IoT for Smart Agriculture

Monitor and improve the efficiency of production processes.

The Challenge

Industry Sector:
Agriculture

Challenge classification:
Limiting manual checking and data acquisition to minimize human errors and have real-time process monitoring and optimization. Waste management based on real-time tracking and demand forecasting. Supply chain transparency and reliability improvement.

Time for Project Completion:
36 months

Farm management is a challenging task from multiple perspectives. Agricultural processes are far from being optimized and they require manual procedures to be scheduled and to obtain useful data. Also, the need for improving sustainability and clever waste and energy management is becoming more and more urgent.

Main Requirements

- Data acquisition from all stages of cultivation, sowing and harvesting in order to support the decision making process;
- Avoid unnecessary waste by optimizing the amount of energy and water needed;
- Support the adoption of novel technologies and agricultural techniques that require more precise interventions;
- Improve the traceability of the supply chain.

Other Requirements

N/A

Key Performance Indicators

N/A

Other informations

The company expects to deploy 30 devices.

Need for device management operations (such as managing or updating the software remotely)?
Yes

Strict deadlines in device operations for doing the tasks?
No

What competence does the company have with this project?
Only agricultural expertise

Use manufacturing execution systems (MES) or enterprise resource planning (ERP) systems?
No

Type and operation of the MES or ERP system used?
-

Use of any existing cloud vendor (AWS IoT, Microsoft Azure, etc.)?
No

Cloud vendor and the services used on this cloud service:
-

Number of machines to be connected:
30

Configuration of each machine and the operation of each:
Data acquisition, forecasting and processes optimization

Machines are equipped with PLC/PAC or CNC controllers and can provide data?
Yes, they can provide data

Machines are not equipped with any digital controller (Legacy Machines)?
No

Communication protocols, sensors or devices with which the solution needs to integrate?
Devices need to send data to the cloud

Research Phase

Research questions:

1. How can we automatically acquire data from cultivation stages?
2. Is it possible to forecast the demand and the crops production?
3. How can we optimize the usage of water and human labor?
4. Is it possible to monitor and reduce the waste and the environmental impacts of our farms?
5. Can we schedule precise and event-based actions to develop advanced and more delicate farming techniques (hydroponics, seawater farming, etc)?

Given the questions and the main requirements of the challenge previously listed:

- *identify possible technologies using the Planet4 Taxonomy Explorer;*
- *identify and analyze the sources (papers, articles, etc.) of those technologies that best suit the challenge;*

Technologies identified in the taxonomy:

- IoT Gateway to detect smart devices and provide real-time monitoring
- Time Series DataBases
- Artificial Neural Networks
- Data Analytics Platform
- Cloud Data Storage
- Digital Twins
- Blockchain

Sources of those technologies that best suit the challenge:

https://www.particle.io/particle-tracking-system
https://www.researchgate.net/publication/326823239_Industry_40_Smart_Scheduling
https://www.digiteum.com/iot-supply-chain/
https://www.scopus.com/record/display.uri?eid=2-s2.0-85070542703&doi=10.1063%2f1.5118042&origin=inward&txGid=05a9422e130e5c2197677a309e426e74
https://www.scopus.com/record/display.uri?eid=2-s2.0-85083532858&doi=10.1016%2fj.promfg.2020.01.107&origin=inward&txGid=ea20fb88bd5dee45e2638f2b081f9a34

Answers:

1. We can deploy IoT devices and UAVs to collect data and send it to the Cloud.
2. With the usage of AI and Machine Learning models we can leverage the data we collected.
3. The obtained data, combined with proper visualization and business intelligence tools, can be used to have a clearer view of the working phases and help in the decision making process. In further

phases, we can combine the data with ERPs to automate the process.

4. The adoption of smart warehousing and the monitoring can address this problem.
5. We can leverage the digital twins technology to create a digital twin for a plant (or a group of plants), monitor their status and create an event-based strategy.

Comparison:

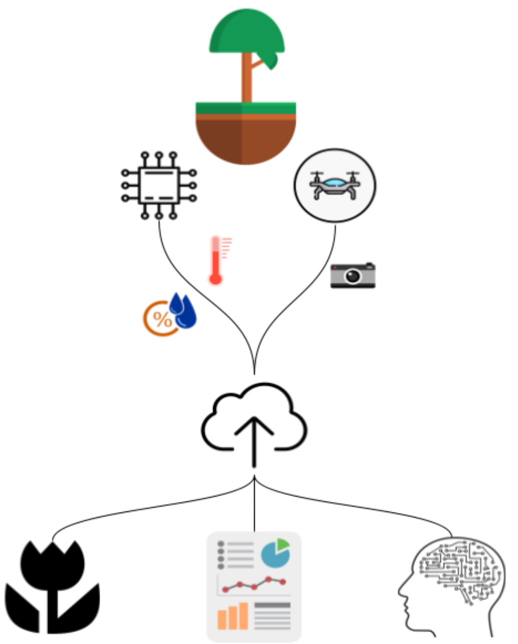
The taxonomy allowed us to identify the technological requirements needed for automatically acquiring knowledge and data. The company requires the deployment of **IoT devices** and **UAVs** to collect different kinds of data. The differences between these instruments relies on the level of expertise required and the type of data they stream. This data needs to be streamed to the **Cloud** via appropriate **communication protocols** and properly **stored** (by using standard relational databases or specialized databases for time series), visualized with **business intelligence** and **data visualization** methods, and used for extracting relevant knowledge thanks to **Data Analytics Platforms** and **Artificial Intelligence algorithms**. These two methods differ for the complexity of the predictions and the level of knowledge needed to adapt them to particular scenarios.

Conclusions:

A possible solution is to leverage the latest evolution of IoT devices, data analysis and visualization tools and artificial intelligence and machine learning algorithms to have a clearer view of the whole farming process. By using and visualizing the data we can optimize the various phases both from a cost and an environmental point of view. To add more features to the solution, we can use the digital twins paradigm to monitor all the steps of the supply chain, maybe combining it with the Blockchain technology.

Proposed Solution

Solution Summary



The schema of a possible solution is represented in the figure above. As shown, the data collection phase is fundamental for all the following phases and possible future developments. This preliminary stage would require the adoption of various types of devices sending data to the Cloud. Then, the data can be analyzed and by adopting the latest AI and Machine Learning models to address predictive tasks as well as other optimization algorithms to optimize the cultivation phases, and visualized on clear and user-friendly interfaces.

Solution Description

The data collection phase requires the use of various IoT devices able to collect different types of data (e.g., humidity, temperature, acoustic signals, etc.) and UAVs to collect images and videos of the fields. These devices need to adopt secure communication protocols to send the data to a Cloud data storage, which has to implement Time Series Databases algorithms to optimize the data storage for such a big amount of data.
After the collection, the data can be combined to obtain digital twins of the plantations and monitor their growth. To do that, clear and user-friendly data visualization tools must be developed that can facilitate the real-time monitoring and the decision-making process. Also, it can be fed into the current State of the Art AI and Machine Learning algorithms to forecast the need of water and the waste production. These predicted results can be used as input for optimization algorithms that allow us to reduce both the costs and the environmental impact of our company.

Finally, these technologies can be the foundation for future developments, such as the use of the Blockchain technology to monitor each phase of the production and allow the customers to know the processes and the steps that the product has done.

Implementation Plan

The solution should take 36 months. Two of the biggest challenges will be:

- *finding and hiring of highly-specialized workers (or the formation of the current ones). The professional figures sought should include a hardware technician, a front end developer, two data analysts/engineers and a project manager.*
- *buying the most appropriate hardware or relying on already existent IoT service providers.*

These two steps should take at most 6 months and will cost approximately 150,000$ per year plus an initial cost of 30,000$.

The following 18 months should be used for the actual development of the solution and should not require any additional cost. Finally, the last year should be aimed at testing the solution, fixing it and looking for possible future developments. Other than the cost reduction (that could be approximately 50-60%), the adoption of these technologies could be used for commercial purposes, thus improving the brand and attracting possible investors.

Additional benefits:

- Enhanced Data-Driven Decision Making: The solution enables data-driven decision making, leading to improved efficiency and optimized agricultural practices.
- Improved Resource Allocation: Accurate forecasting and optimization capabilities allow for effective resource allocation, reducing costs and environmental impact.
- Potential for Commercialization and Investor Attraction: The solutions' innovative nature and transparency can attract investors and enhance the company's market position.

Possible difficulties:

- Technical Complexity: Implementing a comprehensive solution involving various technologies and components can pose technical challenges.
- Workforce Skill Gap: Finding and hiring highly specialized professionals with the required expertise may be difficult due to skill shortages.
- Scalability and Compatibility: Ensuring the solution is scalable and com-patible with future advancements can be challenging.