

# A Robust AI Framework for Monitoring Dynamic Coastline Changes

Coastal areas are increasingly threatened by climate change, stronger storms, and increased flooding, causing risks to ecosystems, communities, and tourism. Monitoring coastline changes is essential for informed decision-making and effective protection strategies. However, current deep learning-driven approaches for monitoring coastline changes face significant challenges, including limited adaptability to varied environments and a reliance on large amounts of labelled data.

To address these challenges, a novel AI approach is proposed using Supervised Contrastive Learning (SupCon), a machine learning technique that improves performance by grouping similar data points while distinguishing them from dissimilar instances. A coordinate attention mechanism is integrated, which can preserve precise positional details, and long-range dependencies along both horizontal and vertical directions. Critical coastal features are obtained, improving the robustness and accuracy in detecting subtle shoreline changes.

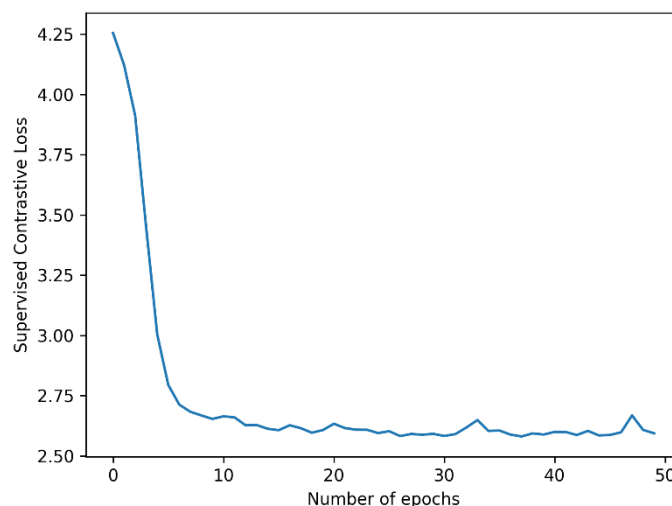


Fig. 1. Coordinate supervised contrastive loss.

The supervised contrastive loss function in Figure 1 highlights a high initial loss due to poor embeddings being learned. As training progresses, the model has an enhanced ability to identify coastline change dynamics and distinguish between transects. Therefore, the model can effectively learn spatial relationships between the transects.

The proposed approach demonstrates an improved accuracy of 97.40% for classifying shoreline change compared to traditional supervised deep learning approaches of 61.04%, and basic SupCon of 75.97%.

The proposed method achieved superior performance in coastal erosion classification, improving the monitoring capabilities by making an adaptable model that requires lower labelled data. This advancement could empower governments and organizations to develop more effective mitigation strategies to protect vulnerable coastal areas.