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INNOVATIVE METHOD OF IMPLEMENTING THE ALGORITHMS FOR PROCESSING IMAGES IN PRECISION AGRICULTURE

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Abstract: The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC). This paper presents general aspects and a comparison between two smart cameras; the first one is black-and-white and the second is a colour camera. Recognition and processing of images algorithm depends on colour, shape or position. If the first uses shape to recognize and make the difference between weed and plant, the second uses the difference of colour pixels to make that difference. The paper also includes the stages of algorithm realization and implementation for images processing and recognition. The experiment was performed on lettuce at INMA Bucharest.
Keywords: intelligent, hoeing, images recognizing method

INTRODUCTION

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras; the first one is black-and-white and the second is colour, endowed with internal memory card able to store the software steps and it has integrated controller aiming to achieve images processing operations. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC). The experiment was performed on lettuce (Figure1) at INMA Bucharest.

Among the new farming technologies, we must mention the GPS automated guide, fields mapping, aiming to obtain maps with soil features (such as, soil electro-conductivity, PH, nutrients quantity, etc.) which should be used by specialists to obtain a high-performance management of cultures, the use of intelligent algorithms for recognizing images of crops' weed percentage level, for evaluating the crops' health degree, aiming to identify possible pests attack, ensuring a sustainable management of sprinkling, etc.

In figure 2 is presented the experimental model of intelligent hoeing equipment – IHE, produced by INMA Bucharest.

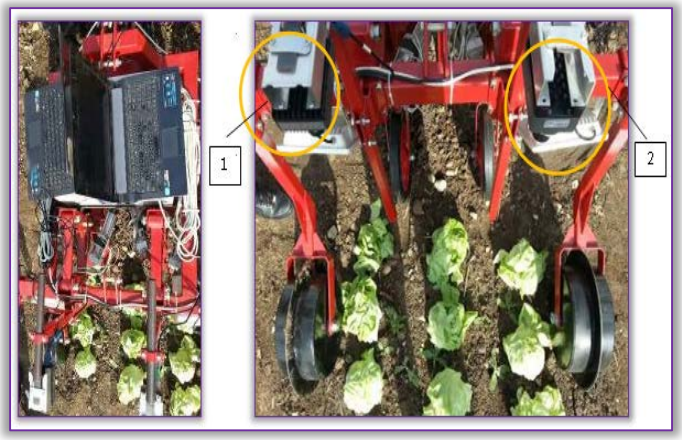

Figure 1. Image from experiment filed with IHE
1) black-and-white camera 2) colour camera

The intelligent hoeing equipment, three-point mounted in front of the tractor, will be traveling in crops with weeds. Through the light sensor, intelligent camera type and the recognition methods implemented in this, the intelligent system will differentiate the weeds from the

plants and will command the knives on plant rows, via electric actuators, to destroy the weeds. To guide the tractor, an agricultural GPS is used. The correlation of the working knives position with the light sensor location will be done through a speed sensor mounted on the equipment wheel.

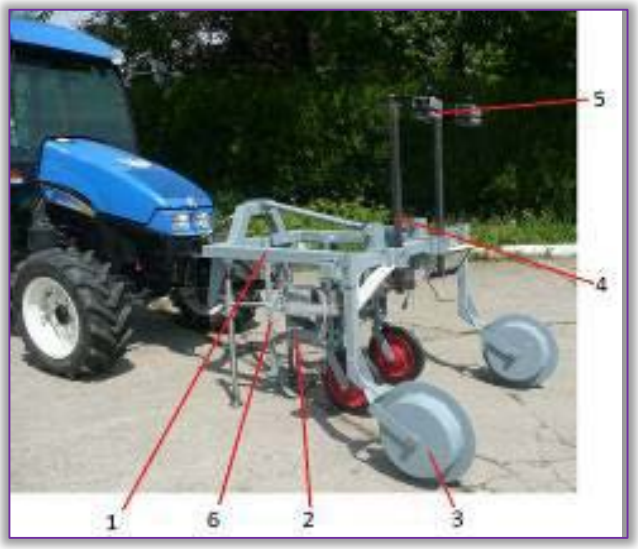

Figure 2. Experimental model IHE
(1–frame, 2 – hoeing section, 3 – wheels of displacement and working depth adjusting, 4 – cameras supports, 5 – cameras, 6 – parking foot)

MATERIAL AND METHOD

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and their latter destruction. It is based on two intelligent cameras, endowed with internal memory card able to store the software steps and have integrated controller aiming to achieve images processing operations.

Each camera surveys two rows of culture and digitally transmits the commands obtained after the images processing, to a programmable logic controller (PLC). PLC achieves the synchronization of cameras with the moving speed of the tractor and with the state of the four electric linear actuators, driving the equipment knives.

PLC also commands the opening and closing of actuators in weed areas, by transmitting digital signals to controllers. Interface between technical equipment, intelligent control system and the operator is made by an operation terminal with touchscreen. By the intermediary of touchscreen, the operator can obtain the start-stop functioning commands of TE, monitor the actuators, number the crop plants and assess the weed level.

At the same time, it can guide the technical equipment by means of a GPS, so that it achieves the optimum crop maintenance, without surpassing the distance between rows and destroying the plants. Cameras are designed by National Instruments company aiming the industrial screening installations and using algorithms for images detection.

Image processing represents the process of modifying the properties of images in order to extract relevant information to the user. Evolution of computerized imaging technology allowed the implementation in a large number of fields, including agriculture.

There are several methods of image processing, such as:

- Image restoration aims to eliminate distortions which affect the image distortion due to known physical phenomena, mathematically modelled or estimated.
- Image segmentation realizes separation of uniform regions of interest in the image. Uniformity is a general concept; it does not reduce the consistency of grey levels (the same texture, the same properties, etc.).
- In the case of computer graphics, it starts from a description of the image, aiming in the most general case a synthesis of a realistic image. Obtaining the realistic image is translated by a sequence of algorithms that "closes" the image synthesized from the real one.
- Contour filling algorithms perform the complementary operation to contour extraction, while expansion is complementary to thinning operation.
- 2D reconstruction restores plane section of the body studied from a set of 1D projection in different directions of the section. Having available several such sections (parallel or radial) of the studied body, its 3D reconstruction can be achieved. The reverse is called 2D projection.
- Shape recognition is a commonly used way to extract information from images acquired. It is a broad field that includes handwriting recognition, human face recognition, fingerprint recognition, etc. Shape recognition consists in a classification and / or a description of the image content.

RESULTS

The method for recognizing the images proposed consists in performing the following operations:

- sequences of images, in real time, taken directly from the field. This operation will be continuously performed by intelligent camera, with acquisition frequency adjusted by the user, each image being subsequently analysed by performing the operations below.
- storing images for a subsequent analysis. This operation is optional, allowing to user to estimate the crop weeds level and, after that, the necessary maintenance works.
- dividing the image in interest areas. The final purpose of this operation is to use a sole intelligent camera for monitoring two rows of crop

simultaneously or to perform maintenance works of several crop types with plants of different growing stages.

- identifying the distinct objects from images (soil, stones, plants, etc.). This operation will be made by numbering the pixels suitable to each different object, depending on the grey tone intensity of each pixel, taking for reference a scale introduced by the user.
- identifying the space between crop plants.
- PLC gives the command according to the existence/non-existence of crop plants. In this stage, the digital command will be given within the range of 0-24Vcc to digital input of PLC, in order to drive the mobile knife arm of the multifunctional technical equipment designed to mechanical maintenance in row and between plants of agricultural crops.

Operations described above are performed by making the following steps (described in the software of Vision Builder AI).

Figure 3. Real-time image acquisition with black-and-white camera

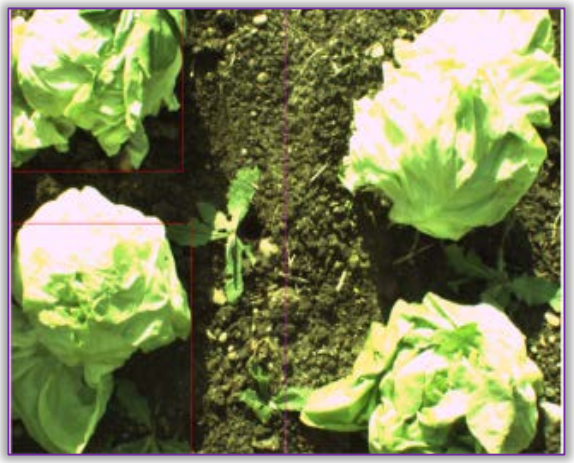

Figure 4. Real-time image acquisition with colour camera

Images are taken in sequences, with 640x480 pixels resolution. Images acquired are stored in the internal memory of the camera. The number of images (frames) the acquisition is made with may be adjustable, according to the exposure time, light and sensor amplifying - figure 3, and with colour camera figure 4.

There are identified the interest objects from image lower part, by numbering the pixels of a certain intensity, appropriate to the respective object (crop plant, weed, stone, etc.). In figure 5 these objects are in the left row identified with black and white camera, while in figure 6 they are in the right row.

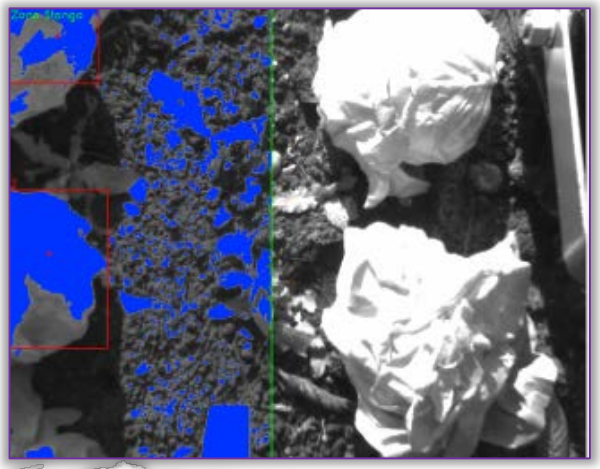

Figure 5. The interest objects from the left row with black-and-white camera

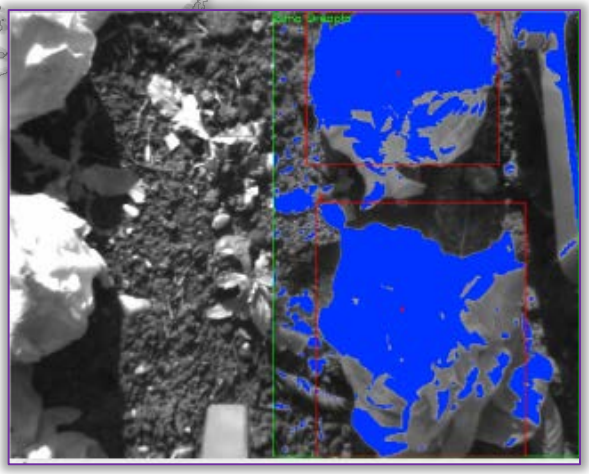

Figure 6. The interest objects from the right row with black-and-white camera

The program identifies the row and makes the acquisition from 2 rows. In the next step, the objects area surpassing 10000 squared pixels is identified (this number can vary according to the crop plant and its average surface at the plant growing level suitable to performing crop maintenance), for image lower part.

The area of weeds location is framed in red, in figure 7, in the left row and, in figure 8, in the right row with colour camera, the gap between them representing the field that requires to be worked.

Figure 7. The area of weeds location with colour camera in the left row

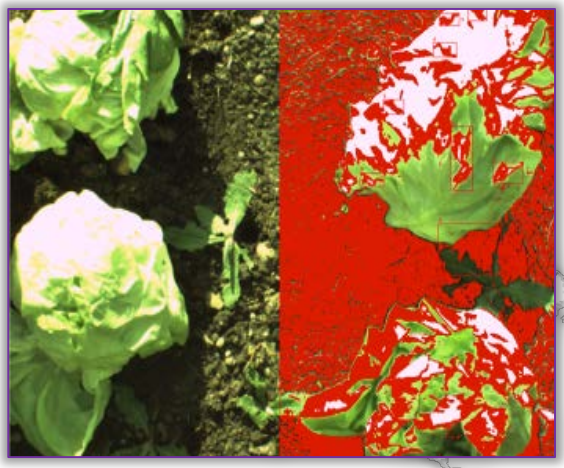

Figure 8. The area of weeds location with colour camera in the right row

During the final step, the output channel, by means of which the signal is sent to PLC, is set as well as the conditions of transmitting it.

CONCLUSIONS

Agricultural research played an important role in order to increase production and the most efficient exploitation of the existing resources, taking into account that the planet's population is constantly growing and exploited agricultural fund is limited and with clear trends of deterioration.

The development of precision farming is one of the main priorities for the development of crops with productivity that satisfy the market demands, in environmentally friendly conditions and with minimal resource consumption. The colour camera is better than the black-and-white one since the number of pixels gives higher accuracy.

Acknowledgement

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