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CROP *Auditing*

Growing the Future From Above

Website

CONTENT

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TEAM MEMBERS

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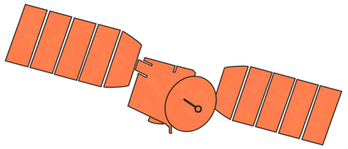
Gonçalo Martins

PROJECT'S SCIENTIFIC ADVISOR AND MENTOR

- **Scientific Advisor:**
  - Luis Caldas de Oliveira (lco@tecnico.ulisboa.pt)
- **Coordinator:**
  - Luis Caldas de Oliveira (lco@tecnico.ulisboa.pt)
- **Mentor:**
  - Tiago Morais (tiago.morais@virtuacrop.com)



PROBLEM DEFINITION

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Problem

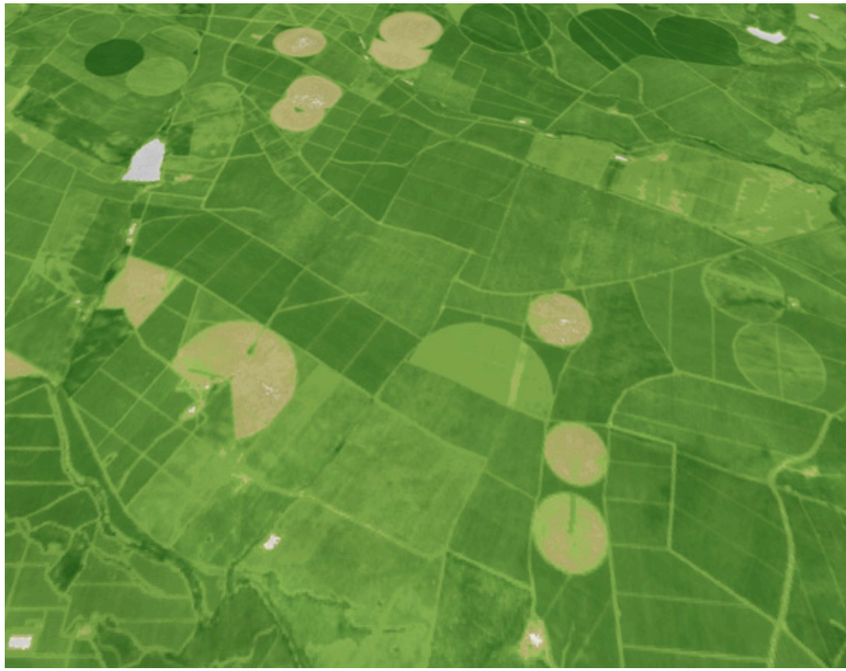
Traditional auditing of large-scale plantations relies on manual surveys, which is slow, costly, and inaccurate, making it hard to verify the area of each crop and monitor its growth, essential information for insurance companies.

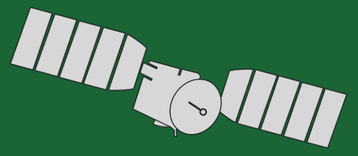
Challenge

Scaling agricultural oversight through advanced auditing solutions that guarantee accuracy across vast crop areas, ensuring maximum operational efficiency while minimizing the need for resource-intensive field inspections.

Solution

We harness the power of satellite-driven machine learning models and data science to deliver comprehensive insights into crop distribution, eliminating manual overhead while ensuring scalable monitoring throughout the growing season.





SOLUTION BENEFICIARIES

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Farmers

- Reduced disputes over declared areas
- Improved access to financing
- Easier demonstration of compliance with agriculture programs

Insurance Companies & Financial Institutions

- Simpler and cheaper audits
- Clear record of crop growth
- Easier fraud detection

TECHNOLOGICAL SOLUTION

Countries in database
Countries not in database

Database

The database will be used for training and validating the model.

Machine learning models are trained to analyze data and automatically identify crop types and their growth stages across different agricultural areas.

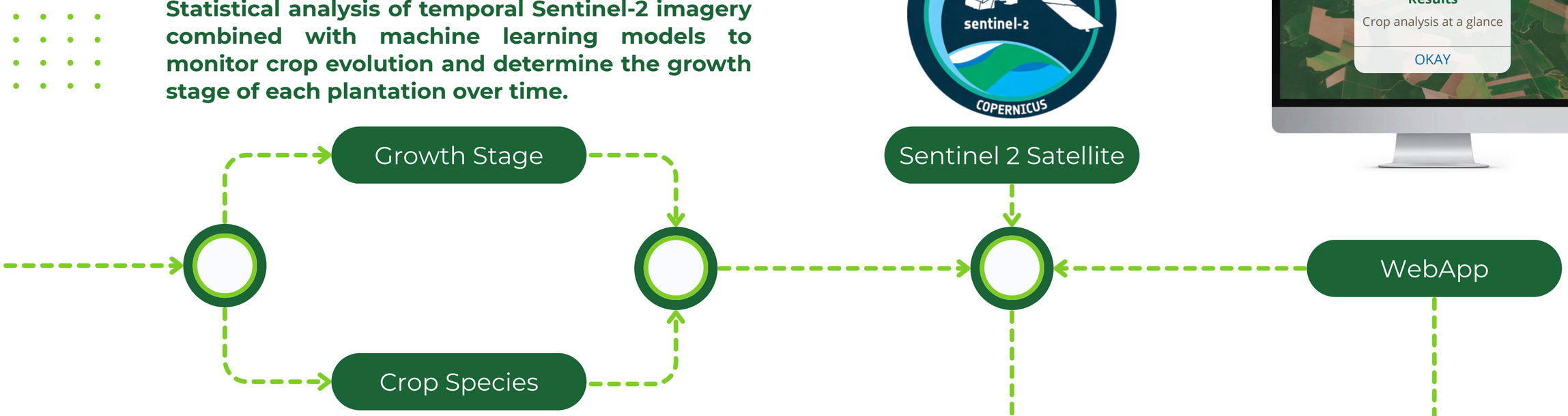
Machine Learning

Statistics

Statistical analysis is applied to support crop classification and improve the accuracy of the results.

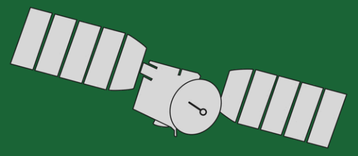
TECHNOLOGICAL SOLUTION

Statistical analysis of temporal Sentinel-2 imagery combined with machine learning models to monitor crop evolution and determine the growth stage of each plantation over time.



Machine learning models and statistical analysis applied to satellite reflectance data to automatically identify crop types and map the cultivated areas within each agricultural region.

Interface for automated analysis of plantations



ACHIEVED RESULTS

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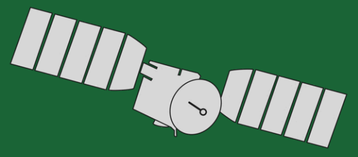
Interviews	Project Management	Background Research	Project definition and scope
Virtua Crop and Besquare client	Website: Built to present the main objectives, methodology, and current results.	Database: EU databases will be used for model training and validation.	The project targets the need for a more efficient way to verify crop areas and monitor growth using satellite data.
Smart Farm Colab and Food4Sustainability	Blog: Developed and regularly updated to document the project's progress and share key developments.	Start of code: The project codebase has been initialized, including repository setup and first functional implementations.	Scope defined to develop a web application that uses satellite data, statistical analysis, and machine learning to identify crops and monitor their growth, including data collection, model development, and interface design.
IFAP and Sintra City Council	Mail and photographs	Work Enviroment (Jupyter)	Our goal is to improve the auditing process by creating an automatic system that identifies the crop and its stage of growth.



STATUS OF SOLUTION DEVELOPMENT

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Requirements

Key requirements such as accuracy, speed, and ease of use have been identified and validated through initial research and interviewee recommendations, guiding the system development.

Communication

Tasks have been distributed among team members, and communication channels (email, meetings, blog) have been established to ensure coordination and progress tracking.

Changes in problem

The initial problem has been refined to focus more specifically on automating crop auditing using satellite imagery. The proposed solution evolved towards a machine learning–based approach integrated into a web application, improving clarity.

System design

The system architecture has been outlined, including data collection, processing pipelines, and a web interface. Initial prototypes and codebase setup have already been developed.

DATABASE AND ML MODEL

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Databse: EuroCropsV2

Source: European Commission

Technology: DuckDB

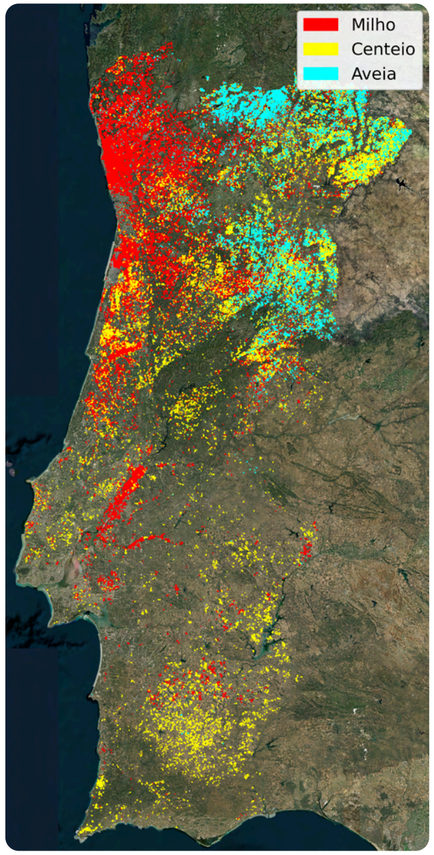
This database was chosen because it provides the locations of declared plots in various European countries over several years, including Portugal, with information on the type of crop. For our study, we chose corn, rye, and oats because of their abundance and because they are not fruit trees, in which it is more difficult to detect variations in fruit NDVI.

Machine Learning Model: Random Forest

We chose this Machine Learning model based on a recommendation from our mentor, Tiago Morais.

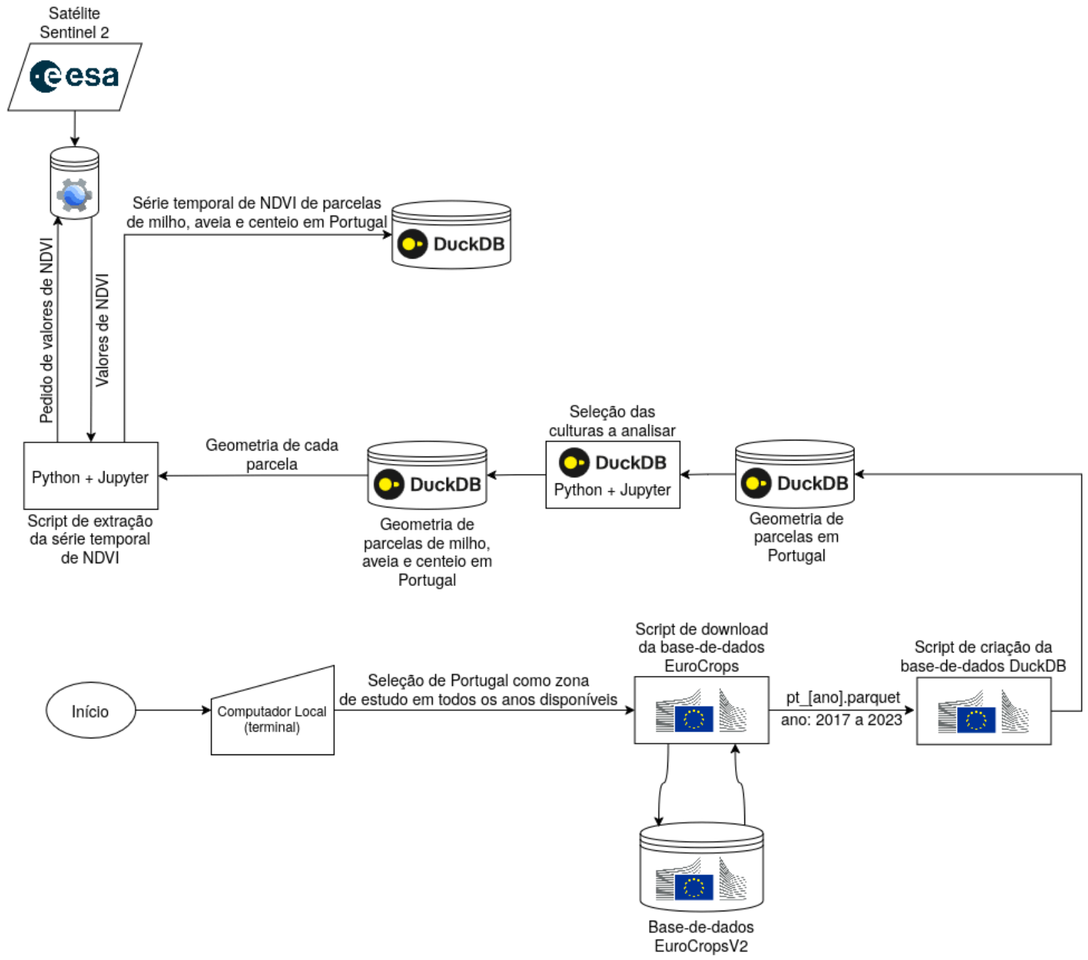
Year	Corn	Rye	Oats
2017	179 362	44 957	27 295
2018	107 397	47 020	14 950
2019	167 708	48 642	25 352
2020	162 106	52 268	23 976
2021	157 133	52 050	23 047
2022	153 165	57 149	23 539
2023	140 835	46 982	21 380
Total	1 067 706	349 068	159 539

Declared parcels in Portugal by year



Declared parcels in Portugal in 2023

DIAGRAM OF THE PROPOSED SOLUTION ARCHITECTURE



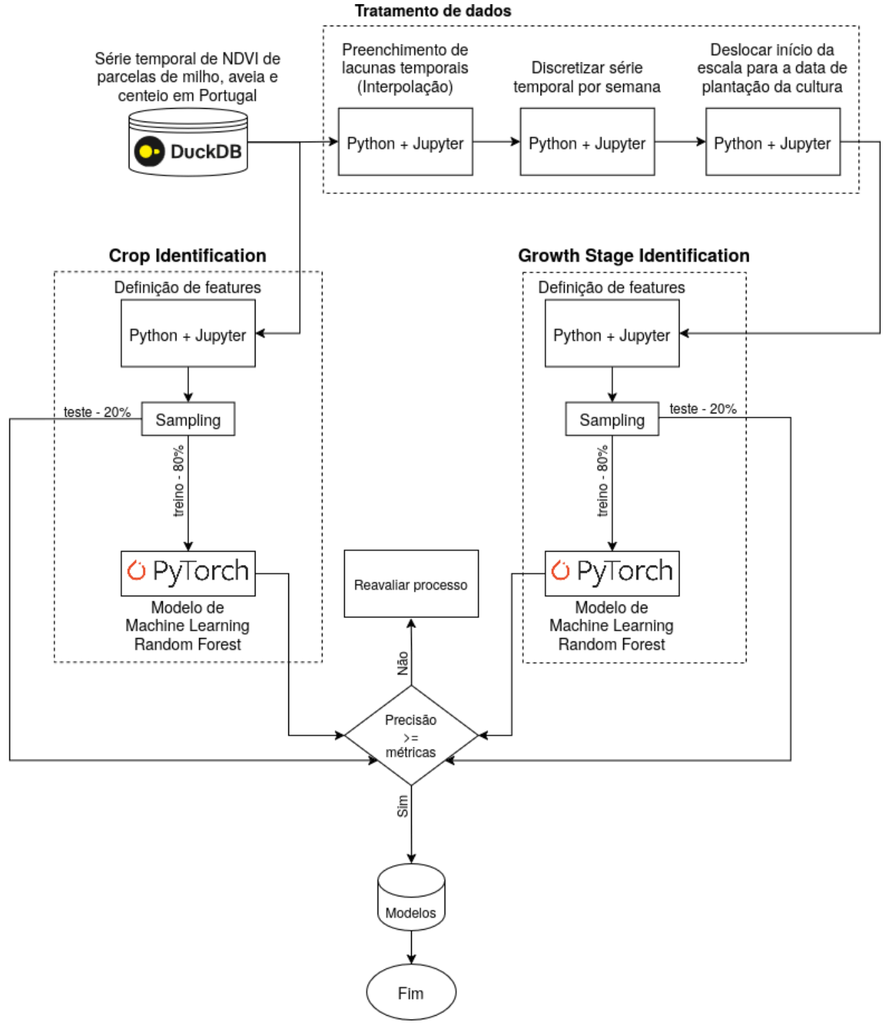
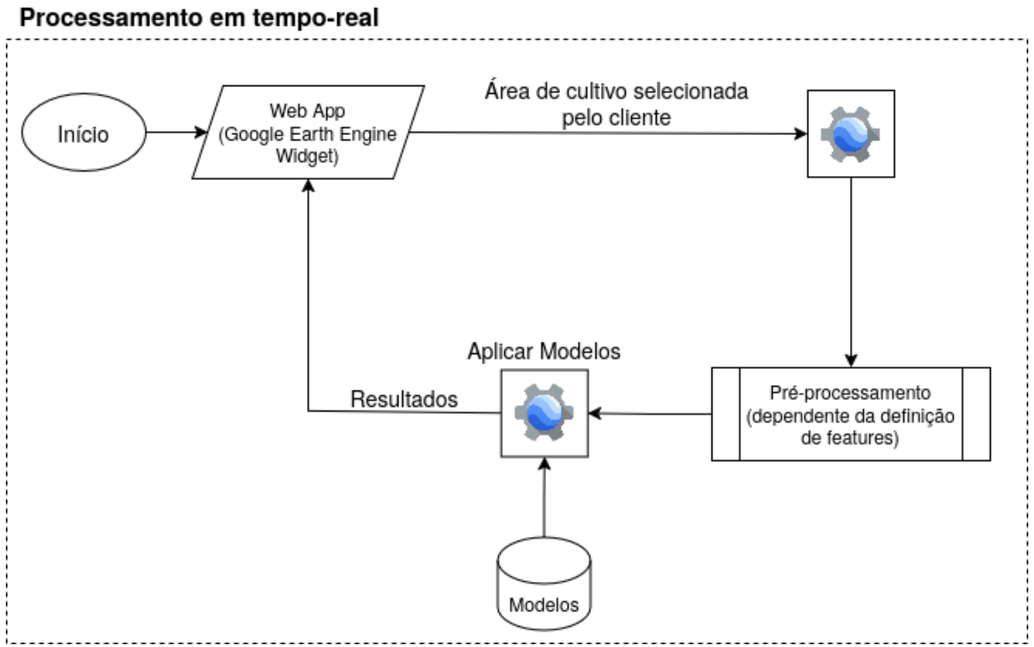
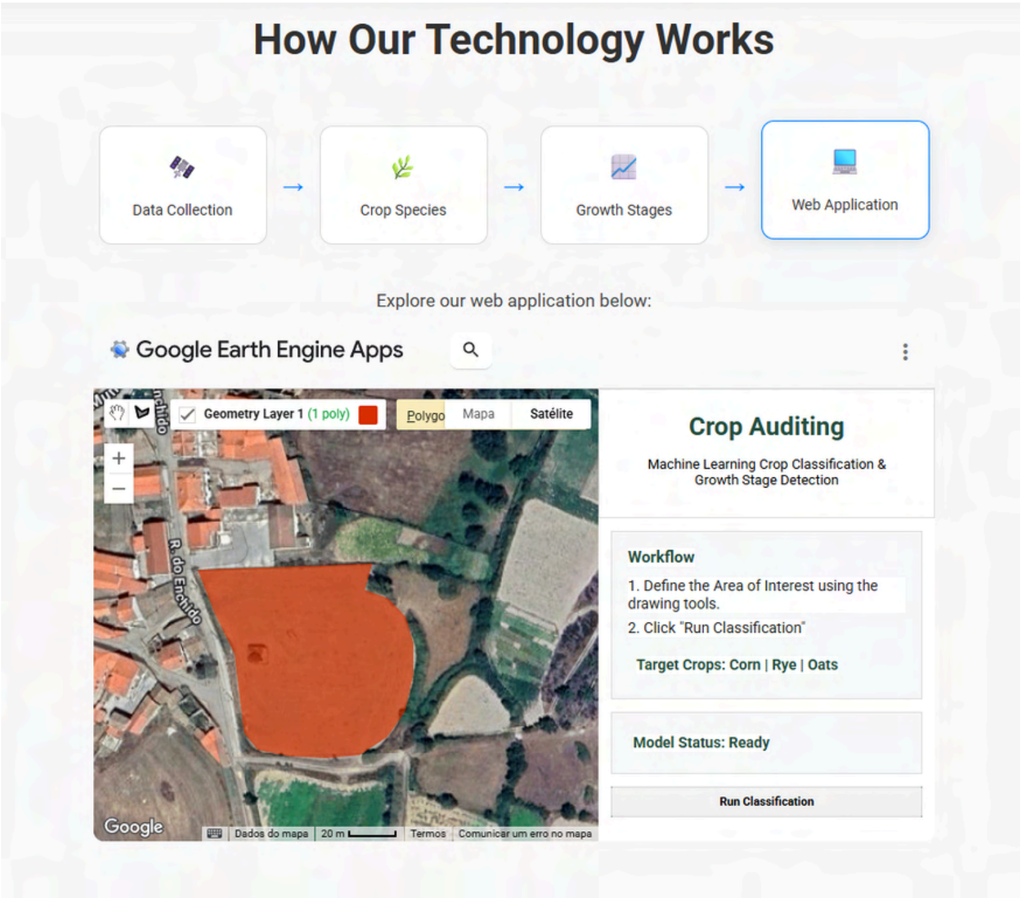


DIAGRAM OF THE PROPOSED SOLUTION ARCHITECTURE





Web Application

Using a Google Earth Engine App, we display a user-interface which classifies the selected agricultural terrain, as shown on the right.

COMPETITORS AND PREVIOUS WORK

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ESA

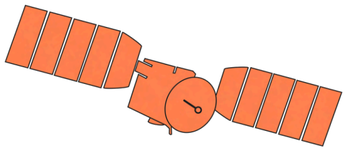
The European Space Agency provides open-access satellite imagery through the Copernicus Programme, which enables scientific research in a wide range of areas, such as this one.

IFAP

IFAP's Surface Monitoring System (SVS) uses Copernicus Programme's imagery to validate compliance for government aids, which demonstrates the practical viability of satellite based agricultural verification at an institutional level.

EOS

EOS provides a crop monitoring system which manages agricultural risks, provides insights on crop health, and determines the area of each crop, with the aim of optimizing resources and farming operations.



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SOLUTION REQUIREMENTS

Accuracy

Our solution must guarantee accurate results, which are essential for insurance companies and financial institutions. To ensure good results, we will use a database from Portugal; some of this data is doing to be used to train the model and use the rest for validation, thus proving our concept.

User Requirements

Our solution needs to be quick and easy to use, ensuring a seamless experience for our clients and streamlining the audit process. We must guarantee that our solution delivers results within the expected timeframe; however, it is possible to demonstrate that it works without this limitation.

TECHNICAL CHALLENGES

Accuracy

Achieving high precision identification of crop species, their area, and their respective growth stages.

Data management

Correctly perform statistical analysis and machine learning training of large volumes of satellite data.

NON-TECHNICAL CHALLENGES

Clarity

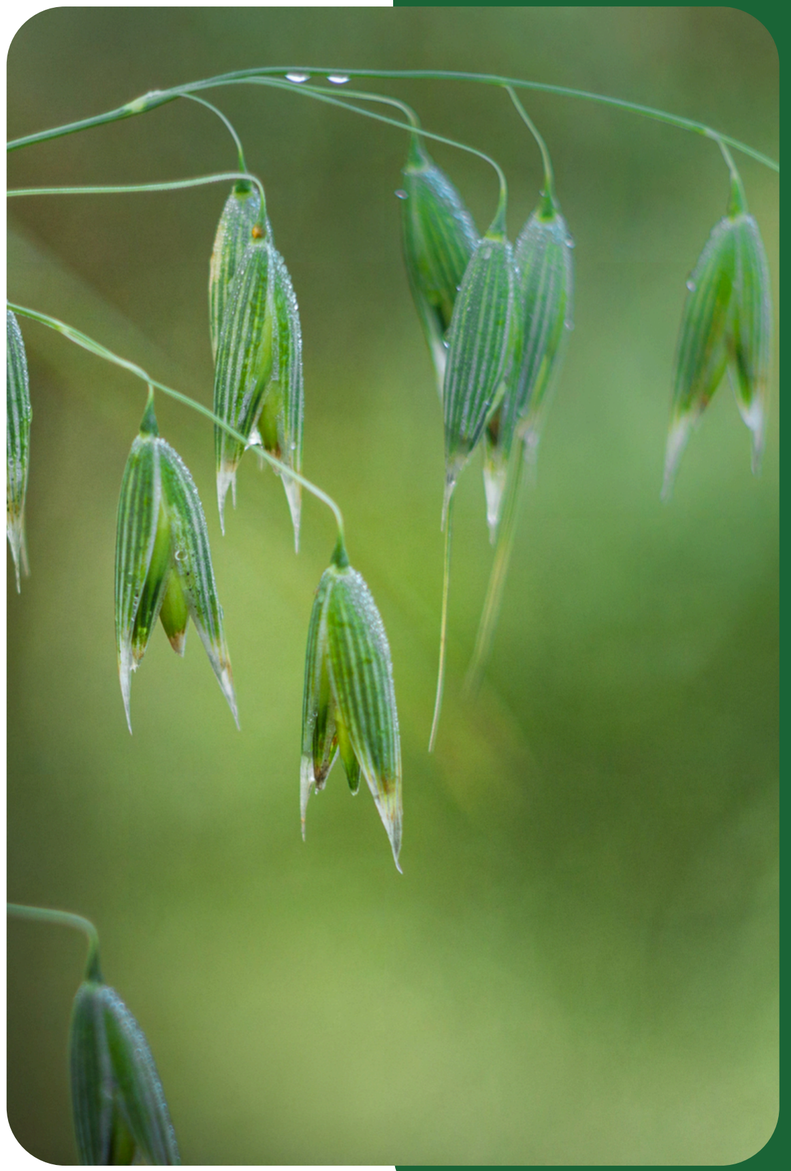
Difficulties in understanding what is most important to have in the solution.

Workload

Balancing the challenges of this program with other commitments.

Ambiguity

Difficulty in understanding what was expected from the different evaluation requirements.



OUR PARTNERS

Besquare

VirtuaCrop

Instituto Superior Técnico

TESTING AND VALIDATION METRICS

We assess crop type and growth stage classification performance, ensuring a balanced evaluation across multiple crop classes and phenological stages. Where we use 80% for training our model and the other 20% for data test

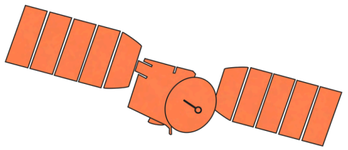
Accuracy & F1 Score

Spatial Accuracy

We compare predicted crop maps with validated agricultural parcel data to measure the percantage of correctly classified agricultural areas

Validation Metrics

Our solution will also reduce the time required for a manual audit. However, it's difficult to give an exact timeframe as it depends on the field size, being more relevant for larger fields.



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TESTING AND VALIDATION METRICS

We compute the temporal error between predicted and observed growth stages derived from NDVI time-series data to evaluate phenological detection accuracy

Temporal Error (NDVI)

NDVI Curve Error

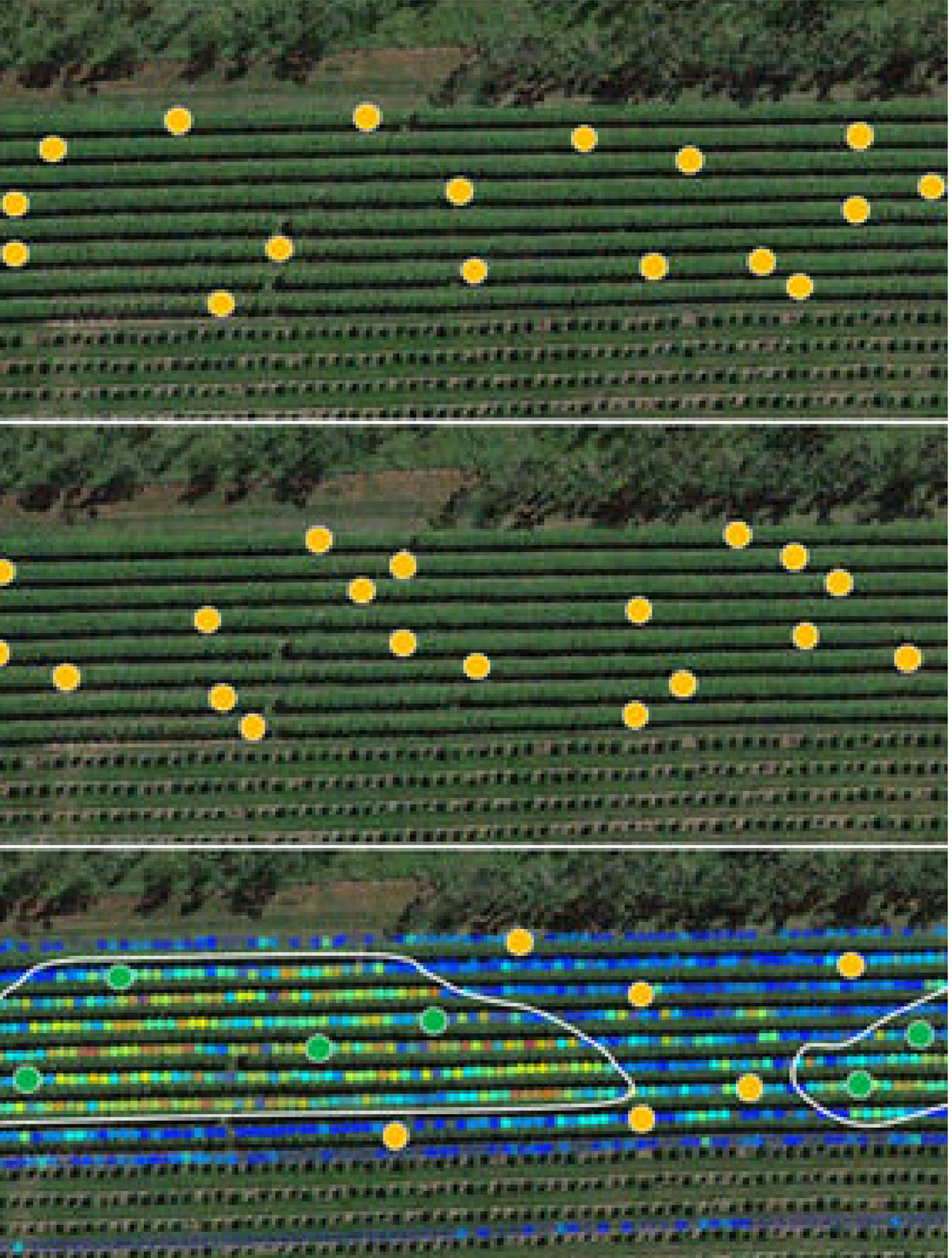
We evaluate deviations between predicted and actual NDVI curves using MAE and RMSE, ensuring reliable vegetation growth monitoring

Validation Metrics

To validate the solution, we need 96% accuracy with the data used. This value relates to the number of images available in the database. It was recommended to us by Besquare, a company with experience in the area.

INTERVIEWS ...

Public Entities	Companies	Research Centers	Education
Play the role of regulating the sector, ensuring policies are followed, and guiding national strategies related to sustainability and development. They create the conditions needed for projects to be implemented.	Develop, adopt and operate practical solutions in the market. Turning innovations into real products, investing in technology, ensuring efficiency, and delivering services to customers.	Research Centers advance scientific and tech knowledge. They test concepts, validate methods and explore innovative approaches that can improve or complement the proposed solution.	Trains future professionals and integrates relevant knowledge into academic programs. It prepares students with skills needed by industry and connects theorectical learning with real-world challenges.



INTERVIEWS ANALYSIS

General Analysis

Although we were not successful in gathering answers from all the entities we would have desired, the key takeaways of the kind companies, instituitions and people behind them who did, proved to be instrumental to turn the sight of our project into another direction.

The first major contribution came for our interview with Dr. Tiago Morais, Co. Founder VirtuaCrop, switching our attention to satelitles as the main vessel for gathering data, which can be far more efficiently employed and automated than a drone would suggest. The suggestion of what AI models to utilize and the concept NDVI actually were key takeaways from this interview.

INTERVIEWS ANALYSIS

General Analysis

Through our interview with Smart Farm Colab, we gained further insight into the harships of the satellite approach. including weather conditions and local differences in plant growth and diversity.

Luis Martins, a member of Food4Sustainability once more revealed to us the usefulness of NDVI, and how best wield it to gain correct information, analyzing leaf density with such technology.

Issac, a owner of large swaths of land in Brasil was able to give feedback in the value proposition of our project, as well as show further points we could take in the current auditing system, such as the lack of manpower and prediction of threats to the plantation.

INTERVIEWS ANALYSIS

General Analysis

Sr. Manuel Marques, representing IFAP, was a later interview, but one that reassured us that we were on the right track. Already following similar principals with satellite usage, they gave us access to their database and insider knowledge to be able to accelerate our work.

Our interview with the Sintra City Council was an important step in understanding how our project could be applied in real-world contexts. They provided valuable insights into local environmental monitoring practices and highlighted potential use cases for our solution. This interaction helped us validate the relevance of our approach.

SWOT ANALYSIS

S

Strengths

- Wide-area coverage: Satellite imagery alows monitoring of very large plantations
- Scalability: Easily scales to national or international levels
- Lower operational complexity: No need pilots or maintenance logistics as with drones

W

Weaknesses

- Lower spatial resolutions: May limit precision in small plots
- Weather and cloud coverage: Optical satellites are affected by clouds

O

Opportunities

- Market expansion through partnerships: Collaborations with banks, insurers
- Product diversification: can expand beyond auditing into yield forecasting, compliance monitoring, nad insurance claim verification

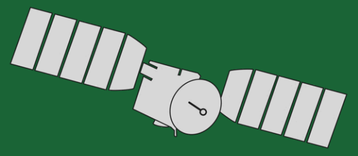
T

Threats

- Price pressure: Availability of free or low-cost satellite data may push customers to expect low pricing
- Established competitors: Large agri-tech firms may dominate contracts with financial institutions

TASKS

- Data Collection
- Crop vs Terrain Identification
- Crop Species Identification
- Growth Stage Identification
- Web App
- Website
- Blog
- Interviews
- Pitch Deck
- Poster
- Video



DIVISION OF WORK AMONG TEAM MEMBERS

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Filipe Ferrão

- Growth Stage Identification*
- Crop vs Terrain Identification
- Web App
- Website*
- Poster

Rodrigo Barreiros

- Crop vs Terrain Identification*
- Crop Species Identification
- Web App*
- Pitch Deck
- Communication

Tiago Rei

- Crop Species Identification*
- Data Collection
- Growth Stage Identification
- Communication*
- Blog

Maria Henriques

- Crop Species Identification
- Data Collection
- Web App
- Blog* / Poster*
- Video

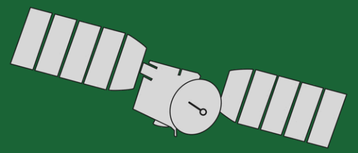
David Freire

- Growth Stage Identification
- Data Collection
- Video*
- Pitch Deck*
- Interviews

Gonçalo Martins

- Data Collection*
- Growth Stage Identification
- Interviews*
- Pitch Deck
- Website

*Responsible



CONTRIBUTIONS OF EACH TEAM MEMBER TO THE RESULTS

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Filipe Ferrão

- Website
- Interviews
- Presentations
- Work Environment

Rodrigo Barreiros

- Data Collection
- Interviews
- Presentations
- Work Environment
- Communication

Tiago Rei

- Data Collection
- Work Environment
- Presentations
- Blog
- Communication

Maria Henriques

- Blog
- Interviews
- Presentations
- Work Environment
- Communication

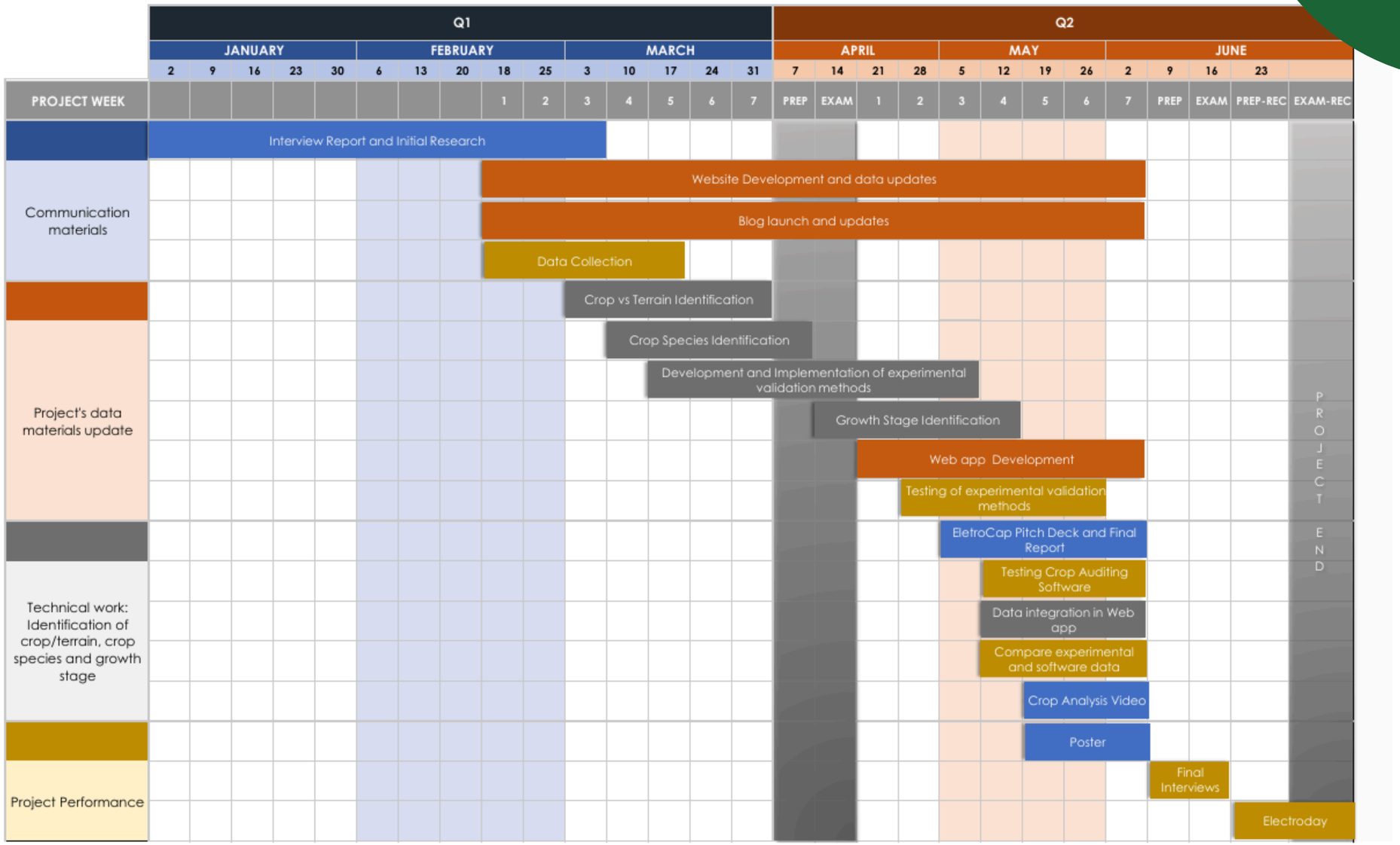
David Freire

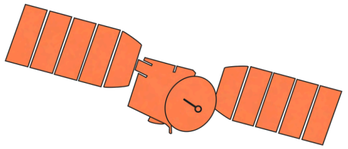
- Interviews
- Presentations
- Work Environment

Gonçalo Martins

- Interviews
- Presentations
- Website

SCHEDULE - P3 E P4





DEVIATIONS FROM THE INITIAL SCHEDUL

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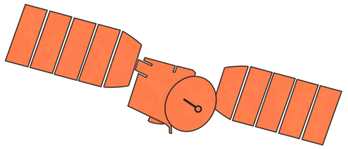
Unclear scope in early stages	Limited expertise in specific areas	Team coordination and communication	Time management and workload
The need to refine the problem and better define the project scope led to adjustments that impacted the initial timeline.	Some aspects, such as advanced machine learning techniques and satellite data analysis, required additional learning and research time.	Aligning schedules and coordinating tasks among team members occasionally slowed down progress.	Balancing the project with academic responsibilities and other commitments affected the pace of development



SCHEDULE OF ACTIVITIES UNTIL THE END OF THE PROJECT

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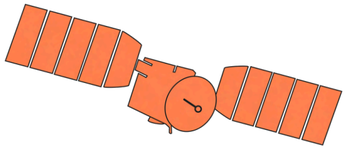
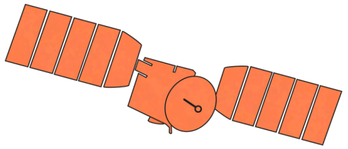
Time	Activities		
April 7 - April 13	Growth Stage Identification and testing	Crop vs Terrain Identification and testing	Crop Species Identification and testing
April 21 - April 27	Growth Stage Identification and testing	Crop vs Terrain Identification and testing	Crop Species Identification and testing
April 28 - May 4	Growth Stage Identification and testing	Crop vs Terrain Identification and testing	Crop Species Identification and testing
May 5 - May 11	Growth Stage Identification and testing	Crop vs Terrain Identification and testing	Crop Species Identification and testing



SCHEDULE OF ACTIVITIES UNTIL THE END OF THE PROJECT

TÉCNICO UNIVERSIDADE DE LISBOA

Time	Activities		
May 12 - May 18	Webapp	Pitch Deck	Prepare final testing and finalize code
May 19 - May 25	Start final testing and validation	Pitch Deck	Webapp
May 26 - June 1	Final testing and validation	Poster/Video	Pitch Deck
June 2 - June 8	Final testing and validation	Poster/Video	Pitch Deck



PROJECT'S DEADLINES

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P3

- **W1** — Beginning
- **W3** — Proposal Revisal Website and Blog
- **W4** — Interviews Report
- **W5** — Solution Requirements
- **W6** — List of Prototype Materials
- **W7** — Provisory Intermediate Presentation
- **Prep** — Intermediate Presentation

P4

- **W1** — Beginning of prototype development
- **W5** — First Prototype for Testing
- **W6** — End of Testing
- **W7** — Communication Materials
- **Prep** — Evaluation Materials
- **Ex** — Project Discussions
- **Rec** — ElectroDay


Thank You!
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