Self-balancing robot

ES197 Project Charter

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1 Purposes and objectives

The goal of this project is to program a 2-wheel robot to be able to balance itself. The robot is expected to be able to balance of a variety of surfaces (e.g., a small carpet is included with the robot as an example of a high friction surface). In addition to this, the robot is expected to be able to balance for a non-insignificant amount of time. We would like our robot to balance for at least 1 minute.

The robot's controller is preloaded with software that runs Simulink models so our task will be to design a model fit for this purpose and load it onto the robot. The specifics of the required model are left open to interpretation as there are, potentially, many models that will solve this task with varying degrees of success (no pun intended).

As well as this, there are some other expectations set out in the provided document. Specifically, at the end of the week, the robot must be returned intact and with all its accessories. As well as this, the robot must be given a name suitable for use with children as it may be used by Warwick Outreach to celebrate Coventry City of Culture 2021.

To summarise, the key objective and key points are given below:

Purpose: Use MATLAB and Simulink to design a control system that allows a self-balancing robot to stay upright for a significant period on a variety of surfaces.

- Self-balancing robot that works on different surfaces for 1 minute at least.
- Robot will be returned in full and intact after Friday.
- MATLAB and Simulink will be the control system.
- Robot will be named in a way that is suitable for children.

2 Project constraints and equipment

For this project, several things have been made available to us to use to complete this project. Specifically, we are provided with a self-balancing robot which we are directed to program. To do this, we have been provided with computers, the Matlab 2020b and Simulink software packages (including the Arduino Support package for Simulink) and a few accessories that come with the robot.

Due the nature of this project, there are several constraints that we need to adhere to in order to complete this project successfully. Specifically, we have 1 week (Mon-Fri) during which we need to analyse, design, implement, test and write up a solution to this project. During this week, we have 6 hours of lab time a day.

The self-balancing robot comes with its own constraints. Specifically, it runs an Arduino Mega that has been pre-programmed with support for Simulink models, so we should use Simulink instead of programming the robot directly in a low-level language. We are also unable to modify the robot in anyway if we wished to raise or lower its centre of gravity. However, this should not cause issues as the robot should be built to compensate its own weight.

3 Prior knowledge and theory

We will be creating our control system using Simulink and Matlab. Using what we have learnt in ES197, know that this robot can be modelled as a mechanical system, as it needs to move forwards and backwards to avoid tipping over. We can model the robot as an inverted pendulum, with a mass at the top. In this model, we are able to apply a force to the bottom of the pendulum by moving the robot's wheels. Our aim is to keep the robot perpendicular to the ground.

The robot has a potentiometer on Arduino pin 57, which we can use to calibrate the desired angle for the robot to be angled at. It also has an accelerometer on pin 55, which is used to measure the current pitch of the robot, which is its angle to the ground in the driving direction. We can feed these two variables into a PID control system to calculate the best way to stabilise the robot at the target angle.

A PID (Proportional Integral Derivative) control system is suitable for this task because it allows calculations to factor in the history of the system (through integration) and the predicted future of the system (through differentiation). It allows us to take an ideal transfer function for our system and use it to control our robot.

4 Team roles

- Oliver Beresford – I will write up a test plan and test data recording document to ensure the project progresses at a rate which allows us to finish the project on time. I will also record data from testing for use in the presentation and help interpret and present it in a way that is useful for the team.

- Felix Bowyer – I will help coordinate the project and make sure that the team is working well together. I will also be helping with programming by ensuring the control system correctly implements our theoretical system, making sure the robot does not get damaged, and ensuring that the correct tests are conducted to ensure the robot meets the customer requirements.

- Betty Liu - I will be responsible for the programming, to implement theory in code and make sure that this code executes properly. Also, I will help to test the data to improve the performance of our product.

- Adam McBride – I will be responsible for collecting research we have used and/or intend to use, as well as gathering any new relevant research that I can that is available to us to use. I will also be coordinating the presentation for the D2 group presentation deliverable and ensure that it is coherent and professionally written.

5 Effective teamwork plan

To coordinate our efforts effectively, we are going to be communicating over Microsoft Teams and taking part in calls either over the whole time available each day or periodically throughout the day. Each team member will be responsible for their role as set out in the previous section.

To ensure that no team member repeats work already done by another member, the team shall coordinate our efforts, letting other team members know the work we have completed over the course of the day. Each team member will also write down what work they have completed in a shared document that will be available for members of our team to view.

To make sure the project is completed on time, we have created a formal plan regarding what should be done on each day of this week.

This plan may be subject to change, particularly on the length of implementation.

Task No.	Task Name	Assigned	Mon	Tues	Wed	Thurs	Fri
1	Project Briefing	Group					
2	Simulink Model	Betty L, Felix B					
3	Project Performance	Ollie B, Adam M					
4	Presentation and Demo	Group					
5	Debrief and Review	Group					

6 Project deliverables and timing

We have 4 deliverables to be submitted for this project.

This project charter should be completed by the end of Monday. It contains a statement of the main objectives of the project, a list of project constraints, a plan of who in the group will take on which roles, some background knowledge and theory that we will need to use, and how each member of the team will work together effectively.

On Friday, we will demonstrate and present our self-balancing robot. The presentation should include an analysis of the problem and customer requirements, how we used the V-model to complete the project, a demonstration of the robot, and evidence of testing. All group members should contribute to the presentation.

After the presentation, the group should complete a team reflection, in which we should reflect how the project went compared to the expected results in the project charter, as well as how effectively we worked as a team, including how we overcame challenges, and how we have developed our skills both as individuals and as a team.

Each member of the team should then complete a peer review, in which we evaluate how well each team member contributed to the project and worked with the rest of the group.

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