CHAPTER III. IDENTIFICATION OF SIMULATION TARGETS

The author identified the following potential "simulation targets" to determine if simulation could be used to evaluate the conclusions documented throughout this research.

III.A. Use Player and Gazebo to evaluate the rollover of a representative challenge vehicle entering 2004 GCE course segment 2570-2571-2572

Simulating 2004 GCE course segment 2570-2571-2572 would allow the author to test the conclusion that no challenge vehicle would have been able to make this turn at the RDDF-allowed speed of 60 mph and would have either rolled over or exceeded the lateral boundary offset and consequently left the course less than one kilometer (890.1 m), or less than two minutes (100 seconds), from the end of the course.

The risk of rollover can be evaluated in simulation by accelerating a realistic model of a challenge vehicle to the 2004 RDDF-allowed speed of 60 mph and then entering a simulation of 2004 GCE course segment 2570-2571-2572, and documenting:

- whether rollover occurs,
- whether the challenge vehicle exceeds the lateral boundary offset and consequently leaves the course, or
- whether the use of simulation provides no useful information.

If rollover occurs, the parameters under which rollover occurs in simulation can then be compared to real-world results to determine if the use of simulation would have enabled teams to identify the risk of rollover.

Realistically, this would require “fitting” a SSF to the challenge vehicle. The inclusion of sensors and computing hardware increases the weight of challenge vehicles, and the use of roof racks as mount points for sensors may have caused challenge vehicles to be “top-heavy” by raising their center of gravity (CG), either of which will affect SSF. Although it is possible to create a model of a challenge vehicle with the physical characteristics of a challenge vehicle in simulation, including dimensions and weight, creation of a realistic model of a challenge vehicle is not possible without knowing the relative positions and weights of the various components in use by the team.

For this reason, a simple model having a SSF matching a selected challenge vehicle was chosen. This model is described in detail in paragraph V.C.1. and Appendix F.

III.B. Modify Player and Gazebo to implement a two-material friction model and evaluate the stopping distance of a selected challenge vehicle

Implementing a two-material friction model would allow the author to modify the friction coefficient of challenge vehicle wheels and the surface of the course in simulation and more realistically evaluate the assertion that team challenge vehicles would not have been able to stop on obstacle detection due to the stopping distance of the vehicle. A two-material friction model would also allow Player and Gazebo to generically simulate low-friction surfaces like sand, mud, or rain-slicked roads, which may be useful for training the controlling intelligence to use one sensor to interpret others. See paragraph XI.A.

Realistically, this would require “fitting” a braking profile to a simulated challenge vehicle. The braking profile would have to be experimentally determined on a case basis.

III.C. Use Player and Gazebo to evaluate field-of-view limitations for selected sensors, specifically navigation RADAR

The author concluded effectively visualizing the interaction of the challenge vehicle with the environment was a key factor, and that lack of experience was a contributing factor.

A relatively simple simulation was designed to visualize the interaction of a selected challenge vehicle with the environment using obstacles DARPA identified as representative of obstacles challenge vehicles would encounter during the 2004 GCE. Specifically, the author chose to visualize the maximum distance between the path of travel in a constant-radius turn and the left- or right-limit of field-of-view, and demonstrate that sensors with a field-of-view of less than 40º should not have been selected as a primary obstacle avoidance sensor.

III.D. Use Player and Gazebo to evaluate the use of LIDAR, in particular the quality of the point map created by SICK LMS 200 and 291 LIDAR sensors, and increase in the number of SICK LMS 291 LIDAR sensors

The author concluded the increased use of high-quality LIDAR and STEREO sensors was a key factor because these sensors provide an accurate "point map" of the environment. The author considers this conclusion well-supported by the facts based on analysis and the success of teams which participated in the 2005 GCE.

Team 2005-06 successfully completed the 2005 GCE course using only two unknown SICK LIDAR sensors. All other successful teams used five LIDAR sensors during the 2005 GCE[10].

The two unknown SICK LIDAR sensors in use by Team 2005-06 were configured atypically compared to other successful teams which used LIDAR sensors, such as Teams 2005-13, 2005-14, and 2005-16. Team 2005-06 configured their LIDAR sensors to scan in a vertical plane, as opposed to a horizontal plane. The author therefore considers the orientation of LIDAR sensors to be testable, in addition to the number of LIDAR sensors. It is possible some patterns using fewer LIDAR sensors provide more useful information to the controlling intelligence than others using more LIDAR sensors.

III.E. Modify Player and Gazebo to simulate sensor “noise”

Simulated sensors are not subject to the same conditions encountered by research platforms. Rough terrain, rain, and fog, for example, are difficult to simulate realistically. However, several teams referred to these limitations specifically in their evaluation of the potential use of simulation. See paragraph II.E. As a result, the author identified simulation of sensor “noise” as a potential simulation target.