Research Report for

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Design and Test of an Assistive Haptic Glove for Blind People

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Motivation

Blind people use canes when they walk on the street. The canes tell if there are obstacles in front of the user through the direct contact. However, it cannot be used when blind people search around in smaller scale such as reaching out to grab household items on the table. In addition, in this type of search for small items, the contact-based sensing is not suitable because the items may be damaged or fall due to the direct contact. Therefore a hand-size wearable device which detects objects without physical contact and transfers the information to the user will be very useful for blind people. This device will not only provide the convenience in daily life to blind people, but also increase their safety.

Goal

The goal of this project is to develop a haptic device wearable to a hand, which has vibration actuators and Infrared (IR) sensors. The device will let the user know if there is an object in front of the hand using the sensor and actuator. Through the Arduino programming, it will process the signals of the IR sensors and return it to the vibrating motors. The actuator will generate vibration when the distance is getting closer between an object and the sensor so that the user can feel the existence and position of the object.

Project Design

For hardware development, we used a small vibration motor as an actuator and an an IR sensor as a distance detector. We investigated a couple of candidates for the sensor and firstly chose a sonar sensor. However we changed it to an IR sensor, because it was cost-effective and its accuracy was enough for this project. We built a circuit for operating the motor and the IR sensor. After that, we soldered the circuit as small as we could to put it on a glove. In addition, for software development, we used an Arduino microprocessor which is Pro Micro – 3.3V/8MHz to handle the sensor signals and control the actuator. I also programed the Arduino board to make the device function such that the vibration motor is actuated when the IR sensor detects obstacles.

The sensor measures the distance to the obstacle at every 0.845 second and the microprocessor computes the difference between the consecutive measurements (first distance – second distance). When the difference is positive, it means that the user's hand is getting closer to the object and the vibration motor is actuated. Finally, we performed evaluation to test feasibility of the proposed system. In the test, we checked the detection success rates under several conditions. Through this test, we found the reliability, the accuracy and the limitation of the device. To mitigate the drawback, the improvement will also be proposed as future work.

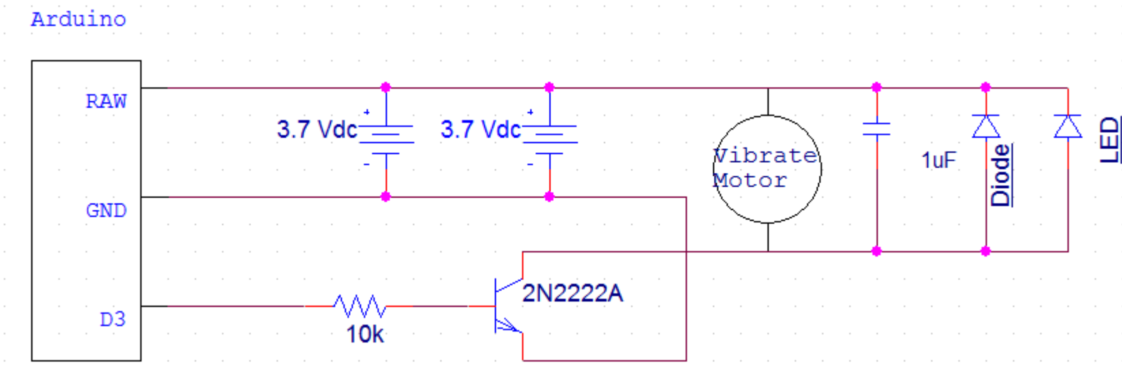

Fig. 1 Circuit diagram

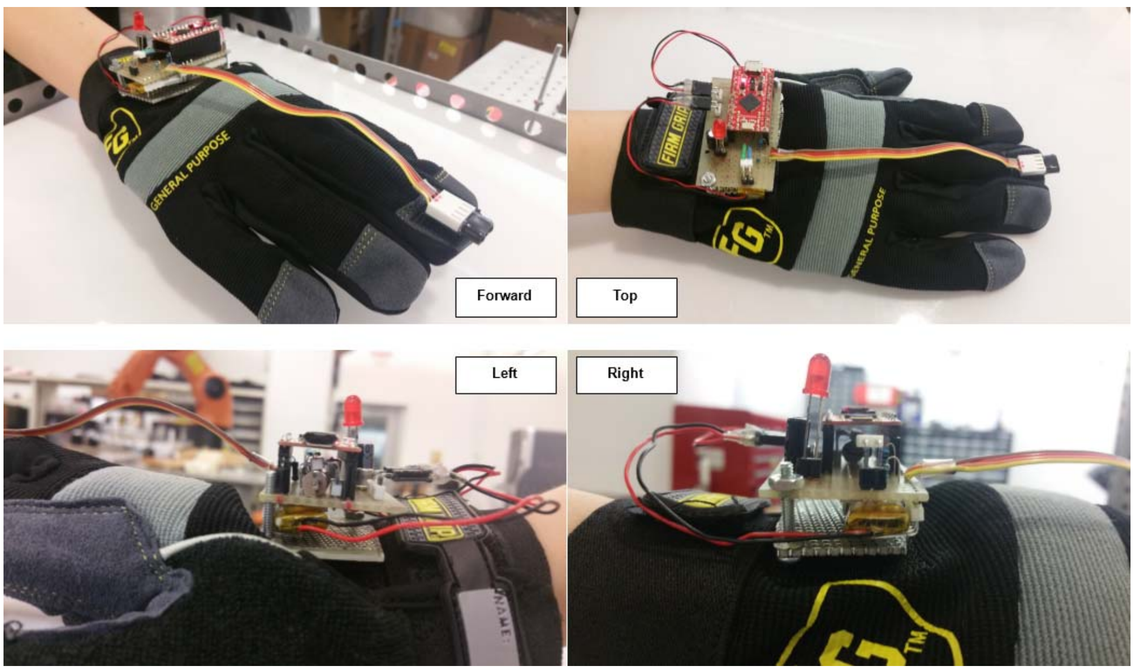

Fig. 2 Prototype of the proposed system

	Area (Blue)				
	237.16㎠	59.29㎠	14.82㎠	3.71㎠	N/A
Detect Rate	30/30	30/30	30/30	21/30	
	Material				
	Paper	Glass	Acrylic	Steel	N/A
Detect Rate	30/30	24/30	26/30	30/30	
	Color (59.29㎠)				
	Blue	Red	Yellow	Black	White
Detect Rate	30/30	30/30	30/30	30/30	30/30
	Average Speed (m/s)				
	0.278902	0.629381	0.733196	N/A	N/A
Detect Rate	30/30	30/30	22/30		

Table 1 Test results

Final Result

We completed a prototype of circuits. Fig. 1 shows the circuit diagram that we designed for operating the system actuator. Fig. 2 shows the soldered circuit attached on a glove with an IR sensor. Under the soldered circuit, we made a battery box which can contain two 3.7V LiPo batteries.

Table 1 shows the result of the experiment with the haptic glove. We performed four experiments under various conditions. The tests were designed to reveal the effect of size, material, color of the obstacle, and the speed of the glove motion.

In the first experiment with varied area of the object, the result shows that the detection rate is 100% with the obstacle size 14.82 cm^2 or bigger. The second experiment reveals that the detection rate for transparent objects is lower than opaque material. Nevertheless, the minimum success rate is 80% for glass. The third experiment shows that the color does not ruin the detect rate. The last condition was the speed of the glove approaching to the object. As the average speed is going faster, the detection rate is getting lower. Through these four experiments, we confirmed the capability and limit of the assistive haptic glove.

Future Works

The proposed haptic glove can make blind people's life much more convenient. For the actual use, the haptic glove should be improved. First, the system should be able to detect the absolute distance of obstacles to give more information for client. Second, we will improve the detect speed. Beyond the object searching, various applications are expected including path planning in the indoor environment. Also, using the haptic glove can be connected to the virtual reality to provide the environment where the user can touch and feel virtual objects.