**Geomorphological mapping of intertidal areas**

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Meng Lu [To co-authors: please add your name and affiliation]

**Introduction**

Geomorphological maps are essential for the management and ecological conservation of the intertidal areas. The classic method that manually delineates different classes from false-colour aerial images is labour intensive and subjects to inconsistency, i.e., an expert may change his opinion or different experts may give different opinions. More recently, the application of OBIA (object-based image analysis) method obtained in general promising results but performed unsatisfactorily in for several classes, namely shoal flat low dynamics (P1), shoal flat high dynamics (P2a), and shoal mega ripples (P2b). Moreover, further separating of P1 with surface formed by sands (P1a) and silts (P1b), which is valuable for tidal area management, is not accomplished in the current OBIA method and is extremely challenging from inspecting spectral features. OBIA allows integrating of prior knowledges, however, when applied alone, does not contribute to feature learning and understanding feature impacts. In this study, we harness machine learning methods in automatic geomorphological mapping and provide insights into the OBIA- and deep neural network-based semantic segmentation, their strengths, limitations, and complementary capabilities.

**Objective**

The objectives of this study are to 1) understand which and how features contribute to the tidal area geomorphological mapping, with a focus on delineating the challenging classes mentioned above (P1a, P1b, P2a, P2b), 2) improve automatic geomorphological mapping in the tidal area, and 3) compare between OBIA- and deep neural networks-based methods in terms knowledge mining and to study the combination of them.

**Methodology**

We used aerial imagery with red, blue, and NIR bands, and DEM of 0.3-meter resolution and form vegetation and other indices. The study is conducted in two study areas, Western Scheldt and Wadden Sea, Netherlands, to evaluate model generality. Three types of methods are developed and compared in terms of the knowledge integrated, model interpretability, and the prediction accuracy and patterns. Method (A) firstly applies OBIA for segmentation and then uses statistical learning methods (e.g. random forest, boosting) to understand feature impacts and optimise predictions. The main challenge and intensive evaluations lie in identifying the spatial unit in OBIA. Method (B) develops and applies end-to-end, encoder-decoder deep neural network architectures. Besides interpreting features extracted at activation layers, we apply channel-attention modules to integrate and understand the impacts of spectral features and DEM, and spatial attention modules with dilated convolutions and multi-scale network architectures for the contextual features. Method (C) applies OBIA to the segmented output from deep neural networks to integrate prior knowledge. At last, we invest in applying generative models and image augmentation to enhance features at the pre-processing stage.

**Impact**

This study is both application- and method-driven. It expects to gain us an in-depth understanding of features that contribute to tidal area classification and greatly improve the automation and prediction accuracy. We emphasize model interpretability and knowledge mining. By comparing and combing OBIA- and deep learning-based models, this study contributes to the development and integration of both methodology domains for semantic segmentation.