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# IMAGE CLASSIFICATION OF HYPERSPECTRAL REMOTE SENSING USING SEMI-SUPERVISED LEARNING ALGORITHM

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***Abstract:* The paper considers the problem of detecting explosive objects from an unmanned aerial vehicle equipped with a hyperspectral (multispectral) camera. A new method for solving the problem of classifying hyperspectral images using semi-supervised learning is proposed.**
***Keywords:* explosive ordnance detection, unmanned aerial vehicle, hyperspectral camera, semi-supervised learning, hyperspectral image classification.**

As of 2023, over 250,000 km2 of Ukrainian territory is contaminated and affected by explosive objects.These figures classify Ukraine as the most heavily mined country in Europe. One of the modern approaches to the use of unmanned aviation for demining tasks is based on the deployment of mine detectors mounted on UAVs as useful payloads (multispectral equipment) [1]. On the one hand, this involves the development of highly efficient UAV navigation systems [2], and on the other hand, the use of intelligent methods for processing hyperspectral (multispectral) images [3].

Hyperspectral image classification (HSIc) usually refers to the use of the spectral-spatial information of hyperspectral images to accurately map the spatial distribution and material content, and identify different types of features in the corresponding scene.

In the task of HSIc, deep learning methods also have became popular due to their impressive performance [4 – 6]. The features extracted by deep learning are better representation than hand-crafted features.

Despite their great success, the deep learning methods heavily rely on enormous amounts of annotated data to achieve good results in supervised learning problems. However, labeling the data manually takes much time, which is a heavy burden for most researchers [7 – 13].

In this paper, we use a novel semi-supervised HSIc framework [8] relying on convolutional neural network (CNN) for feature extraction and representation learning. The details of the proposed model could be composed of three steps: feature extraction, constrained clustering and spatial constraints. The following is the specific implementation process: first, the initial feature sets is extracted directly from the sample set, and each sample feature is an image patch centered on the sample. We implement a number of tiny-scale initial clusters with high self-consistency by over-clustering the initial feature sets. Next, a small number of initial labels are introduced as semantic constraints to assign pseudo labels to initial clusters, which makes these clusters merged into corresponding dominant semantic classes. The initial labels here are provided by the expert at the beginning and the pseudo labels are labels predicted by each iteration of the algorithm. At the same time, the increase of highly confident pseudo labels also enrich the spatial neighborhood information, which enforces the role of spatial constraints. Finally, the pseudo labels are used for CNN training, and the trained network is used for features extraction. The features extracted by CNN will be more friendly to the next round of constraint clustering. This process loops until reaching the end condition.

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*Класифікація зображень гіперспектрального дистанційного зондування за використанням алгоритму напівного контролюваного навчання*

***Анотація: У роботі розглянуто завдання виявлення вибухонебезпечних предметів з безпілотного літального апарату, з гіперспектральною (мультиспектральною) камерою. Запропоновано новий метод розв'язання задачі класифікації гіперспектральних зображень з використанням напівкерованого навчання.***

***Ключові слова: вибухонебезпечні предмети, безпілотний літальний аппарат, гіперспектральна камера, напівкероване навчання, класифікації гіперспектральних зображень.***

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