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Map Generalization using Deep Learning and Constraints: Best of both worlds?

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Abstract:

During the last decades, several paradigm shifts furthered the research on the topic of automated map generalization, introducing then novel approaches such as constraints (Harrie & Weibel, 2007) and agent-based modeling (Duchêne et al., 2018) to cartography. Although these concepts were successfully implemented at several National Mapping Agencies with very promising results, the whole generalization process became very complex and hard to parameterize, leading to some degree to a stagnation in development.

Following the first upcoming applications of deep learning in the field of map generalization (e.g., Feng et al., 2019), a new major impact to the research field was anticipated and according to expectations, numerous approaches applying deep learning techniques to different steps of the map generalization workflow were published ever since. Thereby, most progress was done on tasks such as map feature engineering and operator implementation, while other main steps of the generalization workflow such as operator type selection or process modeling are still under-represented in the scientific literature (Zhou et al., 2026).

Among others, there are two major challenges when implementing deep learning-driven methods to map generalization: First, these models need diverse, balanced and scale-appropriate datasets to learn from. Second, during the learning process, the evaluation of the current model output should be conducted not only by using standardized loss functions, but with respect to cartographic principles.

At this point, one can refer back to the advances of defining constraints and respective measures to formalize and integrate cartographic knowledge into the map generalization workflow. In deep learning models, these constraints could thereby operate as evaluation measures between the original data input and the proposed model output, possibly making the need of sophisticated datasets redundant.

In this work, we therefore investigate the utility of constraint-based loss functions in deep learning models for map generalization, starting with point datasets. First, we integrate different constraints, or measure satisfaction functions respectively, into our Graph Convolutional Neural Network (GCNN) and analyze their effects on the results, starting with the operation of point reduction. As a baseline, we will compare the output of our model quantitatively and visually with basic reduction algorithms such as K-Means, Quad Tree or Label Grid, but also with the output of the deep learning point selection approach of Xiao et al. (2024). In a second step, we apply our constraint-based GCNN model approach to a thematic point generalization task, and compare the results with the output of a comparable agent-based model (Knura & Schiewe, 2024) using the same constraints.

The presentation will present preliminary findings and outline future work, where we will extend our experiments on more complex geometries such as lines and polygons.

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