論文の要旨

題 目　Development of Practical Methods for Detecting Floating Marine Debris and Classification of Underwater Seaweed / Seagrass Beds in the Seto Inland Sea Using Satellite Data
（衛星データによる瀬戸内海の海洋ごみ検出と藻場分類の実用的な手法開発に関する研究）

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Since the last century, anthropogenic climate change, commonly referred to as ‘global warming’ has emerged as a pressing concern. The concentration of CO2 has surged from 280 parts per million (ppm) in 1750 to 368 ppm by 2000, reaching levels unprecedented in at least the past 420,000 years. Concurrently, global mean surface temperatures have witnessed a rise of approximately 0.6 degrees over the past century, contributing to the escalation of tropical cyclones and potentially amplifying their intensity. In light of these environmental challenges, the detection and classification of vegetation in a wide region have become crucial components in mitigating the greenhouse effect and facilitating post-disaster reconstruction. Specifically, the preservation and restoration of seaweed and seagrass beds have gained paramount significance due to their proven capacity for substantial carbon storage. Simultaneously, the imperative for immediate post-disaster reconstruction has intensified, driven by the escalating damages wrought by climate-related disasters.

However, regarding the detection and classification of vegetation, the existing algorithm in remote sensing fields, such as Leaf Area Index (LAF) and Normalized Vegetation Index (NDVI) have been proposed to solve the problem of detecting vegetation. And Sargassum Index (SI) has been proposed for Sargassum detection. Nevertheless, none of them can realize the detection and classifying seaweed and seagrass beds growing beneath the water surface. Simultaneously, concerning the detection of vegetation debris detection for post-disaster reconstruction, common methods involve the use of buoys equipped with Global Positioning System (GPS), aerial photographs, and visual observation. However, these methods face challenges in promptly locating marine debris, prompting the exploration of remote sensing technology applications. Although there has been some algorithm that can detect floating vegetation, such as Floating Algae Index (FAI), the high turbidity marine environment after disaster obstacles to an accurate detection.

Based on the background mentioned, this study aims to propose practical methods for detecting and classifying vegetation in the Seto Inland Sea. Specially, this study initially utilized the corrected Floating Algae Index (cFAI) and the Otsu method to reproduce the marine debris distribution immediately after the July 2018 Heavy Rains in Western Japan, using multidate Landsat-8 Data. Secondly, an algorithm, named Sargassum and Zostera Distinguishing Index (SZDI) was proposed for distinguishing Sargassum and Zostera using Sentinel-2 Data. Thirdly, for reducing the algorithm development time and program creation time for distinguishing Sargassum and Zostera, an unsupervised learning model, K-Means has been attempted to be employed.

This dissertation is composed of six chapters. Chapter 1 clarifies the background, the objectives, and the study areas of this study. In Chapter 2, several existing plant detection algorithms and studies focused on distinguishing seaweed and seagrass beds are introduced. In Chapter 3, a practical method for detecting marine debris immediately after the July 2018 heavy rains in western Japan using multidate Landsat-8 data is proposed and described. By abstracting the spectral reflectance of marine debris, it was confirmed that the marine debris consists of vegetation, meeting the prerequisite of the cFAI method. Subsequently, the turbid background caused by heavy rain was removed using the cFAI method, and effective automatic binarization of cFAI was achieved through the application of the Otsu method. Ultimately, the marine debris distribution was reproduced. In Chapter 4, an algorithm, named Sargassum and Zostera Distinguishing Index (SZDI) for distinguishing Sargassum and Zostera beds using Sentinel-2 data is proposed and described. The results of the field survey conducted in 2021 reveal the spectral reflectance characteristics of Sargassum and Zostera, indicating that both of them exhibit peak reflectance between the blue and red band, but Zostera exhibit relative high reflectance in the green band. Based on these characteristics, SZDI was proposed, and the distribution map of Sargassum and Zostera was generated. In Chapter 5, an attempt to distinguish Sargassum and Zostera using machine learning is conducted and discussed. The K-means clustering is confirmed to be effective for classifying Sargassum and Zostera in this study area in some aspects. Besides, this model demonstrates prominent advantages, including an objective process and a shorter development time for algorithms and programming. In Chapter 6, the conclusions of this study are described.