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Abstract

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COMPARATIVE ANALYSIS OF TERRAIN PASSABILITY MODELS: EVALUATING HIGH-RESOLUTION AND LOW-RESOLUTION GEOSPATIAL DATA FOR UGV NAVIGATION

Ivan Potić[1]*, *Nina B. Ćurčić*[2], *Miroljub Milinčić*[3]

[1]Independent researcher, Belgrade, Serbia; e-mail: ipotic@gmail.com;
[2]Geographical Institute "Jovan Cvijić" SASA, Belgrade, Serbia; e-mail: n.curcic@gi.sanu.ac.rs;
[3]University of Belgrade, Faculty of Geography, Belgrade, Serbia; e-mail: miroljub.milincic@gef.bg.ac.rs.

This study investigates the resolution threshold limits of terrain passability maps, determining their applicability for unmanned ground vehicle (UGV) navigation and their usability for larger, human-operated vehicles. The research compares the effectiveness of high-resolution data, including 0.1 m Digital Terrain Models (DTM) derived from LiDAR and photogrammetric point clouds, with medium- to low-resolution satellite imagery and Digital Elevation Models (DEMs). The focus is on identifying the resolution at which passability maps remain effective for UGVs and the point at which lower resolutions become suitable only for larger vehicles due to the loss of necessary details for precise navigation. Additionally, the study explores the impact of environmental variability on passability assessments, considering factors such as seasonal changes and varying weather conditions that can significantly alter the usability of different resolution maps.

By examining the influence of terrain features—such as slope, terrain indices, soil conditions, land cover, hydrological features, and road networks—on vehicle passability, the study aims to establish a clear threshold. This threshold defines the transition between maps suitable for UGVs and those more appropriate for more extensive, human-operated vehicles. The study utilises a multi-criteria decision-making (MCDM) approach, with GIS, CAD software, and Python programming language employed to process and analyse the geospatial data. The results are synthesised into passability maps with varying resolutions, highlighting the advantages and limitations of each. The findings demonstrate that high-resolution data are crucial for producing reliable passability maps for UGVs, while medium- to low-resolution maps may suffice for larger vehicles, particularly on less complex terrains.

This research offers valuable insights for different applications in which the accuracy of terrain passability assessments is critical for operational success. By establishing the resolution limits of passability maps, this study contributes to optimising vehicle navigation across diverse terrains, ensuring the appropriate use of geospatial data based on vehicle type, operational requirements, and environmental conditions.

Keywords: Terrain Passability Thresholds; Multi-Criteria Decision-Making (MCDM); Geospatial Data Resolution; UGV and Human-Operated Vehicle Navigation; High-Resolution Land Cover Modelling

*Corresponding author, e-mail: ipotic@gmail.com