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Explainable Unsupervised Model for Coastline Change Monitoring in Sentinel-2 Time Series

The problem of coastline erosion is of global concern. Acquisition and processing of useful earth observation data about coastal changes is crucial to accurate change monitoring [1]. With the availability ofsophisticated machine learning techniques, it is possible to accurately detect and analyze patterns of changes in coastal regions. One important aspect here is the explainability of the machine learning model used to predict changes and the possibility to incorporate human expertise in the process of detection [2]. In this research, we use an explainable artificial intelligence model to discover data patterns in Sentinel-2 time-series images to describe changes over a 7-year study period. Timeseries imagery was acquired every month from January 2018 to September 2023, covering 4,694 cloudfree locations along the North Sea and Baltic Sea coastlines, each spanning 5 km x 5 km. These locations were selected using farthest point sampling to ensure representative coverage. The imagery was further divided into smaller scenes of 1.28 km x 1.28 km, and active learning techniques were employed to minimize labeling efforts. We have used Latent Dirichlet Allocation (LDA), a Bayesian generative model recently established as explainable model [1]. Being a probabilistic model, LDA is able to output certainty score for its predictions. We use the LDA as an unsupervised explainable model to create interpretable intermediate visual outcomes that support model explainability, while certainty scores of each prediction enhances trust. These interpretable outcomes are used by the domain expert to assess quality of the outcomes. Two kinds of visualizations are produced: 1) visual topic maps -LDA retrieved visual topics depicting latent data patterns, often perceived by humans as visual objects 2) change class maps and change signature maps - maps showing which land cover classes (e.g wavebreaking zones, dry sand, inter-tidal area, vegetation) have gone through most changes (we produce histograms showing percentage of change per class per year, and also over the whole study period); change signatures describe the nature of change in every class. We conclude the research by validating our results by domain experts.

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