

Rice and weeds in upland rice fields can be discriminated with good accuracy from a commercial-grade small drone

Weed control is an important task to improve the productivity of upland rice, which is a major crop in Laos. Aerial images of fields taken with drones are effective tools for early detection of weeds and rapid herbicide treatment, but there is no practical method that can be used in farm fields. Therefore, based on object-based image analysis (OBIA), this study developed a method for discriminating rice and weeds using RGB (Red-Green-Blue) color images of upland rice fields in Laos taken with a commercial-grade small drone.

The experimental results are summarized as follows.

- In an experimental field (furrow 25 cm × 25 cm), a small drone (DJI Phantom 4) was used to capture RGB images at a flight altitude of 20 m (ground resolution 1 cm) 29 days after sowing. HSV (Hue-Saturation-Brightness) and Texture (spatial variance) were calculated from the RGB color image. As training data, the positions of rice, weeds, and soil on the image were collected from the RGB color image by visual interpretation. In OBIA, (1) the images were segmented by similar pixel values using the SLIC (Simple Linear Iterative Clustering) method, (2) statistics were extracted from the segments of classification class (rice, weeds, and soil) in the training data, and (3) the extracted statistical values were used as explanatory variables for random forest classifier.
- OBIA classified rice and weeds, mainly *Asteraceae* and *Legumes*, which dominated the upland rice fields in Laos, with overall accuracy (OA) of 90% or more (Table 1), and provided the spatial distributions (Fig. 2).
- Soil was classified with a recall value of 99.0% even if only the HSV color information was used, but the accuracies of rice and weeds classification could be improved by adding Texture information (Table 1).
- Since the coverage of rice, weeds, and soil classified from the drone changed between 1, 17, and 34 days after weeding (Fig. 3), it is possible to quantitatively grasp the situation in which weeds grow over time after weeding treatment.

Rice and weeds could be rapidly discriminated with practical accuracy by OBIA with a small drone. Farmers can grasp the weed growth in the field at an early stage and use it as basic information for appropriate weed management (herbicide treatment). If this method is applied to field phenotyping, the influence of weeds can be removed from the image without weed removal in the field, and improvement of the accuracy and efficiency for rice growth monitoring can be expected. It should be noted that it is possible to fly at a higher altitude to shoot a wider area in a short time, but the classification accuracy will decrease accordingly, so it is necessary to formulate a flight plan that suits the purpose of use. In addition, the classification accuracy may decrease for weed species with similar morphology, such as grass weeds.

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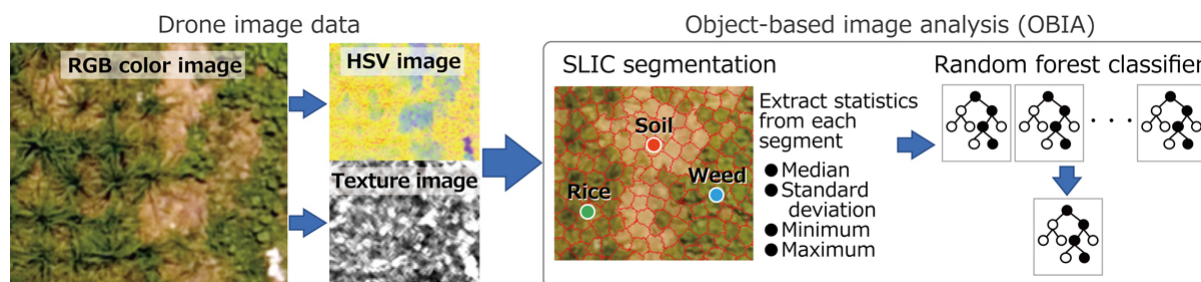


Fig. 1. Processing flow of object-based image analysis using HSV image and Texture image (spatial variance) calculated from RGB color image of drone

Extracted statistics from the segments created by the SLIC (Simple Linear Iterative Clustering) method are used as input values for random forest classifier.



Fig. 2. Spatial distribution map of rice, weed, and soil classified by object-based image analysis of drone images

Comparison of treatment plots with different days after weeding (1, 17, and 34 days after weeding)

Table 1. Confusion matrix in random forest classification

		Classified as			
		Rice	Weed	Soil	Recall
(a) HSV (OA = 0.901, F-score = 0.900)					
True class	Rice	82	18	0	0.820
	Weed	11	89	0	0.890
	Soil	1	0	99	0.990
Precision		0.872	0.832	1.000	
(b) HSV + Texture (OA = 0.910, F-score = 0.906)					
True class	Rice	83	17	0	0.830
	Weed	9	91	0	0.910
	Soil	1	0	99	0.990
Precision		0.892	0.843	1.000	

OA: overall accuracy

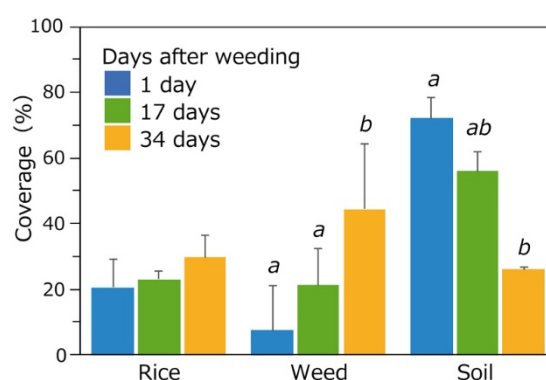


Fig. 3. Comparison of rice, weed, and soil coverages

Different letters on the bar indicate significant differences at 5% level (Tukey HSD).