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Weed detection from multispectral images acquired under uncontrolled illumination conditions

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ABSTRACT

In order to optimize the application of herbicides in crop fields, selective spraying is one of the promising solutions being investigated during the last decades. Multispectral cameras provide radiance images with a high spectral resolution allowing to analyze vegetation signatures beyond the visible domain in narrow spectral bands. In this study, we address the problem of weed detection using multispectral imaging. A multishot camera is used to acquire radiance images of vegetation in a greenhouse under skylight. From the acquired radiance images, spectral reflectance is estimated in a row-wise manner as an illumination-invariant signature. Reflectance spectra and texture features are extracted and used to feed a classifier in order to conduct supervised weed detection. Furthermore, the most suited spectral bands for the weed/crop separation are identified and used to specify a multispectral filter array (MSFA) for a single-shot (snapshot) camera that can be embed on an unmanned aerial vehicle (UAV) suitable to make instantaneous acquisitions in the field.

Keywords: Multispectral, Weed detection, Reflectance, Band selection, Supervised classification

1. MATERIALS AND METHODS

1.1 Snapscan camera

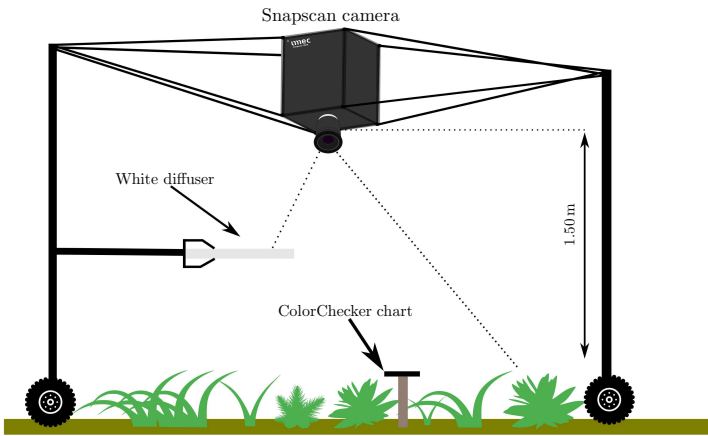
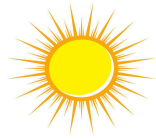
The Snapscan¹ is a multispectral camera manufactured by IMEC that embeds a single matrix sensor, covered by a series of narrow stripes of Fabry-Perot integrated filters. It provides $K = 141$ spectral channels whose central wavelengths range from $\lambda^1 = 475.1$ nm to $\lambda^{141} = 901.7$ nm with a variable center step (from 0.5 nm to 5 nm). Each filter is associated to 5 adjacent rows of 2048 pixels, and samples a band from the visible (VIS) or near infrared (NIR) spectral domain according to its spectral sensitivity function (SSF) $T^k(\lambda)$ with a full width at half maximum between 2 nm and 10 nm.

1.2 Multispectral dataset acquisition

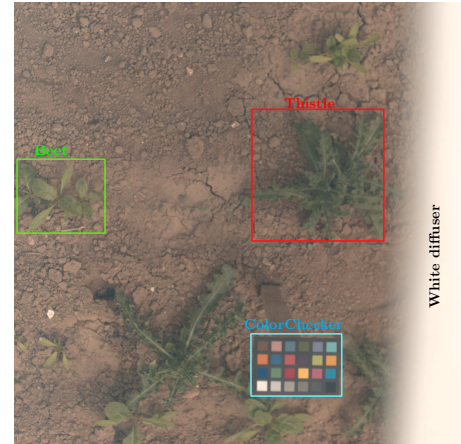
An image acquisition campaign was conducted in a greenhouse under skylight by the Chambre d’Agriculture de la Somme in early April 2019. The targeted plants are beet, wheat and bean for crops, and datura, thistle and goose-foot for weeds. The Snapscan camera observes the vegetation from top at a distance of about 1.50 m from the ground (see Fig. 1(a)). Each image contains a portion of a white diffuser (lambertian surface) at the right border and a Color-Checker (see Fig. 1(b)). This campaign provided more than 300 radiance images of 2048×2048 pixels $\times 141$ channels of 10-bit depth. The memory size of each image stored in ENVI format is 3.2 GB. For our tests, we use 100 images that characterize vegetation at different growth stages, and containing either mixed vegetation types (crop and weeds) or a single vegetation type (crop or weeds).

The spectral reflectance is estimated from the acquired radiance images following a specific method. The reflectance is used as an illumination-invariant feature. Fig. 1(c) shows a classification result obtained using a gradient boosting (LightGBM²) classifier trained with reflectance spectra extracted from training images acquired at different days.

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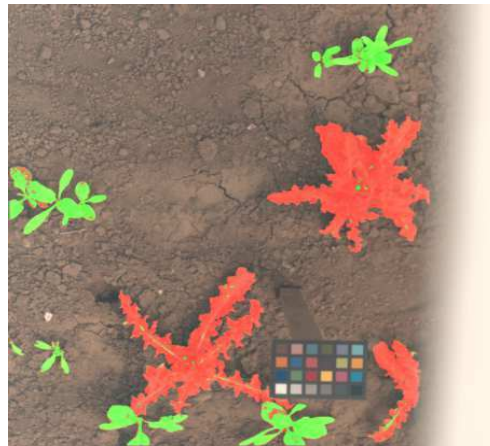


(a) Acquisition setup



(b) RGB rendering of a multispectral image

Thistle (Acc = 98%) Beet (Acc = 91%)



(c) Classification result. Beet is shown in green and Thistle (weed) is shown as red.

Figure 1. Outdoor multispectral image acquisition and classification.

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- [2] Ke, G., Meng, Q., Finley, T., Wang, T., Chen, W., Ma, W., Ye, Q., and Liu, T.-Y., "LightGBM: A highly efficient gradient boosting decision tree," in *[Advances in Neural Information Processing Systems 30]*, 3146–3154, Curran Associates, Inc. (2017).