occipital lobes, which provide the ability to see, is not wither over time, but help to process the information that heard. Burton (2003).

3. Design of instrument working on „echolocation” effect

Initial consideration

During the preparation phase of the device design, the capabilities of the human brain were considered, which are different from species, specialized for this navigation method. Also the ancient „night vision” method was studied, which based on the reflection of the human-made voices.

Criteria which are considered:

- Transportability: Very low weight
- Lifetime of the battery: Little battery with long operation time
- Using of spatial hearing: The basic capability of the human body

Knowing these criteria the distance measurement method was chosen with permanent wavelength.

The working method of the planned device

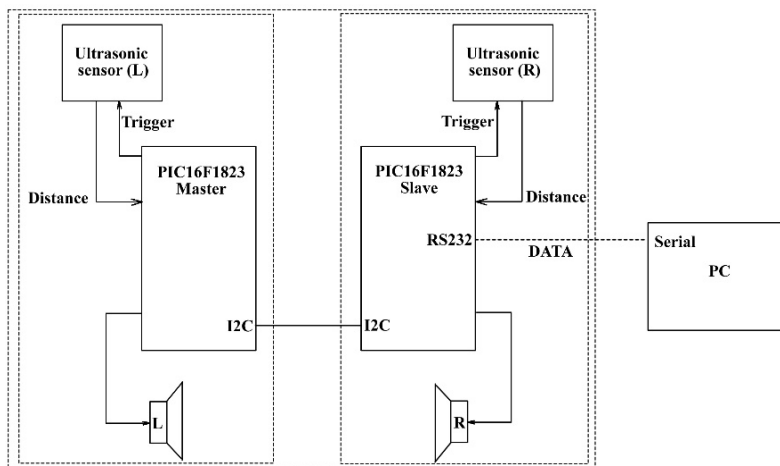


Figure 3. Schematic diagram of the system

Two intelligent ultrasonic distance measurement sensor (which are located 200mm from each other) are instructed by a trigger, after that, there will be a signal impulse on the output of the sensor, which length is proportional with the distance.

The length of the impulse and the knowledge of the sensor’s properties we can determine the distance between the sound source and the object.

With the strength of the sound, which captured with ears, the brain can determine the location and the distance of the object as if the obstacle makes the sound.

The two microcontroller gives the trigger in the same time, that way not just the amplitude of the sound, but also the frequency shifting can be evaluated.

If we compute the distance values – which are appear on the output of the intelligent distance measurement sensors – with a microcontroller, we get a sound that can be heard in the earphone. With that sound, even the human mind can build the 3D „picture” from the virtual area.

Engineering

The circuit was designed by DesignSpark program. The prototype will be produced of DIP parts, which require bigger space, but easier the assembly. If the device will work satisfactorily, the final circuit will be made of SMD parts. That way the constructed device will be much smaller – which is important point of the portability.

The circuit also got a communication channel. By using it, the measured data are available to everybody. To access these data, you will need an RS232 serial data cable, and the MATLAB program. The required programs are written in C and C# languages.

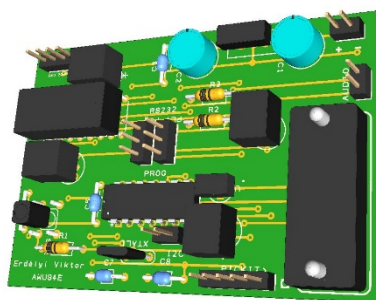


Figure 4. 3D model of the prototype PCB

4. Expected results

This device can help the blinds and the visually impaired people to find their way. It makes the obstacles visible by sound as if those make the sound. The prototype of this research can serve many other projects.

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