Audio Assisted System for Visually Impaired People

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Introduction

The project aims to design and build a non-invasive, bio-inspired system which is based on bat vision that helps visually impaired people to navigate. The system can transmit and receive ultrasound for short range indoor environments, followed by processing to estimate the distance of major obstacles.

Significance

About 284 million people are visually impaired worldwide: 39 million are blind and 245 have low vision [1].

In Australia, tens of thousands of people go blind each year, adding to the half million who are already visually impaired in both eyes [2].

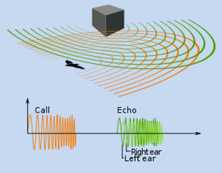
Existing Treatments & Limitations:

- *Walking cane* - cannot detect any obstacle from level of the upper body
- *Guide dog* - people with guide dogs become more dependent on them
- *Medical surgery* - usually invasive, expensive and highly risky

Background

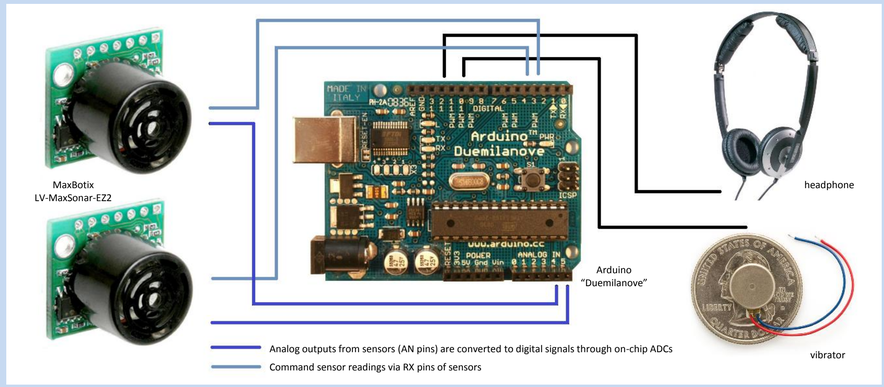
Living in the similar environment of darkness as blind people, the predominant sensing mode for bats is through hearing using echolocation principles. High frequency signals are emitted specifically to produce the echoes. The returned echoed signal would allow the brain and auditory nervous system to produce detailed images of the surroundings by comparing the outgoing pulse.

From consecutive echoes, the time interval between each pulse will determine the frequency at which information are updated and the maximum detectable range [3].



the ultrasound signals emitted by a bat, and the echo from a nearby object [4]

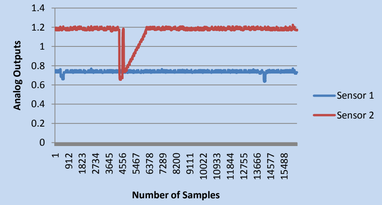
System Overview



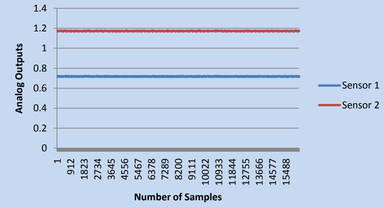
- Ultrasounds are emitted by ultrasonic rangefinders to produce echoes
- Returned waveforms are analysed and output as analog signals
- Analog signals are digitised through on-chip analog-to-digital converters
- Digital signals are analysed through microcontroller to determine direction & distance of the object
- The ranging information is represented by duration of beeps through the headphone, as well as intensity of vibration through vibrators

Testing & Verification (1/2)

In order to make multiple sensors function properly, a 1K resistor is added between the second sensor's TX pin back to the RX pin of the first sensor. The RX pin of the first sensor is pulled high for at least 20uS and then the microcontroller will have to return its pin to a high impedance state so that the next time around the TX output from the second sensor will make its way to the RX pin of the first sensor. As a result, all of the sensors in the chain will run in sequence and this "ring of sensors" will cycle around and around, constantly maintaining the validity of their analog values.



Without suitable chaining methods, outputs are not very stable and some unexpected fluctuations are presented



With Daisy chaining of constant looping, outputs are much stable

Testing & Verification (2/2)

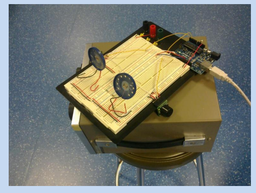
Due to the linear relationship between distance and sensor output, we can calculate the scaling factor to convert readings from serial monitor to corresponding distances (taking output levels of both rangefinders and the Arduino board into account).

- A supply of 5V yields 9.8mV/inch
- A 10-bit ADC maps input voltages between 0 and 5 volts into integer values between 0 and 1023
- 1 inch is about 2.54 centimeters

$$\text{s.f.} = \frac{5V}{1024} \times \frac{1}{9.8mV} \times 2.54 = 1.266$$

Actual Distance (cm)	Monitor Reading (V)	Converted Distance (cm)
25	17	21.560
50	35	44.389
75	55	69.754
100	75	95.120
125	95	120.485
150	115	145.850
175	135	171.216
200	153	194.044
225	173	219.410
250	193	244.775
275	213	270.140

Prototype



The system set up in the lab is able to detect near objects, calculate distance from them, and generate beeps of different duration to warn the user.

Outcomes

The total system is made reliable and portable by integrating to laboratory glasses. The user can perform a rough room mapping by beeps from left/right channel of the headphone, as well as vibrations from vibrators at different positions.

References

[1] "Visual Impairment and Blindness", viewed on May 29th, 2011 from <http://www.who.int/mediacentre/factsheets/fs282/en/index.html>
[2] Al-Sarawi, S. & Rainsford, T. "Audio Assisted Vision System for Visually Impair People – Bat Vision", viewed on Oct 26th, 2010
[3] Jones, G. (2005). "Echolocation", *Current Biology* **15** (13): 484–488
[4] "Animal Echolocation", viewed on May 22nd, 2011 from <http://en.wikipedia.org/wiki/Animal_echolocation#cite_ref-4 >