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# A Fast and Efficient Shape Descriptor for an Advanced Weed Type Classification Approach

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**ABSTRACT**

In weed management, discrimination between families of monocotyledonous and dicotyledonous of the utmost importance. Indeed, the efficiency is much higher with the application of a selective treatment instead of using a single spreading herbicide overall parcel. This article presents a binary shape descriptor designed to discriminate between these two families of weeds, efficiency and speed are proven through real RGB images containing a mixture of weeds, and also by comparison with the latest techniques.



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## 1. INTRODUCTION

The weed control is a key element in smart agriculture. The chemical weeding is widely practiced in order to reduce the infestation rates and to improve harvests. Weeds are divided into two big families: the Monocotyledonous family characterized by long and thin leaves; and the Dicotyledonous family that have short leaves. In view of this diversity, the performance is even better with the application of a selective treatment instead of using a single spreading herbicide overall parcel.

In this regard, recent researches in computer vision have given birth to several efficient techniques for detection and / or classification of weeds. Traditionally, two main approaches are used :

- A spectral approach: This approach consists in decoding the spectral information to detect the presence of weed in the parcels. In [1] and [2], respectively, the authors used the information revealed by the near infrared (NIR) and the simple (RGB) pictures to detect weeds. In [3], the authors used the UV fluorescence spectrum. In [4], the authors analyzed the hyperspectral images to properly detect and select the weeds. Despite his performance, this technique requires an expensive equipment.

- A spatial approach: This technique focuses on the distribution of weeds in the parcel or on their morphological forms [5] in order to identify them. In [6] and [7], the authors detected weeds by observing their presence in the seed line spacing. In [8], the authors examine the shape of weeds by using the seven moments of Hu [9] and six shape descriptors to achieve a better selection of weeds. The results are very satisfactory in spite of the processing time of about 2 frames per second.

In this study, we present a new innovative, fast and efficient approach for the selection of weeds. This approach is essentially based on the application of binary descriptor that we have designed for this purpose. This descriptor called Adjacencies Descriptor returns the number of horizontal, vertical and diagonal adjacencies for a given form of 2D object.

## 2. MATERIALS AND METHOD

The imaging system is composed of a standard RGB camera. The camera is held in vertical position at 25 to 30 cm above the region of interest. Thus, the visible scene covers an area of 50 × 50 $cm^2$ (see Figure 1). This setup allows us to overcome the perspective view problem and to improve the spatial resolution.

Figure 1. Acquisition process: camera on a tripod at approximately 0.3 m height pointing vertically downward

### 2.1. The adjacencies descriptor

Our descriptor is a 2D binary one, it calculates the number of adjacencies horizontally, vertically and diagonally for a given original cell (see Figure 2) and their adjacent cells.

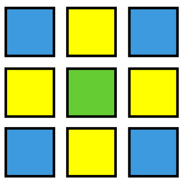

Figure 2. Descriptor structure

The original cell, the green one, is surrounded by eight other peripheral cells yellow and blue. Cells in yellow show horizontal and vertical adjacencies, the blue ones have adjacencies diagonally with respect to the original cell.

The proposed descriptor calculates two numbers of adjacencies for a given original cell ($C_0$) and for their adjacent cells ($C_A$, such as $A = 1, 2, 3, 4, 5, 6, 7, 8$). The first is the number of horizontal and vertical adjacencies ($N_{HV}$), the second is the number of diagonal adjacencies ($N_D$). The adjacency (Adj) is filled by the binary result of the operator XOR between the original cell and an adjacent cell as followings :

$$\text{Adj} = C_0 \ (\text{X} - \text{OR}) \ C_A \tag{1}$$

Thereby, for two adjacent cells, the adjacency (Adj) calculated is "False" when the two cells are equal and "True" when they are different. Thus, both numbers of adjacencies form the sum of zero elements or affected to "False", they are given by the following algorithms (2 and 3):

$$\begin{array}{l} N_D = 0; \\ \text{For}(i = 1; i <= 8; i+ = 2) \\ \{ \\ If(\text{Adj} == \text{False}) N_D = N_D + 1; \\ \} \end{array} \tag{2}$$

$$\begin{array}{l} N_{HV} = 0; \\ \text{For}(i = 2; i <= 8; i+ = 2) \\ \{ \\ If(\text{Adj} == \text{False}) N_{HV} = N_{HV} + 1; \\ \} \end{array} \tag{3}$$

Applying this descriptor on all cells belonging to one particular item, allow to distinguish between a rounded and filled morphology (like a disc) and others with a long and thin shape (See Figure 3).

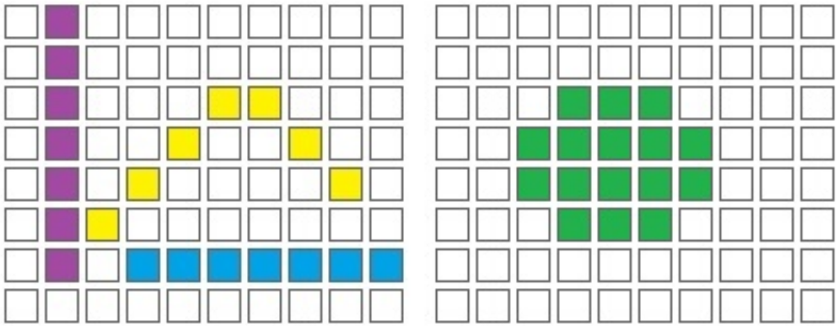

Figure 3. Objects simulation with straight-lined and rounded morphologies

#### 2.1.1. Segmentation and classification

The obtained image is segmented in order to isolate the vegetation of the rest of the scene. According to [10], this operation is effectively carried out by thresholding the image given by the following formula :

$$G = r \times R + g \times G + b \times B \tag{4}$$

with : $r = -0.884$, $g = 1.262$ and $b = -0.311$.

Where $R$, $G$ and $B$ represent red, green and blue components of each pixel. Thus, the pixels related to the vegetation are obtained for $G > 10$ (see Figure 4).

The application descriptor is realized by assuming a 8×8 pixels sliding window. Then, the results returned by the descriptor are classified with an AdaBoost algorithm. The latter is based on the application of attentional cascade of three weak classifiers in the form of affine functions: the first concerns the surface, the second uses the number of horizontal and vertical adjacencies and the last treats the number of diagonal adjacencies returned by our shape descriptor.


Figure 4. Segmentation Vegetation / ground, vegetation and the rest of the scene are represented respectively by white and black pixels

A majority of votes provided by the sliding window obtains the final classification of a region in the image.

## 3. RESULTS AND ANALYSIS

Our descriptor is positioned between the PLB [11] and image filters. It allows describing the size and the morphological form of weeds by two integers ND and NHV. Its main advantage resides in its speed and ease of implementation. In fact: The only parameter to be adjusted is the cells size. These cells are square and have a uniform size, which is equal to the smallest square area, which could be occupied by a weed on the image (see Figure 3). Hence, the descriptor presents a robustness against the brightness change, rotation and translation. In addition, the decrease in image resolution due to cell formation will greatly reduce the execution time (see Table 1).

Table 1. Number of possible comparisons depending on the size of the sliding window.

| **Window Size** | | Number of comparisons |
|---|---|---|
| Height | Width | |
| $H$ | $L$ | $H \times L \times 8$ |
| 8 | 8 | 512 |
| 640 | 480 | 2457600 |

In this table, we can clearly notice that our descriptor has a low computational cost. In practice, in precision agriculture, a scene is never covered with vegetation to 100%, the average number of measured comparisons is of the order of 5000 comparison by frame. This allows our descriptor to work at real time with a standard value of 25 frames per second.

The results of our experiment are very promising. We got a correct classification rate of around 85% on a set of 50 images analyzed. Monocotyledonous weeds have been classified up to 90% of cases, while the dicotyledonous weeds have been recognized to about 80%. The experiments were conducted on a computer with a Dual core processor at 1 GHz with DDR3 ram of 2 GO. Figure 5 shows an example of processing performed by our approach, monocotyledonous weeds are marked in blue and dicotyledonous weeds are marked in red. This figure also shows two errors out of 32 classifications.

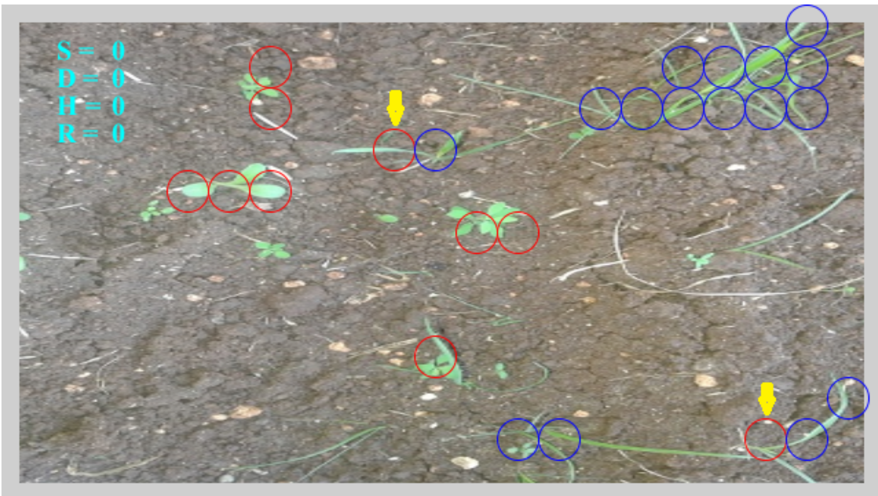


Figure 5. Classification results: Monocotyledonous in blue, dicotyledonous in red and classification errors

## 4. CONCLUSION

We achieved a system for discriminating between weeds of monocotyledonous and dicotyledonous families. This system is based on our adjacencies descriptor designed for this purpose. This is a robust binary descriptor, quick and easy to use. It divides the image into uniform cells and is used to describe the morphological form of 2D objects by referring the number of horizontal and vertical adjacencies and the adjacencies diagonal component of the subject cells. The results obtained were very satisfactory for a fast execution time of the order of 25 frames per second. We plan to improve these results by other adopters of learning and classification methods.

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