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RBE 1001: Introduction to Robotics
C-Term 2019-20
Lab 3: Manipulators and parametric testing

1 Introduction

The first two labs have focused on the control and performance of the chassis and drive train of your BaseBot. You have explored some of the functionality (driving, detecting objects, etc.) and some testing for requirements (speed, slope, etc.). For this lab, you will build and test *two* mechanisms for accomplishing another major function: delivering pizzas.

1.1 Preparation

Unlike the chassis build, which was fully prescribed, here you have a lot of freedom to build physical prototypes to explore and test ideas. You will need to show up to lab with two *substantially different* pizza delivery mechanisms. You do not need to mount them to the chassis – that would be difficult with two options – but you need to build them such that you can test their ability to accept a pizza, adjust the height (to reach different floors), and deposit the pizza. You do not need to be concerned with mobility, in the sense of moving from the pizza slot to the dorms – that will be accomplished by driving once you integrate your mechanism into your BaseBot.

In designing your mechanisms, you are expected to identify where analysis is useful and where you need to rely on physical testing. For example, you should be able to calculate the torque needed to lift an arm and select the appropriate gearing. For a more complex mechanism – say, a telescoping elevator – you would be expected to identify where you could *use* analysis, even if you're not sure how to do the calculations (yet!). Other parameters are harder to calculate and will require testing: the maximum speed at which you can lift a pizza without it falling off, perhaps. You will describe experiments and analysis as part of this assignment.

You will prepare a test plan for how you're going to test your mechanisms. Expectations for the test plan will be covered in class. In building your mechanisms, you will undoubtedly do some preliminary testing – there is no point in showing up with a mechanism that flat out won't work – but there will still be some parameters that are unknown. It will be important that you build a mechanism that will allow you to easily change the parameters that need testing.

2 Testing the mechanisms

Your goal in lab is to test each of the mechanisms and evaluate them both objectively and subjectively. The pre-lab and post-lab sections describe your tasks and what to submit before and after lab, so the instructions here are sparse.

The gist is that you will need to set up your mechanisms and test them. Note that there is no expectation that you will have unlimited access to the "dorms" on the arena, so you may need to

perform some tests at your workbench. For example, you can easily calculate that speed of your mechanism and its ability to hold a pizza without actually delivering it. But if you want to measure the reliability of placing a pizza in a dorm, you'll probably want to use the arena. Please be mindful of others who want to use the arena and think carefully about where you do your experiments.

3 Pre-lab

This is a team assignment. Submit one copy electronically on canvas.

For each mechanism,

1. Draw your mechanism. It does not have to be done in CAD (though some of you are so proficient in CAD, you might do so anyway), but it needs to be detailed – and neat! – enough that any one of your classmates could look at it and understand how it works.
2. Describe how the mechanism will be powered: Location of motor(s), transmission (type, gearing, etc.).
3. Describe how you will control the mechanism during your testing, as well as how you might control it when attached to the BaseBot.
4. Describe any analysis you have done.
5. Describe any analysis that you expect to do later.
6. Describe what you want to learn through testing. For example, accuracy, repeatability, speed.
7. List out the metrics – the data you will collect – to assess performance.
8. Describe what factors you think will affect those outcomes. For example, gearing is an obvious factor for many mechanisms. You do not have to test every single factor (see below), so make this list comprehensive.
9. Describe how you will test those factors – what will you change on the mechanism and how? How many iterations will you perform (hint: $N = 1$ is grossly inadequate). How many different values of the factor will you test ("low," "medium," and "high" is a good place to start). **You must test at least two factors for each mechanism.**

You must build each mechanism and be ready for testing at the start of lab!

4 Post-lab

This is a team assignment. Submit one copy as a .pdf file on canvas.

The primary focus of your post-lab is to make a recommendation for your pizza mechanism and plan out how you will integrate a mechanism into your BaseBot.

1. Describe the results of your testing. For parameters that your specifically altered during your experiments, use charts or graphs to present the results of the testing. For example, if you tested how the speed of a mechanism affected how often pizzas fell, you might make a bar graph of success rate as a function of speed.
2. Synthesize the lessons learned from your testing. Describe both objectively and subjectively which of your mechanisms is better suited to the problem at hand. Draw from the results in the previous step to identify the best set of parameters for operating your mechanism.
3. Make a clear recommendation for the next phase of your design. You might recommend the "clear winner" from your tests; you might continue to pursue both options; or it could be that you are not pleased with either mechanism and plan on pursuing another option. Explain your reasoning, including things you learned and questions that still need to be answered to be confident your mechanism will work.
4. Describe what needs to be done to integrate your mechanism with your BaseBot. Be specific about mechanical and electrical connections (the electrical connections themselves are trivial – VEX is plug and play – but identify what sensors will be incorporated). Describe the control methods you will need to integrate the two.