Smart system for early detection of agricultural plant diseases in the vegetation period

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Abstract. This paper presents a smart system for the early detection of agricultural plant diseases in the vegetation period. The proposed smart system allows the detection of three types of wheat diseases, particularly yellow rust, powdery mildew, and Septoria at an early stage, and significantly improves the soil and ecology by locally spraying harmful chemicals just on sick plants. The proposed disease-detecting method is based on the structure of a convolutional neural network (CNN) using the Pycharm program based on the C ++ programming language. The basic structure of the smart system consists of Raspberry PI 4 MODULE, Raspberry Pi camera module v2, buzzer, HC-SR04 distance sensor, rotor driver, AC motor, power supply, relay microelectronics, and some digital devices.

Keywords: plant disease, wheat, flour dew, yellow spot, Septoria, image, smart system, sensor, neural networks, algorithm, microelectronics, digital device, block diagram.

1 Introduction

Nowadays, agricultural crop disease detection by clean modern methods is one of the most vital problems, and many researchers are conducting research in this area. Scientists such as Vignesh M, Yogeswaran A, Ragunath S, and Rohan Babu D in their scientific article entitled "Plant Disease Detection Robot" proposed a smart system for detecting tomato plant diseases[1]. In this system, the ANN method of neural network is used to detect plant diseases. The above-mentioned system captures video for 5-10 minutes and diagnoses the disease by analyzing this captured image. However, the system provides the farmer with information about the disease via Bluetooth [1]. Unfortunately, you cannot transmit data over long distances using Bluetooth.

Scientists such as G. Kalyani, K. Amrutha, S. Alekhya, S. Lalitha Samrajyam in their scientific article titled "e-AGROBOT- A Robot for Early Crop Disease Detection using Raspberry Pi" proposed a smart system for detecting plant diseases. In this system, the SNN method of neural network was used to detect plant diseases. But, the article does not provide information on which plant or diseases the system specializes in detecting [2].

In 2021 3 million tons of crops have harvested on 148 thousand hectares in Uzbekistan. The population of the republic grows the demand for agricultural products is growing

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annually. Meeting the needs of the population indicates the need to get the maximum yield from small areas and plantations. According to the last statistics, the damage caused to crops and plantations by natural disasters such as floods, earthquakes, droughts, etc. is only 2%, while the damage caused by pathogens is 98%. Early detection of wheat or other plant diseases will help to prevent losses in the yield and quantity of agricultural products, and significantly reduce the amount of damage to the soil and the environment through the local use of chemicals used to eliminate existing diseases [3-4].

2 Materials and methods

One of the key factors in maintaining an abundant harvest of crops, including wheat, and maintaining the crop grown is protection from pests, diseases, and weeds. One of the key factors in maintaining an abundant harvest of crops, including wheat, and maintaining the crop grown is protection from pests, diseases, and weeds. Below in Figure 1 shows a diagram of wheat production and consumption in the world market for the period from 2011 to 2021. This diagram shows that the demand for wheat crops is increasing annually [4].

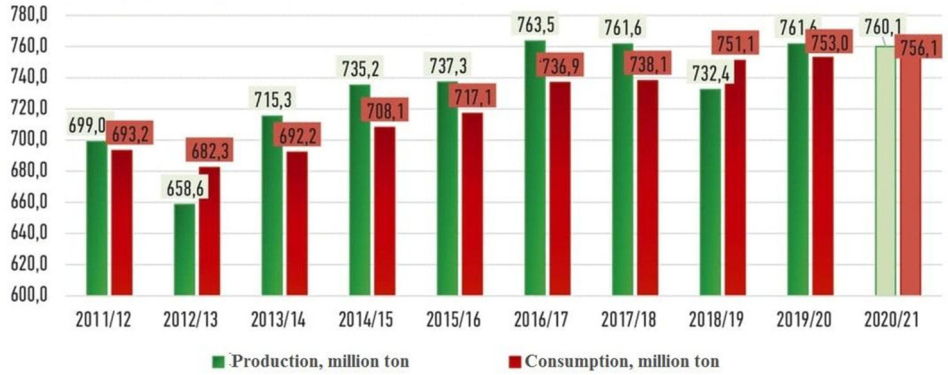

Fig. 1. Production and consumption of wheat in the world market in 2011-2021.[3]

Hence, the issue of increasing the yield of wheat and protection against various diseases is one of the most vital issues, and the spread of diseases in arable lands leads to the destruction of all crops or a significant decline in yield. In the case of wheat, there are cases of crop failure or incomplete development. Such cases occur as a result of factors such as various diseases of wheat, harmful insects, nematodes, genetic and physiological changes in wheat composition, mineral deficiency, and the negative effects of the external environment. Figure 2 shows the factors influencing the physiological state of the wheat plant [5-7].

Currently, more than 10 types of diseases are affecting grain crops in the country. These are brown rust, yellow rust, flour dew, yellow spot, septoria, spike fusarium wilt, powdery mildew, hard blackberry, root rot, and snow mold diseases [3–5, 7].

In this study, we have analyzed the components of the smart system, its operating algorithm, electrical circuit, and the results of a preliminary study conducted using software designed for that system to help identify a healthy or diseased part of a plant.

The system mainly detects the disease using signs on the plant leaf and prevents it from spreading to other areas. When it detects the presence of a disease, it sends information to

the farmer via mobile phone or the Internet and sprays the pesticide on the affected local area. The main goal of the study is to reduce the workforce in agriculture and introduce a developed smart system instead.[5, 7–10]

Once the plants are infected, the disease develops at certain stages, and the symptoms of the disease appear on the leaves, stems, spikes, and rooted parts of the plant. Early detection of the disease in large areas makes it difficult for farmers. This process requires plant disease specialists and a large number of workers as well as a long processing time. It also damages the soil and the whole environment by spraying harmful chemicals on the field.

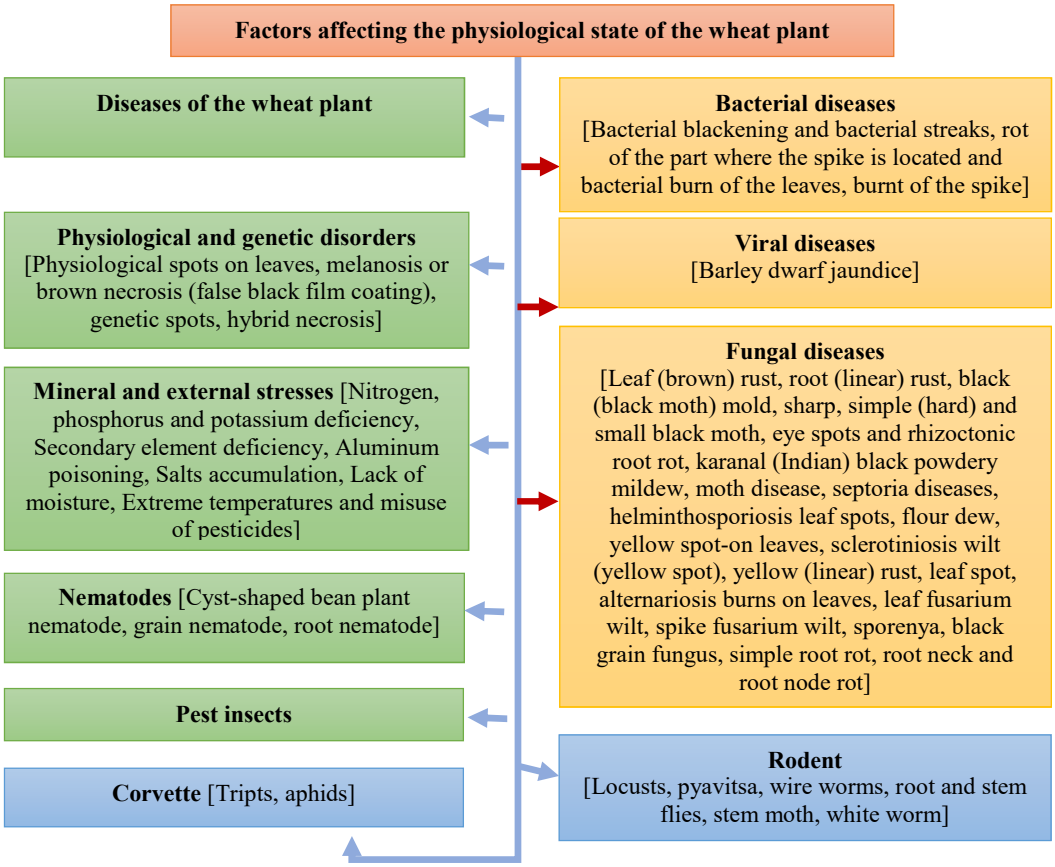

Fig. 2. The factors influencing the physiological state of the wheat plant [5, 7].

Figure 3 shows the functional diagram of the smart system for early detection of wheat diseases: Raspberry PI 4 MODULE, Raspberry Pi camera module v2, buzzer, HC-SR04 distance sensor, rotor driver, AC motor, power supply, relay microelectronics, and digital devices. The smart system has an HC-SR04 distance sensor, which allows it to bypass various obstacles and stop if the plant is detected in the range of 50 cm during the movement of the smart device [11-14].

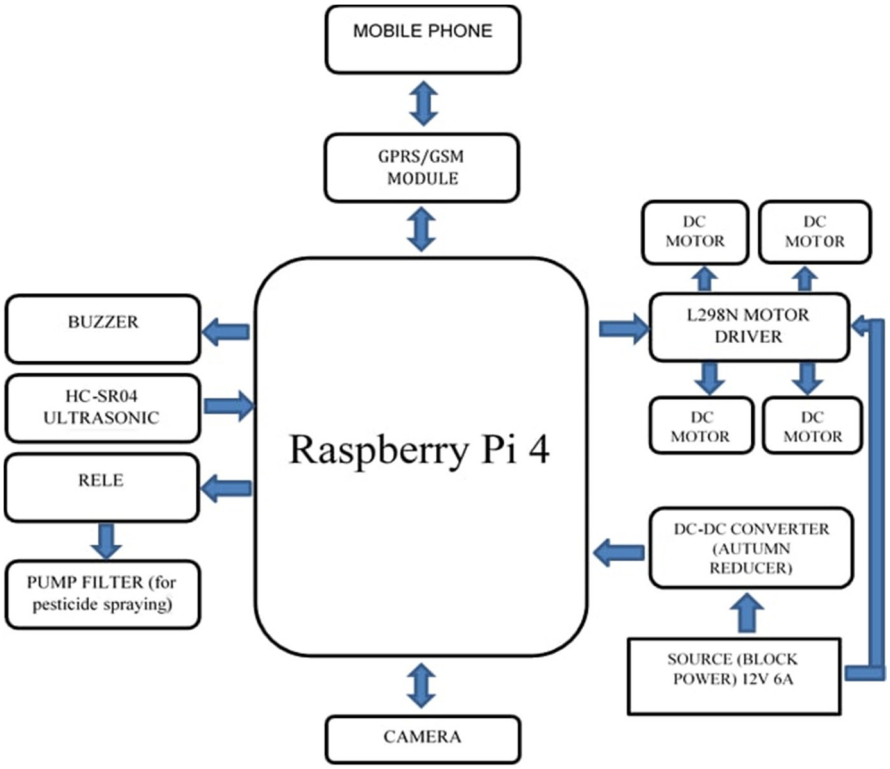

Fig. 3. Functional scheme of the smart system for early detection of diseases of wheat plants.

The Raspberry Pi module v2 camera then separates and captures the parts of the wheat plant in the system where the symptoms of the disease appear at an early stage. The camera is equipped with an eight-megapixel Sony IMX219 Exmor sensor. It allows video and image capture, streaming in 1080p, 720p, and VGA formats. The maximum resolution for images is 3280 × 2464 pixels. If the image is not clear, then wait for the next image. The image captured by the camera is transmitted to the Raspberry PI 4 MODULE. Figure 4 shows the developed algorithm of operation of the smart system [10], [15], [16]. The RASPBERRY PI 4 MODULE is a single-board computer with a small size. When activated by connecting devices such as a keyboard, mouse, external devices, and display to the board, it acts as a mini personal computer [4].

It is mainly used for real-time image processing from a wheat leaf sample, internet-based applications, and robotics applications. The smart system we are developing performs functions such as image reception, image processing, diagnostics, and data transmission to the farmer via the Internet. The program of the operating algorithm of the smart system shown in Figure is developed and uploaded on the microcontroller. With the help of this program, the image of the infected plant is analyzed and diagnosed.

A speaker device will sound an alarm to alert the farmer if a disease is detected in the system. In addition, via GPRS / GSM MODULE, an SMS message is sent to the farmer's mobile phone about the type of disease [18]. In Figure 5, we can see a model created based on the Breadboard and the Fritzing program of the electrical circuit of the smart system that detects plant diseases at an early stage. The electrical circuit is developed based on the block diagram shown in Figure 3 above and the microelectronic devices presented in it, and the names of the elements in the electrical circuit and their functions are described. Figure 6 shows the model of the developed smart system.

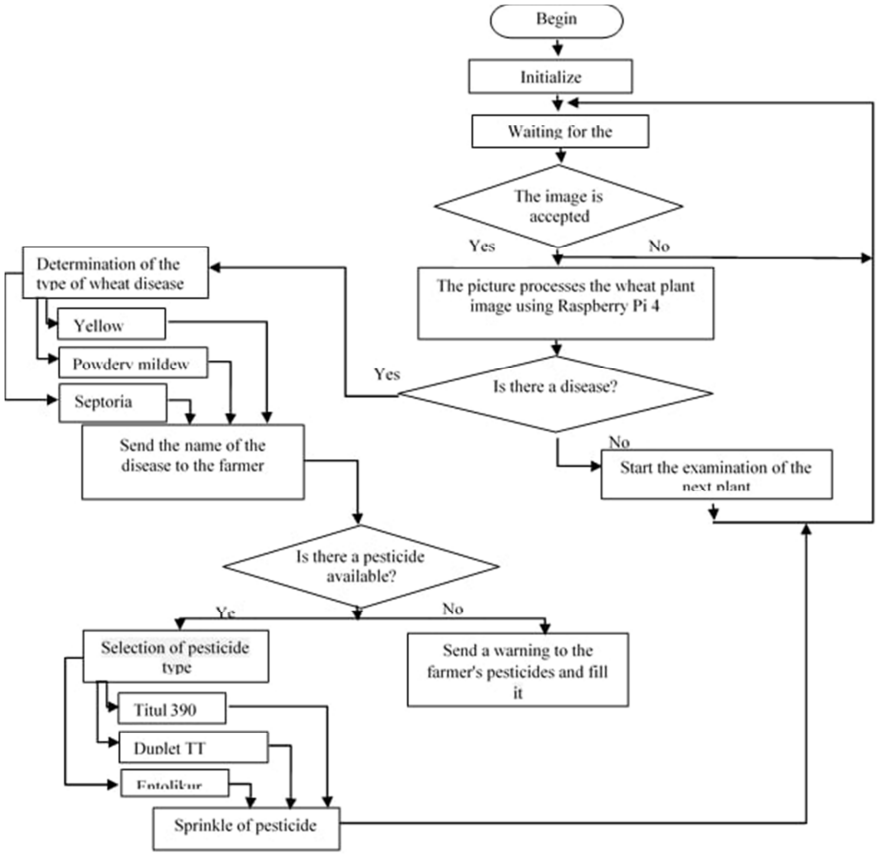

Fig. 4. The developed algorithm of operation of the smart system [1, 2, 4].

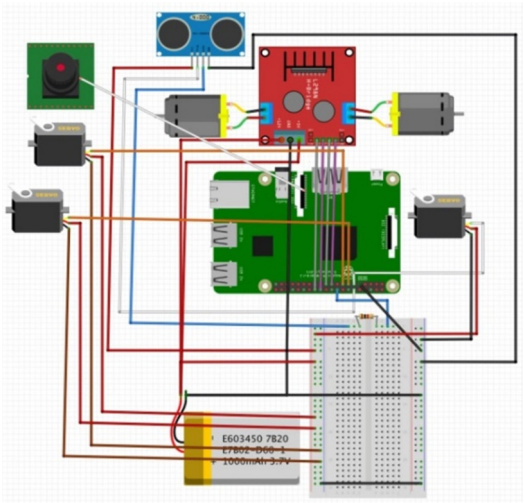

Fig. 5. Electrical scheme of the smart system that detects wheat plant diseases at an early stage.

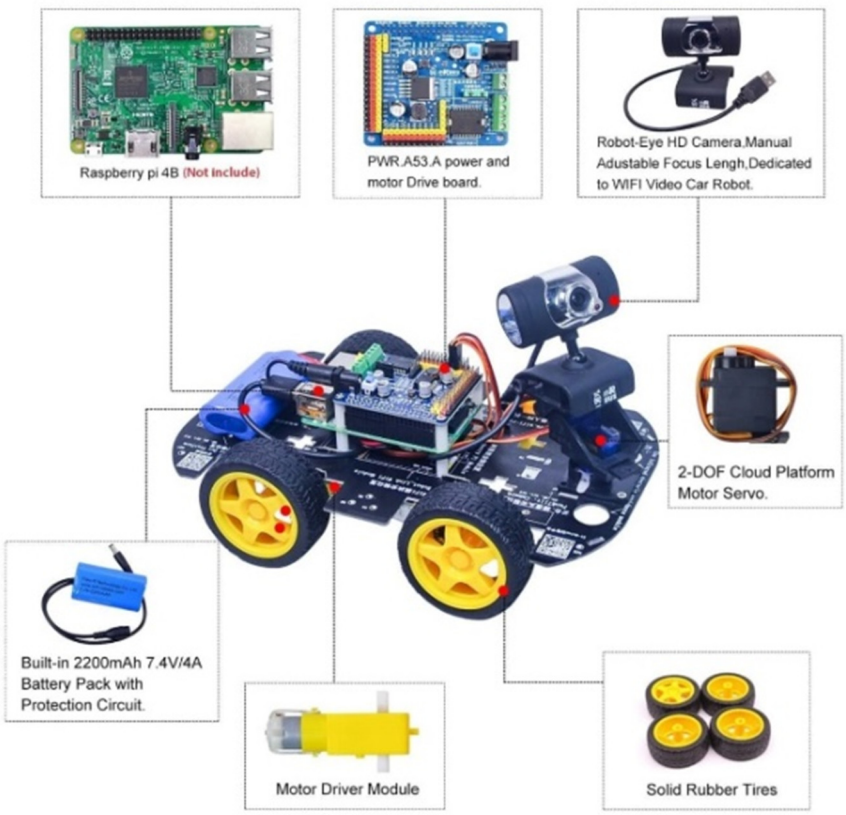

Fig. 6. The model of the smart system.

3 Results and discussion

The results of the work of the smart system with image processing are shown in Figure 7. The smart system is based on the structure of a convolutional neural network (CNN) using the Pycharm program based on the C ++ programming language [9, 16, 17, 19].

CNN works by getting an image and designating it some weightage based on the different objects of the image and then distinguishing them from each other. CNN requires very little pre-process data as compared to other deep learning algorithms. One of the main capabilities of CNN is that it applies primitive methods for training its classifiers, which makes it good enough to learn the characteristics of the target object.

The developed smart system is currently able to distinguish three types of wheat disease and the health of the plant, which detects yellow rust, powdery mildew, and septoria at an early stage in wheat grown in the region of Uzbekistan.

Images of each disease were placed in separate folders to diagnose the disease, and the image of a single disease is now about 200. These images determine the level of accuracy of the program. During the study, it was planned to increase the database of these images to more than 1,000 values.

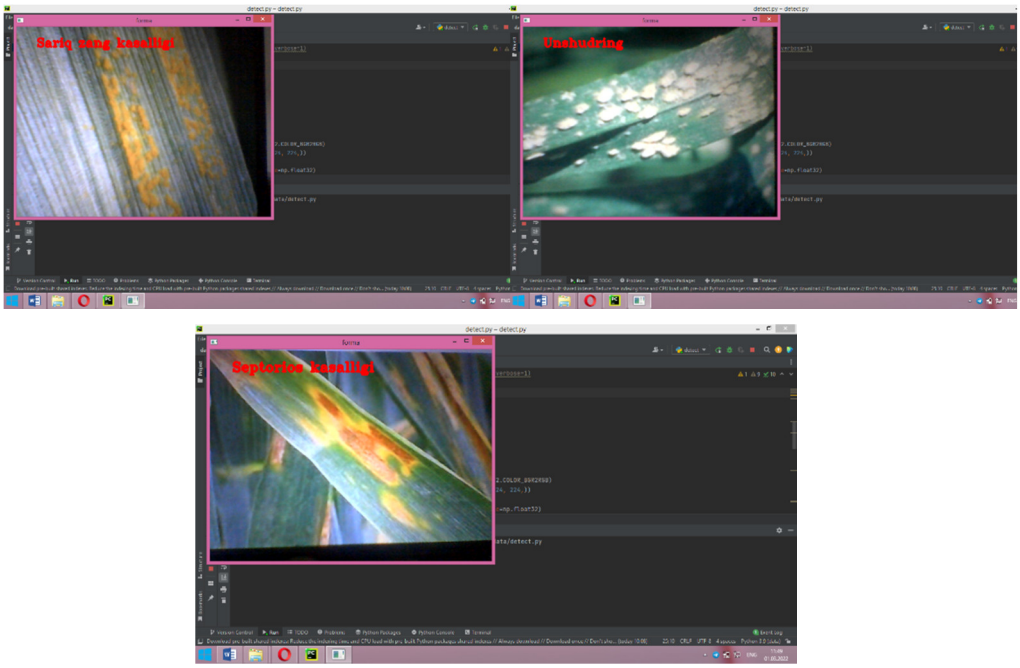

Fig. 7. Results obtained using a software tool based on a convolutional neural network (CNN).

4 Conclusion

When we use the smart system mentioned in the study for measurement and control of the physiological state of the agricultural plants during the growing season we will get:

- plant diseases are detected at an early stage;
- the quality of wheat ears or other products improve and the yield increases;
- the number of specialists involved in the detection of wheat diseases and the number of workers treated with chemicals sprayed on the diseased plant will be reduced;
- the use of harmful chemicals such as fungicides, title 390, Duplet TT, and entolikur, used to eradicate the disease after wheat sickness, is significantly reduced;
- damage to soil and ecology will be significantly reduced.

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