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Can machine learning help to unify river selection for small-scale map design?

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Abstract:

Automated river network selection is a crucial component in the process of map generalization, as it helps to simplify and enhance the readability of small-scale maps. Recent research incorporating artificial intelligence (AI) has shown promising results in river network generalization (Yan et al., 2022), (Wang & Qian, 2023), (Yu et al., 2023). Building on this progress, we want to take it a step further and make one of the first attempts to unify the selection process for river networks on general geographic maps.

In this study, we aimed to automatically select rivers using machine learning-based methods (ML). The input data included the Map of Hydrographic Division of Poland (MPHP) database covering the area of Poland and the swissTLMRegio database for Switzerland. This work focused on 10 river basins in Poland and 5 river basins in Switzerland (Fig. 1). Previous research suggested that enriching the databases, among others, also with physical-geographical and topological variables, as well as calculated measures, could improve the selection results (Le Mao et al., 2024). Consequently, both databases were supplemented with previously selected topological and physical-geographical attributes, including among others: codification of hydrographic units, length, distance from the river segment to the water reservoir, number of settlements within a 1.5 km radius, number of inhabitants in the nearest settlement, length of the flow path, depth of the valley, slope gradient, and slope length. The selection process was conducted using three ML-based methods: decision tree (DT), random forest (RF), and decision tree with genetic algorithms (DT-GA). The methods were developed on the basis of previous studies (Karsznia & Weibel, 2018; Ajdacka, 2022; Karsznia, 2023). In the application of each ML-based method, one unified model for the dataset covering Poland and Switzerland was designed. The overall accuracy of the models ranged from 86% for DT, 78% for RF, to 87% for DT-GA. The generalization results were compared with reference maps, specifically a map developed by the Head Office of Geodesy and Cartography in Poland at a scale of 1:500,000, and the vector National Map of Switzerland at a scale of 1:500,000. The continuity of the overall river network was kept in most of the cases, with some exceptions for certain river basins. Nevertheless, the resulting generalized river networks in Poland and Switzerland look promising both in the quantitative as well as qualitative aspects. Moreover, it should be underlined that one generalization method characterized by the same set of attributes was applied and verified for the two considered countries.

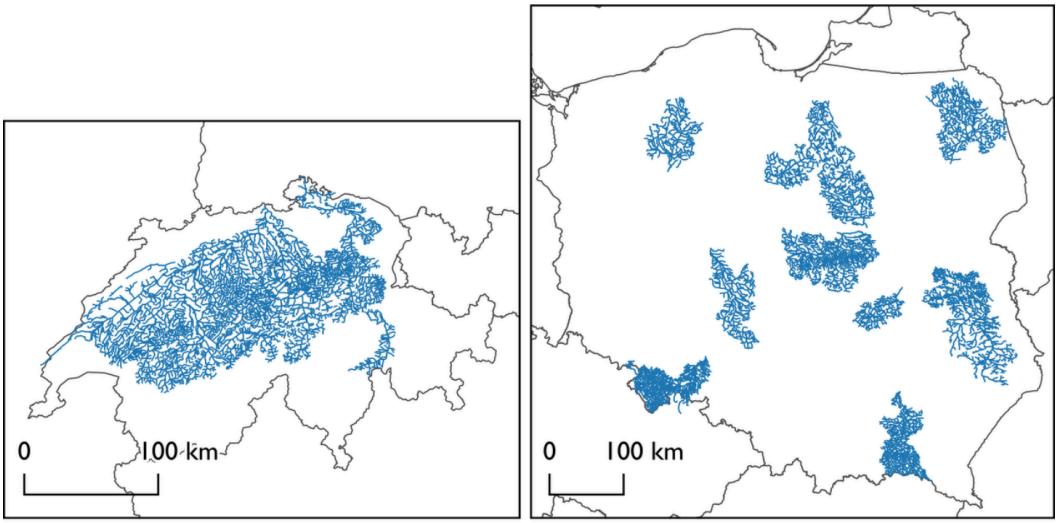

Fig. 1. Source data chosen for generalization from Switzerland and Poland.

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References

Ajdacka I., (2022). The use of decision trees (DT) to automate the selection of rivers for small-scale maps (Wykorzystanie drzew decyzyjnych (DT) do automatyzacji selekcji rzek na mapach ogólnogeograficznych), master thesis in the field of geography, written under the supervision of dr Izabela Karsznia, University of Warsaw, Warsaw.

Karsznia, I. Weibel, R. (2018). Improving Settlement Selection for Small-scale Maps Using Data Enrichment and Machine Learning. Cartography and Geographic Information Science 45(2), pp. 111-127. doi: 10.1080/15230406.2016.1274237

Karsznia, I. (2023). Machine Learning and Geospatial Technologies. In: Alexander J. Kent and Doug Specht (Eds.) The Routledge Handbook of Geospatial Technologies and Society. ISBN 9780367428877, doi: 10.4324/9780367855765-25

Le Mao, B., Ajdacka, I., Karsznia, I., Touya, G., and Adolf, A.: Enriching river network data for multi-scale machine learning based selection: a case study of Poland and France, Abstr. Int. Cartogr. Assoc., 7, 83, https://doi.org/10.5194/ica-abs-7-83-2024, 2024.

Wang, D., & Qian, H. (2023). Graph neural network method for the intelligent selection of river system. In GEOCARTO INTERNATIONAL (Vol. 38, Issue 1, p. 2252762). https://www.webofscience.com/wos/woscc/full-record/WOS:001060064700001

Yan, C., Liu, X., Boota, M. W., & Pan, Z. (2022). A Comparison of Machine Learning Methods Applied to the Automated Selection of River Networks. In CARTOGRAPHIC JOURNAL (Vol. 59, Issue 3, p. 187). https://www.webofscience.com/wos/woscc/full-record/WOS:000854622100001

Yu, H., Ai, T., Yang, M., Huang, L., & Gao, A. (2023). Automatic segmentation of parallel drainage patterns supported by a graph convolution neural network. In Expert Systems with Applications (Vol. 211, p. 118639). https://doi.org/10.1016/j.eswa.2022.118639

Yu, H., Ai, T., Yang, M., Huang, W., & Harrie, L. (2023). A graph autoencoder network to measure the geometric similarity of drainage networks in scaling transformation. In International Journal of Digital Earth (Vol. 16, Issue 1, p. 1828). https://doi.org/10.1080/17538947.2023.2212920