Written report

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1 - Overview

1.1 - Context

In France, most of the population possess a garden or at least a plant in a pot. This study from the IFOP and the UNEP shows that 63% of the french population have a garden, 58% of these gardens are private and 5% are shared between multiple people/families. This study also shows only 42% of Parisians are owning or participating in the maintenance of a garden. Finally, 70% of the participants grow either vegetable or fruits to sustains themselves or to reduce the cost of food.

Learning about this, a question arose in my mind, what can I do with these information? Then I learned that people couldn't recognize a plant disease and in consequence deal with a disease accordingly. This is how the project named OLAF began.

1.2 - The idea

My idea is OLAF, which stands for OnLine Automated Farm. As the name suggests, it is an automated farm or more precisely an automated plant pot linked to a mobile app to detect when a disease or a virus is infecting a plant.

To achieve this, an AI can be used to analyze an image and detect specific patterns linked to a disease or a virus.

Additionally, the project can be divided into two sub-projects:
the mobile app with the AI and an automated plant pot connected to the user's account on the mobile app.

2 - Project organization

Before diving into the project details, it is important to clarify the relationships between the project and the different groups whether they are internal or external to the school.

2.1 -Project representatives

Project stakeholders	Roles	expectations
Aurélien Fernandez	Project owner	Lead the project by imagining, creating, and delivering the final product.
ALGOSUP	School	Offer guidance throughout the project and provide feedback or approval for the launch of the project. The school also provide a review after a formal presentation of the project.
Reviewers	external reviewer	Evaluate the project during a formal presentation and provide an objective assessment on a set date.

2.2 - Milestones

Dates	Milestones
30/08/2024	The main branch of the GitHub repository is frozen for the first review of the project.
13/09/2024	First presentation of the project in front of the school and external reviewers to assess the quality of the project.
unknown	The main branch of the GitHub repository is frozen for the second review of the project.
unknown	Second presentation of the project in front of the school and external reviewers to assess the quality of the project.

3 - Project definitions

3.1 - Targeted audience

The targeted audience could be defined to anyone maintaining a plant, more particularly vegetable.

In France, using the numbers from the study mentioned earlier, it represents at least 42 million 455 thousand 700 people (63% of a population 67.39 million as in 2019).

The targeted audience could be increase by internationalizing the application.

Please notice that the targeted audience includes only people who are of legal age.

3.2 - Scopes

To measure the success of the project a set of scopes have been set, this ensures the projects keep tracks of the set scopes and avoid implementing features that are not required for the project.

3.2.1 - In scopes

Mobile app
The app is accessible for any user once the authentication form is filled
The app can pull a lexicon from the server
The app displays a lexicon describing either a plant or a disease
The app can take pictures and detect diseases and viruses on a plant
The app displays the result of the analysis of the given picture
The app possess at least 2 languages: english and french
The user can change the language of the app
The app can communicate to the server to access the different data, lexicon or user data
The AI must be able to differentiate the type of plant and its current status (healthy or infected) with a precision of 95%

Desktop app
The desktop app is available only for users identified as administrators
An administrator can modify the lexicon
An administrator can modify the AI model
An administrator can update the role of a user, elevating the user from administrator, or removing administrator access to another user
An administrator can pull an update from the server
An administrator can upload the changes directly into the server

Plant pot
The possibility to add a plant pot to an account
The possibility to remove a plant pot from an account
The possibility to edit a plant pot of an account
The plant pot collects data (temperature/soil humidity) in real time.
The plant pot reacts to the data to benefit the plant
The plant pot takes images of the plant's leaves
The plant pot detects infections from the image
The plant pot send data and alerts of infections to the user's app
The plant pot can water the plant when the humidity is low enough

3.2.2 - Out of scopes

Out of Scope
The detection of an infection in plants that cannot fit in a plant pot
The collection of fruits/vegetable, as it would require a robotic arm

3.2.3 - Nice to have

Nice to have
The app can be used on multiple platforms: Android, IOS
The admin app can be used on multiple platforms: Windows, MacOs, Linux
A solar panel to allow the pot to be placed outside and operate independently
A moving camera, as it would increase the probability to detect an infection if a plant is infected
The app is translated in other languages than english and french

3.3 - Compatibility

The mobile app must be compatible with Android systems. It is also desired but not mandatory to be able to export the mobile app to IOS.

The desktop app must be compatible with Windows systems. Similarly if possible a version for MacOS and Linux could be created.

3.4 - Personas

Alexandra Davies

The patient one

79 years old

My garden is my little paradise

Goals	Frustations	Personality
- Fill her garden with flowers and small fruits - Show off her gardening skill to her friends	- She is not really interested in the new technologies and needs a simple interface to use an app - She is never sure if she watered her plants enough	- Cheerful - Compassionate

John Tatle

The passionate

21 years old

I want to know why my plants are dying.

Goals	Frustations	Personality
- Grow his own vegetables for himself and his family - Keep his plants healthy	- John knows nothing about plant diseases - Every time a plant is suffering from a disease, he doesn't know how to cure it	- Outgoing - Generous

4 - Design

4.1 - Colors

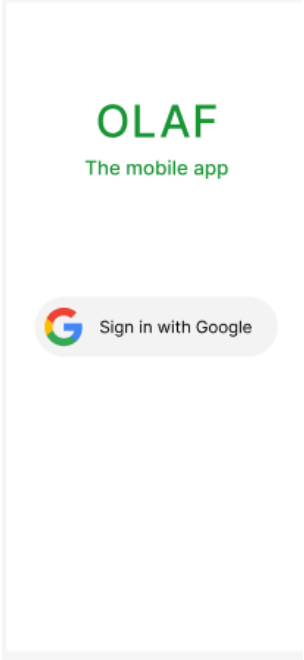
The app will possess a theme with the colors being mainly based on green-like colors: (in hexadecimal):

- Main color: `#395B29`,
- Secondary color: `#629B47`,
- Background color: `#CEFFB7`,
- Text color: white `#FFFFFF`,

The icons are all outlined icons. The icons used for navigation are only in white. The icon for the "disease finder" present on the home page uses the main color. Finally, the icons representing diseases are in white and yellow.

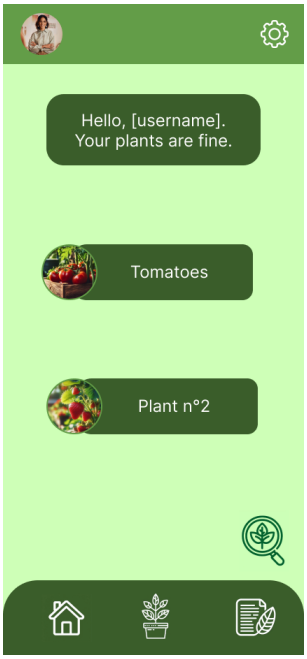
4.2 - Original design

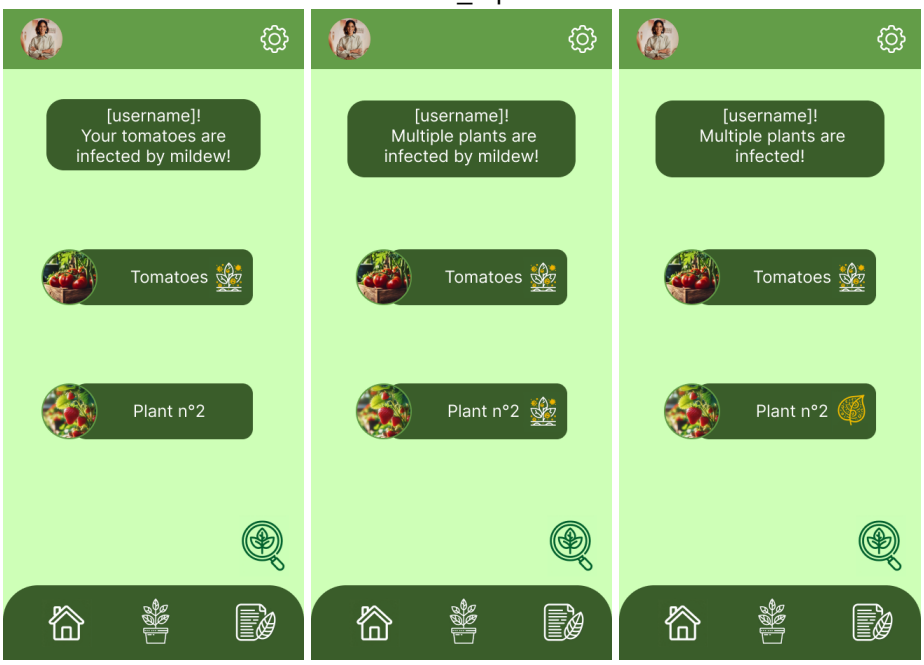
The first page is the connection page, it will appear only the first time or after the user has disconnected his account. If the app has been opened for the first time, it shows a small window to set up the color theme, to permit color-blind people to see the app correctly.



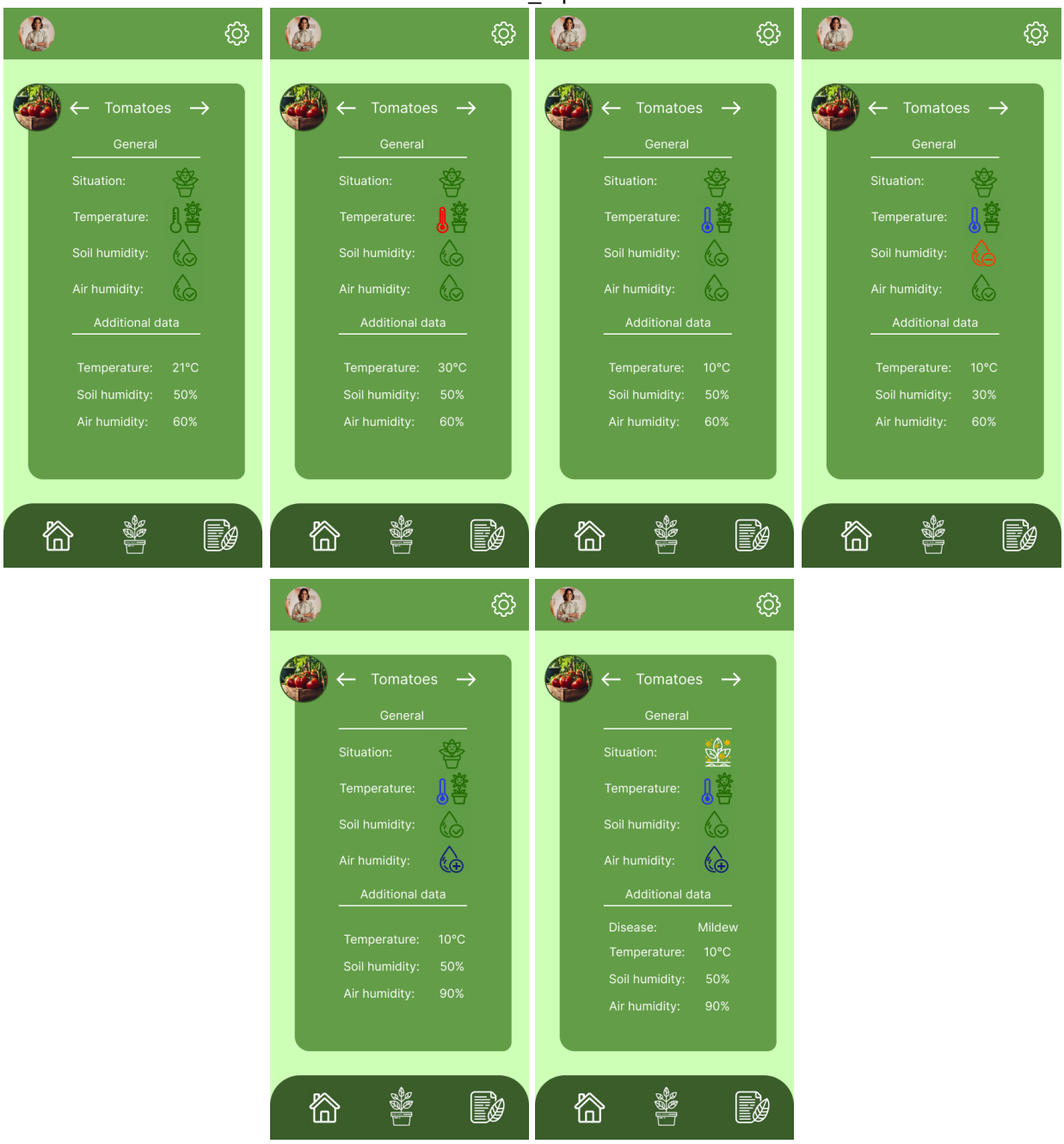
The home page displays the names and images of all plants. the name can be modified by the user but the images are set when specifying the plant species when connecting a new planter.

The Home page also possesses a small icon at the bottom right which is the "disease finder", it requires the user's agreement to use their camera. Finally, by taking a picture of a vegetable's leaves, it will find out if there is an infection or not.

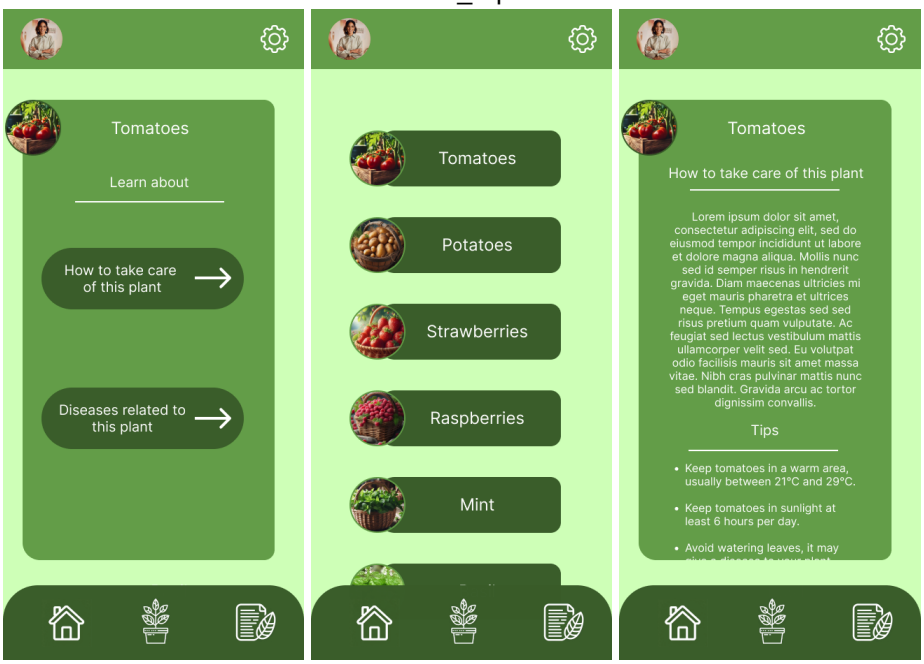


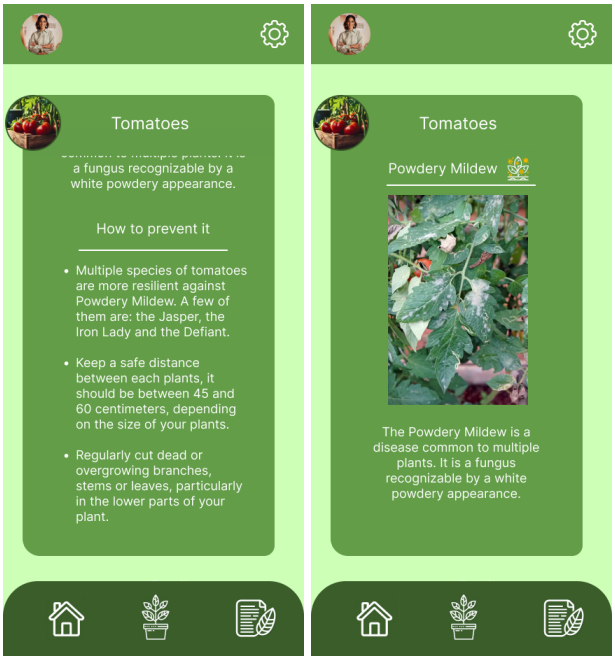


Then, there is the "plant's status" page, which displays the status and information of a plant linked to the account. Users can see the data collected by the planter's sensors, including the ambient temperature, the soil and air humidity and the plant's current state, if it is infected or not.

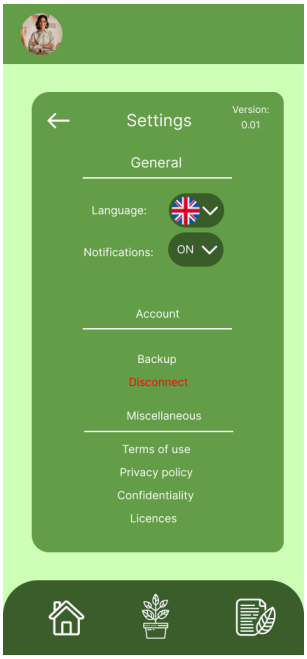


The third page is the lexicon, which allows users to learn about plants and the diseases related to each plant. It shows users images of the disease and how to prevent/cure a disease.





Finally, there is the settings page, with multiple settings such as account management, language and other pages about confidentiality, terms of use and licenses.

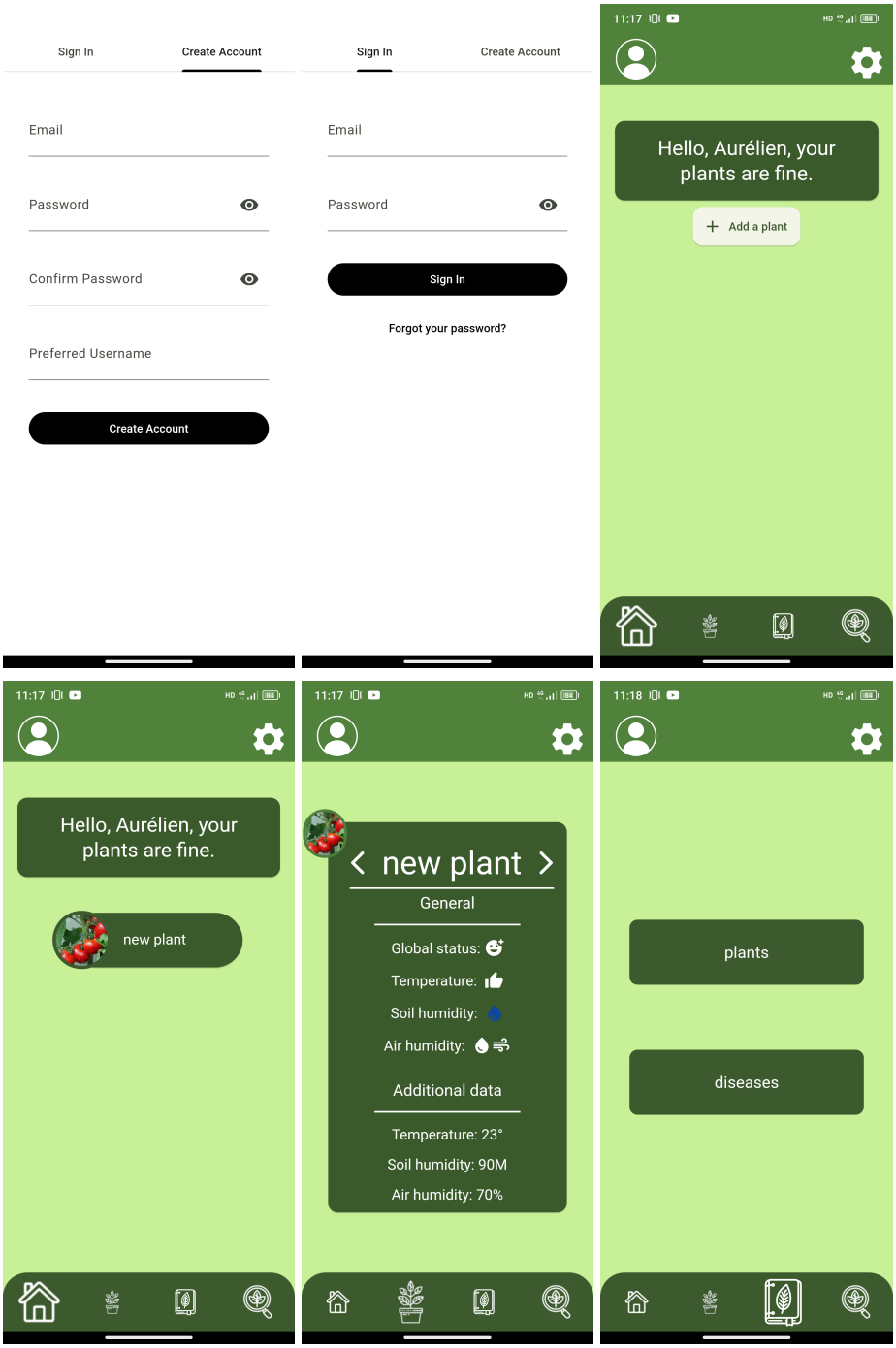


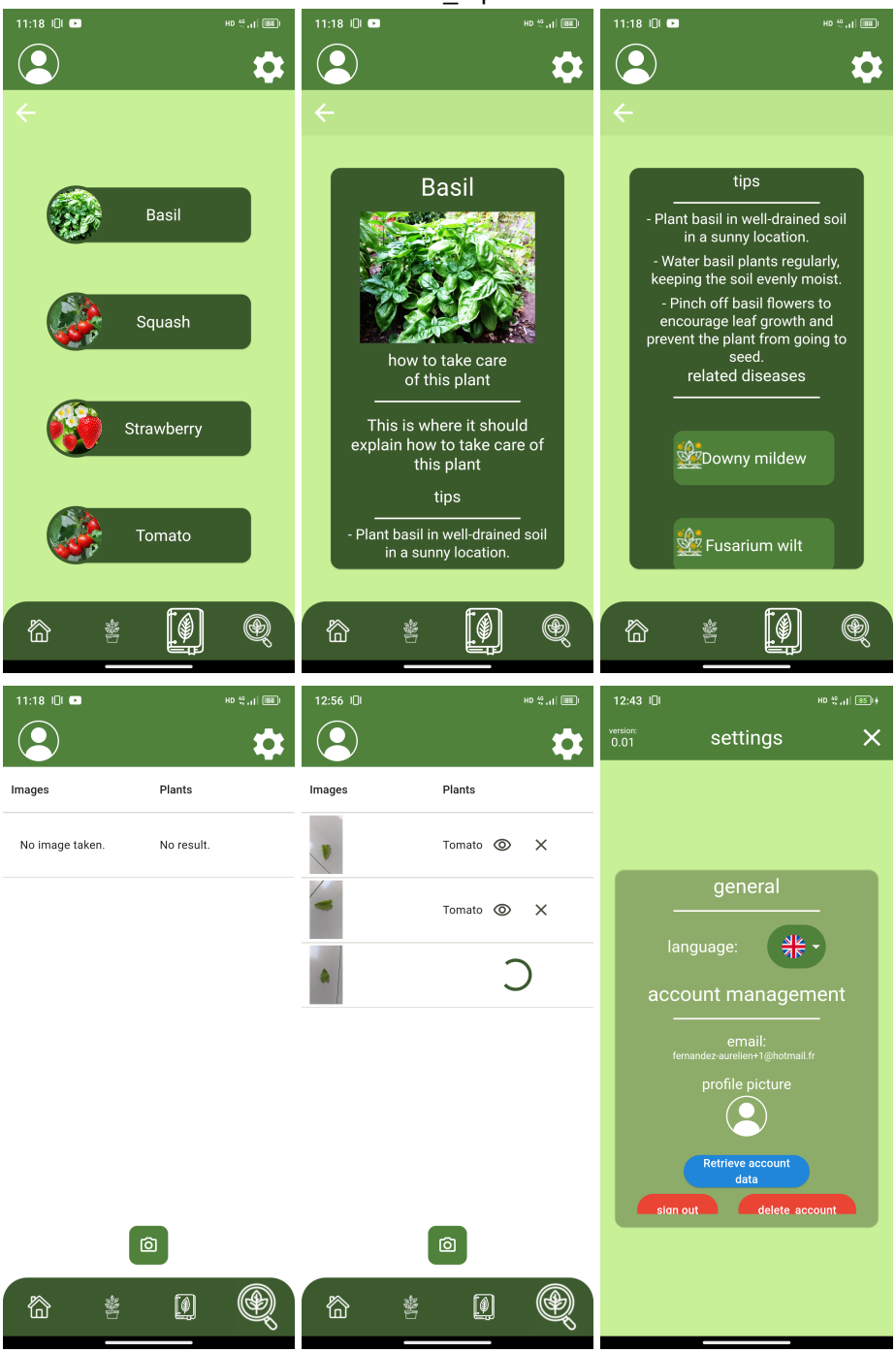
4.3 - Current design

The current design is not entirely different from the one created at the beginning of the project. It has been updated due to the constraints linked to the different devices, user feedbacks and the technologies used.

The current design can also be found at this link: mockup.

The following order is identical to the user path presented in 3.4.6 - Original design.


Sign In
Create Account
Email
Password
Confirm Password
Preferred Username
Create Account
Sign In
Create Account
Email
Password
Sign In
Forgot your password?
11:17
Hello, Aurélien, your plants are fine.
Add a plant
11:17
Hello, Aurélien, your plants are fine.
new plant
11:17
new plant
General
Global status:
Temperature:
Soil humidity:
Air humidity:
Additional data
Temperature: 23°
Soil humidity: 90M
Air humidity: 70%
11:18
plants
diseases



5 - Constraints, drivers and assumptions

Types	Constraints
Energy and ecological constraint	The energy consumption of the pot must not exceed 10W.
User experience constraint	The app must be responsive to deliver a clear and understandable interface.
Economical constraint	With limited funding, the project costs are covered directly by the project owner, which constrains the choice of technologies and solutions available for completing the project.

Drivers
Limit the spending related to the project as much as possible
Provide an app that can be used by anyone, regardless of location or time
Create an architecture which can be easily maintained and easily modified
Ensure the security of user's data

Assumptions
The phone of the users are able to download and run mobile apps
Users are able and will react in case of a plant infection

6 - Non-functional requirements

The project must also achieve multiple non-functional requirements:

Requirement	Definition
Accessibility	The planter and the mobile app must be designed to be accessible to all users, including those with disabilities. This includes ensuring the app accommodates color-blind individuals and those who are unfamiliar with technology.
Updates frequencies	The mobile app must update the planters data with a frequency of 2 per hours minimum
Mobile app & desktop responsiveness	The app must be responsive to scale with the user's phone/computer size
Mobile app & desktop reaction time	The time between a user's action and the app/desktop app response must not exceed 0.01ms
Maintainability	The overall project must be easily maintainable, to ensure an easy way to update the project
Security	The project must be secure, no one other than the administrators must access user's data or have access to the servers

7 - Resources allocation

The project being without any funds, the funding of the different pieces of the project will be provided directly by the project owner.

8 - Law and regulations

The laws this project has to follow are relatively simple, most of the laws impacting this project are under the GDPR (General Data Protection Regulation), which include:
- The user must consent before collecting any data,
- Ensure a secure way to store user data,
- Ensure the user knows which data the project is using,
- Ensure the user knows how the project uses the provided data,
- Ensure the user can access and delete all data linked to the user's at anytime.

II - Technical specifications

1 - Project conventions

This project follows multiple convention in order to keep the maintaining of this project as simple as possible.

1.1 - Commit conventions

In a GitHub repository, maintaining an easy-to-navigate structure is crucial. To facilitate locating a specific commit, it is important to fully utilize the key elements of a commit. Each commit in GitHub can be divided into four essential elements:

- **The hash:** A unique identifier generated automatically for the commit, represented by a long string of characters. Typically, the first 7 characters (e.g., `060ce7a`) are used to identify the commit.
- **The title:** A brief, one-line summary of the commit's purpose. It serves as the name of the commit.
- **The message:** A more detailed description that explains what the commit includes and why the changes were made.
- **The content:** The actual changes made in the commit, including files that were added, modified, or deleted in the repository.

The conventions used in this project are heavily inspired by this document: Conventional commits.

1.1.1 Title

The title is one of the most important elements in a commit. It serves to describe what the commit is about and provides a quick summary of what is implemented, fixed or removed. As such, it has to follow a few rules.

It has to begin with one of the following:

- "FEAT:" if the commit implements a feature to the project.
- "FIX:" if the commit fixes a bug encountered after an implementation.
- "CHORE:" If the commit is about a routine task, for example, refactoring, it is mostly used for tasks that are neither features nor fixes.
- "DOCS:" if the commit is about changes to a document or adding documents.
- "PERF:" if the commit is about optimizing the performances.
- "REMOVE:" if the commit removes a feature.

Furthermore, a title shouldn't be more than 50 characters long and must describe the action of the commit, a verb, and the name of the implementation or the name of the file involved.

1.1.2 Body

The body describes the commit with more details, and as titles, it has to follow specific rules:

- Provide context: explain why this change is needed.
- If possible, summarize how changes were applied, notably for implementations, fixes, refactoring, or optimization.
- Reference issues if needed.
- Avoid long paragraphs. Make a list of what has been done.
- No jargon without explanations. Other contributors must understand commits.

The body can also contain specific keywords that can interact with the repository, such as adding co-authors, closing issues, etc. They can be found here in the footer section.

1.1.3 Examples

For a feature:

```
Feat: implementation of multiplications

Implement a new feature to support multiplication operations in the
calculator.

- Implementation of the multiplication algorithm.
- Update the user interface to include multiplication.
- Add unit tests related to multiplications.

This feature enhances the usability of the calculator, providing users with
a new set of operations.
```

For a fix committed after the previous example:

```
Fix:  overflow with multiplications

Fix an issue where the multiplication may create an overflow if the inputs
are higher than expected (over a trillion).

see commit: 1a2b3c

- If one of the values is higher than the limit, divide it into two separate
values.
- If a value is too high, represent it with exponent (1e10 is equal to
1x(10x10))

This fix allows users to apply multiplications to higher numbers without
being subject to an overflow.

Closes: #324
```

1.2 - Branches

Branches are one the of the key elements of Git, it allows members of a project to add, modify or remove files or parts of files without interfering with the work of another member. For example, a document present in the branch of the same name, wouldn't appear in the main branch, unless a merge has been made.

- **main**: Where the official version of the project is stored along with the documents.
- **dev**: Where the code of the project, is stored. It is moved into the main branch when the required features are finished and no known bug is present in the code.
- **documents**: Where all documents are stored, awaiting to be pushed into the main.

1.3 - Naming conventions

Dart, the programming language used for this project is using strict rules regarding the naming of the different elements composing a project, here is the list of these rules:

- **Files and Folders**: Names of files and folders should use **snake_case**. This means that if a name contains more than one word, the words are separated by underscores. For example, `my_project_folder`.
- **Functions**: Function names should use **camelCase**. In this style, multiple words are written together without spaces, and each word after the first one starts with an uppercase letter. For example, `calculateTotalSum`.
- **Classes**: Class names should use to **PascalCase**, where each word, including the first one, starts with an uppercase letter. For example, `UserAccountManager`.

1.4 - Comments

Another way to ensure the ease of maintaining a project is to add comments. Comments help improve code readability and make it easier to understand and maintain.

1.4.1 - Import comment

As Dart implies the use of multiple libraries, the use of import comment can be important to differentiate which import is created specifically for this project or comes from libraries. Here is an example from the file main.dart:

```
//------------------- CUSTOM IMPORTS --------------------
import 'package:olaf/amplify_configuration.dart';
import 'package:olaf/app_localization.dart';
import 'package:olaf/cache/shared_preferences%20.dart';
import 'package:olaf/home/home_page.dart';
import 'package:olaf/cache/loader.dart';
import 'package:olaf/settings/save_settings.dart';

//------------------- FLUTTER IMPORTS -------------------
import 'dart:async';
import 'package:camera/camera.dart';
```

```
import 'package:flutter/material.dart';
import 'package:flutter_riverpod/flutter_riverpod.dart';
import 'package:flutter_localizations/flutter_localizations.dart';
import 'package:flutter/services.dart';

//------------------- AMPLIFY IMPORTS -------------------
import 'package:amplify_auth_cognito/amplify_auth_cognito.dart';
import 'package:amplify_authenticator/amplify_authenticator.dart';
import 'package:amplify_flutter/amplify_flutter.dart';
import 'package:amplify_storage_s3/amplify_storage_s3.dart';
```

1.4.2 - Functions comments

Comments can also help order to be able to update and re-use functions. Here is an example of one of them:

```
///This function creates a copy of a given image to the directory used to
contain the profile picture,
///allowing the app to update the new picture as the download needs a reload
to be used.
///
///[image] is a file containing an image and [user] is the connected AWS
AuthUser.
Future<String> ChangePictureLocal(File image, AuthUser user) async {
```

2 - Choice of technologies

The choice of technologies was made depending on the factors mentioned in 5 - Constraints, drivers and assumptions.

2.1 - Devices

- For standard users, the decision to create a mobile app for phones was driven by the second driver, as most people own a phone, and it can be used nearly anywhere.
- For administrators, the decision to create a desktop app was driven by the need to send files, specifically a file containing the AI model. Additionally, separating the administrator app from the user app enhances security by ensuring that the functionalities are not combined in the same application, reducing the risk of code-related security leaks.

2.2 - Programming language

The choice of the programming language was driven by the need to create both a mobile app and a desktop app. This lead to the programming language Dart along with its SDK Flutter, which can create an application for Windows, MacOS, Android and IOS from the same source code.

2.3 - Backend

The choice of backend was made due to multiple needs:

- A service available everywhere at any time,
- A service that can handle a large number of user at the same time,
- A secure storage, to avoid security leaks,
- A service capable to create and handle a user pool.

These needs lead to the decision to use Amazon Web Services. As it offers services handling these needs. AWS also has the advantage of being cheap, which was required due to budget constraint.

3 - Artificial Intelligence

3.1 - What is an artificial intelligence?

An artificial intelligence, is a system or machine designed to perform tasks that usually require human intelligence. These tasks can include understanding natural language, recognizing patterns, making decisions, solving problems, and learning from data. Artificial intelligence can be used in many field such as : image classification, virtual assistant, autonomous vehicle and more.

3.2 - Why use artificial intelligence?

In this project, the use of artificial intelligence is crucial, as it is the only way other than the human eye to detect diseases from an image.

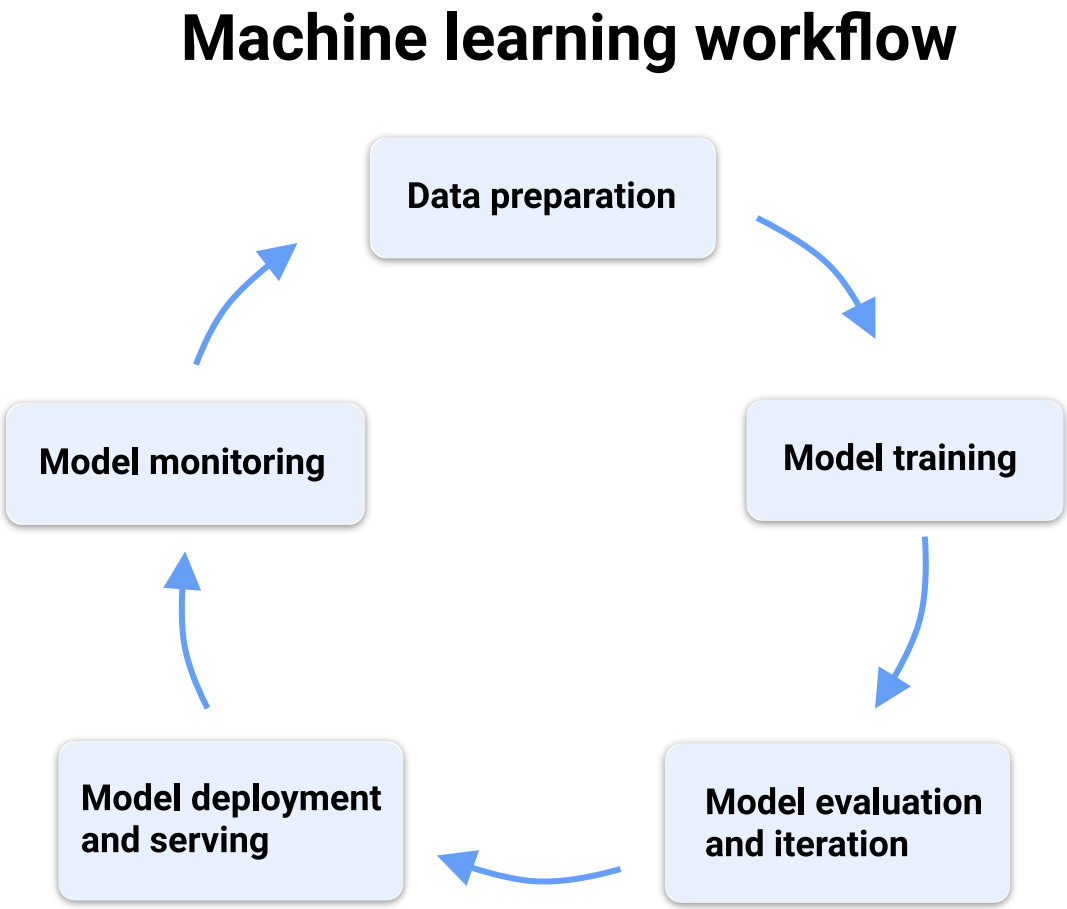
For this project, the artificial intelligence used is designed for image classification, which can be defined of an artificial intelligence trained to analyze an image and specify in which category the image is belonging. For example an AI trained to differentiate cars from bicycle could classify cars in the first category.

3.3 - training an artificial intelligence

Training an artificial intelligence requires multiple elements:

- A consistent amount of training data
- A equivalent amount of validating data
- A model composed of neural networks

The process of creating an artificial intelligence can be represented by a simple loop as this:



As represented above, to create an |AI, the most common way is to prepare data to train the model, then to train the data, at the same step the model will be evaluated automatically, giving a success rate in percentage. The next steps are deploying the artificial intelligence to use it and monitor it.

The data preparation can be divided into three steps:

- The collecting of data,
- The filtering of the data,
- The modification of data, for example for images, modifying each images by changing colors, rotation and scale increase the quantity of the training data available.

Then the training is composed of a four steps, which are autonomous:

- The model will start a cycle, also named an epoch,

- During this cycle, the model will try to classify images,
- The result of the model will be compared to the same data but classified correctly,
- The success rate will be returned in percentage and the model will start a new cycle.

3.4 - The difficulties of training an artificial intelligence

The difficulties of training an artificial intelligence are numerous, here is a list of the most common risks:
- The lack of training data,
- The excess of training data,
- The presence of undesired training data,
- A lack of balance in the training data,
- The lack of epochs,
- Overtraining the model,
- The lack of training cycles.

3.5 - CropAI

CropAi is the name given to the AI used in this project. CropAI is trained over the data provided by the PlantVillage dataset. The dataset as been reduced for the purpose of this project as some data weren't necessary.

Finally the model used for the creation of CropAI as base is ResNetV2, as it has been heavily trained on image classification it is a good match for this project.

4 - Backend architecture

4.1 - S3 storage

Amazon S3 buckets, which means Simple Storage Service, is a scalable cloud storage service designed for storing any data from anywhere. More information about this technology can be found here: What is Amazon S3?

This project only use one S3 named olaf-s3. This S3 is composed as this:

```
olaf-s3
├── users
│   └── [userID]
│       ├── analyzed
│       │   └── [date].json
│       └── profile-picture
│           └── [userID].png
├── update
└── model
    └── CropAI.keras
```

This S3 contains 3 mains folders:

- **users**: A folder containing sub-folder dedicated to a user, they are named after the id of their dedicated user.
- **update**: A folder used to update the lexicon and the AI model.
- **model**: A folder containing ai AI model.

Each user folder contains two folder:

- **analyzed**: A folder containing a json named after the creation timestamp, it contains 2 elements: the image taken by the user, stored in base64 along with the result of the AI.
- **profile-picture**: A folder containing the profile picture of the user.

Finally, the update folder is made to temporarily store either a json file named "update" or a Keras file named CropAI.

The json file shall be structured as this:

```
{
        "plants":{
                "tomato": {
                        "name": "Tomato",
                        "howTo": "A description on how to take care of the
plant",
                        "image": "either a link or a base64 image",
                        "tips"[
                                "A tip on how to take care of the plant",
                                "A tip on how to take care of the plant"
                                ]
                        "diseases":[
                                {
                                        "name:" "Powdery mildew",
                                        "image": "A link or a base64 image
representing the plant with said disease"
                                }
                        ]

                        }
        },
        "diseases": {
                "Yellow leaf curve": {
                        "name": "Yellow Leaf Curve",
                        "image": "either a link or a base64 image",
                        "icon": "either a link or a base64 image",
                        "description": "a description of the disease",
                        "prevent": "A description on how to prevent the
disease",
                        "cure": "A description on how to cure the disease if
possible"
                        }
                }
}
```

Note that in this json file, if no disease or plants needs to be added or updated from the lexicon, the category is not necessary. For example if an administrator wants to add a single plants, the "diseases" part can be completely removed, leaving only the plants part.

4.2 - Dynamo database

Amazon DynamoDB is a fully managed NoSQL database service provided by AWS that offers fast and predictable performance with high scalability.
This service is used in this project to store the lexicon, containing definitions of plants and diseases.

In this database, each plant and disease has a key value assigned, this key value is the version. The version was created to be able to revert the changes made to an element if need be.
For example:

- The plant tomato has 4 version inside the database,
- An administrator wants to add a tip to the tomato but instead delete all of the tips,
- The administrator revert to the version 4.

This ensures a secure way to modify the lexicon without loosing time correcting mistake made by updating the lexicon.

On the user's part, each time the mobile app is started, the lexicon is fetched and stored temporarily in the cache. This ensure the app doesn't need to send a request each time the user navigate through the lexicon.

4.3 - Lambdas

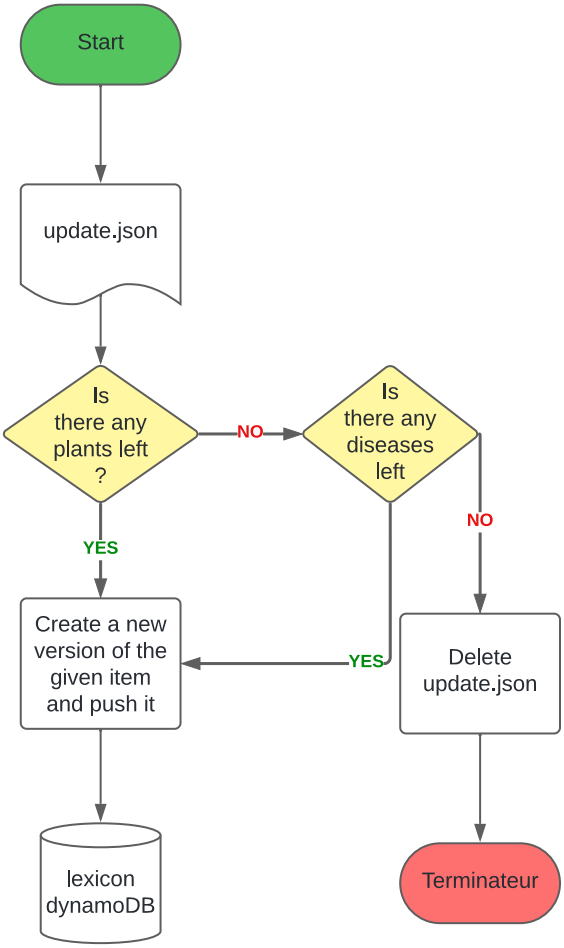
AWS Lambda is a serverless computing service provided by Amazon Web Services called upon specific events without provisioning or managing servers. Additionally, it automatically scales to handle the number of requests. More information about this technology can be found here: What is AWS Lambda?

Here is the list of the lambda used in this project:

name	trigger	effect
olaf-lexica	Upon the creation of the update.json file in the update folder	Add new versions of the plants and diseases mentioned in the file. Once finished delete the file in the update folder.
ai-update	Upon the creation of the file CropAI.keras in the update folder	Replace the file present in the folder model by the new one. Once finished delete the file in the update folder.
image-analyzer	Called directly by the mobile app	Process the given image with the CropAI.keras model. Then create a new json file in the user's "analyzed" folder in the S3. It also send the result to the mobile app to inform the user of the result.

Hereunder, you can find the multiple flowcharts describing how each lambda works:

olaf-lexica


Start
update.json
Is there any plants left ?
NO
Is there any diseases left
NO
YES
Create a new version of the given item and push it
YES
Delete update.json
lexicon dynamoDB
Terminateur

ai-update

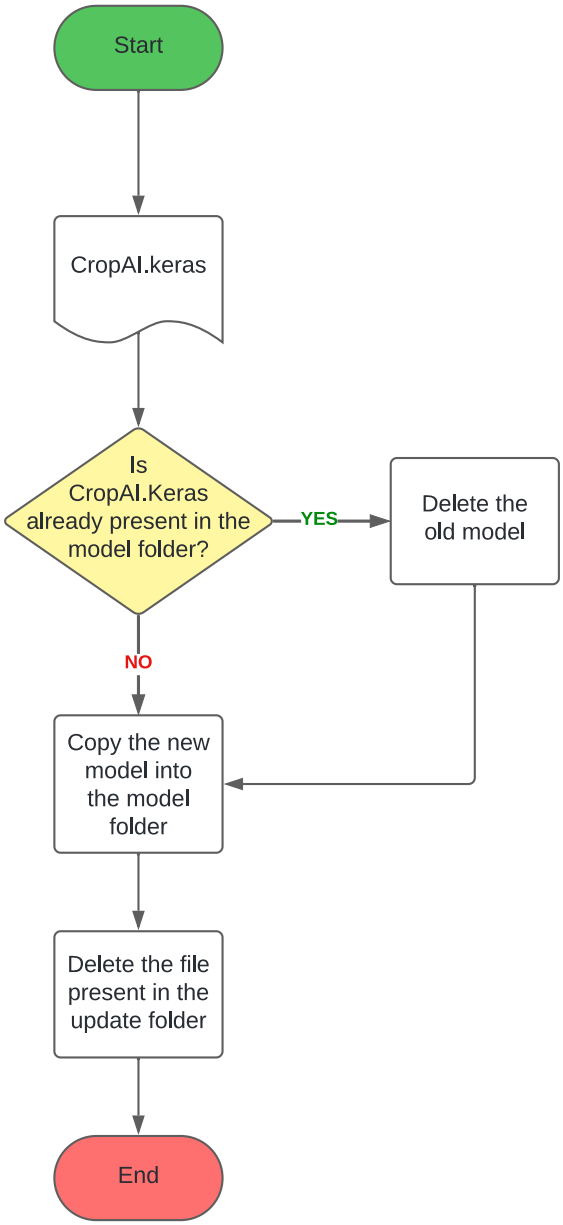
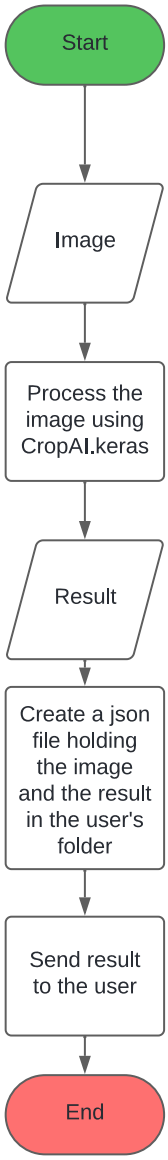

Start
CropAI.keras
Is CropAI.Keras already present in the model folder?
YES
Delete the old model
NO
Copy the new model into the model folder
Delete the file present in the update folder
End

image-analyzer



III - Conclusion

1 - Retrospective

The creation of an application and of an artificial intelligence brought much more insight to me than I first thought. I learned a lot about AWS along with AI and finally I had to deal with multiple roadblocks I first thought impossible to overcome, first of, the training of my AI took time, multiple hours were needed only to find out the result was unsatisfactory. But at the end, I succeeded in most of the criteria I wanted to succeed. I indeed lacked insight regarding artificial intelligence at the beginning of the project, leading to mistakes, since then, I learned, I understood where I made mistakes, why I couldn't increase the success rate of my AI. I am now able start this project a second time or even enhance the current outcome without the unclear areas I couldn't apprehend when I started.

Glossary

- **IFOP**: Institut Français des Opinions Publiques.
- **UNEP**: Union Nationales des Entrepises du Paysage.
- **GitHub**: A web-based platform that hosts Git repositories and provides collaborative features for version control and project management. It enables developers to store code, track changes, review and discuss contributions, and manage software development workflows through tools like pull requests, issues, and actions.
- **Git**: A distributed version control system used to track changes in files and coordinate work among multiple people. It allows users to manage project versions, revert to previous states, and collaborate efficiently by merging changes from different contributors.
- **Libraries**: A collection of pre-written code that can be used by developers avoiding the need to recreate recurrent functions or functionality.
- **Dart**: An open-source programming language developed by Google, designed for building web, server, and mobile applications.
- **Flutter**: An open-source UI framework developed by Google for building natively compiled applications across mobile, web, and desktop from a single codebase.
- **SDK**: A collection of software development tools and libraries that provide a foundation for creating applications for a specific platform or framework.
- **User pool**: A centralized repository or service for managing user accounts and authentication details. It stores information such as usernames, passwords, and other attributes necessary for user identification and access control.
- **Keras**: An open-source high-level neural networks API written in Python, designed for easy and fast experimentation with deep learning models. It also represent the extension used by some AI models.
- **AI**: Artificial Intelligence.

References

- PlantVillage
- Study by IFOP and UNEP
- ResNetV2 documentation
- Keras documentation
- AWS documentation for Flutter
- Dart documentation
- Flutter documentation