CANADA WIDE SCIENCE FAIR

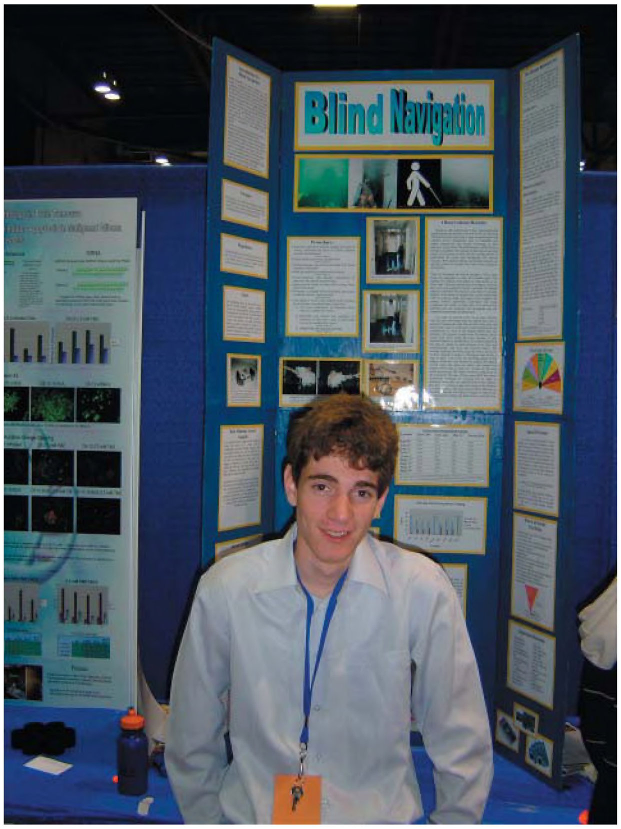
From File Reports

Steven Gasior is the winner of this year's Special Award from the Canadian Acoustics Association for his project - Blind Navigation.

Steven Gasior, 16 yrs old, is now attending St. Joseph Secondary School in Mississauga Ontario as a grade 11 student. He has competed in science fairs every year beginning in Grade 7 and has received medals or special awards for every project submitted. In addition to the Canadian Acoustical Association Award for his work on Blind Navigatio, Gasior also won the S.M Blair Family Foundation Award, and lastly a Bronze Medal in the engineering division at CWSF.

In his spare time, Steven enjoys building and designing new and innovative creations that mainly make science fiction a reality. His creations range from a robotic submarine to new flying vehicles. He designs robots and writes various computers programs that mainly pertain to the robotics club. He enjoys converging multiple devices together and making all-in-one devices. He has a strong fascination with aviation and power sports (ATV, Dirt Bike, sea-doo) and hopes to get his recreational aircraft license by the time he is 20. In his spare time, Steven enjoys making movies and creating his own dance tracks by combining old lyrics and modern beats.

Steven is an active member in the robotics club and is working towards completing his qualification to become a lifeguard along with being a swimming instructor.



Steven Gasior's full article is reproduced below.

BLIND NAVIGATION*

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Editor's Note: The submission by Steven Gasior was reformatted and edited to fit in to the Journal format.

INTRODUCTION

Blind navigation is a project dedicated to assist people or professions that are faced with vision impairment. Blind navigation will help people who are physically blind or visually impaired due to aging or disease by providing information of what exists in the space around them, allowing them greater freedom and mobility. Firefighters in dense smoke filled buildings and divers in muddy waters face similar difficulties in navigating their surroundings due to having their vision impaired by environmental factors. This could save lives in rescue situations where locating or navigating an area without vision is critical.

Humans use their hearing to pinpoint the source or location of sounds by analyzing time delays, amplitude and frequency variations. Each ear detects a different sound intensity and frequency, which ultimately leads to the location of the source of sound. Blind navigation uses this ability and interfaces it with wearable proximity sensors. Using audible frequencies based on the location of stationary objects, tones are created by using the same principal of sound directional comprehension. Thus people with vision impairment can quickly, accurately and safely navigate their surroundings.

URNS

URNS stand for ultrasonic range navigation system. It was designed to assist those individuals who have impaired vision or work in environments that make navigation, by means of sight, difficult (firefighter, diver). The URNS invention is an engineering feat primarily because it converges natural brain operative habits with proximity sensors that take advantage of natural brain phenomenon. As mentioned before humans have the capability to pinpoint location/origin of sound based on the difference of frequency and time delays. Because sound is a wave, the wavelength gets greater as distance increases and there is a brief sound delay as the sound hits the right ear before the left and vice versa. Human brains take advantage of this difference to identify the speaker's location. URNS takes this phenomenon to the next level. Using proximity sensors, a 180 degree array is formed around ones head. Based on the location of stationary objects the sensors can pinpoint that location in relation to the other sensors. Then based on the location of the object the computer program plays a tone supposedly generated from that exact location. These tones provide a sense of the environment. The program could also be written to play sounds depending on the context. This is common in the programming, as tones are played based on comparisons between all 10 sensors. Basically URNS is similar to the surround sound system that many entrainment systems have. The sounds are infinitely changing based on the environment one is in but still provides a general location much like the same as a television.

URNS is still in development. The programming language used is Pbasic, which is a weak language and hence all the sensors need to be pulsed sequentially rather than simultaneously resulting in a sampling rate of 2 seconds rather than 200 milliseconds. Also the size of URNS is rather big, however it has much potential to be sized down to fit in a normal pair of glasses. Because of limitations to URNS only frequency can be regulated and amplitude cannot. With modifications to URNS internal circuitry it is hoped to be able to change the amplitude and frequency as well as play many frequencies at one time much like a symphony. Only difference is the symphony changes as you walk and rarely plays together. A prototype of URNS is shown in Figure 1.

Figure 1. URNS for Blind Navigation

GOALS

The engineering goals of the project are to provide visually impaired persons a portable, easy to use, and inexpensive device to assist in navigating their surroundings, using URNS technology. The device should be able to extrapolate data from an array of sensors and provide non-visual information about an objects location.

INSTRUMENTATION

A list of materilas required to produce the necessary device is shown in Table 1 below.

-Breadboard x2
-Ping ultrasonic sensors x10
-Stereo headphones and female headphone jack
-Bs2e microprocessor
-Switch x2
-LED x2
-5v regulator and 9v battery x2
-10uf capacitors x4
-8Ω resistor x2
-Stamp holder
-Data cable
-5mm acrylic sheet
-Plastic glasses
-3mm foam
-Battery holder x2
-Electric solder and Hot glue
-Adhesive spray and Crazy glue
-20pieces of 4x28 screws
-μMp3 module

Table 1. Required Materials

EXPERIMENT

The experimental process is briefly described below in point format.

- Research methods of distance ranging and types of sensors. Determine the needs of visually impaired people and professions
- Develop computer model and use of criteria such as priority, distance calculation, velocity calculation, sampling rate and audible output.
- Sensor array and main electronic components were bread boarded.
- Sensor location was tested for optimal functionality, ease of use and cosmetic appeal. Positions include foot, waist, torso, head, arms or hand.
- Computer program was tested and confirm functionality of all components.
- Main prototype was constructed and all electronics were mounted to frame
- Master program was written and tested with components mounted on the prototype frame. Sensor functionality was tested by placing objects in front of sensors and determining how the output/tone changes.
- Once prototype bench testing is complete experimentation with humans commenced to determine the optimal programming and interface that is most understandable, accurate in terms of spatial perception, and easy to use. A person is seated while objects are placed around them and told where there are located in order for the person to become familiar with its use. The person while seated is then blindfolded and asked to identify where objects were placed to determine the accuracy of the prototype.
- The subject wore the prototype and had to determine moving objects in front of sensors. Human subjects then identified the motion of the object to determine

understanding of object movement and describe their surroundings.

- In this experiment the subject would be timed while walking a controlled course under a number of conditions given below:
  - No visual impairment to determine ideal times to complete the course.
  - Blindfolded and without the prototype to determine if other cues could be used to complete the course. If the subject strayed too far from the laid out course the test would be stopped. Subject is asked to continually describe their location in the laid out course.
  - Blindfolded and using a cane. If the subject strayed too far from the laid out course the test would be stopped. Subject is asked to continually describe their location in the laid out course.
  - Blindfolded and using the prototype. If the subject strayed too far from the laid out course the test would be stopped. Subject is asked to continually describe their location in the laid out course.

RESULTS

The experimental results show that using frequencies between 350-700 Hz for no less than 200 millisecond works best in data comprehension and comport. Lower frequencies may be inaudible and higher frequencies can become annoying.

A trend in the way humans perceive tones was observed. A tone sequence of less than 200 milliseconds is difficult for a human to interpret. The amount a data sent at one time needs to be limited to allow for the average person to understand the tones and extrapolate the objects location. However many of these factors can be compensated for in the master program to allow for optimal understanding on the subjects behalf. With greater training and practice with the system people can interpret the tones more accurately and quickly.

Due to limitations of the speed of the microprocessor and the type of sensor, the sample rate is two seconds to scan a 180 degree array. Thus a slow walk of roughly 2 feet per second is the fastest speed of travel with full scanning. It is anticipated a faster processor could conduct a greater number of calculations as to velocity change and direction of motion to alert the subject of impending collisions even while the subject is running. Greater memory storage would allow storing the location of all objects scanned and predicting collisions based on the direction of travel.

Table 2 presents the data that illustrates time taken by four subjects to navigate a 118 ft course using the apparatus, a cane, and normal sight. The sighted test subjects were asked to walk slowly at no faster than 2 feet per second since the subject could run the course and complete it within 5 seconds. At 2 feet per second it would take 59 seconds to complete the course. All sighted subjects completed the course in less than 59 seconds. Subjects were asked to navigate the course blindfolded with no external aides, but none completed the course without significant redirection and none completed the course on their own.

The chart shows how the apparatus compares to a cane, or sight. The sight test resulted in the lowest time. All tests with the cane took longer than the sighted trail. This is primarily because the data flow is slow since only one sensor (the cane) is used and it must traverse the arc continuously in front of the subject. All subjects would have hit objects above shoulder level using the cane because it only identifies objects at ground level unlike the apparatus, which senses objects at eye level. All subjects described the cane as easiest to learn, this is primarily because of its slow and understandable data flow that allows for ease. The URNS (Ultrasonic Ranging Navigation System) uses a more complicated means of interpretation but can scan 180 degrees at one time and contains an upward ranging detector to locate objects at eye level. Due to the complexity of five tones for left and right ear amateur subjects initially find it more difficult to interpret but there is much room for improvement as the subject uses and relies on the apparatus more and more to navigate. The average sampling rate using the cane is about two to three seconds to make a 180-degree scan before a step is taken. This limits the traveling speed of the subject. Where no objects were located by the cane the subject moved faster but when more than object was located the subject often took at least two sweeps of the cane before walking. However the URNS has the capability to sample at 200ms or 20 times faster than a cane leaving much room for improvement.

Subject	Time to navigate with sight.	Navigate blindfolded using cane	Navigate blindfolded using apparatus 1st time	Navigate blindfolded using apparatus 5th trial
Subject 1	17 sec	102 sec	150 sec	86 sec
Subject 2	24 sec	107 sec – subject strayed off course and was redirected	187 sec	130 sec
Subject 3	33 sec	119 sec	243 sec	98 sec
Subject 4	29 sec	148 sec	322 sec	156 sec

Table 2. Effect of Blind Navigation

However the prototype unit completes the 180-degree scan in 2 seconds due to chipset limitations and sensor type. The URNS program sets a priority that a tone is emitted if an object is less than one metre from the subject. This allows the subject to walk quickly when hearing no tones, since the subject knows that no objects are in their path.

CONCLUSIONS

The current investigation showed that it is possible to use an array of sensors to assist visually impaired persons navigate their surroundings. However training and practice in use of the device is necessary to obtain maximum benefit. As well, the speed at which most humans can comprehend information and the maximum frequency at which people find comfortable can be incorporated to assist the visually impaired navigate.

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Pictures

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Picture of mp3 player- <http://www.roguerobotics.com/store/images/roguerobotics/UMP3.jpg>

Picture of Ping)) sensors - <http://www.parallax.com/images/prod_jpg/28015-5pack.jpg>

Picture of blind individual- <http://www.deafvision.net/mdba/whtcne.jpg>

Picture of firefighter- <http://www.southboroughfire.org/70_Newton_2-5-05_07.jpg>

Picture of diver- <http://www.triton-ast.co.yu/EKSPEDICIJE/MLAVA/z11.JPG>

Picture of fog pathway- <http://digicam.co.za/gallery/details.php?image_id=2744>