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# Automated Extraction and Cartographic Visualisation of Agricultural Machinery Trajectories to Assess Soil Erosion Risks: A Proof-of-Concept Study

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**Abstract:**

Soil erosion remains a critical threat to high-quality arable land in Czechia, largely driven by inappropriate tillage and land management practices. A significant contributing factor is soil compaction caused by the movement of heavy agricultural machinery. This proof-of-concept study uses freely available Czech orthoimagery with a spatial resolution of 12.5 cm/px to identify and extract trajectories of agricultural machinery over a limited geographical area in the Moravian region. To achieve this, we developed a custom annotated dataset of thousands of trajectories. This dataset was used to train and evaluate several deep learning segmentation models, including traditional Convolutional Neural Networks (CNNs) and Vision Transformer architectures. The best-performing model was subsequently selected and deployed for the automated detection of agricultural machinery trajectories across the study area. Furthermore, the segmentation accuracy of these models is evaluated against the Normalized Difference Vegetation Index (NDVI) to determine the relationship between detection performance and vegetation height.

The extracted trajectories serve as a critical variable for defining tillage techniques and assessing their impact on soil erosion. We spatially analysed selected farming practices, such as prevailing ploughing directions, field entry directions, and the intersection angles of agricultural machinery trajectories relative to slope gradients and contour lines, all in the context of field shape, slope, and crop yield. This analysis is supported by morphometric data and the RYPE tool, which is used to estimate relative crop yield from long-term series of Sentinel and Landsat imagery. In addition to examining the morphometry characteristics of trajectories, this study includes a multi-temporal analysis comparing 2022 and 2024 data to monitor changes in trajectory patterns and directions over time. This temporal framework will be expanded in the future as new orthoimagery of Czechia is published. To effectively communicate these complex spatial relationships, this study employs advanced cartographic visualisations, including bivariate maps, trajectory heatmaps, or 3D terrain models.

This study serves as a proof-of-concept covering a selected area of approx. 30 000 ha near Brno to test and demonstrate the segmentation algorithms and the used methodology. In the future, we aim to scale this methodology across the entire agricultural lands of Czechia. The results provide a foundation for scaling the automated analysis nationwide to identify trends in field management practices and examine possible relationships between agricultural machinery trajectories and field morphometry. Ultimately, these trajectories could serve, together with field morphometry, as a proxy indicator of soil erosion and health.

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