ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
Tome XVIII [2020] | Fascicule 4 [November]

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TENDENCIES REGARDING USAGE OF INTELLIGENT ALGHORITHMS OF IMAGE RECOGNITION WITHIN AGRICULTURAL CROP MAINTENANCE WORKS

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Abstract: An important topic of agricultural works to be performed in order to obtain healthy crops and increasing productivity is the maintenance works of agricultural crops. The development of precision agriculture is one of the basic priorities for achieving crops with productivity that will satisfy the demand on the market, in environmentally friendly conditions and with minimal consumption of resources. Precision agriculture involves the very precise regulation of the inputs to the agricultural system (seeds, fertilizers, pesticides) so that they are distributed where it is needed exactly when it is needed. This paper presents the actual state of the art regarding maintenance works of agricultural crops, using machine vision for crop characterization. Image recognition algorithms are used in order to identify different crop diseases and to select the right treatment scheme with phytosanitary substances or the right hoeing technique. Further we present a synthesis of the current state of research regarding the use of intelligent algorithms of image recognition within agricultural crop maintenance works.
Keywords: image recognition, agricultural crops, intelligent algorithms

1. INTRODUCTION

In the context of practicing a precision agriculture, which according to the European Union Horizon 2020 Programme must incorporate the significance of the SMART concept, more and more researchers are turning their attention to implementing the latest technological achievements in the agricultural machines they create.

The development of equipment for maintaining agricultural crops with low consumption of pesticides, herbicides, fuel and with minimal effect on soil organic matter is in accordance with European legislation and with the H2020 requirements for reducing the consumption of plant protection substances for environmental protection. Organic farming is also an important market for this equipment.

Among the new technologies that have begun to be used in agriculture, we mention GPS auto-guidance, land mapping in order to create maps with soil properties (such as its electroconductivity, PH, nutrient quantity, etc.) to be used by specialists in order to achieve a good crop management, the use of intelligent algorithms of image recognition to characterize the degree of crop weed encroachment, to evaluate the health degree of the crops, to identify possible attacks of pests [2,5].

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ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665

The measurement of the different working parameters by sensors and transducers, the analysis of the information received through the specific computer systems and software and the sending of orders for the modification of other parameters on tractors and agricultural machines created the Intelligent Agriculture system which is based on the use of logical schemes and very well defined process programs, aiming at increasing the quality indices of the works carried out concurrently with reducing the errors induced by the human factor. Most aggregates are driven using GPS systems, and for each operation, mapping can be done using the GIS method.

Some of the advantages obtained through the development of Intelligent Agriculture are:

≡ self-driving of aggregates or of self-propelled machines using GPS;
≡ automatic maintenance of a pre-set adhesive force;
≡ modification of the working depth in real time for the soil works depending on the amount of plant debris existing on the surface;
≡ modification of the working depth in real time when sowing and placement of seeds in the area with optimum humidity;
≡ detecting plants and weeds and distinguishing them;
≡ automatic correlation of the movement speed according to the needs (material flow, ripeness degree, plant density, etc.);
≡ monitoring and control for each nozzle separately in case of phytosanitary treatments;
≡ optimization of fillings and management of solution residues for phytosanitary treatments;

Further we present a synthesis of the current state of research regarding the use of intelligent algorithms of image recognition within agricultural crop maintenance works.

2. MATERIAL AND METHOD

One method of using vision systems in agriculture is to assess the quality of work of certain equipment during work process. In [3] the author used a vision system in order to evaluate the coverage degree obtained by an orchard sprayer machine. They designed a specialized stand, especially for simulation of the tree height levels and the vehicle speed. They used water-sensitive material, which maintained the initial position and form of the sprayed droplets. After the tests were taken high resolution pictures of the material and analysed using custom designed vision software. The analysis results represented the covering degree.

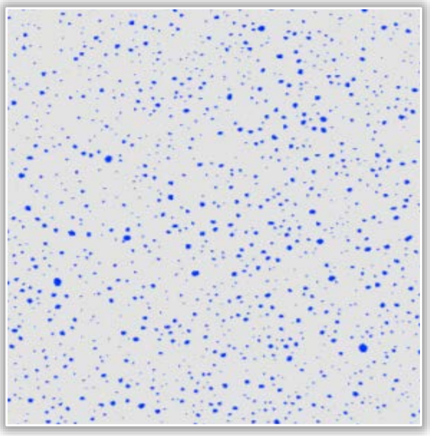
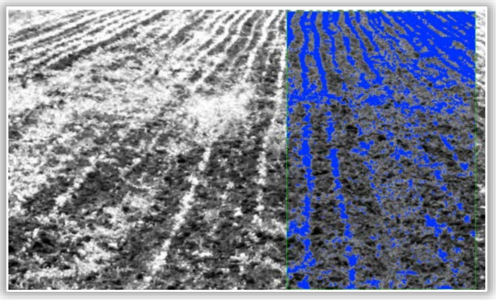


Figure 1. Coverage degree evaluation by counting blue pixels surface, [3]

One of the objectives of precision agriculture is to reduce the volume of herbicides applied by using a weed management system according to their geographical distribution. In order to achieve this goal, we must take into account the physical characteristics of the weeds (shape, colour, texture, similarities between crops and weeds) and the unequal distribution of weeds in the crop.

In [4] the authors used a smart camera system in order to assess the weeds degree within a maize crop. The vision algorithm for weed area identification consisted in real time image sampling, identification of crop rows for each interest area analysed, identification of the space between crop rows for each interest area analysed and determination of the percentage degree of weed infestation, by conducting an analysis on the colour difference between the surface covered by weeds, the soil and crop rows. In figure 2 is presented the original image and the identified crop rows after processing.

a)



b)

Figure 2. a) original image, b) Identified crop rows – blue coloured, [4]

In [7] the authors propose an automatic method using the computer and image recognition to detect a specific weed Avena sterilis in cereal crops and a differential method of spraying treatment. By means of an image acquisition system a digital image of the crop is created, it is rasterized and then, by means of a decision algorithm on the fuzzy-type spraying operation, it is automatically decided whether or not a particular segment of the crop will be treated.

The images used for the paper were collected from an experimental land of 1.7 ha, cultivated with barley, in the research resort La Poveda, Arganda del rey, Madrid. Target weed, A. Sterilis showed densities between 10 to 400 plants per m^2. Although other weed species were present in the field, at the time of image acquisition, most were destroyed by herbicide treatment.

The method proposed by the authors involved two stages: image segmentation and decision making. The segmentation of the image consisted of dividing the image into cells that made it possible to distinguish the weeds from the crop plants. Based on this information, the decision-making process determines whether the cell will be sprayed or not. For this purpose, a database containing weeds form was created prior to the spraying work, so that there is a reference. The decision was made by comparing the samples from the database with those taken in real time.

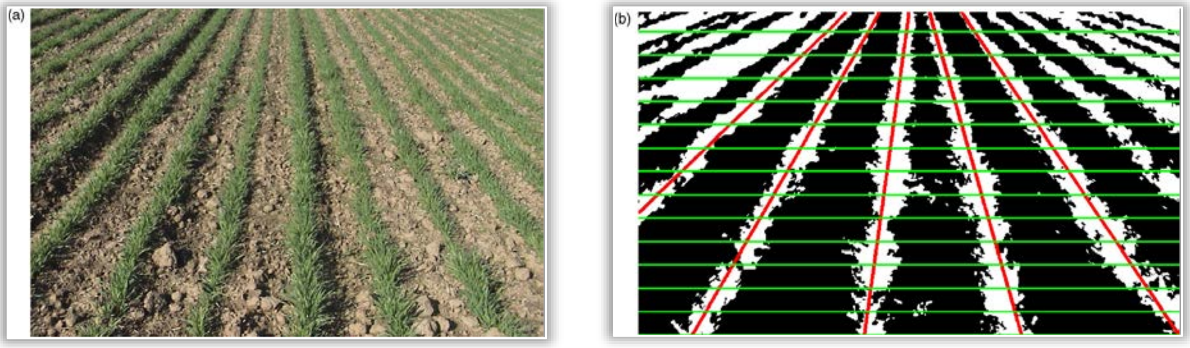


Figure 3. a) Original imagine, b) Segmented image, [7]

Figure 3 shows the initial image of the crop, acquired in real time and the image processed by segmentation. The concept of segmentation involves the acquisition and binarization of images, the detection of crop rows, the rasterization of images in cells and the extraction of the attributes corresponding to each cell. After the implementation of the command algorithm proposed by the authors, the general image in figure 4 is obtained, in which the cells marked with S need to be treated.

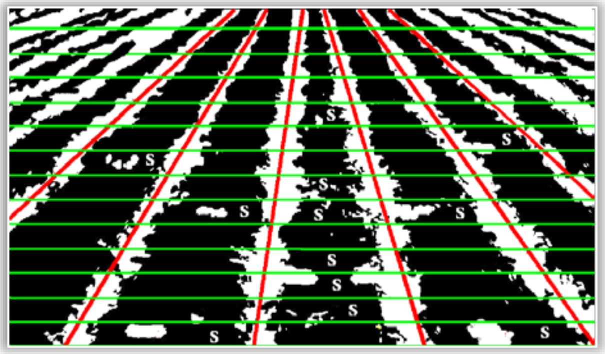


Figure 4. Processed image, [7]

In [1] the authors present another application of the technology of image acquisition and form recognition, this time in a chili crop, a vegetable recognized for its gastronomic properties. Figure 5 shows the image of the chili plant, the target crop and 5 harmful weeds.

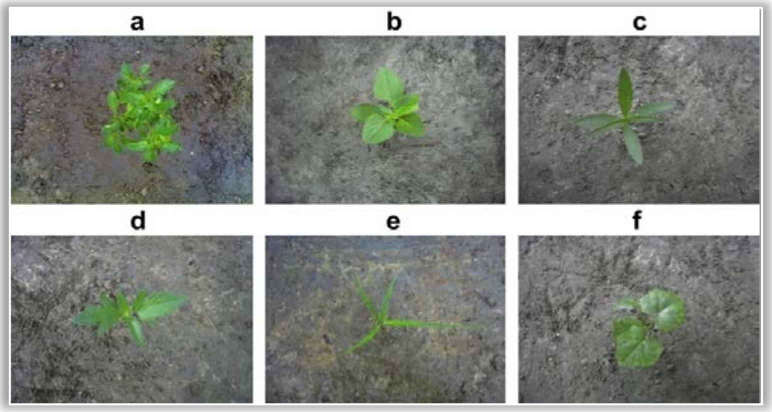


Figure 5. Acquired images (a) Capsicum frutescens L. (b) Amaranthus viridis L. (c) Enhydra fluctuans Lour. (d) Chenopodium album L. (e) Imperata cylindrica (L.) P. Beauv.; (f) Sicyos angulatus L., [1]

The technique used by the authors to process the images also in the segmentation of the images, this time in order to separate them from the ground. Figure 6 shows the final result obtained after image processing.

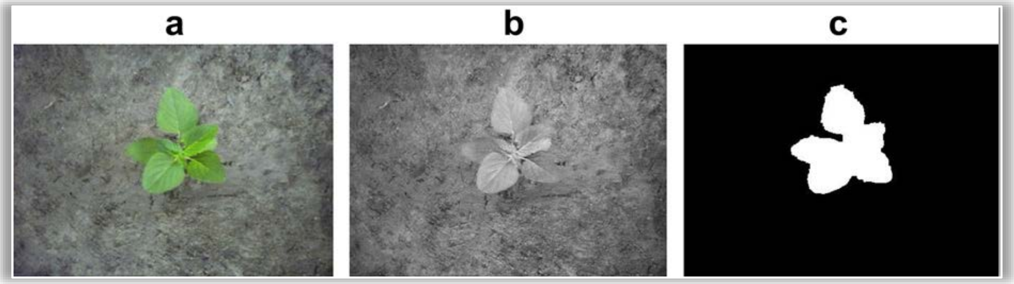


Figure 6. Images a A. viridis L.; (a) RGB image (b) grayscale image (c) segmented binary image, [1]

The information thus obtained is used for the purpose of determining the weed encroachment degree of the chili culture.

Other authors decided to use image recognition technology to control an agricultural robot, which independently decides whether or not to spray a cereal crop.

Thus, in [6] the authors present such a robot that differentiates the different cells in which the culture was divided following the analysis of the images acquired by it. Figure 7 shows the autonomous robot specially designed to perform chemical weeding in cereal crops.

Figure 7. Robot – that acquires images and processes them for the purpose of weed monitoring and spraying A = box with camera and xenon lighting; B = box with computer, GPS and memory disk; C = GPS antenna; D = herbicide tank; E = spraying ramp, [6]

Another approach is that of Trimble, which developed a system called WeedSeeker spot spray which senses if a weed is present and signals a spray nozzle to deliver a precise amount of chemical — spraying only the weed and not the bare ground, most effective in areas where weeds occur intermittently [8]. This system can be mounted even on traditional spraying machines with some modifications.

3. CROP MECHANICAL MAINTENANCE WORKS

The research on the mechanized hoeing technology on a row was started, worldwide, in 2001 by Garford Farm Machinery under the name - Robocrop MK2 - using the electronic part from Robydome [9]. This technology uses on-board computers to identify and locate crop plants in real-time with digital video images on crop scenes. Following a successful research project in collaboration with Garfords, they are now on the market at a high technology level, regarding weed control between crop plants.

Robocrop uses two technologies, one of GPS type, to guide the technical equipment on the cultivated rows to perform the hoeing operation on the interval, with precision and high speed range. The technology relieves the mechanizer of the need to focus on the forward direction, allowing him to monitor operations without a high level of stress. A camcorder mounted on the machine sees the crop first and passes images to a computer that processes the images and calculates the lateral position relative to the crop rows, activating a lateral displacement mechanism so as to minimize any non-alignment.

The second technology refers to hoeing in the row, between plants, in which each row plant is identified. The computerized system then synchronizes the rotation of a cyclic disc for soil processing between plants on a row. The result is a significant increase in the cultivated area eliminating the need for manual weeding of crops. The maximum productivity of the Robocrop system when hoeing on the interval between crops, as well as in the row between plants, has reached a rate of up to 2 plants per second.

The differences between mechanical and manual hoeing between plants are very large, according to a research study done on green salad, the Robocrop MK2 machine was used to thin the crop and to remove the weeds and the operation lasted 8.4 h/ha compared to the same procedure performed manually that lasted 23.2 h/ha, and the plant density was 62000 plants/ha compared to only 56000 plants/ha. The technology for tracking and tracing the crop was developed by the THTechnology team in 12 years of research.

The active parts for hoeing in the interval between the plants are classic, while those for hoeing between the plants in a row have a special construction. They consist of a special crescent-shaped disc, mounted parallel to the ground, working at a reduced depth (typically 10 to 20 mm) in the crops' row. It is mounted on a vertical support and on a flange on the axis of a hydraulic motor operated by a proportional hydraulic valve controlled and synchronized with the speed of the Robocrop computer according to the information taken from the camera.

The crescent profile of the disc is designed to maximize the precisely worked surface (up to 10 mm from the average position of the detected plant leaves) around the plants and in the area between plants.

Table 1. Mechanical hoeing machines

Firm	Tractor power	Working width
Garford Robocrop MK2 [9] 	80 HP	2 m
	100 HP	3 m
	150 HP	6 m
Nanne Kooiman Robovator [10] 	100 HP	3 m

The Nanne Kooiman Robovator robot is equipped with a special plant detection camera, placed on the frame of each working section. It has a mechanical instrument that is operated by the hydraulic system. The hydraulic components are very robust and designed for high speed operation and long service life [10].

The cameras, specially designed to detect plants, mounted on each parallelogram continuously monitor the plants. If a plant passes through the range of the camera, the computer will send a signal to the hydraulic instrument which, at the time specified by the camera, will be moved out of the row. When the crop plant has passed, the instrument is moved again in the row.

If there is a discrepancy of the rows, for example one or more plants are missing, the hoeing active parts will only remain in a row. The automatic side control ensures that the machine remains in the exact position, even if the tractor leaves the path.

Features: Automatic side control of the machine, can operate in the dark, high capacity, low energy requirement, low maintenance.

Working field: size of plants 2 cm to 30 cm;
plant spacing 5 cm to infinity;
working speed 1-4 km/h

In table 1 are presented the 2 machines created, which perform mechanical hoeing in the row and between the plants.

4. CONCLUSIONS

Throughout the development of mankind, a main branch of economic activity was represented by agriculture. Agricultural research has played a particularly important role in increasing production and in the most rational exploitation of existing resources, with the population of the planet constantly increasing and the exploited agricultural fund is limited and with clear trends of deterioration. In this context, the mechanization of agriculture has played a fundamental role from the technical, economic and social point of view, especially in the highly industrialized countries, offering substantial possibilities to reduce costs, increase the quality of works, as well as the creation of new products especially in the energy field. Another important aspect is the one related to energy consumption for the production and processing of agricultural products. It is widely recognised that, at present, agricultural processes have high energy consumption and cause environmental damage, which has led to the search for alternative working methods and has determined the research orientation towards the optimization of energy consumption and the reduction of the negative impact on natural resources (water, soil, air).

Acknowledgement

This work was supported by a grant of the Romanian Research and Innovation Ministry, through Programme 1 – Development of the national research-development system, subprogramme 1.2 – Institutional performance – Projects for financing excellence in RDI, contract no. 16PFE. This work was supported by a grant of the Romanian Research and Innovation Ministry, through Sectoral Plan, contract no. 1PS/2019.

Note:

This paper is based on the paper presented at ISB–INMA TEH' 2019 International Symposium (Agricultural and Mechanical Engineering), organized by Politehnica University of Bucharest – Faculty of Biotechnical Systems Engineering (ISB), National Institute of Research–Development for Machines and Installations Designed to Agriculture and Food Industry (INMA Bucharest), Romanian Agricultural Mechanical Engineers Society (SIMAR), National Research & Development Institute for Food Bioresources (IBA Bucharest), National Institute for Research and Development in Environmental Protection (INCDPM), Research-Development Institute for Plant Protection (ICDPP), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and "Food for Life Technological Platform", in Bucharest, ROMANIA, between 31 October – 1 November, 2019.

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ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665