Effect of Grouser Angle of Attack on Performance of Adjustable Robot Wheel Assistive Grouser

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Abstract. Wheeled rover mobile robot was designed to help human with the task that is out of human capability. Usually, it was used for driving over rough terrain for example on unconsolidated sandy dune incline. Normally rover was equipped with fixed grousers that were attached on its wheel but this type of wheel has a problem which is it tends to slip and sink into the sand. This problem happens when the wheel rotates and the grouser moves the sand from below of the wheel to the back of the wheel. This situation caused the sand accumulated behind the wheel. Previous researcher has designed an "assistive" grouser with adjustable angle to minimize the sand movement and subsequent sinkage to prevent this problem. The interaction between the rotation motion of an assistive grouser and the sand movement cannot be seen clearly during the experiment. The purpose of this study is to investigate the interaction between the rotation motion of single grouser and the sand movement by using computer simulation. Discrete Element Method (DEM) is used for the simulation process. From this simulation, the effect of grouser movement towards generated resistance force by the sand particles was observed. In high slip condition where the grouser rotates in a static position, when there is higher number of particles move upward toward the surface as the grouser rotated, it will cause the wheel to dig the sand surface. It has high tendency for the wheel to getting stuck in real experiment.

Keywords: Assistive grouser, Discrete Element Method, wheel rover.

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References

1. Arvidson, R.E., Bell, James., Bellutta, P., et al.: Spirit Mars Rover Mission: Overview and selected results from the northern Home Plate Winter Haven to the side of Scamander crater. Journal of Geophysical Research E: Planets 115(9), [E00F03] (2010). https://doi.org/10.1029/2010JE003633.
2. Wong, J.Y.: Terramechanics and off-road vehicle engineering : terrain behaviour, off-road vehicle performance and design. 2nd edn. Butterworth-Heinemann (2009).
3. Smith, W., Melanz, D., Senatore, C., Iagnemma, K., Peng, H.: Comparison of DEM and Traditional Modeling Methods for Simulating Steady-State Wheel-Terrain Interaction for Small Vehicles. In 7th Americas Conference of the ISTVS, pp. 4-7. Tampa, FL, USA (2013).
4. Ibrahim, A.N., Fukuoka, Y.: Effect of Assistive Grouser Mechanism on Lightweight Rover Power Consumption Pattern on Steep Soft Sand Inclines. In Intelligent Manufacturing & Mechatronics, pp. 343-351. Springer, Singapore (2018).
5. Ibrahim, A.N., Aoshima, S., Shiroma, N., Fukuoka, Y.: The Effect of Assistive Anchor-Like Grousers on Wheeled Rover Performance over Unconsolidated Sandy Dune Inclines. Sensors 16(9), 1507 (2016).