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B.E.E.R.-Bot

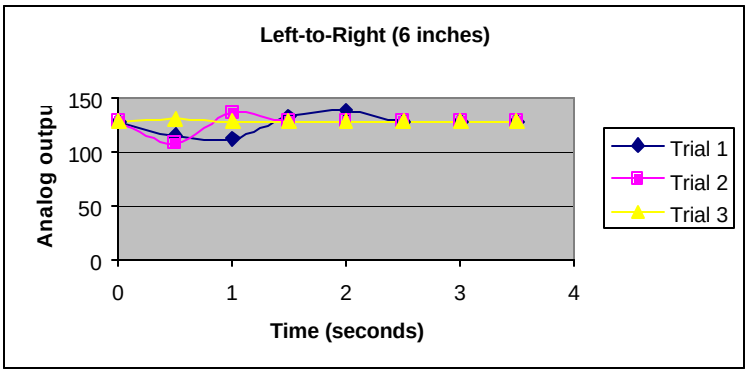
Beverage Equipped Entertainment Robot

Special Sensor Report

Pyroelectric Sensor Package

B.E.E.R.-Bot incorporates an Eltec 442-3 dual-element lithium tantalite pyroelectric sensor. The lithium tantalite crystal is doped with an electrode on opposite sides. When infrared energy between the range of 8 and 14 micrometers hits the substrate, heat is generated which displaces electrons and creates a charge between the two electrodes. The voltage difference between the two elements is amplified and creates a change in the nominal output voltage of the sensor. The output rises when motion is detected in one direction and falls when motion is detected in the opposite direction. Thus the pyroelectric sensor is ideal for detecting the movement of humans, as the wavelength of maximum energy radiated by humans is about 10 micrometers.

I tested the pyroelectric sensor by walking across its field of view at ½, 3, 5 and 8-foot intervals at a moderate walking pace in the left-to-right and right-to left directions for each interval. The nominal value when no movement is in the field of view of the sensor is 2.5 volts on the output pin, which corresponds to a reading of 128 on the analog output of the microprocessor. The LCD is set to refresh every 0.5 seconds and two people recorded results as another walked across the field of view. The first result on each graph is the nominal value of 128, the next result is the first non-nominal value seen. The following graphs show the results of these tests:



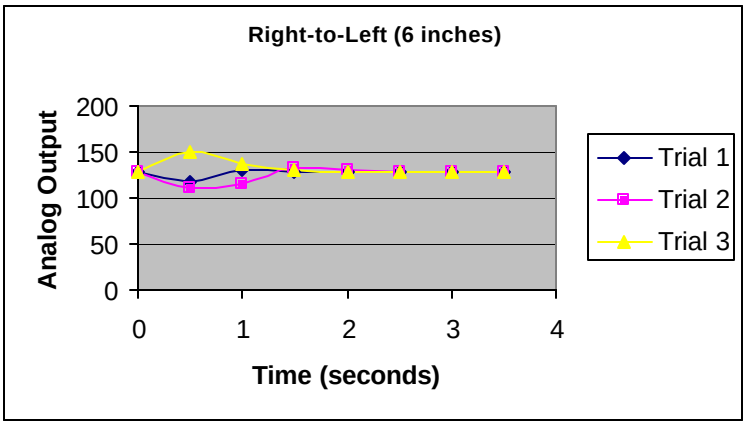


Figure 6 Pyro at 6”

As can be seen from these graphs, there are no distinct differences in the outputs between the left-to-right and right-to-left motions at six inches from the sensor. Therefore the presence of a person can be detected, however people following capabilities will not be possible at this distance.

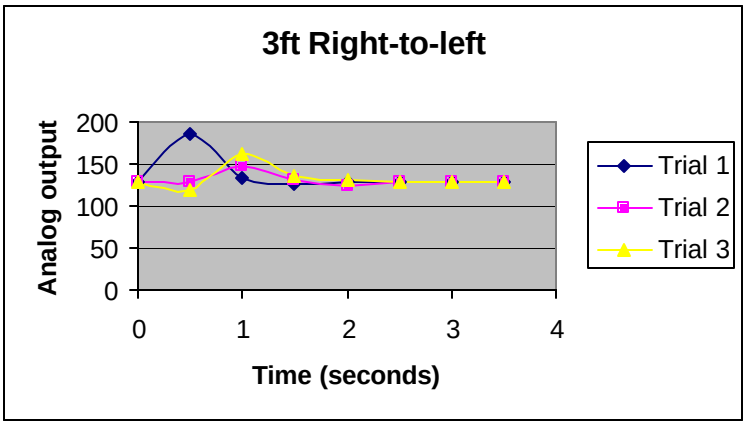
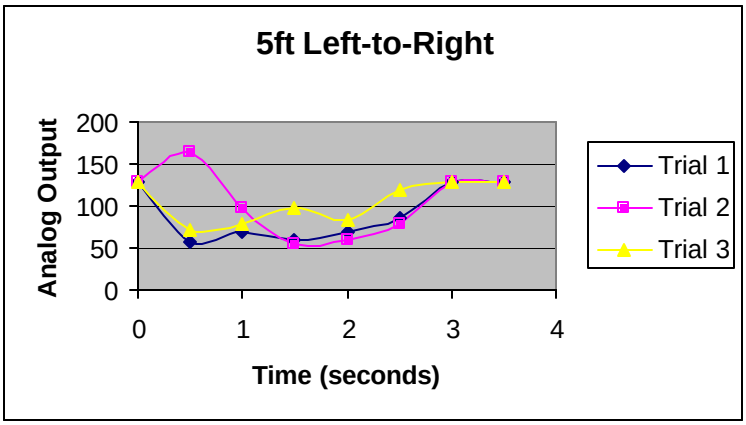


Figure 7 Pyro at 3'

In the preceding graphs there is a marked difference between the separate directions. When moving in the left-to-right direction there is a strong down trend in the output before it levels back to the nominal value, while the right-to-left movement demonstrates a strong up trend in the output and drops back to the nominal value of 128. People following skills and detection can be implemented fairly easily at this distance.



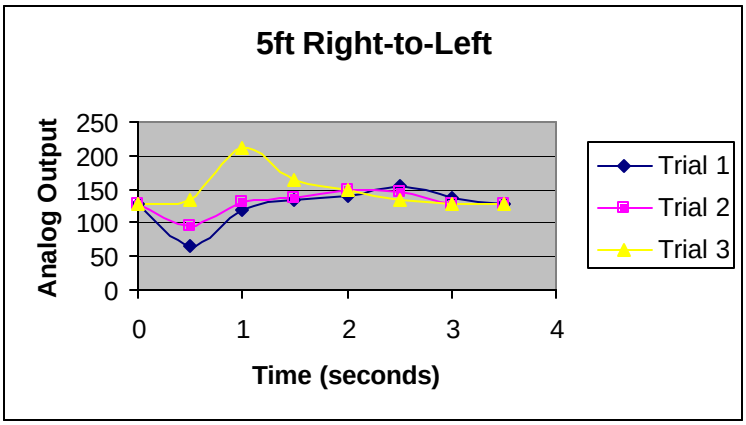
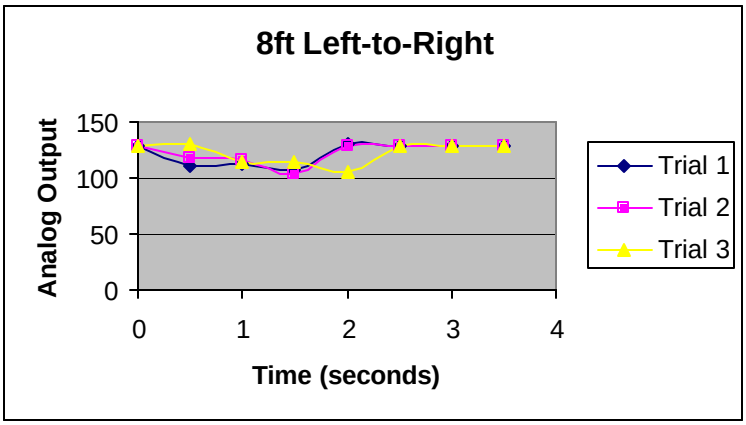


Figure 8 Pyro at 5'

At a distance of 5 feet, there is still noticeable difference between the separate directions, however they are not as tolerant as before. The left-to-right graph drops below the nominal 128 and the right-to-left rises above the nominal value. In both graphs there is at least one anomaly where the output goes in the opposite direction before going in the expected direction. Human detection is obviously possible at the distance however determining the direction of the individual may not be as accurate as before.



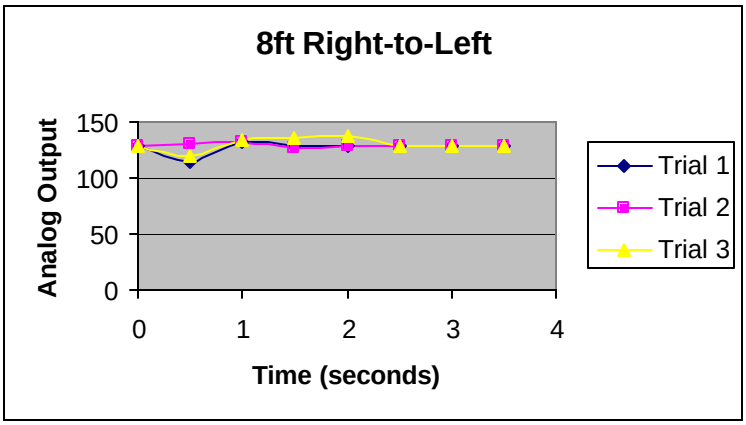


Figure 9 Pyro at 8 ft

At 8 feet, the difference in data is too obscure to determine accurately the direction of motion. Human detection is the only reliable attribute at this distance.

Trying to detect the presence of an individual can be done reliably at any distance between 6inches and 8 feet. However direction of motion should be done between the approximate distances of 3 to 5 feet. This may be accomplished my setting minimum and maximum detection values to create a range of tolerances that can be used to determine whether direction can be accurately detected.

The problem I found when trying to do people following was that the pyro-sensor has a large window to detect motion in and it has no depth perception. To compensate for these faults I columnated the sensor with a 1 ¼'" card stock tube. This shrunk the window size of the sensor and made the system more accurate when locating people. I then used the pyro-sensor together with the I.R. sensors to locate a person, go towards that person and verify that it has indeed found a person.

Testing

I attempted several different ways of following/locating people using the pyroelectric sensor.

The first attempt used a piece of modified code from the “Eltec Pyroelectric Sensor Package”. The subroutine is listed in the appendix as Follow. The code turned the robot left if the pyro-sensor read greater than 134 and turned right if the sensor read less than 122. This code is problematic in the sense that the persons’ relative position changes as the robots direction changes. This procedure caused a very jerky motion that was unacceptable for the objective of B.E.E.R.-Bot.

I then tried turning the robot until the pyro-sensor detected a person. When it detected a person it would stop turning and go forward towards the person. The problem here was that the window size is too large and the robot would stop before it was centered on the person.

I took a small piece of card stock with a thin slit cut out of the middle to reduce the window size. This worked, but proved to be unreliable as the sensor had to be perfectly aligned with slit in the card. Simple movements of the robot would jar the sensor out of alignment.

I then columnated the sensor as described in the sensor section of this report and that seemed to work perfectly.

The pyroelectric Sensor can be purchased from Acroname www.acroname.com.