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Machine Learning-Based Coastline Classification for Semantic Enrichment in Map Generalization

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Abstract:

Coastline generalization has been a subject of research within the cartographic community for several decades. In nautical charts in particular, it is a critical process, as it affects not only map legibility and the effective communication of spatial information, but also the fundamental requirement of safe navigation. Previous automated generalization approaches have demonstrated that semantic enrichment of the source data constitutes a crucial step in the generalization workflow, enabling more informed and consistent generalization decisions. However, despite its importance, the reliable implementation of semantic enrichment remains challenging, particularly for complex coastline structures.

Traditional analytical cartographic methods support this enrichment process by identifying the shape of different coastline elements (Skopeliti et al., 2021). However, they face significant challenges when dealing with complex artificial coastal structures, where the intricate geometry of features such as marinas hinders the reliable identification of morphological types. This limitation restricts the automation of the generalization process, particularly in cases where knowledge of a structure's morphology is required to apply specific generalization rules, as reflected in the guidelines of the International Hydrographic Organization (IHO).

In recent years, there has been a growing interest in the integration of Machine Learning (ML) techniques within map generalization workflows (Courtial et al., 2024; Karsznia et al., 2024; Feng et al., 2019). Although these approaches have primarily focused on other cartographic features, their results demonstrate promising potential for improving automation and supporting data-driven decision-making. Initial efforts have also begun to address coastline-related tasks, including coastline shape classification (Gao et al., 2024; Knura, 2024), highlighting the relevance of ML in this domain.

To address these limitations, this study investigates the integration of Machine Learning into the data enrichment stage, focusing on the classification of coastline segments as natural or artificial. As an initial step, the problem is formulated as a supervised binary classification task in order to evaluate the fundamental capability of ML models to distinguish between these two classes. The proposed framework utilizes Electronic Navigational Charts (ENCs) provided by the National Oceanic and Atmospheric Administration (NOAA), using labels derived from existing ENC attributes. A key challenge in this context lies in how coastline geometry is represented in a way that enables effective learning.

A central aspect of this work is the exploration of geometry-driven representations of coastline segments. Initially, classification is performed using only raw geometric information, represented as sequences of coordinates derived through a fixed segmentation strategy. This approach aims to assess whether ML models can capture meaningful morphological patterns directly from geometry, without relying on handcrafted cartographic features.

Subsequently, the framework is extended to incorporate additional geometric descriptors inspired by traditional cartographic analysis, such as angular relationships between consecutive segments. This enables a comparative investigation between geometry-only and feature-enriched representations, providing insight into when and to what extent domain-specific knowledge improves classification performance.

The proposed workflow consists of five stages: (i) exploration and preparation of ENC coastline data, (ii) coastline segmentation, (iii) geometric representation using either raw coordinates or geometry-derived descriptors, (iv) supervised classification of coastline segments into natural and artificial classes, and (v) integration of the predicted semantic labels into subsequent coastline generalization workflows.

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This work evaluates the potential of Machine Learning techniques to support semantic enrichment in coastline generalization workflows. By focusing on this fundamental classification stage, the proposed approach aims to establish a scalable foundation for more advanced, morphology-aware generalization processes in nautical cartography. As the study is currently in the experimental phase, its primary contribution lies in the design and evaluation of the proposed framework, providing a foundation for future morphology-aware coastline generalization rather than reporting finalized classification results.

References

Courtial, A., Touya, G., Zhang, X., 2024. DeepMapScaler: a workflow of deep neural networks for the generation of generalised maps. Cartography and Geographic Information Science, 51(1), pp. 41–59.

Feng, Y., Thiemann, F., Sester, M., 2019. Learning cartographic building generalization with deep convolutional neural networks. ISPRS International Journal of Geo-Information, 8(6), 258.

Gao, A., Ai, T., Yu, H., Xiao, T., Chen, Y., Li, J., Huang, H., 2024. A vector-based coastline shape classification approach using sequential deep learning model. International Journal of Applied Earth Observation and Geoinformation, 129, 103810.

Karsznia, I., et al., 2024. Using machine learning and data enrichment in the selection of roads for small-scale maps. Cartography and Geographic Information Science, 51(1), pp. 60–78.

Knura, M., 2024. Learning from vector data: enhancing vector-based shape encoding and shape classification for map generalization purposes. Cartography and Geographic Information Science, 51(1), pp. 146–167.

Skopeliti, A., Tsoulos, L., Pe'eri, S., 2021. Depth contours and coastline generalization for harbour and approach nautical charts. ISPRS International Journal of Geo-Information, 10(4), 197.

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