Summer 2010

Grocery Shopping Assistant for the Visually Impaired(Grozi)

TEAMS IN ENGINEERING SERVICE

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Client: National Federation of the Blind

Summer 2010

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Introduction

There are currently 1.3 million legally blind people living in the United States who face daily obstacles with routine tasks. These individuals cannot shop independently for grocery store items without sighted assistance.

Developing assistive technologies and handheld devices allows for the possibility of increasing independence for the blind and visually impaired. Currently, many grocery stores treat those that are blind as “high cost” customers, and dramatically undersell to this market, neglecting to take their needs into consideration. The use of computer vision can be advantageous in helping these blind customers, as restrictions such as the limited ability of guide dogs of white canes, frequently changing store layouts, and existing resources do not allow for a completely independent shopping experience. Using technologies such as object recognition, sign reading, and text-to-speech notification can allow for a greater autonomous solution to the relevant problem.

In conjunction with Calit2, UCSD’s Computer Vision Lab and TIES, the GroZi project is working to develop a portable handheld device that can help the blind to collect information and navigate more efficiently within difficult environments as well as better locate objects and locations of interest. GroZi’s primary research is focused on the development of a navigational feedback device that combines a mobile visual object recognition system with haptic feedback. Although still in its early stages of development, when complete, the GroZi system will allow a shopper to navigate the supermarket, find a specific aisle, read aisle labels, and use the handheld grocery assistant device to then scan the aisle for objects that look like products on the shopper’s list (compiled online and downloaded onto the handheld device prior to going into the store).

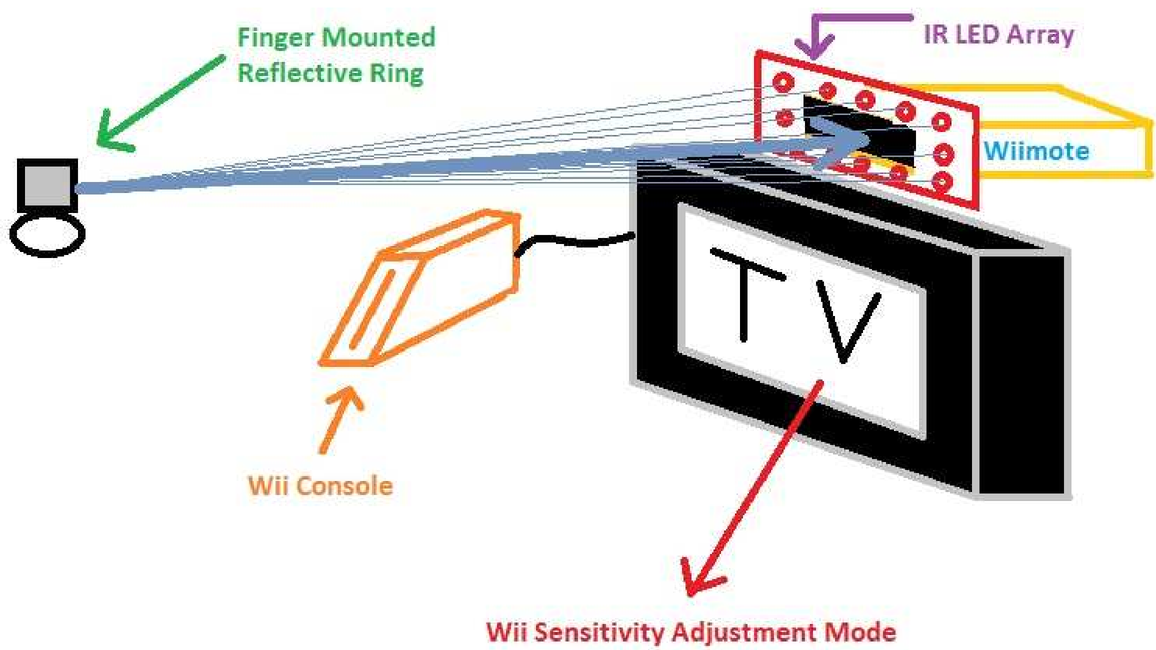
The goal of GroZi for this summer is to study and prove the concept of finger motion tracking by conducting a simulation using a Wiimote. In order to accomplish the goal, the following four significant features of this simulation must be comprehended: finger mounted reflective ring, Wiimote as an IR signal receiver, IR LED array, and Wii sensitivity adjustment mode.

General Description of the Project

As mentioned in the previous page, we will use Wii and Wiimote for the project. Wii is a common household game console that everyone can play easily, and it is based on Bluetooth technology that has many applications of finger motion sensor. Because of the reasons, we decided to choose Wii, instead of other game consoles, for this simulation.

For conducting the simulation, we need to break it down to four important steps. First step is to build a finger mounted reflective device, and the second is to understand that the wiimote is used as an IR signal receiver. Third step is building an actual IR LED array, and the last step is to run the final test on Wii sensitivity adjustment screen.

The general diagram of the simulation is shown below:



As the diagram is shown above, the Wii console is connected to the television, and the TV screen is showing the Wii sensitivity adjustment mode. IR LED array and the Wiimote are placed on top of the TV, and IR LEDs is shining at the reflective ring that is approximately 4.5 – 5 feet away from the TV screen. The reflective ring is reflecting the incoming IR lights back into the Wiimote, which receives the signal. Once the Wiimote reads the signal that is reflected back from the ring, the TV screen shows a dot on the Wii sensitivity adjustment screen. The dot will move accordingly as a finger (the reflective ring) moves.

Details of Project Tasks

*Finger Mounted Reflective Ring

This is one of the most important features in the simulation. It is the finger mounted device that reflects the incoming signal back into Wiimote, so this enables the dot that appears on the sensitivity adjustment screen to move. The reflective ring is made with acrylic, Velcro, and reflective tape.

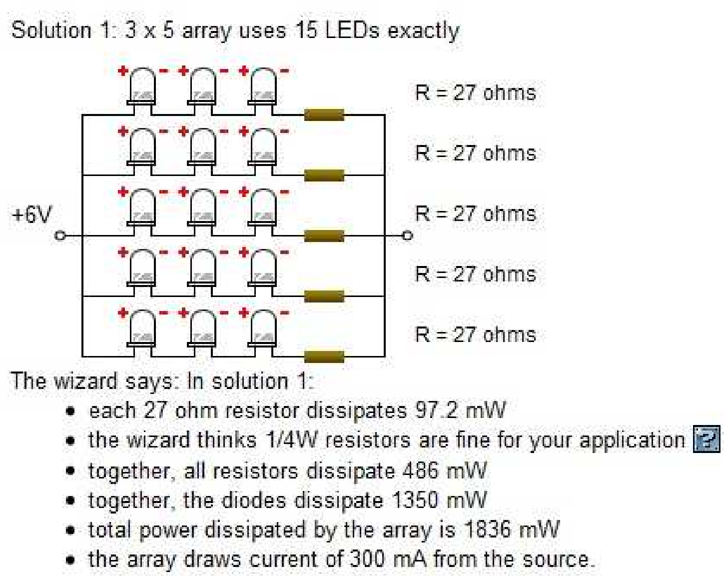
The picture of the ring is shown below:

As the image of the ring shown above, the ring consists of two big parts: acrylic piece with the reflective tape and the Velcro ring. The acrylic piece is cut out using LaserCAMM (which is available at MAE 3 Design Studio), and its dimension is 1x1 inch. The Velcro ring is simply wrapped around in a size of an index finger; the size of the ring can easily be adjusted.

On behalf of the reflective ring analysis, the maximum distance of the reflective tape is calculated based on the information that is given from the back cover of the reflective tape. This particular reflective tape has 600 candelas, 1lux, and 45 degree angle of reflection range. By using combined formula (steradians formula: $sr = 2\pi \times (1 - \cos(\theta/2))$, $1\ cd = 1\ lm/sr$, $1\ lux = 1\ lm/m^2$, $Area = 2\pi \times distance^2$), the maximum distance of the reflective ring is calculated to be 6.75 meters, which converts to approximately 22 feet. Since the reflective ring is going to be located 4.5 – 5 feet away from the television screen, the distance is more than enough for the simulation.

*IR LED Array Analysis

Before building an actual IR LED array, it is important to come up with a layout of the array and calculate the resistor values that can make LEDs the brightest without burning them. In order to have a general design of LEDs, LED calculators that are available online can be used (This is one of many LED calculators - http://led.linear1.org/led.wiz). As long as the required information is given, it shows the possible layouts for the number of LEDs and calculates the desired resistor values and power dissipation on each LEDs and resistors. For this particular simulation, we need 15 IR LEDs, 6V – voltage source, 1.5V forward voltage for LEDs, and 60mA forward current for LEDs. Based on the information, the IR LED array's layout is shown below:



According to the LED calculator, it is recommended to use 3x5 LEDs and 27Ω-resistor for each row to make this IR LED work. For testing this, it is necessary to implement the same layout on a breadboard to see if this really works. As we tested on a breadboard, we realized that the 37Ω-resistor is more suitable for this layout **(Note: when using the 37Ω – resistor, be sure to use 1/4W resistors)**. When we used 27Ω resistors, a couple LEDs were burned. Since the resistor value has changed, the power dissipation is also changed; the 37Ω-resistor dissipates approximately 133.2 mW. As a result, the total power dissipation of the array is 2016 mW.

*Battery Analysis

It is also important to know how long a battery can last for the IR LED array if this system were to be implemented in a smaller scale in the future. It is very inconvenient to replace batteries frequently since they only last for a couple hours. In order to get rid of this hassle, batteries must be able to last for a long period of time, and at the same time, they must be easily purchased at a local store (e.g. for some batteries, a person needs to make a special order).

One of the ways that we came up for the long-lasting battery is to have four 1.5V batteries in series, which makes 6V total. 1.5V batteries have approximately 2400mAh capacity, and our IR LED array draws 300mA. Since there are four 1.5 batteries in series, we simply multiply 2400mAh by 4, and it comes out to 9600mAh. For calculating the battery life, we divide 9600mAh by 300mAh, and the battery life for this particular case is 32 hours.

32 hours are not bad at all. If we make an assumption that it takes about two hours for grocery shopping and a person goes to grocery shopping as frequent as twice a week, we are only spending 4 hours per week. If we divide 32 by 4, the battery life is 8 weeks (2 months). Plus, 1.5V batteries can be found at any local store. Since all these calculated values meet our requirements, we choose to use 6V (four 1.5V batteries in series) as the voltage source of our IR LED array.

*Building an IR LED Array

Based on all the researches that we did above, now we need to build an actual IR LED array. For materials, we need to have a battery holder with a switch (available at a local RadioShack store), a circuit board, five 37-ohm resistors, wires, 15 IR LEDs, and a soldering kit. Once we have all these materials, we can start building an IR LED array.

First of all, we solder everything on a circuit board just like the LED array layout that is shown in the previous page. When soldering is done, insert four 1.5V batteries into the battery holder and turn the switch on to see if LEDs light up. Once the LEDs light up, we move onto the next step of making an IR LED holder. If the LEDs do not light up, check the circuit board and troubleshoot the problem.
(Note: IR light is theoretically invisible because it is out of our visible wavelength range. However, there are two types of IR LEDs are available at a store or online. One is with

the wavelength 850 nm and the other with the wavelength 940 nm or above. 850 nm IR LED is visible; red glow can be seen. On the other hand, 940 nm or above IR LED is completely invisible to our eyes. For this particular simulation, we choose 850 nm IR LEDs to easily notice whether the LEDs light up. The specification sheet of the IR LEDs is shown below.)

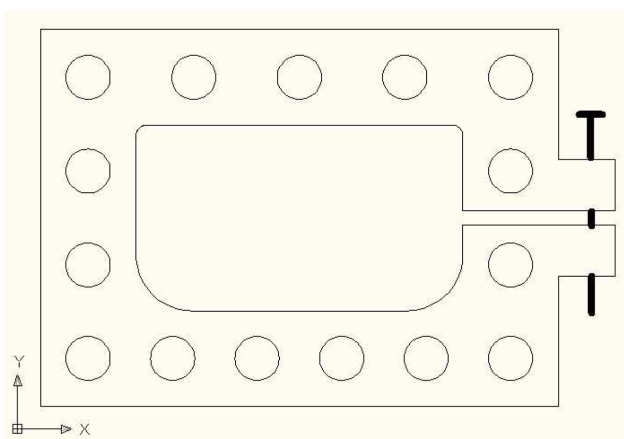
Key Features of the 5mm 90mWW IR LED

* Hight Power Output
* Excellence for night vision light source
* Affordable

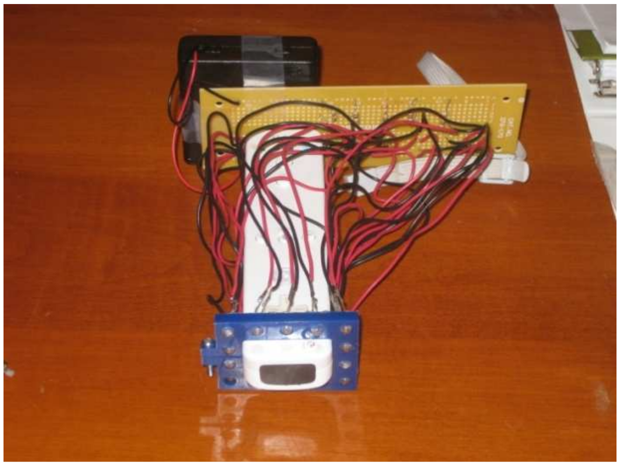
Specification

* Wavelength : 850nm
* Vf: 1.4~1.5V
* Vr: 5V
* If: 60mA
* Ipusle: 120mA
* Power Dissipation:90mW
* Tjun: 125'C
* Tsol: 5second @ 260'C
* Angle: 30'

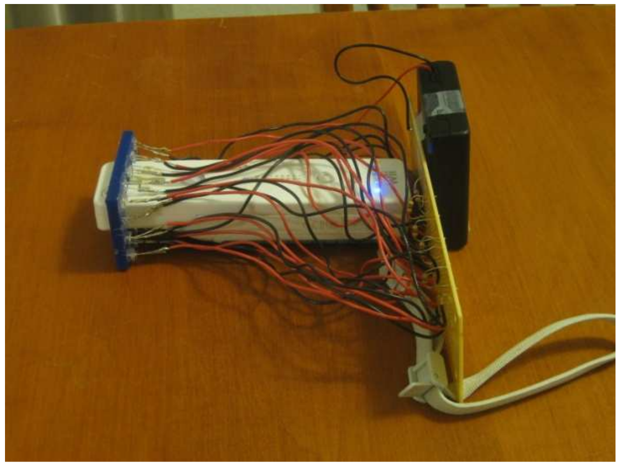
Second of all, we need to construct an IR LED holder since it keeps the LEDs in place, and the LEDs should surround the Wiimote. By using AutoCAD, we designed the LED holder that is square-shaped and has 15 holes for the LEDs. The schematic is shown below.



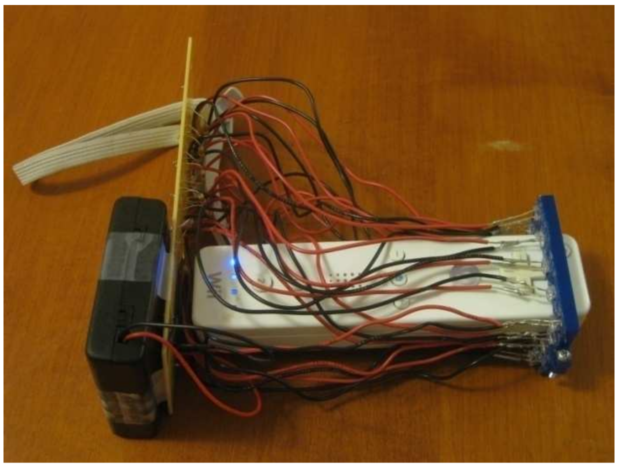
For the inner rectangle, we curved the edges so that the Wiimote can fit in much more smoothly. Once the Wiimote is inserted in the curved rectangle, the bolt can be tightened to hold the Wiimote more firmly. When building an IR LED array is completed, it should look like the pictures as following.



Top and Front View



Left Side View



Top and Right Side View

Front View (When lights on)

Since the IR LED array is built, we can use this as the light source for the simulation that we are trying to conduct.

*Testing on Wii Sensitivity Mode and Observation

Now that we have all components (Finger Mounted Reflective Device, Wiimote, and IR LED Array) available, we can run the test on Wii sensitivity adjustment mode to see if the concept of finger motion tracking actually works. For the set up, we connect the Wii console to the television and have the sensitivity adjustment show up on the TV screen. After that, we place the IR LED array and Wiimote on the top of the television, and the finger mounted reflective device (a person) is 4.5 – 5 feet away from the television screen. As the IR LED array shines at the reflective ring (a person), the ring reflects the incoming IR LED signals right back into the Wiimote, and the Wiimote receives and reads the signals. In result, the dot appears on the television screen, and it moves correspondingly as a finger moves (the ring).

The Wii sensitivity adjustment screen is shown below:

Wii sensitivity adjustment mode is usually used for testing the Wiimote's signal strength, but for this particular simulation, it is used for running the final test of the project.

As we ran the test, we were able to make a few notable observations. The dot's movement was rather choppy and discontinuous. In order to fix the problem, we ran the test once more with hand mirror instead of the reflective ring. In the test, the dot showed much more clearly and the movement was much more smooth and continuous. However, when we tried to move our fingers a little farther, the dot disappeared from the television screen.

Comments on the Test

After running the test, it is certain that the concept is proven. Minor adjustments, however, must be made for the continuation of the project in the future. From the final test, we certainly realized that the IR LED emission was not strong enough to demonstrate the dot much more clearly. In addition, the LEDs' emitting angle was not wide enough to cover full hand motion. On behalf of finding solutions to fix the problems, the idea of replacing to hand mirror was brought up. The test showed that the hand mirror reflected the signal better than the reflective ring, and the dot's movement was much smoother and more continuous. The problem, however, is that the area coverage of the IR LED signals was even smaller than the reflective ring. Since mirror reflects the light/signal only at the angle it came in, it is easy to lose the incoming light/signal when a person moves his or her finger a little farther. On the other hand, the reflective tape has a rough surface area that causes the ridges, which enables to scatter the incoming light/signal in all directions. In conclusion, it is better to preserve the idea of wearing the reflective ring.

Then how do we fix the problems? There are easy solutions that can make the simulation work much better. Because we know that the IR LED signal is not strong enough, we can just increase the number of LEDs. We are currently using 15 IR LEDs. Instead of 15 LEDs, we can use 25 – 50 IR LEDs to strengthen the signals. Next, we can simply purchase IR LEDs that have wider angle range of emission, approximately 50 – 60 degree. In that way, it will increase the area coverage of the IR LED signals. Lastly, we can make the IR LED in a curved manner. As pictures shown on page 9, the LED array is flat and rectangular. We instead make the LEDs in a curvature so that LEDs point outwards, which results in more area coverage.

Once all these changes are made, we need to figure out how we will implement this system in a smaller scale. That will be the future GroZi Wiimote team's project in the Fall 2010.

References

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