Coding Simulations of Mechanical and Robotic Devices

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Abstract

- Simulation plays a very important role in building and optimizing robots because robots are costly and performing tests on them is very risky.
- They allow us to simulate any test scenario on robots and find any obvious points of failure, thereby reducing the risk of failure when tested on actual robots.
- Drake is an open-source toolbox that has a variety of tools to analyze designs of robots and optimize them
- In this UROP project, I try to learn how to use the Drake toolbox and simulate some relatively simple models like pendulums, double pendulums, etc.
- Doing this will give us a basic understanding of how to use Drake and will allow us to simulate more complicated systems.
- Currently, we are learning to debug the code interface which will allow us to visualize and simulate more complex systems.

Introduction

- Complex physical models and machines like Robots are known to offer a wide variety of benefits. They save our time, and effort, so we can focus on other more important things.
- The problem, however, is that these sophisticated automatons are often quite difficult to design. They require years of research, masses of funding, countless numbers of prototypes, and an exorbitant amount of testing to prove their use.
- To avoid wasting such valuable resources, we must build them only when we are fairly certain their design is feasible has at least a small chance of being successful. This will help cut down the time and resources we would have otherwise put into building models that would have failed.
- This is where precursory simulations are extremely beneficial. They help us view robots in 3D and run them through different test cases to find any defects in their design.
- Drake is a toolbox that can helps us with this.

Methods

- For my research project, I worked with the Drake toolbox.
- Drake is a relatively new open-source C++ or Python toolbox, that was created by the Robotic Locomotion Group at MIT and has tools to design and analyze the dynamics of robots and build systems to control these robots, with the goal of optimization.
- It helps simulate models from ones as simple as a pendulum to ones as complicated as a robot arm, as accurately as possible.
- It is a relatively new software and there is not much documentation on this software. I had to learn most of it from my peers in the research group, the internet, and by asking questions on online forums like Stack Overflow.
- To compile the code written in pydrake, we used Deepnote. Deepnote is a data science notebook, which like Jupyter allows users to create blocks of code, run them and visualize data. We used it to compile and run the Drake program, to view simulations.
- We used URDF to create the actual model of the system to be used in the Drake program. URDF is an XML specification that allows users to model multibody systems, like pendulums.

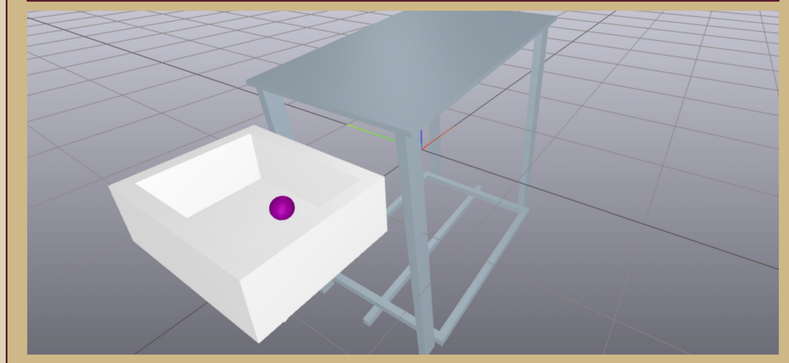

Figure 1:- A simulation of a ball rolling down a table made using models available in Drake toolbox.

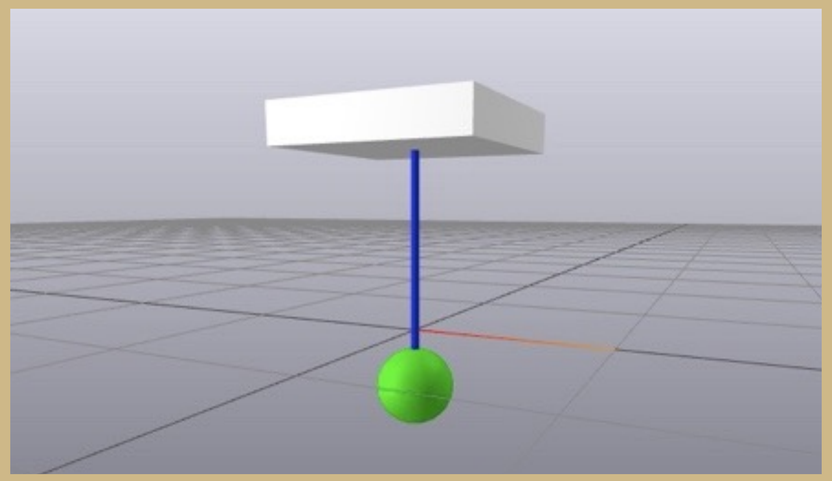

Figure 2:- A model of a pendulum made from scratch with URDF.

Results

- We are able to view simple simulations, like a ball rolling down a table using Drake, but only if all the models used in the simulation are already available to us.
- There are not a lot of models readily available to use, so we are trying to learn how we can create model systems on our own, which will allow us to simulate more complicated systems.
- We are able to create such models visually but are having issues assigning physical properties like inertia to them. We aim to learn how to add these properties to models so that we can make more complicated models to simulate in future.

Conclusion

- The world of robotics has now entered the phase where it is no longer considered a science fiction. People across the globe are trying to build new and more optimized robots every day.
- Creating prototypes to test feasibility and testing under different scenarios is almost essential to any form of robots we create.
- Simulation is the best and most reasonable solution for this.
- From this research we will learn how to use Drake to simulate simple models in Drake. In future we aim to simulate and optimize more complex systems in Drake.

References

"Pydrake," *pydrake - pydrake documentation*. [Online]. Available: https://drake.mit.edu/pydrake/index.html. [Accessed: 28-Feb-2022] ; Russ Tedrake and Drake Development Team, "Model-based design and verification for Robotics," *Drake*, 2019. [Online]. Available: https://drake.mit.edu/. [Accessed: 28-Feb-2022] ; "Wiki," *ros.org*. [Online]. Available: http://wiki.ros.org/urdf. [Accessed: 28-Feb-2022].