RobotWits

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Learning Math Through the Lens of Robotics
Resources for Educators & Students

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Lesson 101 - Robotics: An Introduction

Description: A quick introduction video for basic robotics that covers the different design elements: Locomotion, end-effectors, and appearance of a typical robot. Discusses the pros and cons of different options and why a particular combination may help the robot to perform its assigned task better or faster.

Math Concepts: None (Design Elements of a Robot)

Challenge Questions Handout

Lesson 102 - Sense, Plan, Act Framework

Description: Introducing the Sense, Plan, Act Framework for describing the process a robot goes through when trying to accomplish its assigned tasks. The SENSE phase is when the robot gathers information - where am I?, am I done? Once the robot gathers the information, the next step is to PLAN- what action and how to perform that action. Finally, the robot executes the plan during the ACT step.

Math Concepts: None (Sense, Plan, Act Framework)

Challenge Questions Handout

Lesson 103 - Robot Measurements

Description: How do robots measure? What kinds of things do they need to measure? In this lesson, we will discuss how robots use the metric system as their system of measurement and explore how they measure distances, angles, and time. We will walk through how to calculate the distance to objects if we know the time it took for light to leave the robot, bounce off the object and return to the robot. Finally, we will see how trigonometry can be used to determine how long a robot arm must be, or how high of a table can be reached by a robot with a simple arm.

Math Concepts: Conversion to Metric Units and Unit Prefixes (mili, kilo, etc...); Scientific Notation; Angles and Conversion to Radians; Basic Speed, Distance and Time relations; Basic Trigonometry

Challenge Questions Handout

Lesson 104 - Robot Localization

Description: How do robots determine their location? In this lesson we will explore a three-step process to find the position by 1) finding at least 3 nearby landmarks with known positions 2) determine the robot's range to each landmark using onboard sensors and 3) calculate the intersection point of the 3 range circles to find the robot's position.

Math Concepts: Circle Equation: -Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation, -Intersection Points of two Circle Equations; Roots of quadratic equations

Challenge Questions Handout

Lesson 105 - Robot Motion

Description: Robots need to move, but how do they determine how far to turn the wheels to get where they want? In this lesson, we explore the equations of motion for differential drive robots. We will walk through how to derive these equations as well as talk about some of the possible wheel configurations a robot could have.

Math Concepts: Circle Circumference; Speed, Distance and Time: Linear and Angular Velocity and the relationship between them; Basic Trigonometry: Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle.

Challenge Questions Handout

Lesson 106 - Robot Vision

Description: How do robots see? How do they transform what the cameras sense into meaningful data? In this lesson, we will discuss the pinhole camera model for cameras and see how a robot can use that to find the distance to a nearby object using a stereo camera setup.

Math Concepts: Pinhole Model and Camera Calibration: Equation of a Line given two points, Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

Challenge Questions Handout

Lesson 107 - Robot Sensing

Description: How do robots sense their surroundings? How do they keep track of where obstacles are? In this lesson, we will examine how robot sensors work and see how that information is stored in a convenient, easily updatable format that accounts for errors in the robot measurements. We will use conditional probability to calculate the updated values after we get a measurement and see how to store this in an occupancy grid.

Math Concepts: Probability: Describe events as subsets of a sample space (the set of outcomes), Conditional Probability: Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. Understand the conditional probability of A given B as P(A and B)/P(B). Construct and interpret two-way frequency tables of data, Total Probability, Bayes' Theorem.

Challenge Questions Handout

Lesson 108 - Robot Controls

Description: How do robots follow a line? How do they know how to correct for errors or disturbances as they try to follow a path? In this lesson, we will explore how a robot can use vector math to determine which side of a line it is on, and how far away the line is. We will also see how the robot can use this information as part of a Proportional Feedback Controller to constantly update the motor commands to account for any errors that may occur and successfully follow a provided trajectory.

Math Concepts: Vectors: Vector Format of a Line using the start and endpoints of the line (Pend - Pstart); Cross Product of 2D Vectors; Using Dot Product and Normal Vector of a line to calculate the distance from a point to a line; Pythagorean Theorem

Challenge Questions Handout

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