Simulation Environment for Object Manipulation with Soft Robots in Shared Autonomy

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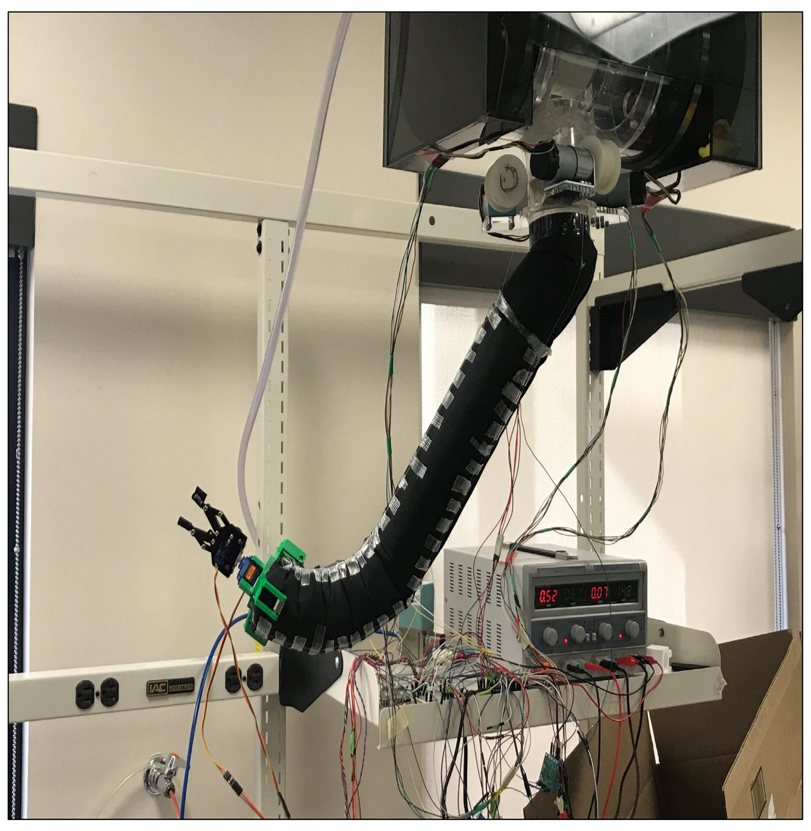
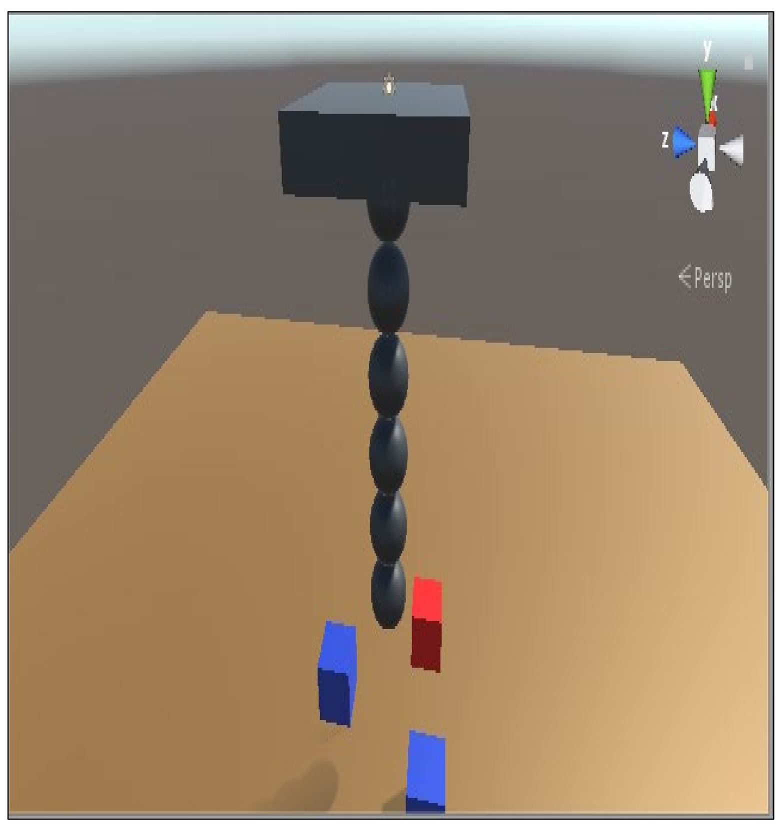
Introduction

We developed a virtual environment for a soft robot being designed in the CHARM Lab termed the Vine Robot and implemented an autonomous algorithm that allowed the robot to manipulate objects in its virtual space.

Much like the physical model, the virtual Vine Robot is composed of a growing manipulator with a grasping end-effector that can pick up and move objects in its virtual space.



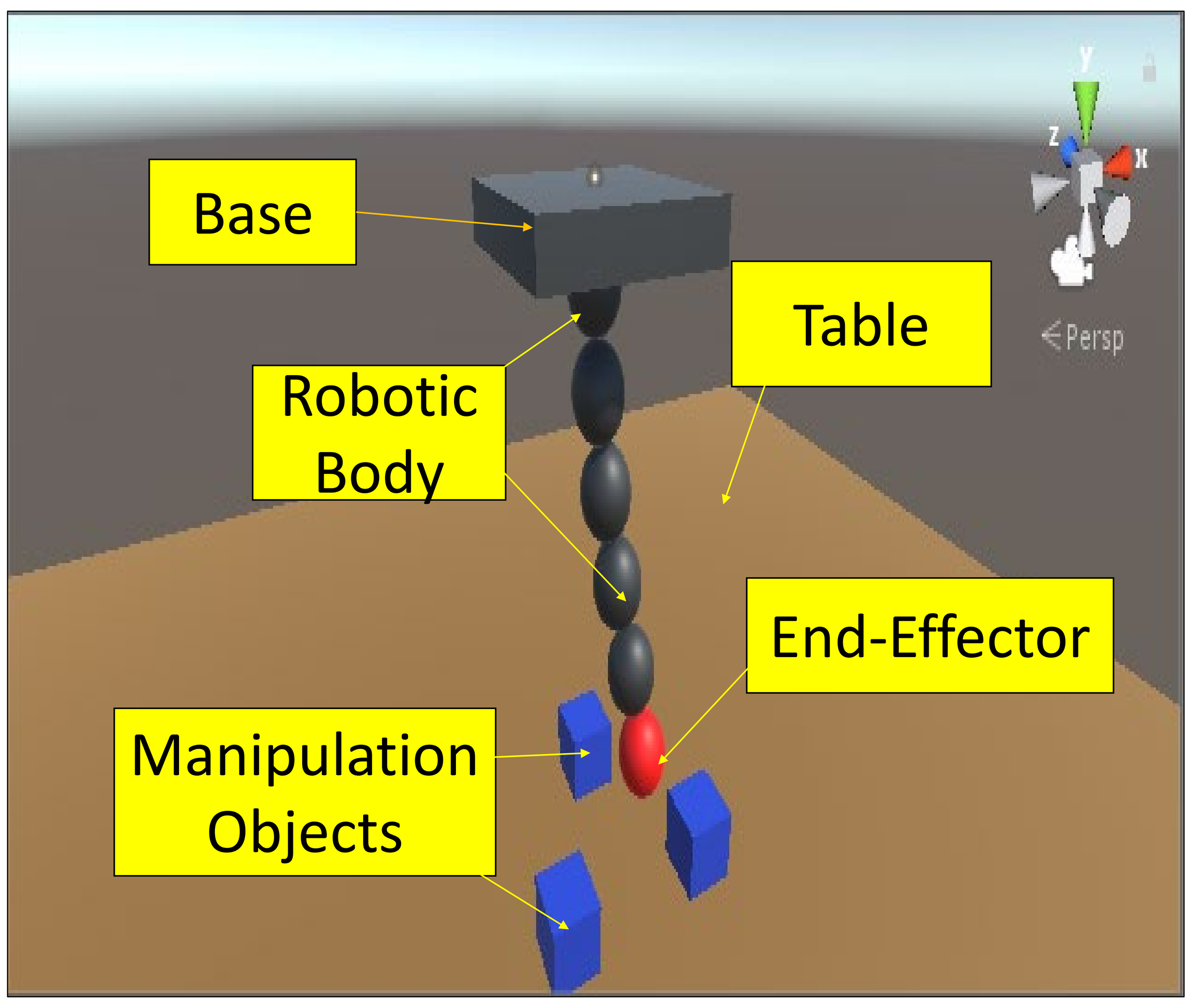
Physical Model of Vine Robot



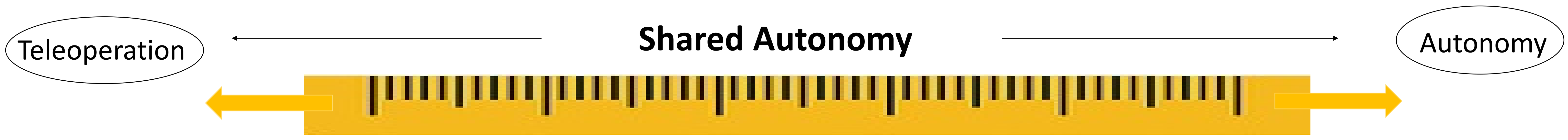
Virtual Model of Vine Robot

Virtual Environment

This virtual model was developed in Unity – the 3D environment software used primarily by video game developers. We chose this software due to its simple, but powerful inverse kinematics toolbox that allowed us to move the end effector around its virtual space along with its realistic physics engine when the robot is manipulating objects around itself.

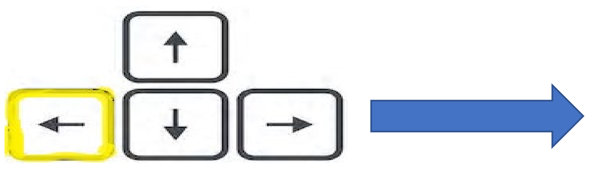


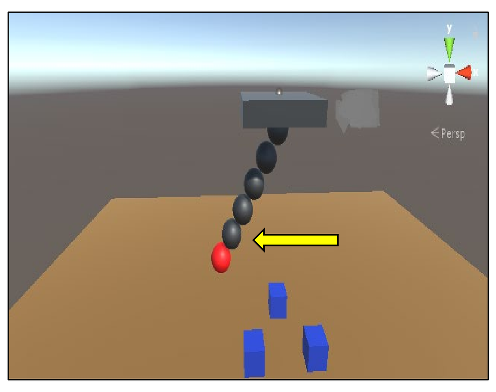
What is Shared Autonomy?



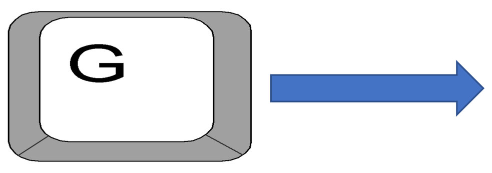
Teleoperation

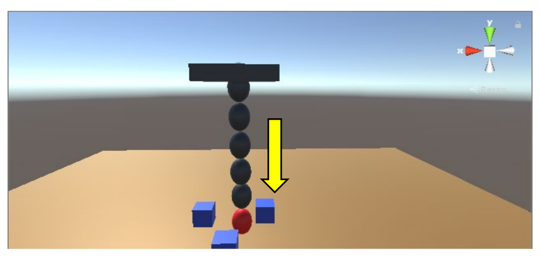
We allowed for user-input control of the virtual robot by mapping all of its movements and functions to different keyboard keys.



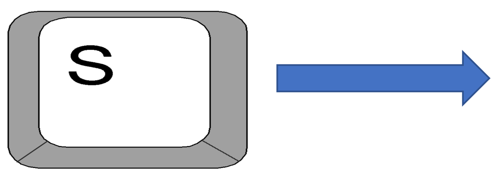


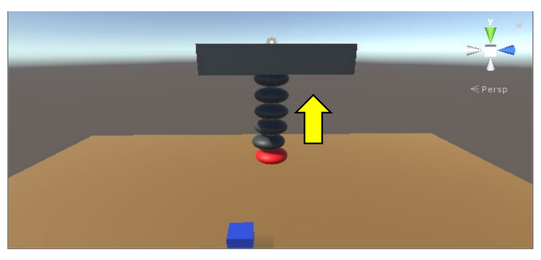
Left Key = -X Direction
Right Key = +X Direction
Up Key = +Z Direction
Down Key = -Z Direction



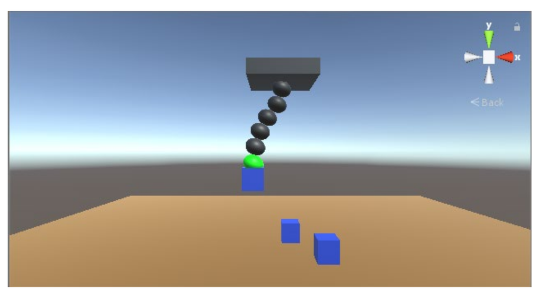


G Key = Grow





S Key = Shrink

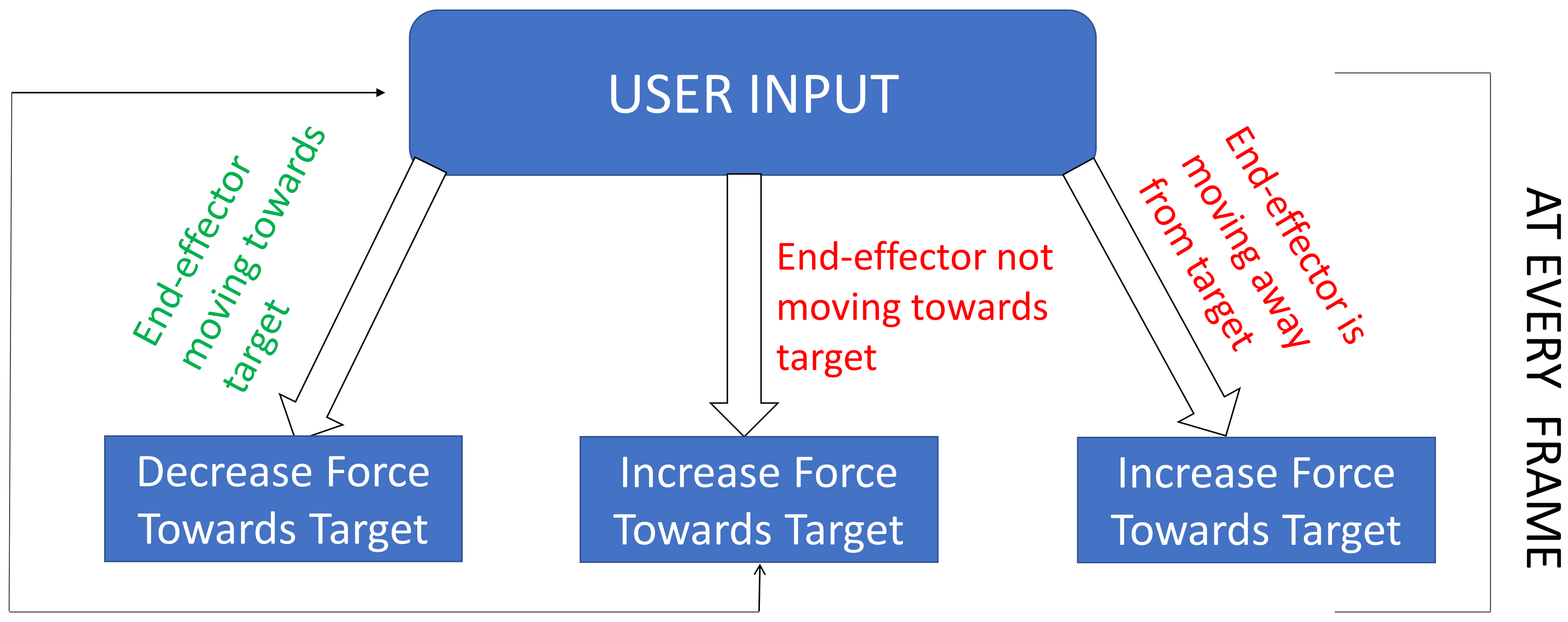


Space = Gripper Open/Close

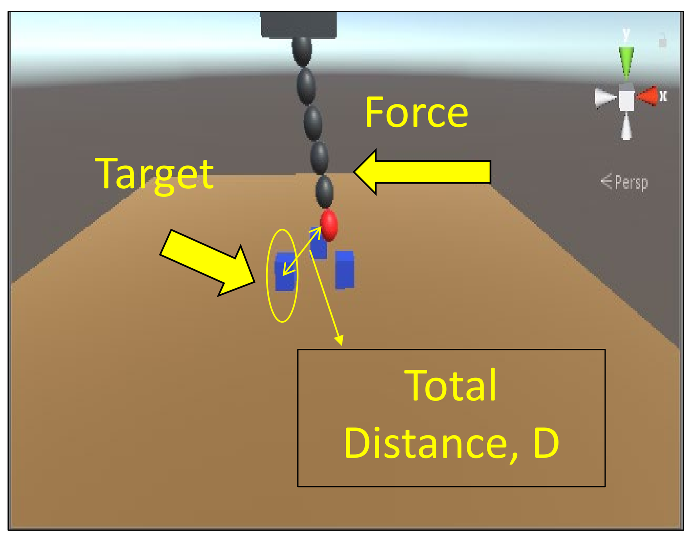
Shared Autonomy

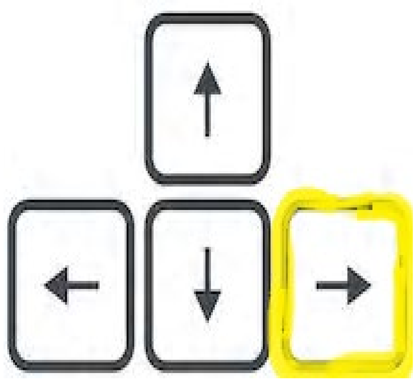
The algorithm that we implemented that allowed for the robot to interact with its environment as well as the user input from the player autonomously is called Movement-Based Smart Assistance (MBSA).

So How Does MBSA Works?



MBSA Further Explained:





Distance Between End-Effector and Target

The total distance between the end-effector and the target is given in the equation below:

$$D = \sqrt{(T_x - E_x)^2 + (T_y - E_y)^2 + (T_z - E_z)^2}$$

, where D is distance, T is the position of the target and E is the position of the end-effector

Conclusion & Future Work

Overall, we were able to successfully achieve shared autonomy between the human user and the virtual Vine Robot through the implementation of the Movement-Based Smart Assistance (MBSA) algorithm. Future work within this study will involve implementing obstacle avoidance within the MBSA algorithm so that the simulated Vine Robot will be able to detect obstacles within its environment and avoid them while it is completing its task.

Acknowledgements

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