Leveraging Robotic Simulation in Design for Space Applications

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***Abstract* - Space explorations to Mars have come to the forefront of aspirations for the scientists of NASA, and organizations like NSBE have been researching methods to emulate the use of robotics in aiding with data collection on the planet. To make this more successful it is necessary to simulate the conditions a robot may face in the field, so the goal is to create a program that will allow these simulations to be performed by EVA crew members. With the use of the web browser and gamepad, teams would have access to means of collecting data on robot performance through controlled actions. By implementing both first person and third person camera angles for the robot, it is expected that simulations can be successful and useful in practicing and experiencing the handling of these robots. Once implemented, the desired simulation will make plausible the notion of providing a web-based robot driver, making it more feasible for teams to research the capabilities of future Mars explorations.**

Index Terms - Teleoperations, Aerospace simulation, NSBE robotics, Web-based robotics

INTRODUCTION

So, why use a simulation? When answering that question I thought less about the benefits to using a simulation, and more about the downsides to using physical robots. And then I looked to see if a simulation could possibly solve that problem. For example, the construction, maintenance, and use of physical robots often require a team of people with different skills. It would also require a decent amount of money and resources to build one, let alone multiple robots. However, if the robot were inside of a simulation, these problems, although not completely eliminated, would be lessened. Instead of having several different types of people for building and maintaining the robot, using a simulation could make it so that a team of specialists can offer the handle all of the robot's needs. A simulation would also help with the problem of limited money as well as the need for more robots outweighing the available resources. A hundred robots could be simulated inside of a virtual environment for MUCH less money than it would take to build that many physical robots. However, in my mind, the biggest benefit of using a simulation instead of physical robots is the ease of sharing the simulated robots with anyone across the world almost instantly. This speed of sharing could not occur when using physical robots. With all of these benefits in mind, it must be noted that my goal is not to make physical robots obsolete, but to provide another research asset that may eliminate just a few of the hindrances that may hold back the development of aerospace environments.

METHOD

To create the various simulation environments that I needed I used a 2.5D environment simulation software called Stage. Stage utilizes a combination of various image and "world" files. World files are a combination of Python code and the image files. The Python code tells the image files out to react when they are rendered inside of the simulated environment. More often than not, multiple images files were needed inside of a single world file.

To get an outline of the tests that were to be used to assess the effectiveness of employing a simulation I referred to a serious of previously outlined experiments[1] that were run at the Mars Desert Research Station (MDRS) near Hanksville, Utah. The tests had to be run from multiple points of view (POVs) as to fully encompass any possible situation that would require a robotic asset to navigate in an aerospace environment. Effectively, my experiment then became a simulation of a simulation.

PROCESS

I. Creating the Simulated Worlds

The worlds that my simulations would run in had to be as accurate and similar as possible to the environment of the MDRS. I utilized a multitude of topography maps and past research picture galleries of the area to begin to construct the look of the worlds. I also had the opportunity to converse with Dr. Christianna Taylor. Dr. Taylor was involved with the research that I originally drew my tests from. 4 different visual constraints were simulated in my environments to test the effectiveness of the various POVs:

- No visual condition - A blank track to follow

- A visual obstruction between the robot itself and the task - Simulated rocks that the research subject had to maneuver around to continue on the path
- A visual obstruction between the camera position and the task - A large simulated wall between the camera and the path the robot was to follow
- A visual obstruction between the robot and the task and a visual obstruction between the camera position and the task - Both the simulated rocks and the large simulated wall (As shown in Figure 1)

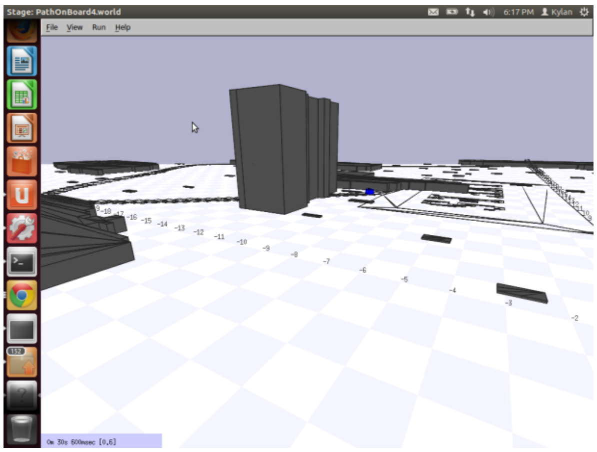

FIGURE 1
SAMPLE ENVIRONMENT

II. The Tests

The research subjects had 15 minutes to complete each section of the tests. As previously mentioned, multiple POVs had to be used to accurately test the effectiveness of using simulations over physical robots. When testing began, four different POVs were used:

- Extravehicular Activity (EVA) – Simulates a researcher in a space suit who is following the robot while using a controller to move it towards its goal.
- Support Vehicle (removed) – Simulates a researcher inside of an enclosed vehicle following the robot as they move it with a controller.
- Third Person Camera (removed) – Simulates a researcher controlling the robot from inside of a stationary building with a wide window.
- Onboard Camera – Simulates the point of view from the robot's perspective.

However, before proceeding into the final testing phase, both the Support Vehicle POV and the Third Person Camera POV were removed. There were not enough differences between the Support Vehicle POV and the EVA POV even with multiple additives to the few variances that they had. So that particular POV was removed from the final tests. The Third Person POV was removed because of a series of problems all dealing with the fact that it was essentially stationary. The view from the Third Person building did not cover all of the task area. There would be moments when the robot could not be seen at all. Also, Third Person had a severe problem with parallax. This meant that it was very difficult for the researcher gauge depth.

III. The Research Subjects

The subjects that participated in the tests were selected from various persons either at Clemson University during the time of my research there. To remove outliers, the subjects were all given a short survey before beginning the tests. The survey had questions such as, "How much do you consider yourself to be a 'gamer'?" and, "What type of controllers are you must accustomed to using, if any?" This was meant to give me an idea of where select subjects would have an advantage over others. After that, the only instruction that they were given was a brief description of what they needed to do for the current task. They were also given a post-test survey. This was given so that I could see the common problems areas that the research subjects were encountering during the tests.

RESULTS

After completing the tests, the data showed that, on average, the test with the fourth constraint was by far the most difficult. The subjects also "cheated" the most when the fourth constraint was involved. This meant that they diverged from the path given in order to take what they perceived as a short cut. The data was surprising uniform when it came to the duration of time that it took the subjects to complete the various tests, regardless of their prior expertise with similar tests or controls. Even with the minimal instructions, the subjects were able to easily complete the tests and improve as they continued. (See table 1 for a snippet of Subject 1's results)

TABLE 1
SUBJECT 1 RESULTS SNIPPET

Onboard Camera POV		
	Subject 1	
	Total Time min:sec:milisec	Time off Track min:sec:milisec
Constraint 1	6:05:03	0:12:30
Constraint 2	8:28:07	0:02:07
Constraint 3	6:06:34	0:39:45
Constraint 4	8:55:07	4:16:03

CONCLUSION

I was able to successfully carry out the tests within a simulated environment as per my initial goal. I was also able to collect meaningful data that may assist the previous works that I drew the simulations from. This leads me to believe that it is quite possible to continue using this method of testing in further research involving Mars exploration, which a greatly look forward to doing so.

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