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WEB PLATFORM SOLUTION FOR SMART FARMING MANAGEMENT

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Abstract

In the last decades, technology has evolved rapidly across all industries. As expected, farming has also benefit from the digital transformation era, becoming more technology-driven. Nowadays, farmers use smart devices to gain knowledge about their crops and livestock, to make predictions and take better actions, improving efficiency and production. However, a great challenge of the present is combining and integrating data from a variety of data sources, in a manner that is both easy to use and understand. This paper presents a solution for integrating and analysing data collected from smart agriculture sensors inside a web platform. The solution allows the user to visualize metrics regarding productivity, crop stage, make predictions, take actions and deploy field workers for planned activities. The first part of the paper introduces the research farms of the University of Agronomic Sciences and Veterinary Medicine. These were used as part of the study, being spread across the country, with different types of soils, terrain and crops. Further, we introduce a series of data collected from the farms, including drone imagery data collected in 2017 and 2018, respectively. Finally, we present the web platform, its functionality and the workflows that allows a smart farming management.

***Key words**: crops, environment engineering, IOT, livestock, GIS, sensors, smart farming, web GIS.*

INTRODUCTION

The 21st century is marked by the digital revolution. Accessible, easy-to-use technology has increased the social and economic opportunities around the world. Also, is the direct cause of this fast rhythm of development that has not been achieved in human society until now. Access to information, education and financial instruments has led to economic growth worldwide. We have a better living due to the technology that improves our daily basic tasks, we travel faster, we have mobility with jobs, we can even work remote. Added to that, we have access to medical and life insurance, modern medical plans, which all contribute to a better life expectancy.
In this context, United Nations announced last June that the world's population had exceeded 7.6 billion inhabitants, and by 2050 is estimated the number will grow by another 2.3 billion people. With that increase in the number of inhabitants, demand for the food sector will increase proportionately. However, some measures need to be taken to cover global needs. First, it should be taken into consideration that as a cause of the increased living standards and the automation of various industries, people have concentrated around towns. Only few have remained in the rural area and still maintain an agricultural activity that ensures their own needs as well as the commercialization of the products.
The unprecedented development of the society has left a strong footprint on the planet that does not come at a low cost. According to the UN, by the middle of this century, the effects of global warming will intensify strongly and will bring about significant changes; higher average temperatures, changing rainfall patterns, increased levels of seas and oceans, and increased frequency and intensity of extreme weather phenomena. If added to the possible emergence of resistant diseases and pests, the effects will strongly impact the agricultural sector and, implicitly, the food sector. Unfortunately, the most exposed population is also the one that is struggling now with damaged lands and those from developing countries (Koester, 2015). Thus, over the next decade, society will have to address the demand for food, while at the same time ensuring sustainability of the natural resources for the next generations. The solution lies also

in the digital revolution. New, autonomous technologies have been developed to modernize agricultural practices: mechanical systems for watering, sowing, fertilizing and harvesting. To monitor crops, UAVs equipped with multispectral cameras are now widely used, capable of providing complete information on crop health status. The system can be complemented by a network of sensors placed in the field to retrieve information about air and soil conditions. All integrated into a platform easily accessible anytime, anywhere, from any device, will generate disruptive changes in current farming practices.

Sharing Data and Knowledge

Despite the development opportunities presented, there are of course also many barriers to the adoption of these modern agricultural practices. The high costs of such a system, as well as limited knowledge, might represent barriers, especially in developing countries. This context can produce a gap between the large agricultural associations, capable of supporting implementation efforts and small farmers. On the other hand, the public sector can gain from the data collected for the purpose of monitoring and controlling (Kaushik, 2017). So, it is expected to get involved in the financial and education tools for farmers. At the same time, this would be a great opportunity to lay the foundation for a platform of collaboration and selling agricultural products.

Romania is a member of the European Union and is subject to its regulations. Thus, according to the Inspire Directive (2007/2/CE), which entered effect on May 15th, 2007, we are responsible for reporting to the CE a series of 34 spatial data sets. One of these themes is Agricultural and Aquaculture Facilities and refers to *"physical instruments and constructions with permanent or semi-permanent occupation (inland or outland) that are related to agricultural and aquaculture activities*" (Inspire Directive). In Romania, the Agency for Payments and Intervention for Agriculture (APIA), is the body charged by Ministry of Agriculture and Rural Development (MARD) for the collection and delivery of INSPIRE data sets related to agriculture. This naturally came about because the agency has the role of collecting information on agricultural parcels in the LPIS system, based on which farmers are granted financial aid. In addition to activities related to cultivating soils, producing crops and manning the land in good agricultural and environmental condition, APIA also deals with harvesting, milking, breeding animals, holding animals for farming purposes. There were some cases where farmers misrepresented locations and areas of plots, land use or livestock farms and have paid compensation perhaps even higher than the subsidies originally received from APIA. From our experience, these cases occurred due to uncertain land situations, misunderstanding of the reporting process, and non-recognition on the map of own land.

Aim

A GIS system would primarily help farmers make asset management - in order to have a clear picture of the areas they cultivate. Not always what they cultivate is in their property, there are cases when lands are leased. It is essential for a farm that administers large areas of land to know the legal/contractual situation of each plot. Then, it is very important that alongside this information there is data on what is cultivated on these lands (Schaller, 1992). This will help them not only when reporting to APIA, but also to ensure sustainable agricultural practices through crop rotation. The overview of available surfaces, as well as other sets of data as: soil quality data, irrigation system, or irrigation channel location, allow the farmer to make the best strategy for the next crop season. Technological equipment and people also play a very important role. If equipped with GPS, then the control and monitoring of field operations is also ensured by integrating them into the GIS system (Yousefi Reza, Mohammad Razdari, 2015). Most of the time, even the best strategies are diverted by unforeseen events, even in the current climate, when we record more and more weather abnormalities. In order to obtain the planned production, the farmer must ensure that the plant development parameters are assured. The most basic analysis of this type is the NDVI. It can be obtained from satellite imagery or high-resolution images taken from drones, depending on the surface and the

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culture being targeted. The results, combined with the parameters of the ground sensor network, represent the trustworthy decision support that will improve or even save the harvest in critical years (Delenne et al., 2010).
From our experience so far, we have found that some farmers are well educated in what precision farming means. Many own some of component or more of the presented system. The problem we have identified is that they administer them individually and there is no integration to allow them to correlate the data.
The purpose of our study is to build a web platform that performs asset management, field operation, analysis and decision support that is easy to implement and can serve as a tool for collaborating and selling products on a farm.

MATERIALS AND METHODS

Location

The study focuses on the nine research centers of the University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMVB) as follows: Belciugatele/Moara Domneasca Training Center; Pietroasa Vine-Growing Research and Development Center; Istria Farm and Istria Nursery Farm; Stoenesti Research and Development Farm and the lands of Pietrosani - Giurgiu and Teleorman, Borcea and Fetesti - Ialomita County, Gradistea and Cuza Voda - Calarasi County. All nine centres are spread across the south-est part of the country (Figure 1) and have special plots for vegetable crops, orchards and livestock's farms.

Figure 1. Map of the research areas of USAMVB

Their complexity from the perspective of the crop and agricultural works diversity make them ideal for a GIS Management Platform.

System architecture

The proposed system was designed to support the collection, storage, manipulation and analysis of spatial data in a web interface. Implementation was accomplished using proprietary Esri solutions, but similar results can be obtained using open source tools.

Data

The base of the proposed system is represented by the data storage format, the geodatabase format. It is preferred in favour of other storage formats (shp) because it allows for complex behaviours between spatial object classes. From simple functionality's such as the ability to declare domain values across fields to subtype classification, to attachments, relationship classes, and topology that provide the attribute and spatial integrity of data. It also provides support for SQL and the creation of complex query expressions (De Filippis et al., 2010). Finally, it allows viewing, editing, and querying data by multiple users simultaneously, without generating conflicts.
Most of the project data was digitized and organized into spatial objects classes, geodatabase storage subdivisions. The raster's obtained after processing the photogrammetric flight were also managed in the same geodatabase. After building the structure, we migrated the data on parcels and which existed in various formats. After loading them into the geodatabase and running the topology to check for any fault data, we proceed to upload it to the server. From here, data was deployed as web services on the web map and finally on the web application.

UAV

A special step in the project was considered for flaying the drone and obtaining high resolution imagery of the crops. The images were taken over the period of two years 2017 and 2018, respectively, from June to September. In 2017, we used a classic rgb camera for taking the pictures, and next year with a Sequoia multispectral camera in order to obtain information about the health of the plants. We will be repeating the flights this year, this time at shorter intervals - monthly / bimonthly, in order to watch the crops in different stages of development. The drone used is eBee from

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SenseFly, a fixed wing UAV, suitable for precision farming (Figure 2).

Figure 2. eBee Drone and cameras

Web

The web map is a dynamic map, optimized for use on the internet in order to display geographic information and facilitate user interaction with it.

Also, whatever you click on the map, displays the information available in the geodatabase regarding that object.

The purpose of the map is to add and view data, to collect and integrate information from the field (people, agricultural vehicles and sensor network), and to allow simple data queries. In the context of our project, the final web application consumes this web map (Figure 3).

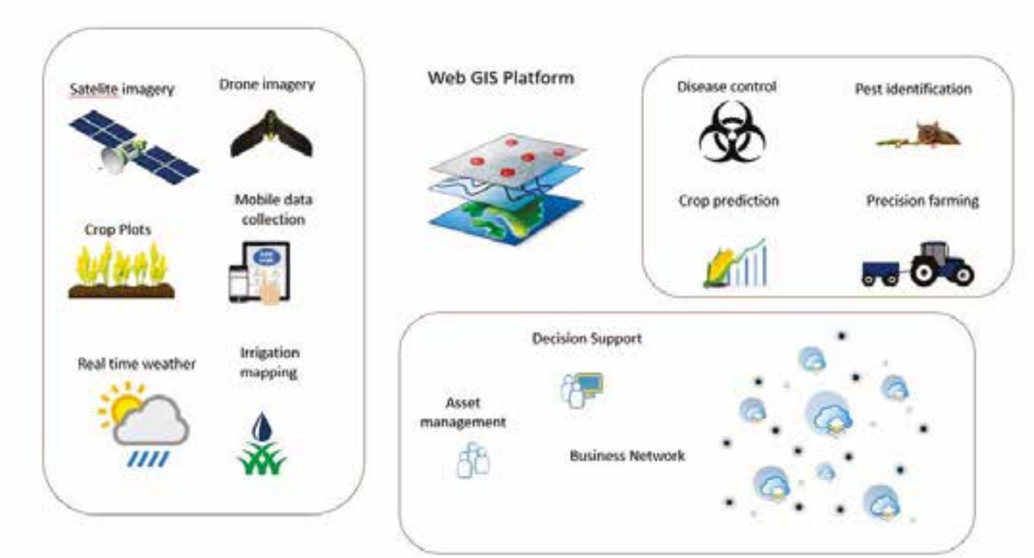

Figure 3. System Architecture of Proposed Platform

RESULTS AND DISCUSSIONS

The initial processing of images in order to obtain photogrammetric products was done with the Pix4D software. In the first year, we only had the standard camera that the drone comes with. So, we were able to obtain only the basic photogrammetric products - orthomosaic, point cloud, DSM and DTM. Even so, we were able to easily detect gaps in corn and wheat crops just before harvesting (Figure 4). Their main cause is the soil texture. However, there were also some anomalies due to the way the seeds were sown. Next year, 2018, we used the Sequoia multispectral camera with sensors in Green, Red, Near Infrared and Red Edge bands, and the photogrammetric products we have obtained allowed us to do more complex analyses (Tang L. & Tian L.F., 2013).

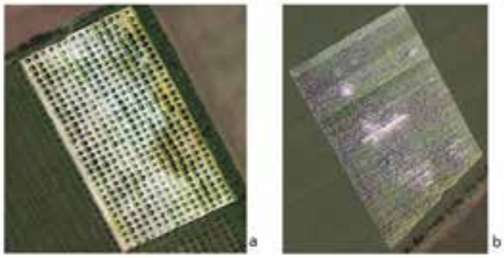

Figure 4: a) Fruit trees; b) Corn crops

For example, using Envi and the Crop Science module, we were able to obtain, in addition to the vegetation indices, the number of trees in an orchard, and the condition of each's health (Figure 5 and Figure 6).

Along with these high-resolution images, we also integrated Sentinel 2 satellite imagery. Sentinel-2, 10, 20, and 60 m Multispectral, Multitemporal, 13-band imagery services are rendered on-the-fly and available for visualization and analytics.

After postflight processing of images and running vegetation health analyzes, the rasters have been published as tilled package services for the online use alongside vector data sets.

At the same time, another data service has been prepared and published that will allow field teams to collect and transmit real-time information on plant observations and possible pest invasions.

All data services have been merged at the level of a web map which was used in the deployment of the web application (Figure 7).

Various widgets where added for generating and printing crop maps, charts about crops and planted areas as well as tools for quering other pieces of information.

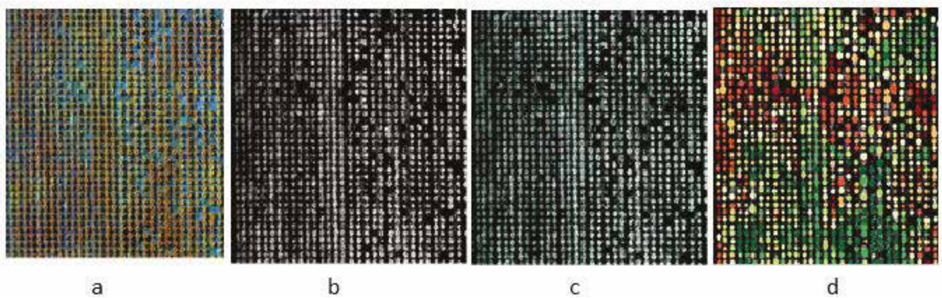

Figure 5: a) Picture of an orchard taken with multispectral camera; b) Individual trees automatically counted - detected locations marked with green circles; c) Individual trees identified by colour: green = healthy, red = poor, yellow-orange = between values; d) The analysis obtained by running hot spot analysis - green areas represent trees with a better state than the average, red - trees with a worse state than the average

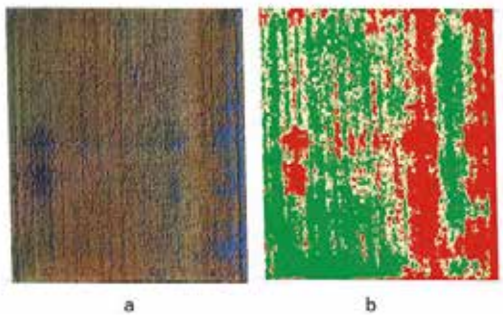

Figure 6: a) Picture of a corn crop taken with multispectral camera;
b) The analysis obtained by running hot spot analysis - green areas represent plants with a better state than the average, red - plants with a worse state than the average

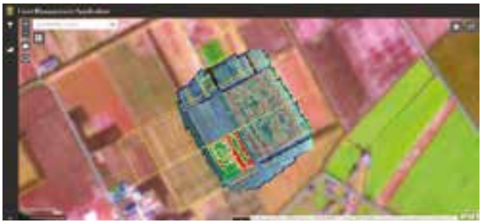

Figure 7. Web Application integrating all data sets

CONCLUSIONS

Since the beginning of the 21st century, the global agricultural market has evolved significantly, but naturally, to serve the increased demand. Since the financial crisis in 2008, international commodity trade has been slow due to slow financial recovery. However, agricultural trade proved to be more resilient than fuel, mineral and manufactures.

The digital revolution in the agricultural sector will revolutionize the way the spatial data on crops and livestock farms are collected, stored, analysed and used. GIS platforms that integrate data from various farm sources will become important tools in the hands of decision-makers. Today we are seeing more and more equipment for use on farms with built-in GPS, automatic irrigation systems and specialized weather stations. All this is no longer news for farmers.

The period will bring challenges to analysing the data produced by these systems. The sensors we have today around us: satellites, drones, mobile devices, air and soil sensors produce a huge amount of data today. Therefore, in the coming years we will have to train the machines for the integrated analysis of these very large sets of data to produce forecasts and plant needs.

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