SIMULATION OF CURIOSITY AND EXO MARS ROVERS ON AGRICULTURE TERRAIN

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Abstract. Improving agricultural productivity is one of the biggest challenges Agriculture and Engineering face. A possible solution is the creation of soil databases and/or maps to apply precision agriculture techniques, aiming to produce more in the same land, using less agricultural supplies. This practice may be developed with the help of rovers applied to e.g. agricultural data collect, mapping, scouting and supply tasks. However, the rover needs to move and adapt to the terrain to obtain a real appropriate map of soil, and the correct application of supplies. In this context, this work presents the simulation of two types of rovers applied to precision agriculture. The models were developed in the software SolidWorks based on two rovers Curiosity and Exo Mars, developed by NASA and ESA, respectively. The paper presents the comparison between Curiosity and Exo Mars models, and their ability to navigate on real terrain. The parameters for comparison were torque, energy consumption and lateral deviation.

Keywords. *Mobile Robotics, Rover, Precision Agriculture, Simulation, Mechatronics*

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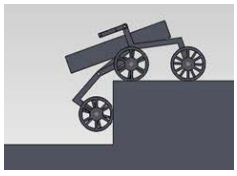
INTRODUCTION: According to IBGE (Brazilian Institute of Geography and Statistics) Brazilian agriculture is growing and currently corresponds to approximately 23% of GDP of the country. The expected growth is 2.4% for 2016 (CEPEA, 2015). This makes the country one of the principal agricultural suppliers in the world. The biggest challenge of producers nowadays is enhancing productivity using the same land and less supply. Therefore, current methods of food production have to be more efficient. For this reason, the use of new techniques and technologies to support agriculture production is remarkably important. Some of the new technologies to be applied in agriculture production are provided by mobile robotics. They are used to automate repetitive tasks and/or apply techniques of precision agriculture, assisting specific needs of each plant in the crop. These new technologies present considerable challenges. The agricultural environment, for instance, has spatial and temporal variability. It consists of an unstructured environment, where the development of outdoor mobile robotics platforms is relevant. The present research presents the models and simulations of two types of rovers used to spatial exploration - MSL (Mars spatial Laboratory) commonly named Curiosity, developed by JPL-NASA (North American Space Agency), (Welch, 2013) and ExoMars, developed by ESA (European Spatial Agency)(Patel, 2010). The models were studied and simulated in agricultural environment. The results contemplate energy consumption, torque and lateral slip comparative study.

METHODOLOGY: The methodology used was based on the one proposed by Faber Archila and Becker, 2013. Firstly, a study of passive suspension systems and work environment and application was carried out. It was followed by an investigation on kinematic and dynamic parameters. CAD (Computer Aided Design) and CAE (Computer Aided Engineering) models were developed. Respective simulations and findings allowed the comparison between Curiosity and Exomars. We used the topography of a perennial crop field in the simulations.

SIMULATIONS AND RESULTS: Two types of simulations were performed. The first one used a step terrain to compare the climb ability. The second simulation was run in a real terrain that was modeled and based on Maringa farm (Citrosuco). In the first simulation we obtained the maximum step to climb and the maximum to go down. According to the results obtained in the first phase, the rovers were tested using the same obstacle size. The results are presented on Tab. 1.

Table 1. Simulations results for step test.

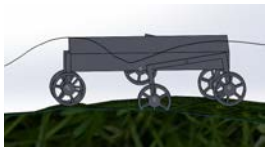
Rover	MAXIMUM STEP (CLIMB) [Wheel diameters]	MAXIMUM STEP (GET OFF) [Wheel diameters]	MAXIMUM TORQUE [N-m]	AVERAGE TORQUE [N-m]
MSL	1.85	1.05	1.399	0.141
ExoMars	2.86	1.19	1.964	0.194



The second simulation uses real terrain data obtained at Citrosuco, on Maringa farm, Brazil. The terrain was modeled in Solidwork and was used in the simulations. The simulation evaluated torque consumption and lateral deviation. The results are presented on Tab. 2.

Table 2. Simulations results for real soil.

Parameters	MSL	ExoMars
Maximum torque [N-m]	2.836	2.96
Higher average torque [N-m]	0.262	0.244
Total average torque [N-m]	0.194	0.237
Average power consumption [Watts]	2.967	3.618
Lateral deviation (Y/X)*100	1488/19733 7.54%	915/19956 4.59%



Conclusion or Summary

The first simulation used the models of rovers MSL, ExoMars and a controlled route. The metrics used were the capability to overcome obstacles and torque values. The best performance was ExoMars's. The second simulation used the models of MSL, ExoMars and real soil. The metrics were torque and lateral deviation. This simulation presents different routes to each rover using the same initial conditions. The best performance was MSL's.

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