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Using video processing to classify potato plant and three types of weed using hybrid of artificial neural network and partincle swarm algorithm

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ABSTRACT

Fighting weed is an effective way to increase crop yield, which can be achieved with mechanical methods or spraying herbicides. Although the latter type is the most used, it can cause environmental pollution and food poisoning. For this reason, precision farming technologies are applied to minimize the required amount of herbicides, spraying only in small areas where weeds appear. The aim of this study is to locate and identify potato plants and three common types of weeds (*Chenopodium album*, *Secale cereale L*, and *Polygonum aviculare L.*) using a novel machine vision system. This system comprises two main subsystems: (1) a video processing subsystem capable of detecting green plants in each frame; and (2) a machine learning subsystem to classify weeds and potato plants. A hybrid approach, consisting of artificial neural networks (ANN) and particle swarm optimization algorithm (PSO), is used in classification. This approach is able to optimize the number layers, neurons per layers, network functions, weights and bias. Image capture was performed in four farms of Agria potato variety located in the Iranian province of Kermanshah, under controlled lighting conditions using white LED lamps. After shooting, plants were segmented and 30 color, texture and shape features were extracted from each one. Then, a decision tree is used to select the 6 most significant features, in terms of difference between potato plants and weeds. Finally, ANN-PSO method is applied to classify the inputs as potato plants or weeds. A comparison is performed using a Bayesian classifier. The experimental results show that ANN-PSO and Bayesian achieved an accuracy of 99.0% and 71.7%, respectively, on the training set, and 98.1% and 73.3%, respectively, for the test set. These results indicate that a precise site-specific sprayer can be designed using the proposed approach, optimizing the use of herbicides in precision farming.

1. Introduction

With the increase in world population, one of the approaches to provide food is using site specific management system or so-called precision farming. In this management system, management of crop production inputs such as fertilizers, lime, herbicides, seed, etc. is done based on farm location features, with the aim of reducing waste, increasing revenues and maintaining environmental quality. Precision farming involves various aspects and is applicable on farm fields at all stages of tillage, planting, and harvesting. Today, in line with precision farming purposes, and to control weeds, pests, and diseases, all the efforts of specialists in precision farming is to reduce the amount of chemical substances in products. Increased agricultural production has had increased use of herbicides.

Although herbicides improve the quality and quantity of agricultural production, the possibility of applying inappropriately and unreasonably is very high. If the dose is too low, weed control is not performed correctly. If the dosage is too high, herbicides can be toxic for crops, can be transferred to soil and stay in it for a long time, and can also penetrate to groundwater. By applying herbicides to variable rate, the potential for significant cost savings and reduced environmental damage to the products and environment will be possible. It is evident that in large-scale modern agriculture, individual management of each plant without the use of some advanced technologies is not possible. In this regard, there are no problems in the design and manufacture of micro-nozzles, solenoid valves, and related components. However, optimization of machine vision algorithm that is able to detect and separate main plant from the weed is still a topic of study of the researchers. In this regard, morphological, texture detection, and color separation methods have been studied. The main problem in using these features is that in the real images of farm that includes several plant species such as weeds or the main plant, these features cannot be used. In addition, the shape of leaves and plants are highly variable and overlapping of leaves, wrinkles, cuts, folding of leaves, and varying plant growth in different parts of the field actually make using this method difficult.

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One of precision farming techniques to identify weeds is the use of machine vision systems. Machine vision systems commonly have two main parts: (1) the part of imaging and video processing that has the task of imaging, pre-processing and feature extraction and (2) the part that analyze and classify the extracted features. Segmentation is the main operation in pre-processing section, since it is vital in future process such as feature extraction and classification and effective action based on this analysis, e.g. precision application of herbicides in smart agriculture applications [1].

Because of the importance of the fighting weeds, recently, researchers have done different research in the field of weeds separation from crops. Søgaard [2] offered a classification method using image processing and active shape models for different weed species. In this study, young weeds with more than two complete non-overlapping leaves were diagnosed. Database had image content of 19 important weed species related to agriculture farm Denmark. Images were used as a training database to make an active shape model for each species. Based on these models, an algorithm was developed to identify weed species in digital images. The results show that the classification of performance rate depends on the type of weed from 65% to over 90%. As it became clear from the investigation conducted, the research has not been done on natural conditions. The means of natural condition is the use camera for taking video in field and analyze films instead images. Peng and Jun [3] stated that motions blur and defocus blur occur when the relative motion between the imaging camera and the target object is present. This two blurs decrease the quality of image and thus reduce recognition accuracy of next patterns. They presented a plan to identify *wild buckwheat*, *foxtail* and *pigweed* using the low quality images and with these two types of blurs. The plan had three main steps: (1). separating the soil from the plant, (2). calculating moment invariants features corresponding to blurred image, (3). weed recognition using Euclidean distance based on the moment invariants. The results showed that by increasing the number of displaced blurs, weed recognition accuracy that was measured using Tian's algorithms reduced. For example, when a motion blur with 60 pixels was used, weed recognition accuracy reached below 60 percent. This accuracy was very low for online detection and intelligent spraying and practically not usable. Swain et al. [4] conducted a study on *Nightshade* crop from weeds by using the automated active shape matching system (AASM). Images taken of specimens under controlled lighting conditions that were obtained using a white LED. The proposed method focuses on the separation using morphological features. Using the algorithm, automatic active shape matching form of leaf's model and placed at the center of the target plant and the process of transformation model was implemented. The parameters used to deform the model were estimated, updated, and improved to achieve the best-fit model with the target plant. The results showed that about 90 percent of *Nightshade* plants were correctly diagnosed using this method. The time required to detect the target plant was 0.053 s. Arribas et al. [5] using computer vision classified the images related to sunflowers. Images were taken in the field and in natural light. Classification was done using artificial neural network. In this classification, the sunflower crops were distinguished from non-sunflower. The proposed algorithm consisted of four main steps: 1 – Separation based on RGB color space, 2 – identification and extraction of several features of the segmented images, 3 – selecting a set of features that can provide differentiation, and 4 – classification with the Generalized Softmax Perceptron (GSP) method. The results showed that the proposed system just by using five features-perimeter, area, major axis of the best fit ellipse, minor axis of the best fit ellipse and logarithm of height to width ratio- is able to classify with accuracy of 85%. The proposed system has two important limitations. First, images are taken in static conditions, and for real-time processing the camera is moving, therefore not usable, second, the proposed system can only detect the crop of weeds and not weed from each other, so the ability to perform certain actions on one kind of weed is not possible. Using image processing, [6] tried to separate the corn from weeds in arable land. The system consisted of two independent subsystems: the first sub-system has the task of fast delivering of results in real-time image processing (image processing fast) and the second subsystem has the task of slower processing with more accuracy. This combination provides a high-precision system under different soil moisture and lights. After doing the experiments in a field, the results showed that recognition accuracy for crop and weeds were 95% and 80%, respectively. The proposed system recognized two rows of corn and then everything that were green and placed between two rows assumed as weed. Therefore, the type of weed was not identifiable and there isn't possible for performing specific operations related to weed type. Ahmed et al. [7] studied on chili separation from 5 weeds of *Pigweed*, *Marsh herb*, *Lamb's quarters*, *Cogongrass* and *Sicyos angulatus* with support vector machine method. They shoot from different parts of the farm under controlled conditions of light. In the next step, they extracted 14 features from chili and weeds. The extracted features include color features (average of red, green and blue color of image), shape features (form factor, elongatedness, convexity and solidity) and moment constants. The results of the related to 224 image analyzed showed that Support Vector Machine (SVM) has a precision more than 97%. For two reasons, practical implementation of this procedure is not possible in the fields. (1) Each crop and weed has been photographed separately this is while on the farm two or more weeds and crops maybe together, then how machine vision system recognizes several types of plant in a photo. (2) Images are taken with high quality without blur while the camera should be moving on the farm. Rumpf et al. [8] using SVM algorithm and based on extracting shape features by image processing attempted to classify small grain weeds with a focus on species *Cirsium arvense* and *Galium aparine*. In this study, three SVM were used for classification. With initial support vector machine, the same plant species (monocotyledons plants, dicotyledonous plants and barley) were diagnosed. It was very difficult to differentiate among dicotyledonous plants. Using the second and third SVM, the plants in this class were classified. In each of these SVM, different vector machines were used. Finally, a general classification with accuracy of 97.7% was achieved for the first classification. For the other two classifications, an accuracy of 80% for the separation of *Cirsium arvense* and *Galium aparine*species was obtained. In this study, the samples were arbitrarily taken and the ability to distinguish between the different sub-species was not very high. Therefore, implementing real-time on the farm is not possible. The use of vegetation indices for classifying thistle and sugar beet in sugar beet fields was investigated by [9]. For this reason, 474 field images of sugar beet and thistles were collected. From each image 14 indices were extracted. Two methods namely Linear Discriminant Analysis (LDA) and Mahalanobis Distance (MD) were used for classification. The results showed that these two methods had 97% accuracy. The classification based on leaf shape was used by [10]. In this regard [10] proposed a computer vision system for classification 14 different types of leaves. For training computer vision system, 817 leaves were used. From each leaf some features in field of morphological features, Fourier descriptors and a newly proposed feature called shape-defining feature were extracted. In final, the result shown that artificial neural network classifier with accuracy 96% classified these 14 different types of leaves. In another study [11] proposed two methods for invariant pattern recognition based on 2D Fourier power spectrum with guaranteed translation invariance for extracting features from 15 different type of leaves. 1125 images were captured from these leaves. Kernel Support Vector Machine and self-organizing neural network were used for leaf classification. The results showed that the correct classification accuracy of SVM classifier was about 93%. [12] After investigating uniform herbicides spray method on all surface of field concluded that this spray method causes the pollution of environment and decrease of quality in agricultural crops in addition to wasting herbicides and working forces; therefore, they suggested the identification of weeds and precision spray for stable development of agriculture. For this reason, a research was implemented about site-specific spray under