FRED: An Automated Change Detection System that Keeps the Cartographer in the Loop

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Introduction

The international maritime community's ongoing digital transformation has resulted in an exponential increase in the volume of Electronic Navigation Chart (ENC) data. National Geospatial-Intelligence Agency (NGA) analysts face the challenge of processing and analyzing this data influx to identify critical changes within the 28-day cycle to ensure Maritime Safety of Navigation. How can cartographic agencies leverage technological innovation to manage this operational tempo while preserving, and even enhancing, the importance of human expertise?

This work introduces FRED (Find and Rank ENC Differences), a system developed by NGA in collaboration with the Naval Research Lab (NRL) and Oak Ridge National Labs (ORNL). It provides an automated change detection capability to ensure the accuracy and timeliness of maritime safety products. The FRED workflow creates a human-machine team that efficiently balances automation with expert intervention.

Method

The FRED system achieves its objectives through a structured, three-step workflow that integrates human expertise with automated decision-making.

Step One: The Selector Tool

The Selector Tool is where an NGA analyst first interacts with the system. The interface allows analysts to register for ENC cell subscriptions. When a source's geographic footprint changes, analysts are given a choice of "new coverage"; when coverage is deleted, they are offered a "suggested replacement." This initial step ensures the cartographer remains in control of the data pipeline. On the backend, the Selector's automated Decider service continuously monitors for new ENC versions in the Maritime Source Processing System (MSPS), retrieves the relevant data, and forwards it for comparison.

Step Two: The Differencing Tool

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Step two uses the Differencing tool, developed by NRL in conjunction with NGA analysts, to categorize changes into three types: Critical, Non-Critical, and Eyes-On. It is the Eyes-On category—those instances where the ruleset was uncertain—that triggers the system's most innovative component: DALE (Deep Active Learning for Electronic Navigational Charts). DALE is an AI model that analyzes uncertain data and assigns predicted criticality with a confidence score. This enables analysts to focus their limited time and attention on the most difficult cases, bringing the cartographer back into the loop via the web-based Review Tool.

Step Three: The Review Tool and AI Accuracy

The Review Tool is where the cartographer actively collaborates with the AI. The analyst is presented with a rich geospatial environment featuring side-by-side map views and attribute comparisons. For the "Eyes-On" findings, DALE provides its prediction. The analyst's task is to validate or correct this assessment, making the definitive determination of whether a change is "Critical" or "Non-Critical."

This human-verified decision is not just a quality control measure; it is the critical input for DALE's active learning framework. The model is continually retrained on these expert decisions, allowing the AI to learn directly from their nuanced expertise. This symbiotic process has enabled the DALE AI model to achieve over 80% accuracy in predicting change criticality.

Discussion and Conclusion

The ultimate goal of the FRED workflow is to continually refine DALE to where human analysts need only review the most marginal of changes. FRED is a prime example of a system designed not to replace but to empower cartographers, enhancing efficiency and ensuring navigational safety in an age of information overload.

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