AI for Plants Diseases Use Case - Smart Agriculture

Statement of Work (SoW)

Overview on Smart Agriculture

Agriculture has seen many revolutions, whether the domestication of animals and plants a few thousand years ago, the systematic use of crop rotations and other improvements in farming practice a few hundred years ago, or the “green revolution” with systematic breeding and the widespread use of man-made fertilizers and pesticides a few decades ago. We suggest that agriculture is undergoing a fourth revolution triggered by the exponentially increasing use of information and communication technology (ICT) in agriculture.

Autonomous, robotic vehicles have been developed for farming purposes, such as mechanical weeding, application of fertilizer, or harvesting of fruits. The development of unmanned aerial vehicles with autonomous flight control, together with the development of lightweight and powerful hyperspectral snapshot cameras that can be used to calculate biomass development and fertilization status of crops, opens the field for sophisticated farm management advice. Moreover, decision-tree models are available now that allow farmers to differentiate between plant diseases based on optical information. Virtual fence technologies allow cattle herd management based on remote-sensing signals and sensors or actuators attached to the livestock.

Taken together, these technical improvements constitute a technical revolution that will generate disruptive changes in agricultural practices. This trend holds for farming not only in developed countries but also in developing countries, where deployments in ICT (e.g., use of mobile phones, access to the Internet) are being adopted at a rapid pace and could become the game-changers in the future (e.g., in the form of seasonal drought forecasts, climate-smart agriculture) [1].

Technology and Architecture

Human ingenuity, scientific breakthroughs and technological advances have given the world an unprecedented array of tools to transform the food system and mitigate its impact on nature and climate. In precision agriculture, real-time weather forecasting helps farmers with day-to-day decisions on when and how much to irrigate, fertilize and apply pesticides to their crops. Controlled-environment agriculture promises to further reduce the impact. Some smart greenhouses are completely automated, run by algorithms that ensure optimal conditions for plant growth by adjusting inputs like roof ventilation, artificial lighting and heating.

Ultra-high resolution imaging can spot early symptoms of disease, water stress and soil degradation, while drones spray fertilizer, pesticides, and water with pinpoint accuracy. By reducing the guesswork in farming, smart agriculture enables crops to reach their full genetic potential without the excessive use of chemical inputs. Biotechnology is another field that continues to make breakthroughs. Advances in seed science are making crops more resistant to drought, pests and infestation, boosting agricultural productivity and increasing the resilience of food producers to environmental shocks. [2]

Smart Farming aims to optimise the production in farms by using the most modern means in a sustainable way, thereby increasing the production and delivering the best products in terms of quality while maximizing the return. It makes use of a wide range of technologies including IoT sensors, wearables, GPS services, UAVs, robots and drones operating in the field which provide real-time data to systems helping to monitor the production line and support decisions. This enables less waste and maximum efficiency in operations. The Reference Architecture of Smart Farm Management Systems (Smart Agrifood) ”Powered by FIWARE” relies on a “system of systems” vision. The existence of a context information management layer breaks the silos of information associated with the several vertical smart solutions, information systems and connected devices, enabling an overall management of Farm processes. [3]:

Plants Diseases

An impairment of the normal state of a plant that interrupts or modifies its vital functions. All species of plants, wild and cultivated alike, are subject to disease. Although each species is susceptible to characteristic diseases, these are, in each case, relatively few in number. The occurrence and prevalence of plant diseases vary from season to season, depending on the presence of the pathogen, environmental conditions, and the crops and varieties grown. Some plant varieties are particularly subject to outbreaks of diseases while others are more resistant to them.

Plant diseases are a normal part of nature and one of many ecological factors that help keep the hundreds of thousands of living plants and animals in balance with one another. Plant cells contain special signaling pathways that enhance their defenses against insects, animals, and pathogens. One such example involves a plant hormone called jasmonate (jasmonic acid). In the absence of harmful stimuli, jasmonate binds to special proteins, called JAZ proteins, to regulate plant growth, pollen production, and other processes. In the presence of harmful stimuli, however, jasmonate switches its signaling pathways, shifting instead to directing processes involved in boosting plant defense. Genes that produce jasmonate and JAZ proteins represent potential targets for genetic engineering to produce plant varieties with increased resistance to disease [4].

Other Types of Challenges

Climate Change.

Biodiversity Issues.

Water supply and irrigation.

Supply Chain and Logistical Issues.

Lake of Expertise and Manpower.

Fast Economic Changes Impact.

AI Solution Specifications

To address the plants diseases toward smart agriculture transformation where needed equipment with technology components are provided like smart cameras, drones, embedded PCs, IoT devices with efficient data acquisition capabilities, many topics need to be covered where AI solution could be of excellent fit. In this use case, we are including the following main topics under each could be several areas of implementation. The reset of the activities in this project from 2 to 18 are focusing on detailed process of getting real-life solution in place:

- Topic #1: Plant Attributes Recognition: Discovering the identity of one or more plant in an image and their family genus, species…etc., size, color, contour, dimensions including comparing and normalization to reference values.

- Topic #2: Plant Structure Recognition: Discovering and identifying the part of the plant like stem, leaf, fruit, root, flower…etc. including multiple parts in one image, parts of multiple plants and associated detailed attributes.

- Topic #3: Framing Environment Identification: Analyzing and identifying the surroundings, layout, farming areas, facilities, equipment, climate conditions, soil attributes and other frames elements.

- Topic #4: Diseases Infection Recognition: Detecting and identifying different types and forms of diseases per plant type, plant structure elements type, symptoms of infections, fungi, virus, disorder status of farming environments, including multiple infections, potential severity, recommended actions, and risk impact indication.

- Topic #5: Attacks Infection Recognition: Detecting and identifying different types of insect pests/worms per plant type, plant structure elements type, symptoms of infections, status of farming environments, including multiple infections, potential severity, recommended actions, and risk impact indication.

- Topic #6: Infection Spread Analysis: modeling and predicting the speed/transmission pattern diseases and attacks are likely to spread and affect further landscape specially with invasion-type ones while associating with the plants and farming environment.

- Topic #7: Statistical Modeling and Simulation of Events: set of models to analyze, predict, and simulate important events for data extracted from above topics including columnar and graph structures for example associating climate conditions, farming cycles, irrigation rounds, spatial distribution, seasonality, simulating change impact in farming schedules and distribution with respect to diseases and infections.

References & Resources

#	Topic	Source
1	Smart Farming is Key to Developing Sustainable Agriculture	https://www.pnas.org/doi/10.1073/pnas.1707462114
2	How Technology Can Help Address Challenges in Agriculture	https://www.weforum.org/agenda/2022/03/how-technology-can-help-address-challenges-in-agriculture/
3	Example of Smart Farming Architecture by FIWARE IoT Framework	https://www.fiware.org/community/smart-agrifood/
4	Soft Introduction to Plants Disease	https://www.britannica.com/science/plant-disease
5	Collection of Plants Diseases and Disorders	https://www.rhs.org.uk/disease
6	The Future of Food and Agriculture: Trends and Challenges	https://www.fao.org/3/i6583e/i6583e.pdf