Smart Testing

Grade Levels

This activity is intended for students grades 3rd-6th

Objectives and Topics

This purpose of this activity is to introduce (or continue to introduce) students to robotics, programming, and how robots (computers) interpret commands. In this activity, students will actively measure, collect, and analyze their own data in order to accomplish a simple task using the Lego NXT.

Materials and Resources

- At least one pre-assembled NXT "Full Car Model" (more if resources are available)
- Specifically, one computer with NXT Mindstorms programming software installed
- Five tokens (playing cards or poker chips)
- Students must have notebooks for data collection
- Measuring tape
- Painter's tape
- Clipboard, paper, and writing utensil

Introduction and Outline

Prior to class, pre-assemble the "Full Car Model" for the Lego NXT described in the Constructopedia. The front wheel can be either a swivel wheel or fixed straight wheel (both designs are in the Constructopedia). In addition, place two lengths of marking tape (a start and finish line) parallel to each other on the ground at an arbitrary distance (e.g. 185 cm apart).

The students will be tasked with programming the NXT (or NXTs) to stop on the one strip of tape (the finish line), starting from the other strip of tape. The activity can be made more competitive by measuring time or distance from the finish line to rear tires. The groups will have at most five attempts to perfect this behavior. They will need to take accurate measurements (distance and time) to complete this task effectively.

Procedure

Explain the goal of the activity to the students. Ask students if they think they could easily write this program (answer should be a resounding 'yes'). Tell them that this time, there is an additional constraint.

Explain to students that in the real world, it is common that testing a robot is expensive. Robots can consume fuel or other resources, testing environments can be expensive to set up and maintain, measuring equipment can be expensive, and paying people to set up experimental trials and observe the outcomes is also expensive. So there is a motivation to use brain power, which is relatively cheap, to reduce the number of attempts needed to perfect a robotÕs behavior.

Using some simple reasoning and math, they probably could have cut down the number of experimental trials needed to program the robot correctly.

In this activity, the tokens represent the cost to run one experiment with the robot. Emphasize the high value of the tokens. Each group is given five tokens, which means that the groups will have at most five attempts to achieve the goal. Place the student work stations far from the experimental range (the start/finish lines) so that students are forced to pay a token to test on the range (otherwise they may attempt to eyeball the distance by running the robot a short distance away). They will load a program on the robot, and come to the range to test it. Before allowing a test run, ensure that the lab sheet is being correctly used.

Through discussion, determine the importance of data collection with each experimental trial. Is it enough to simply see that the robot fell short of the goal? If an expensive experiment is being run, donÕt the researchers want to collect as much data as possible about what happened? In this case (moving forward a specified amount), what data would be useful (the distance traveled)? Emphasize to students that it will be very important to gather concrete data, and that measuring the distance traveled by the robot will be the key piece of data in this experiment. Together, reason that the students should record data on a lab sheet. This lab sheet should record the goal distance to travel. Then in a table of data, record the trial number (#1Ð5), the computer program (e.g. forward 4 seconds at 75% power), the result (e.g. went 50 cm), and comments.

If necessary, review measurement with a measuring tape, in particular that after one meter, '85' means '185' cm, and so on. Measure some distances together if necessary.

For an easier challenge, measure the goal distance as a class before the activity begins. If not, the students make a blind guess on the first run of the experiment, and have a chance to measure the goal distance in the first trial (as well as the result of this trial, as always).

After all groups have achieved the goal or run out of tokens, gather students for discussion. Tell them that a follow-up session will be held, and at this point the groups will compare results and discuss strategies used to achieve the goal. Tell students to write a math journal entry describing their teamÕs result, and what strategies they used to make smart choices when modifying the program between trial runs

Discussion

What was the goal, what were the constraints, what were the outcomes? Remind students that the big idea was to be smart about coming up with a modified program, not just to eventually get a good problem through guess-and-check alone.

Discuss strategies used. Each group will share its result, and describe the strategy used to refine the program at each step. Students should generate their own strategies, and one or two class-wide strategies can evolve from this. The teacher can aid in refining these strategies and making a well-defined statement of how to follow the strategy. In previous experience, here are some general strategies that are found.

Previous Experiences

- Unit rate. May be a higher-level (5/6th grade) strategy. Take first measurement (e.g. 50 cm in 5 seconds), and determine the unit rate (10 cm per second). Use this rate to find the time needed to travel the goal distance (divide distance by unit rate).
- Proportion. May be a higher-level (5/6th grade) strategy. Make a proportion between the known time and distance with the goal time and distance. Three values are known after the first trial run: known time, known distance, and goal distance. Solve the proportion to find the time needed to reach the goal.
- Narrowing in on the solution (any grade level). This is not a definite method, as the above two are. For this method, draw a horizontal number line and mark the start (at zero) and finish on a number line. Take the first measurement (time and distance) and mark this point on the number line. Above the point put the time, below the point put the distance. This point may be shorter or further the goal distance. If the point is shorter, mark what would be expected if the robot ran for twice as long, three times as long, etc. In which interval does the goal fall? The next guess should be a time between the upper and lower time bounds shown by this number line. Likewise, if the first distance is greater than the goal, imagine what would happen for half or one third of the time. In either case, mental math is used to narrow down an upper and lower bound for where the correct time lies. Once a good guess can be found, a second test is run, giving a new piece of information to find an upper and lower bound.

For all of these strategies, multiple tests are needed. A first test is always needed to get an initial data point. The first two methods above should give the exact answer in the next guess, but robots do not always behave exactly as we theoretically expect them to. The whole point is to be making a smart choice about the successive test runs.

Scientists use these exact methods to run their tests. Advanced robot creators use these same ideas when they test and refine their creations.

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