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Efforts to Streamline Bathymetry Compilation for Marine Navigation

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Abstract:

Maritime shipping is the backbone of international trade and the global economy, as it is the most economically and environmentally efficient mode of transport. To ensure the safe navigation of ships and timely delivery of goods to global ports, mariners rely on up-to-date nautical charts, which portray navigation related information of the coastal and marine environment. Updating nautical charts, and particularly the bathymetric information, is not only costly but also a challenging and time-consuming task. Specialized vessels collect high-resolution bathymetry that is subsequently generalized by cartographers to the scale of the product. Spot soundings and depth curves, complemented by features such as rocks and wrecks, are used to maintain and emphasize the morphological details and characteristic features of the seafloor on charts. Among the vast number of survey soundings, the cartographer is called to select only a fraction of representative soundings for charting, and to produce safe and aesthetically pleasing depth contours from the raw derivations. This work reviews the automation efforts in increasing the efficiency of nautical chart compilation.

The two primary product constraints driving chart data generalization are safety and topology. For the safety constraint, the requirement is that the expected depth, based on the charted bathymetry, must not appear deeper than the source information. Safety is of utmost importance in nautical cartography and the reason that most algorithms developed for topo mapping are not readily applicable for use in the domain. In terms of topology, for example, displacement of soundings, self-crossing of contours, as well as gaps and overlaps of the, so-called, “Skin of the Earth” features are not permitted. Violation of the former may result in vessels’ groundings, whereas violations of the latter may cause the Electronic Chart Display and Information Systems (ECDISs) on board, loaded with the official Electronic Navigational Charts (ENCs), to crash (while they may also be a safety issue). The two primary product constraints are further restricted by specific ENC requirements, such as the minimum distance between vertices composing line segments (“point-density”), which makes cartographic generalization tasks even more challenging.

A long-term goal of the cartographic community has been the automation of the tasks involved in nautical chart production, and particularly those associated with bathymetry, with the aim to streamline the data collection to product dissemination workflow. Various researchers have developed algorithms for sounding selection and depth contour generalization and the IHO has compiled a series of validation tests for the verification of safety and topology. Recent works have identified some limitations and proposed improvements to the –not exhaustive– list of validation tests. This work reviews the current state of the art in automation of the above generalization tasks, as well as recent efforts for modelling the compilation workflow towards a fully automated solution, their limitations, challenges, and possible future work. For example, most automation efforts in sounding selection investigate the task in isolation, although it is known that depth contours and other features play a role in making the cartographic judgements. Furthermore, they predominantly do not assess the safety of the output; however, recent works incorporate forms of safety validation in their process. Also, the output of contour generalization algorithms is sometimes judged as unnatural, or that contours may be pushed extensively toward deep waters, or, most commonly, that the contours’ point density exceeds the requirements for ENCs and ECDIS.

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