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Robotic Technologies in Agriculture: A Revolutionary Tool for Farmers

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Abstract
The rapid development of new technologies and the changing landscape of the online world (e.g., Internet of Things (IoT), Internet of All, cloud-based solutions) provide a unique opportunity for developing automated and robotic systems for urban farming, agriculture, and forestry. Intelligence technologies, using machine vision/learning, have been developed not only for planting, irrigation, weeding (to some extent), pruning, and harvesting, but also for plant disease detection and identification. However, plant disease detection still represents an intriguing challenge, for both abiotic and biotic stress. Many recognition methods and technologies for identifying plant disease symptoms have been successfully developed; still, the majority of them require a controlled environment for data acquisition to avoid false positives. Machine learning methods (e.g., deep and transfer learning) present promising results for improving image processing and plant symptom identification. Nevertheless, diagnostic specificity is a challenge for microorganism control and should drive the development of mechatronics and robotic solutions for disease management.

Key words: Robotic, disease detection, mechatronics, disease management, symptoms.

Introduction
Research in agricultural robots has been growing in the last years, thanks to potential applications and industry efforts in robot development. Their role was investigated for many agricultural tasks, mainly focused in increasing automation of conventional agricultural machines and covering processes such as ground preparation, seeding, fertilization, and harvesting. Systematic, repetitive, and time-dependent tasks seem to represent the best fields of application for robots, especially in an arable farming context with temporary crops. Agricultural scientists, farmers and growers are facing the challenge to meet out the food requirements to the growing population. It is predicted that world will reach 9.8 billion populations in 2050. India Second most populated country. The world need lot more food and farmers will face serious pressure to keep up with demand. Precision agriculture plays an important role to maintain the future food security with less labour and energy at the same time improving the environmental management to ensure a productive agricultural output. "Precision agriculture is one of the means of producing on site data to guide decision making, thus to manage the growing of crops for better yield and quality". Automation and mechanization are one of the components of precision agriculture, automation in agriculture includes mainly the agricultural robotics. "Agricultural Robotics is the logical proliferation of automation and cost-effective technology into bio systems such as agriculture, horticulture, forestry, fisheries and livestock". Term Robot is picked up from a play in **Czech**: "**Robota**" meaning servitude or forced labour. "A **Robot** is an autonomous machine capable of sensing

its environment, carrying out computations to make decisions, and performing actions in the real world".

Parts of Robots

1. SENSORS

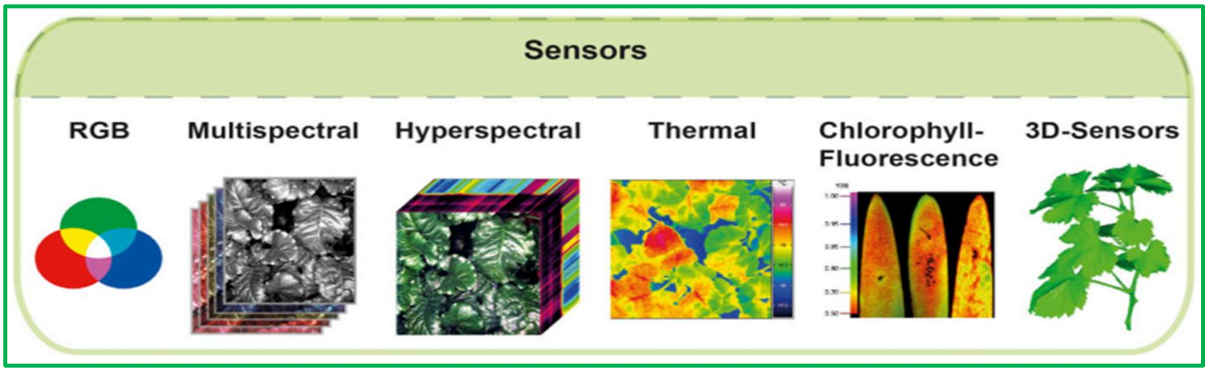


Fig. 1 Types of sensors

a. **RGB Imaging:** The appearance of an object in RGB images is the result of the light reflected from the object, its optical characteristics, and the human perception. Color or RGB (red, green, blue) images are useful to detect biotic stress of plants. Color, gray levels, texture, dispersion, connectivity and shape parameters can be used for detection and identification of disease symptoms in plants.

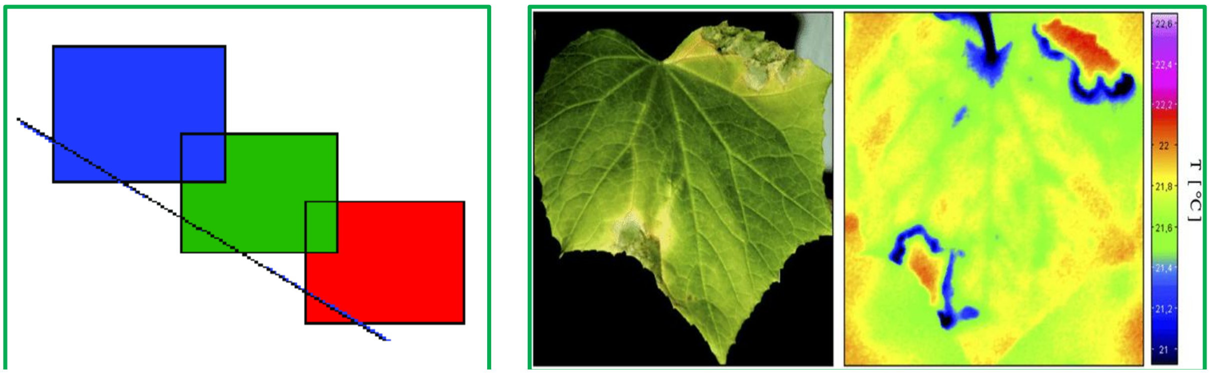


Fig. 2 RGB Imaging

b. **Multispectral reflectance sensors:** Multispectral sensors usually detect spectral information of red, green and blue electromagnetic spectrums, and also the red edge and near-infrared wave ranges. Multispectral sensors were the first spectral sensors invented. These methods can be used to identify crop health, weed species, crop injury after herbicide spraying and diseases symptoms.

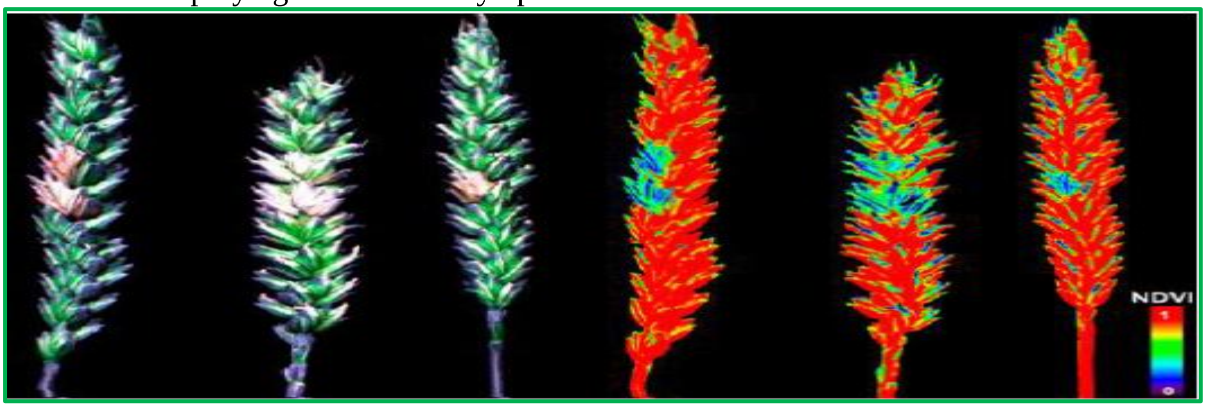


Fig. 3 Multispectral reflectance sensors: Spikelet's showing symptoms of the disease Fusarium head blight can be visualized by a normalized difference vegetation index (NDVI).

c. **Hyperspectral reflectance sensors:** Hyperspectral cameras measure spectral reflectance of plants throughout the visible, near-infrared and mid-infrared portions of the electromagnetic spectrum. Spectral reflectance of individual plant species at the canopy or single leaf scale is unique and referred to as a spectral signature. Absorption of light by plant pigments, plant structure and leaf chemistry produce unique spectral signatures which are helpful to monitor crop conditions.

d. **Thermal imaging:** Thermal imagery is based on the fact that objects emit infrared energy (heat) as a function of their temperature. Thermal cameras are essentially heat sensors which detect the differences in object temperatures. Thermal imaging can be useful for monitoring plant temperatures across a field plant disease symptom.

e. **Chlorophyll fluorescence imaging:** Chlorophyll fluorescence imaging is used for the early detection of viral, bacterial and fungal infection, before symptoms are visible by eye.

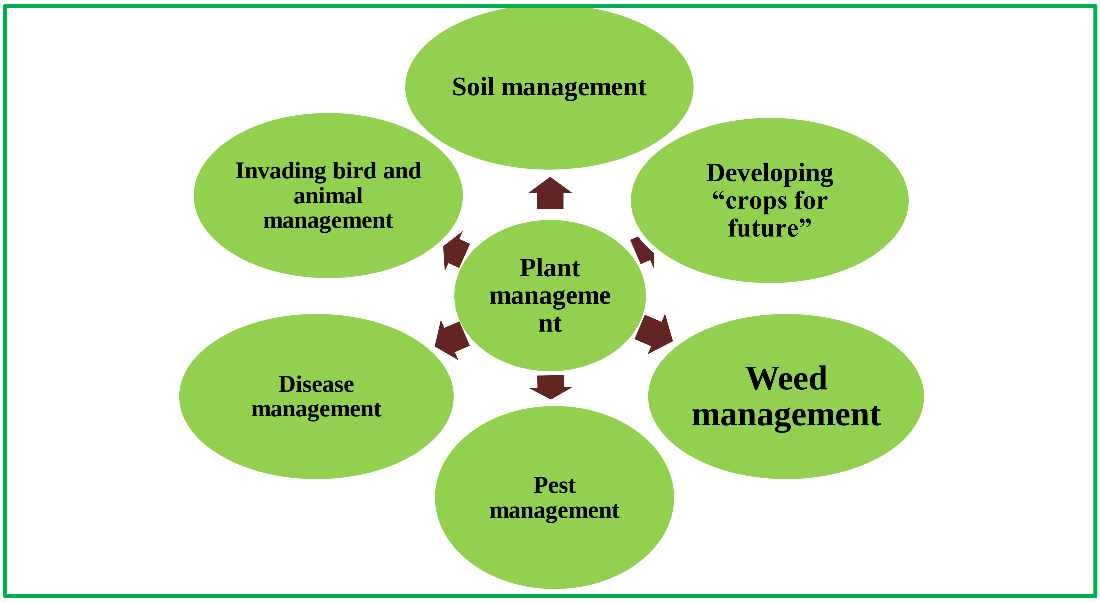
Chlorophyll fluorescence parameter F_v/F_m

The emergence of diseases affects the fluorescence of phenolic compounds and chlorophyll.

f. **3D Sensors:** 3D sensors consider morphological features like length, width.
   - Perimeter, roundness of object for detection.
   - 3D imaging appears as an essential for automatic plant disease detection.
   - LiDAR Sensor (Light Detection and Ranging) is an optical remote sensing technology using lasers that can measure the distance to other features by illuminating the target with Light.

2. **COMPUTERS:** Computers are used as a database to process and store thousands of images. It processes the input data irrespective of numbers or images using definite algorithms and send the output signal to the robot.
3. **ACTUATOR:** The actuator is the “engine” of the robot. It is defined as “a mechanical device that produces motion”. Types are hydraulic motor, pneumatic motor, stepper motor, DC motor and servo motor.
4. **ARM:** A robot’s arm is just like the human arm with a shoulder, elbow, wrist and fingers. It positions the end effectors and sensors to do their pre-programmed business.
5. **END EFFECTOR:** The end effector is the last link of the robot. At this end point the tools are attached, it is that part of the robot that interacts with the work environment.

Applications in Plant Management



Uses of robotics in Indian agriculture

1. Robots for seeding

- The arm consists of three main components; plowing tool, seeds container, and excavation tool.
- Plowing tool would move the soil and create a place for the seed to be placed in.
- Excavation tool would move back the soil and close the hole.

2. Robots for weed control

- Robots' direct chemical or cultivation tools to target weed plants
- Farmers intentions are sent to robot which decides on what to destroy
- Mostly based on Spectral reflectance characteristics

3. Robotics for soil moisture management

- Soil moister sensor control the status of the water pump to perform the soil watering function.

4. Robots for harvesting

- Based on machine vision and sonar technology, the independent navigation system for harvesting robot was built.
- The fruits were distinguished according to color histogram and the picking-point was located by binocular vision system.

5. Robotic insect management

- Locust swarms invaded parts of India, especially Rajasthan
- Nearly 90,000 ha of land affected across 20 districts
- Organophosphates were sprayed using drones
- 2.5 ac in merely 15 minutes
- 30 drones in 22 districts during evenings were used
- Efficiency: 60-70%

Robotic disease diagnostics

- India is well known for agriculture and around 60% of the population depend on agriculture. It contributes a majority to the economy of India.
- In this situation the yield of the crops must be high and of good quality which leads to a good amount of income in agriculture.
- Diseases to crops may affect both quality as quantity of the crops. Crop diseases are of mainly three types namely bacterial, fungal and spots.
- A solution to this is to use modern methods in agriculture that helps the farmers to detect the diseases faster and increase the crop yield.
- The agricultural robot developed is capable of detecting the disease and monitoring the field condition by moving around the field. It will continuously alert the farmer by sending the SMS so that farmers can take the appropriate action.
- Disease identification is challenging due to lack of necessary expertise and infrastructure.
- Disease detection is a visual task; hence robots are incorporated with vision-based technologies.
- A model robot called Far maid robot was developed for disease diagnostics.
- Mostly colour camera and multispectral camera are used in disease detection.

Advantages of robotics in agriculture

- Precision Agriculture
- Solution to lack of labour
- Full field capacity work
- Safety of farmers and consumers

- High productivity
- Enables alternate employment and additional source of income
- Useful for insurance claim – PMFBY

Conclusion

- To meet the increasing food requirements, introduction to mechanization and automation is inevitable. Robots act as an experienced pathologist that recall 1000's of images to deliver diagnosis.
- A robot's "eye" is far better than human one, and it can collect a large amount of data that are invisible for us. However, we have to consider that processing of images won't be enough for every pathogen, host and environment combination.
- A parallel field of investigation for enhancing "robotic pathologists" involve the further development of manipulators and sampling hardware, shifting the research focus from "experienced robotic observer" towards "robotic observer and analyst".
- RGB and multispectral sensors for detection showed that it is important to include an RGB sensor as part of the disease detection sensor suite. Such a sensor should be added to the sensor apparatus either instead of, or alongside the multispectral sensor. Inclusion of both sensors should be carefully scrutinized, as it will increase system cost and will increase end-effector size, which may mandate a change in path to avoid collisions with the plants.
- A disease-sensing system based on multispectral imaging and associated detection algorithm was integrated with real-time manipulator control in a ROS based communication framework. The robotic system was tested on four different grapevine canopy preparations, which exhibited varying powdery mildew disease symptom levels and spread density within the foliage.
- The agricultural robot developed is capable of detecting the disease and monitoring the field condition by moving around the field. It will continuously alert the farmer by sending the SMS so that farmers can take the appropriate action.

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