Worksheet

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Data Logging in RCJ Football: the Infra-red Ball

Exercise 1 –measuring ambient light levels

Research Context:
In this exercise, you will manually collect sensor data and explore how the background light levels can vary around the room you are in.

Minimum requirements:
- RCX brick, host computer (with IR tower) running Robolab
- A light sensor connected to input 1
- A touch sensor connected to Input 2

1. Start Robolab, select Investigator and create a new project. Name your project appropriately.
2. Using Program 1 in Program Level 1, change the clock setting (underneath the light sensor on input 1) to a touch sensor, and give the program a more appropriate name.
3. Download the program to your robot by clicking on the single large white arrow.
4. Press the *View* button on the brick until an arrow appears underneath Input 1 and sample the ambient light levels around the room.
5. Press the green *Run* button on the RCX brick and collect 10 ambient light samples by presing the touch switch.
6. Upload your data to Robolab and rename the data file to something more appropriate

What happens to the background light levels in various parts of the room?
Why is the data spread along the x-axis in the way it is?
What are the advantages and disadvantages of manual data collection? How might it be automated?

Exercise 2 – measuring the brightness of the IR ball over distance

Research Context:
In this exercise, you will investigate how the measured brightness of the ball changes according to how far away the ball is from the light sensor.

Minimum requirements:
- RCX brick, host computer (with IR tower) running Robolab
- A centrally mounted forward facing light sensor connected to input 1
- A motor driving the left hand wheel connected to RCX output port A
- A motor driving the right hand wheel connected to RCX output port C

1. In the programming panel of your Investigator project, create a new program and give it an appropriate name (for example, *linear distance*).
2. Using Program Level 2, construct a program that will log 40 data points at 0.05s intervals as the robot slowly reverses in a straight line.
3. Download the program to the robot, switch on the ball and place it directly in front of the robot, touching the forward facing light sensor. The robot should have enough room behind it to allow it to reverse for 2s.
4. Run the program until it completes, upload the data to new, appropriately named data file, and place it in an unused coloured bin.

Why are the samples arranged regularly along the x-axis?
From the ambient light measurements you made in exercise 1, and the data on the graph, do you think the robot will be able to distinguish the light emitted by the ball from the ambient light using the light sensor?

5. Repeat the experiment but this time remove the ball (or switch it off). Upload the data to a new data file and place it in a new bin.

6. Compare the data in the View and Compare area.

In each case, how do the light readings change as the robot reverses away from the ball? Do you think the robot will be able to see the ball?
Is there a simple way for the robot to tell how far away it is from the ball? What is the maximum distance at which the robot is likely to be able to detect the ball?
If the ball was in front of the robot, how would the robot know that it was moving towards or away from the ball?

Exercise 3 – measuring the brightness of the IR ball over angular distance

Research Context:
In this exercise, you will investigate how the measured brightness of the ball changes depending on the angular distance the ball is away from the light sensor.

Minimum requirements:
- As in Exercise 3.

1. In the programming panel of your Investigator project, create a new program and give it an appropriate name.
2. Using Program Level 2, construct a program that will log 40 data points at 0.05s intervals from a light sensor connected to input 1, as the robot slowly rotates on the spot. Download the program to your robot.
3. Place the robot so that the light sensor is facing the ball. The robot should be as close to the ball as possible and yet still have enough room to do at least a single complete rotation. Turn on the ball and run the program. *If the robot does not perform at least a single complete rotation, modify your program so that it samples enough data points for the robot to complete at least a single rotation, download it to the robot and repeat this step*.
4. Upload the data to a new, appropriately named data file and place it in a new bin.
5. Put the robot back in the same spot, and facing the same direction as it started in previously, although this time without the ball (or with the ball switched off). Run the program, upload the data into a new data file, place it in another bin, and compare the two results in the View and Compare area.

Discuss whether you think your robot will be able to tell when the ball is directly in front of the robot

6. Repeat step 4, although this time place the robot so that its back is facing the ball. Upload the data to a new, appropriately named data file, place it in a new bin and then compare all three sets of data.

From the new data set plotted on the graph, discuss whether the robot will be able to tell when the ball is directly in front of it.

7. Repeat step 4, although this time place the switched on ball a few centimetres further away from the robot. Upload the data to a new, appropriately named data file, place it in a new bin and then compare all four sets of data.

How does the increased distance between the ball and light sensor affect the reading?

8. Modify your program so that the robot rotates in the other direction, download the program to the robot and repeat steps 4 and 7. Compare all the data sets in the View and Compare area.

How does the direction in which the robot turns affect the readings from the light sensor?

Exercise 4 – using two forward-facing light sensors to detect the ball

Research Context:
In this exercise, you will use two (binocular) light sensors to see whether it is possible to identify the bearing on which the ball is away from the robot.

Minimum requirements:

- As in Exercises 3 and 4 **except for**:
- The forward looking light sensor connected to input port 1 should be moved so that it is still forward facing but now mounted at the left-hand side of the robot
- A second forward looking light sensor should be connected to input port 3 and mounted at the right-hand side of the robot

1. In the programming panel of your Investigator project, create a new program and give it an appropriate name.
2. Using Program Level 2, construct a program that will log 40 data points at 0.05s intervals from light sensors connected to inputs 1 and 3, as the robot slowly rotates on the spot. Download the program to your robot.
3. Place the robot so that the light sensors are facing the ball. The robot should be as close to the ball as possible and yet still have enough room to do at least a single complete rotation. Turn on the ball and run the program. *If the robot does not perform at least a single complete rotation, modify your program so that it samples enough data points for the robot to complete at least a single rotation, download it to the robot and repeat this step*.
4. Upload the data to a new, appropriately named data file and place it in two new bins. Compare the data in the View and Compare area.

How do the readings differ as the robot turns?

5. Modify your program so that the robot rotates in the other direction, download the program to the robot and repeat steps 4 and 7. Compare all the data sets in the View and Compare area.

How do the readings differ as the robot turns in each direction?

6. Repeat your experiment, although this time place the switched on ball a few centimetres further away from the robot. Upload the data to a new, appropriately named data file, place it in new bins and then compare the data with that collected previously.

How does the increased distance between the ball and light sensors affect the readings?

Mini-Challenge 1

Write a Robolab program to help calibrate the robot. In particular, you should identify an ambient light threshold level that can be used to help the robot decide whether or not the ball is in sight.

From a random or chosen starting position on the pitch, your robot should explore the whole of the pitch area for 1 minute, sampling the ambient light levels and then setting a container with a threshold value for the ambient light level. Create your new program using Program Level 4.

It is up to you how you set the ambient light level threshold, but you may wish to consider the following issues:

- *The mean of the light sensor measurements will give an average value of the ambient light levels all over the pitch.*
- *When the robot sees the ball, are the light sensor measurements greater than or less than the ambient light levels?*
- *How do the maximum and minimum ambient light levels compare with measurements recorded when the robot is facing the ball at a range of distances? Would it make sense to use one of these limiting values the threshold?*

How did you calculate the ambient light threshold value? Why did you choose this approach?

Mini-Challenge 2

a) Write a Robolab program that will allow a randomly placed and oriented robot to turn on the spot until it is facing the ball. When the ball is in front of the robot, the robot should stop rotating and play a short celebratory tune.
Create your new program using Program Level 4. You may find it useful to calibrate your robot beforehand and make use of the ambient light threshold in your program.

b) Extend your program so that after the celebratory tune the robot moves at full speed towards the ball. When the front bumper makes contact with the ball, the robot should beep, reverse for 0.5s and then stop.

Mini-Challenge 3

Write a Robolab program that will allow a randomly placed and oriented robot to wander about the pitch until it sees the ball. If the robot bumps into a wall, it should reverse and turn away from the wall before continuing its search. When the robot sees the ball, it should stop moving, play a short celebratory tune, and then dash at full speed towards the ball. When the front bumper makes contact with the ball, the robot should beep, reverse for 0.5s and then stop..
Create your new program using Program Level 4.