remote sensing

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Correction

Correction: Tian et al. Multiscale Superpixel-Based Fine Classification of Crops in the UAV-Based Hyperspectral Imagery. *Remote Sens.* 2022, *14*, 3292

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Error in Figure

In the original article [1], there was a mistake in "Figure 1" as published. "UAV-manned" in the text in these figures should be modified as "UAV-based". The corrected "Figure 1" appear below.

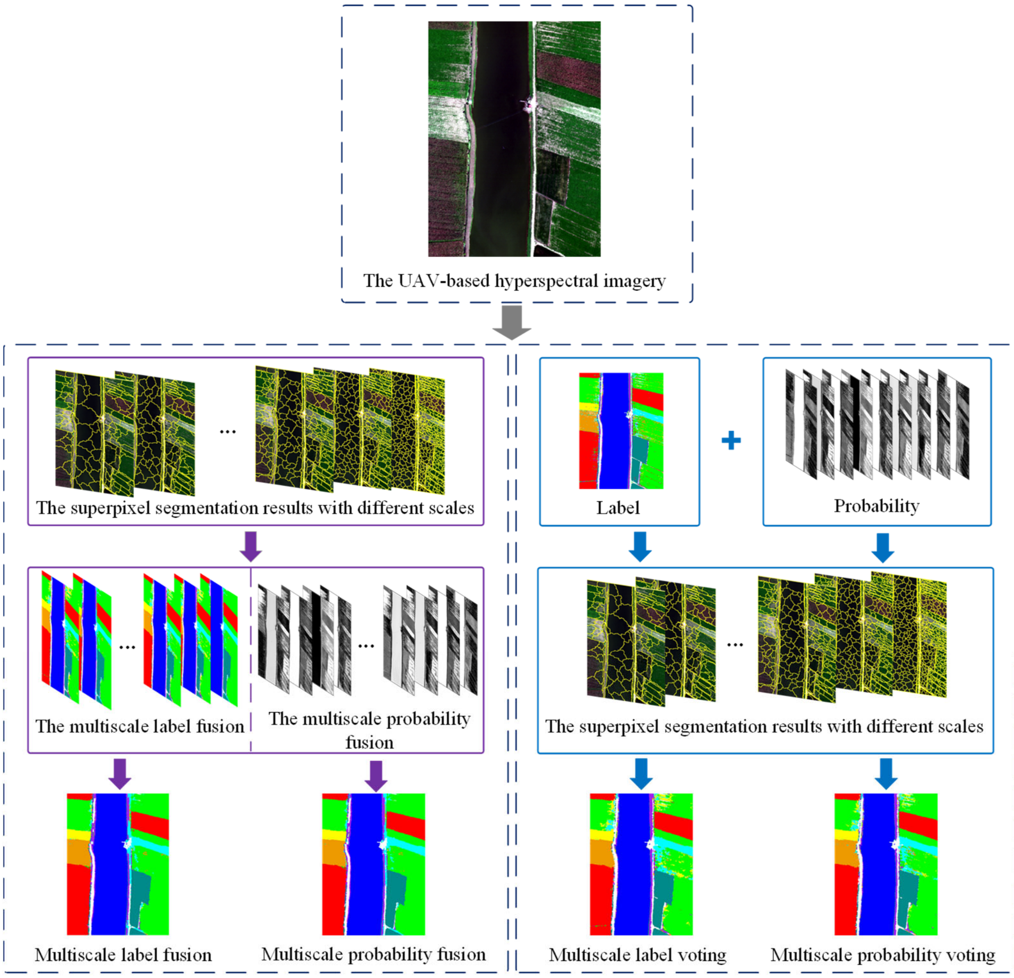

Figure 1. Flow chart of the research.

check for updates

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Table Legend

In the original article [1], there was a mistake in the legend for "Table 10". There was a typo, where "Honghu" should be modified as "Longkou". The correct legend appears below.

Table 10. Classification accuracies given by different methods for the Longkou dataset using SVM and RF with 100 training samples per class.

Text Correction

There was an error in the original article. "UAV-manned" in the original article should be modified as "UAV-based".

A correction has been made to Abstract, Paragraph 1:

Abstract: As an effective approach to obtaining agricultural information, the remote sensing technique has been applied in the classification of crop types. The unmanned aerial vehicle (UAV)-based hyperspectral sensors provide imagery with high spatial and high spectral resolutions. Moreover, the detailed spatial information, as well as abundant spectral properties of UAV-based hyperspectral imagery, opens a new avenue to the fine classification of crops. In this manuscript, multiscale superpixel-based approaches are proposed for the fine identification of crops in the UAV-based hyperspectral imagery. Specifically, the multiscale superpixel segmentation is performed and a series of superpixel maps can be obtained. Then, the multiscale information is integrated into image classification by two strategies, namely pre-processing and post-processing. For the pre-processing strategy, the superpixel is regarded as the minimum unit for image classification, whose feature is obtained by using the average of spectral values of pixels within it. At each scale, the classification is performed on the basis of the superpixel. Then, the multiscale classification results are combined to generate the final map. For the post-processing strategy, the pixel-wise classification is implemented to obtain the label and posterior probabilities of each pixel. Subsequently, the superpixel-based voting is conducted at each scale, and these obtained voting results are fused to generate the multiscale voting result. To evaluate the effectiveness of the proposed approaches, three open-sourced hyperspectral UAV-based datasets are employed in the experiments. Meanwhile, seven training sets with different numbers of labeled samples and two classifiers are taken into account for further analysis. The results demonstrate that the multiscale superpixel-based approaches outperform the single-scale approaches. Meanwhile, the post-processing strategy is superior to the pre-processing strategy in terms of higher classification accuracies in all the datasets.

A correction has been made to 1. Introduction, Paragraphs 3 and 5:

In recent years, the unmanned aerial vehicle (UAV) opens a new avenue to precision agriculture owing to its flexibility and intelligence [15,16]. To extract the crop distribution from UAV-based imagery, a lot of research has been conducted. Senthilnath et al. [17] investigated the application of a UAV imaging platform for vegetation analysis based on spectral-spatial methods. In this study, vertical take-off and landing (VTOL) quadcopters and fixed-wing were used to acquire images for vegetation analysis, and experiments illustrated the effectiveness of the spectral-spatial methods. Ye et al. [18] used a UAV equipped with a five-band multi-spectral sensor to capture imagery for the identification of banana fusarium wilt using supervised classification algorithms. Moreover, the UAV-based hyperspectral imagery shows abundant spectral properties as well as detailed spatial information [19,20], making it a satisfactory data source for the accurate recognition of crops [21,22]. A survey focused on the combination of UAV and hyperspectral sensors was proposed, in which the hyperspectral sensors, inherent data processing, and applications focusing both on agriculture and forest were investigated [23]. Ishida et al. [24] used a liquid crystal tunable filter to select the optimal combination of spectral bands for vegetation classification. Wei et al. [25] proposed a spectral-spatial-location fusion method based on conditional random fields, in which the spectral information, the spatial context, the spatial features, and the spatial location information were integrated into the conditional random field for crop recognition. Zhong et al. [26] built a UAV-borne hyperspectral dataset with high spectral and spatial resolution and proposed a deep convolutional neural network with a conditional random field for precise crop identification.

In this manuscript, multi-scale superpixel-based approaches are developed for the fine classification of crops in UAV-based hyperspectral imagery. On the basis of the spectral similarity and spatial relationship among pixels, the image is segmented as a series of superpixels. To exploit the multiscale information of remote sensing image, several segmentation maps with different numbers of superpixels are generated. The superpixel information can be introduced in classification by two different approaches, namely the pre-processing method and the post-processing method. Specifically, the pre-processing method regards each superpixel as a minimum processing unit instead of a pixel, and the post-processing method combines the superpixel segmentation maps with pixel-wise classification results by using a voting strategy. For the pre-processing method, the classification is performed on superpixels, and the feature of a superpixel is calculated based on the pixels located in it. For each scale, both the crisp and soft classification outputs can be obtained. Therefore, label-based and probability-based approaches are proposed to fuse the multiscale information. For the post-processing method, pixel-wise classification is first performed to obtain the label and probability information of each pixel. Based on the superpixel segmentation map at each scale, label-based and probability-based voting can be implemented. Then, the multiscale information is fused by combining the voting results obtained at different scales. To test the effectiveness of the proposed method, three UAV hyperspectral images obtained by UAV over agricultural areas are adopted in the experiments.

A correction has been made to 2. Methodology, 2.3. Multiscale Superpixel-Based Classification, Paragraph 1:

The objects in remote sensing images always show different characteristics in different scales, making it difficult to select the optimal scale to represent different kinds of objects. Hence, the multiscale superpixel-based approaches are proposed for the fine classification of crops in the UAV-based hyperspectral image. Similar to the traditional superpixel-based classification approaches, the proposed approaches can be divided into the pre-processing and post-processing methods. The flow chart of multiscale superpixel-based approaches is shown in Figure 1.

A correction has been made to 5. Conclusions, Paragraphs 1 and 2:

In this manuscript, multiscale superpixel-based approaches were developed for the fine recognition of crop types in UAV-based hyperspectral images. Superpixel segmentation was performed with different parameters to exploit the multiscale information of objects, and several superpixel maps can be obtained. To fuse the multiscale superpixel information, the pre-processing and post-processing strategies were proposed according to different principles. Specifically, the pre-processing strategy views the superpixel as the minimum image processing unit, and the classification was conducted on the superpixel level at each scale. Then, the label of each pixel was assigned to the domain class among multiscale results. Moreover, the post-processing strategy was inspired by the voting approach, and the class information of the superpixel was determined by the majority classes of pixels within it. By fusing the voting result obtained at different scales, we can obtain the final classification map. Note that, for the pre-processing and post-processing methods, the class probability output and label information were taken into consideration to generate the final classification results by different approaches.

The experiments were conducted on the WHU-Hi dataset provided by the RSIDEA research group, which contains three individual UAV-based hyperspectral images. Moreover, for each dataset, seven training sets with different number of labeled samples were supplied, as well as the hyperspectral image. Meanwhile, SVM and RF were employed to test the effectiveness of the proposed methods. The comparison of the single-scale approaches demonstrates that it is hard to select an optimal scale for a complex image scene. Moreover, the best result among the single-scale superpixel-based approaches was inferior to the multiscale superpixel-based approaches. Furthermore, it is found that the post-processing strategy shows better result than the pre-processing strategy, which illustrates the effectiveness of voting methods. Additionally, the classification maps show that the proposed method is able to preserve the object boundaries while avoiding the discrete misclassification pixels. Future work will focus on the extraction of superpixel-based features for better classification of crops.

The authors apologize for any inconvenience caused and state that the scientific conclusions are unaffected. The original article has been updated.

Reference

1. Tian, S.; Lu, Q.; Wei, L. Multiscale Superpixel-Based Fine Classification of Crops in the UAV-Based Hyperspectral Imagery. *Remote Sens.* **2022**, *14*, 3292. [CrossRef]