Traversability analysis using high-resolution laser-scans, simulation, and deep learning

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ABSTRACT

Traversability is of major importance in forestry, where heavy vehicles, weighing up to 40 tons when fully loaded, traverse rough and sometimes soft terrain. Forest remote sensing is becoming available at resolutions where surface roughness and slope can be determined at length-scales smaller than the forest machines. Using 3D multibody dynamics simulation of a forest machine driving in virtual terrain replications, the interaction can be captured in great detail. The observed traversability is then automatically a function of the vehicle geometry, dynamics, and of the local terrain topography relative to heading. We express traversability with three complementary measures [1]: *i)* the ability to traverse the terrain at a target speed, *ii)* energy consumption, and *iii)* machine body acceleration. For high traversability, the latter two should be as small as possible while the first measure is at maximum. The simulations are, however, too slow for systematically probing the traversability over large areas. Instead, a deep neural network is trained to predict the traversability measures from the local heightmap and target speed. The training data comes from simulations of an articulated vehicle with wheeled bogie suspensions driving over procedurally generated terrains while observing the dynamics and local terrain topology. We evaluate the model on laser-scanned forest terrains, previously unseen by the model. The model predicts traversability with an accuracy of 90% on terrains with 0.25 m resolution and it is 3000 times faster than the ground truth realtime simulation and trivially parallelizable, making it well suited for traversability analysis and optimal route planning over large areas. The trained model depends on the vehicle heading, target speed, and detailed features in the topography that a model based only on local slope and roughness cannot capture. We explore traversability statistics over large areas of laser-scanned terrains and discuss how the model can be used as a complement or in place of the currently used terrain classification scheme.

REFERENCES

[1] E. Wallin, V. Wiberg, F. Vesterlund, J. Holmgren, H. J. Persson, and M. Servin. Learning multiobjective rough terrain traversability. *Journal of Terramechanics*, 102:17–26, 2022.