DETECTION OF ALGAL BLOOM IN WATER RESERVOIRS BASED ON SATELLITE IMAGERY AND CNN

Bartłomiej Ostrowski
Warsaw University of Technology
Warsaw, Poland
bo.1999@wp.pl

Stanislaw Osowski
Warsaw University of Technology and Military University of Technology
Warsaw, Poland
stanislaw.osowski@pw.edu.pl

***Abstract*— The paper is devoted to the early recognition of bloom areas of surface water based on satellite imagery data from the Sentinel-2. The original images delivered by the satellite are subjected to special processing, resulting in transformed forms that use spectral representation. The dataset of these transformed images is used to train convolutional neural networks (CNNs) to recognize three classes: class 1 - no algal bloom, class 2 - threat of a bloom, and class 3 - state of a bloom in surface waters. The CNN Xception model, selected as the best, was used in experiments. The numerical results from data across different areas of Poland have shown the potential of the developed system for early recognition of algal blooms.**

Keywords— algal bloom, satellite imagery, image processing, convolutional neural networks CNN.

I. INTRODUCTION

Algae are a diverse group of water-living primitive plants. The existence of algae in water may result in harmful effects like blocking sunlight, causing a depletion of oxygen levels in the water, releasing natural toxins into the water, or mechanical damage to other organisms. Blooms may harm aquatic life and can lead to fish die-offs, cities cutting off water, etc. The most important factor in reducing the impact of algae on natural water resources is early recognition of the danger. This paper concerns such a task. It describes the steps for processing the available Sentinel-2 images to identify bloom areas and determine the level of bloom danger. Three classes have been considered: class 1 - no algal bloom, class 2 - threat of bloom, and class 3 -state of bloom

II. SATELLITE IMAGE PREPROCESSING

The numerical experiments concerning algal bloom areas have used images from the Sentinel-2 mission within the Copernicus program, which monitors Earth's environment. The first task is to automatically recognize water areas in the image. This is based on the Normalized Difference Water Index (NDWI). The NDWI index yields positive values for water features and negative or zero values for soil and terrestrial vegetation. The water areas are found applying the thresholding operation in the analyzed images. For the water areas, the direct B5/B4 index will be used. It is based on the red (band B4, 650-680 nm) and red-edge (band B5, 698-713 nm) ratios.

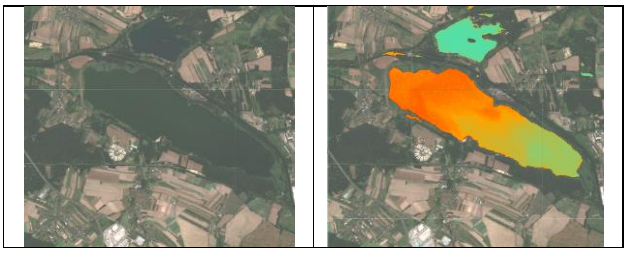

Fig. 1 The original Sentinel-2 image of the Earth's surface (left) and in B5/B4 representation (right).

Fig. 1 compares the original Sentinel-2 image and its B5/B4 index representation.

III. CNN APPROACH TO ALGAL BLOOM RECOGNITION

To avoid the problem of a strict definition of class boundaries, we have developed a deep learning method based on convolutional neural networks. The B5/B4 representation of satellite images, generated according to the procedure described above, is used to split the data into training and test sets for the CNN. The grey-scale image of the extracted water area are used to prepare training data for convolutional neural networks. According to the different (rather large) sizes of the investigated body of water, we have divided it into smaller subregions of size 300x300.Such sub-images are next classified into 3 classes: class 1 - no algal bloom, class 2 - threat of bloom, and class 3 -state of bloom. Many pre-trained CNN structures available in Python have been tried. They include VGG16, VGG19, Xception, Inceptionv2, InceptionresnetV2, Densenet201, Densenet121, Nasnetlarge, Resnet152, Resnet50, EfficientNetB1, and EfficientnetB7. The results of these experiments indicated that Xception is the most successful on this task.

IV. RESULTS OF EXPERIMENTS

Fig. 2 presents the results of applying Xception, shown as a confusion matrix, on the test data not used in the learning.

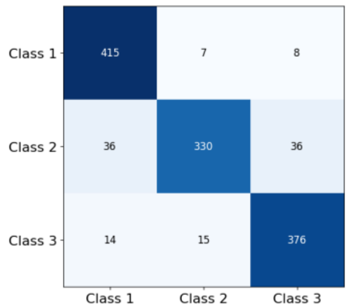

Fig. 2 The confusion matrix representing the results of 3-class recognition using the Xception classifier.

The next experiments checked performance of the developed system when using testing data from other parts of the country, which is different from those taking part in previous experiments. This test was performed using 300 samples (100 per class). The results of such a test are presented as the confusion matrix given below.

	Class 1	Class 2	Class 3
Class 1	94	6	0
Class 2	6	71	23
Class 3	0	18	82

The results are of slightly lower quality. The average accuracy across all classes is now 82.33%, compared to 90.62% in the previous case.

V. CONCLUSIONS

Numerical experiments have demonstrated the potential of the proposed method for predicting algal bloom risk using satellite imagery. Thanks to the GUI application, it can help assess the condition of the country's water reservoirs and pinpoint potential risks.