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Lands DSS:
A Decision Support System for Forecasting Crop Disease in Southern Sardinia

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ABSTRACT

Decision support systems (DSSs) are used in precision farming to address climate and environmental changes due to human action. However, increments in the amount of data produced continuously by the latest sensor and satellite technologies have recently incentivized the integration of artificial intelligence (AI). A review of research dedicated to the application of DSSs and AI in forecasting crop disease is proposed. In this paper, the authors describe the DSS LANDS developed for monitoring the main crop productions in Sardinia and the case study conducted to forecast potato late blight. A feed-forward neural network was implemented to investigate if weather data provided by regional stations could be used to predict a disease risk index using an AI technique. The test performed by stratified k-fold cross validation achieved an accuracy of 96%.

KEYWORDS

Artificial Intelligence, Crop Disease, Decision Support Systems, Late Blight, Neural Network, Precision Farming

1. INTRODUCTION

Today's challenge in the agriculture sector is to address the continuous climate changes that are undermining food security and are driving economic, social and livelihood impacts. The Food and Agriculture Organization (FAO) outlines in (Steduto et al., 2012) that the climate changes are expected to cause serious declines yield of the most important crops in developing countries. Furthermore, it is estimated that agriculture will have to produce 70% more food by 2050 to feed the world's population which is expected to be 34% larger than today. Since most land suitable for farming is already farmed, this growth must come from higher yields thought the use of more sustainable practices.

The intensive and unsustainable agriculture adopted to date, have exposed the ecosystem to the risk of a progressive deterioration of their production capacity. Indeed, 25% of the world's agricultural land is already degraded (FAO, 2011). This challenge requires a radical change in the paradigm that governs the agricultural and food sector. The request translates into virtuous management of natural resources in which the concepts of territorial protection, environmental sustainability, and food safety are the key elements for the new agriculture model. In response to this emergency, Precision Farming was born, able to maximize productivity through a more complex vision of a production system.

In the literature, it is described as a data-based approach to agriculture (Ruß, 2010). It operates in areas that need treatment using the latest sensor and satellite technologies that continuously monitor the environment by producing a large amount of data at an unprecedented rate. The analysis of this Big Data through Artificial Intelligence (AI) techniques allows to better understand the interaction

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between the physical (soil, atmosphere, water) and biological elements (plants and parasites) that exist in the production process. These agricultural data can be collected, organized, analyzed and integrated automatically into Decision Support Systems. Decision support systems represent the brain of Precision Farming (Tan,2016). They can process these agricultural data with specific algorithms to suggest the actions to be used in the fields promptly. The integration of forecasting models which use AI techniques into DSS let farmers to be provided: (i) a holistic view of problem (ii) possibility to exploring from different points of view all the variables necessary to make timely decisions (iii) possibility to predict and evaluate several scenarios (iv) possibility to create a historical database. In this context, Artificial Intelligence and Decision Support Systems are emerging as an indispensable operating node for performing predictive analyses that take into account temporal, spatial, cultural, inter and intra-field variability to recommend strategic and eco-sustainable actions.

In this paper, we describe the system and the test conducted through the prototype DSS LANDS (*Laore Architecture Network Development for Sardinia)* developed to study artificial intelligence methods and models which can be used to know, understand and evaluate the relationship, patterns, and trends from data to simplify the agricultural decision-making process. The DSS has been developed in collaboration with the LAORE Sardinia Agency. LAORE Sardinia Agency deals with providing advisory, education, training and assistance services in the regional agricultural sector. The described system allows farmers and LAORE workers to upload monitoring data, use different and several analysis models and view the results as guidelines to be adopted in crop management. As many other existing Decision Support Systems, we aim DSS LANDS to be a tool that can improve business by optimizing the use of resources and preventing crop risk situations, thus saving unnecessary and unproductive interventions. The test conducted describes an application of artificial neural network to forecast a disease risk index for the potato crop.

The paper is structured as follows. In Section 2, we present a literary review of how the Decision Support Systems have been used in agriculture. In Section 3, we describe the DSS LANDS components. In Section 4, we illustrate the case study conducted to forecast potato late blight disease. In Section 5, we present the experimental framework. We end up in Section 6, with a discussion of our main findings and future lines of research.

2. AGRICULTURAL DECISION SUPPORT SYSTEMS

The application domain for Decision Support Systems in the agricultural sector has evolved significantly in the past decade. A decade ago, DSSs have mainly been introduced in agriculture for improving on-farm crop productivity. At that time, the earliest decision support systems were DSSAT (Jones et al., 2003), APSIM (Keating et al., 2003), CROPSyst (Stöckle et al., 2003), EPIC (Izaurralde et al., 2006) and STICS (Brisson et al., 2003).

In recent years, the application of DSSs does not focus only on improving productivity but has expanded its scopes in a range of applications: food security, risks of pest and disease losses, livestock production, climate change mitigation and adaptation, policy assessment, farmer advice.

Manos et al. (2004) have categorized the field applications, in the following five categories: Diagnostic-Forecasting DSSs, Advisory DSSs, Control DSSs, Educational – Informational DSSs, Operational DSSs. This expanding application domain is caused by the need to conduct more sustainable agriculture damaged by continuous human activities and climate changes.

Advances in technologies such as Global Positioning Systems (GPS), Geographic Information Systems (GIS) and remote sensing have increased the interest in developing Decision Support Systems that integrate new data analysis techniques like Artificial Intelligence (AI) and Machine Learning (ML). New Decision Support Systems have been developed to address different aspects of these purposes.

Soyemi et al. (2018) proposed a web-based decision support system to suggest sustainable agricultural practices that serves better both the communities and the Nigeria nation. In satisfying

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