Technical Documentation
Snail Map Project

Chandana Karanam

Thanh Duy Tang

Huanyu Zhou

Ankita Bhagat

Limin Zhou

Table of Contents

1. Executive Summary

The group has been engaged by Dr. Mehdi Ravanbakhsh from Mapizy to build the system to facilitate Agriculture pest control application for WA farmers. The system we intend to build will be composed of three separate sub-systems, each focussing on a distinct aspect of the problem: understanding, and amelioration. The first, a data collection and visualization system, aims to provide a platform to users for detailed analysis and investigation of the snail in the farms lands and localize and quantify their analysis. The goal here is to aid in decision making to address the difficulty faced by farmers due to snails. This helps the farmers to locate where the snail density more or where the snail density is less and accordingly using the snail baits to trap the snails in paddock. The second sub-system, an agriculture pest control mobile application, will enable the users(farmers) to take pictures of the paddock, can see the density of the snails using heat map and also save the coordinates. The third sub-system, cloud storage, will enable the data to be stored in the cloud for the future analysis.

2. Project Introduction

The aim of the project is to deliver a system that will help farmers in controlling snails in their farm lands which in turn helps in good yields of the crops and quality grains.

2.1 Background and Motivation

Snail control is estimated to cost the Western Australia (WA) grains industry $1.86 million dollars per annum. If these pests are not controlled, then damage is estimated to cost $19.25 million dollars in lost yield and quality in grain crops (Murray et al, 2013). In WA, snails are mainly an issue in southern grain growing regions. The three main pest species are the small pointed snail (Prietocella barbara), white Italian snail (Theba pisana) and the vineyard snail (Cernuella virgata). These were introduced from Europe and are now present along the south coast of WA with the small pointed snails having a wider distribution than any other mollusc pest in WA.

These snail species feed on emerging crops causing retardation of crops or seedling losses, especially in canola, but can also be harvested with the grain causing contamination and loads can be rejected or downgraded if snail numbers are above receival standards (CBH, 2017). Removal of snails from harvested grain is problematic if the snail is the same size as a single grain. Consequently, to avoid possible contamination issues and crop loss, snail control is recommended to occur before crop germination.

The most common control method employed by growers for snail control is the application of baits at a single rate over the entire paddock (McDonald et al, 2017). The efficacy of baits on snails depends on the rate that is applied, the evenness of distribution and whether the snails are mobile and actively feeding (McDonald et al, 2017). However, a single bait application may not provide adequate control and a follow up bait application is usually required.

If a map could be produced showing the density and distribution of snails across a paddock, growers could target their controls more effectively. This could be done by using variable rate technologies to apply higher densities of bait to sections of the paddock in which snails are greatest

in number. It is estimated that using variable rates to apply baits, rather than a single rate across a paddock could make savings of more than $10 per hectare. The location of snails is an important factor when determining how to map them. When actively moving, small pointed snails are more likely to be found on the ground and can be more easily be detected with vehicle mounted cameras when moving across a paddock.

2.2 Project Goals & Deliverables:

The primary goal of the project is to deliver a system that will help the farmers described above. As it's unlikely there will be any parties to conduct future maintenance/operation of the system, it must be as simple and future-proof as possible.

The deliverable of the project will be described below:

1. The mobile application with camera and heatmap functionality
2. The cloud platform for saving the data.

The mobile application with heatmap visualization aims to create increased awareness about the problem, provide a platform for detailed investigation and breakdown, and in doing so farmers can able to understand the snail patterns on farm lands. The camera in the application is used to take picture of the paddocks for detecting the snails. The cloud platform is used to store the data for further analysis. Its store the latitudes, longitudes and count of snails in each picture.

2.3 Stakeholders

The various stakeholders involved are:

- The Project Manager (Team Leader): It involves the person who is responsible for managing the entire project. He is the one to plans ahead for the project, executes it and takes all the control. He is accountable for assigning the tasks to the other team members and keeping the record of all the updates whether it is a success or a failure.

- The Project Team: It includes the other members of the team who are working in the project. They are responsible for the completion of the task allotted to them by the project manager and keeping him up-to-date. It involves members who are given distinct jobs given to them such as the programmers, developers, testers etc. They can enhance the productivity of the entire project and its deliverables with their knowledge.

- Client: The client is a very important stakeholder in the development of the project. The client specifies all the details and the requirements that they want in the project. It is important to communicate with the client regularly so that it is easy to understand what they expect the end product to look like. The final product is sum of all the specifications that the client wants so it is very healthy for the project to listen to every detail properly.

- End Users: The end-users refer to the people who are going to use the final product developed by the whole team. They are the main users of it with the help of which their job is going to be a lot easier and effective.

3. System Description:

The android mobile application that will aim to help farmers for detecting the snails and use snail baits according to the snail density by using the heatmap visualization and saves the data regarding each picture such as latitudes, longitudes and count of snails.

3.1 System Description and Purpose:

The system proposed is an android mobile application, the primary users will be farmers. The system is web-connected application that allows users to take pictures of the paddocks to detect the snails using snail detection analysis. The deep learning model is used to detect the snails in the picture. The machine learning model is used to find the latitudes and longitudes where the snails are present and also counts the number of snails. The heatmap in the mobile application is used to visualize the density of the snails in each picture thus helps the farmers use snail baits accordingly.

3.2 Deliverable

The primary deliverable of this system is a functional and usable mobile application, runnable on Android devices. This application is intended to be used by farmers in WA for controlling snails in farmlands. The mobile application is compatible with cloud platform to save the data in the cloud.

4 Utilization of Android Utility Libraries

To implement the requested requirements, several Android utility libraries are used and deployed in this app including Google Maps Android Heatmap Utility, Firebase Android and TensorFlow Lite Android.

4.1 Google Maps Android Heatmap

The heat map in this map is used to present the density of snails at a certain area. In order to show it, the required data is a collection of information including latitude, longitude and intensity value which are identified from the taking picture function.

The website of the heatmap deploying tutorial: Google Maps Android Heatmap

4.2 Firebase Android

This app uses Google Firebase for cloud storage, it requires the user has an active google firebase account and input the account in the app backend script before using the app. Firebase cloud storage supports multiple formats of files, but this app will only saves snail numbers, longitude and latitude information as strings inside firebase cloud storage.

The website of the heatmap deploying tutorial: Firebase Cloud Storage on Android

4.3 TensorFlow Lite Android

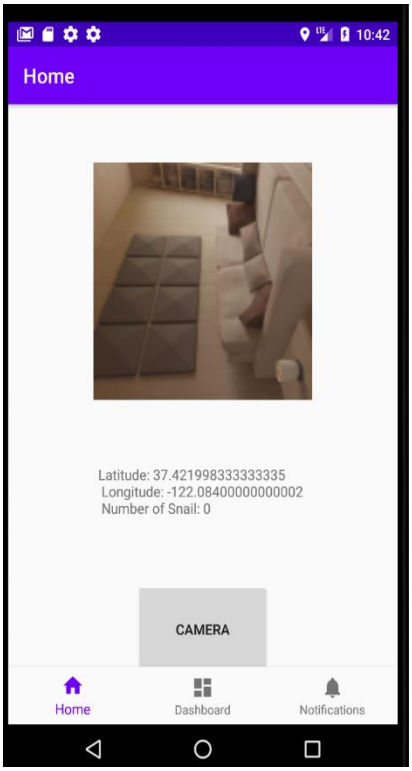
The original AI model is trained on PC with MobileNetV2, the TensorFlow Lite Android is needed to run the AI model. First the full TensorFlow model needs to convert to TensorFlow Lite format for Android Application, the converter is already provided by TensorFlow Lite itself

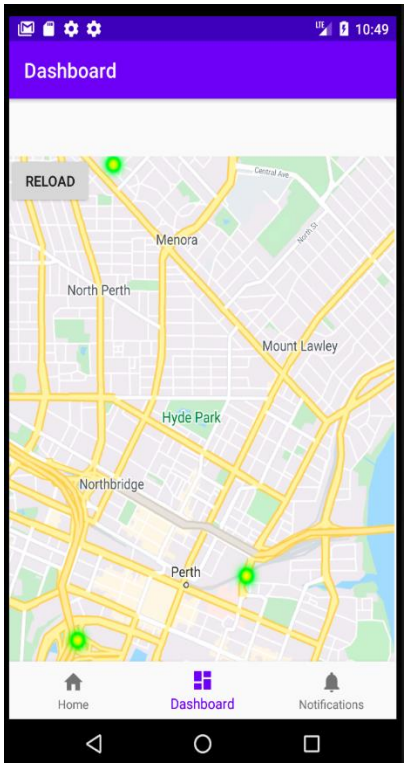
which is very convenient, then the tutorial online exactly states how to deploy TensorFlow Lite Android which makes the project app successfully running the converted model.

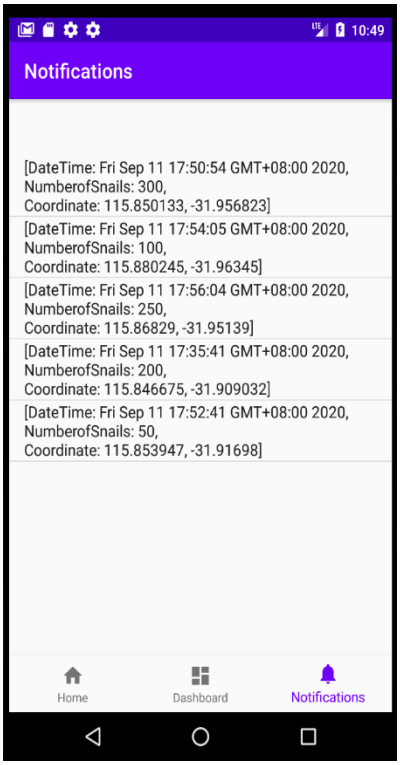
The website of the heatmap deploying tutorial: [TensorFlow Lite Android]

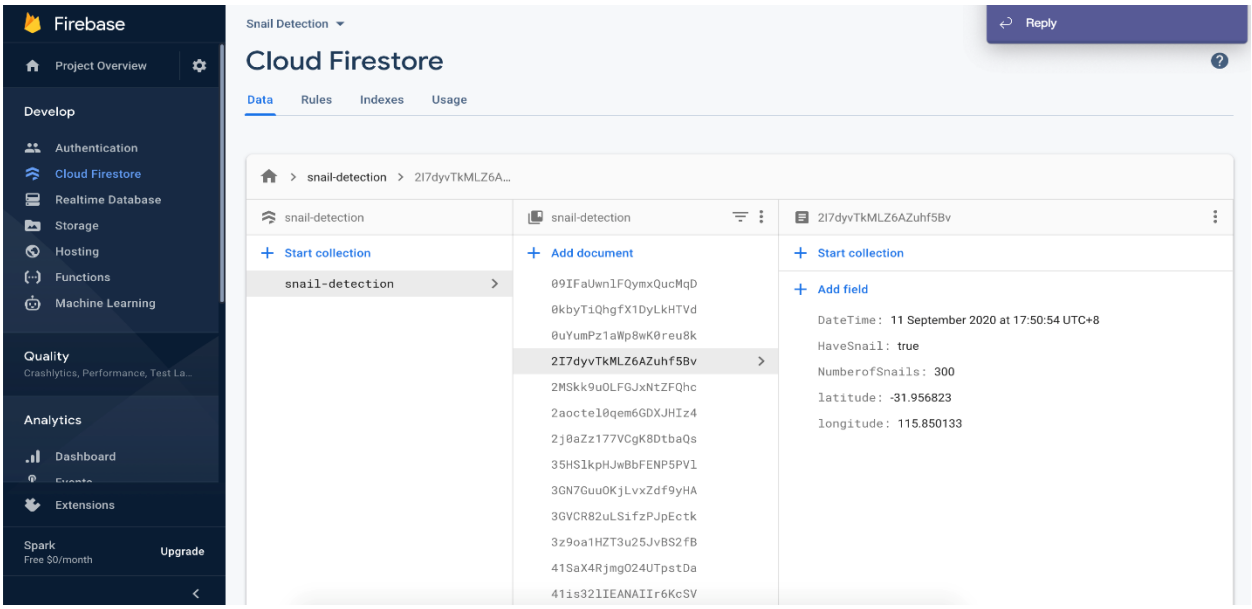
5 System Mock-ups:

The system mock-ups illustrating various common user workflows have been prepared and are shown below.

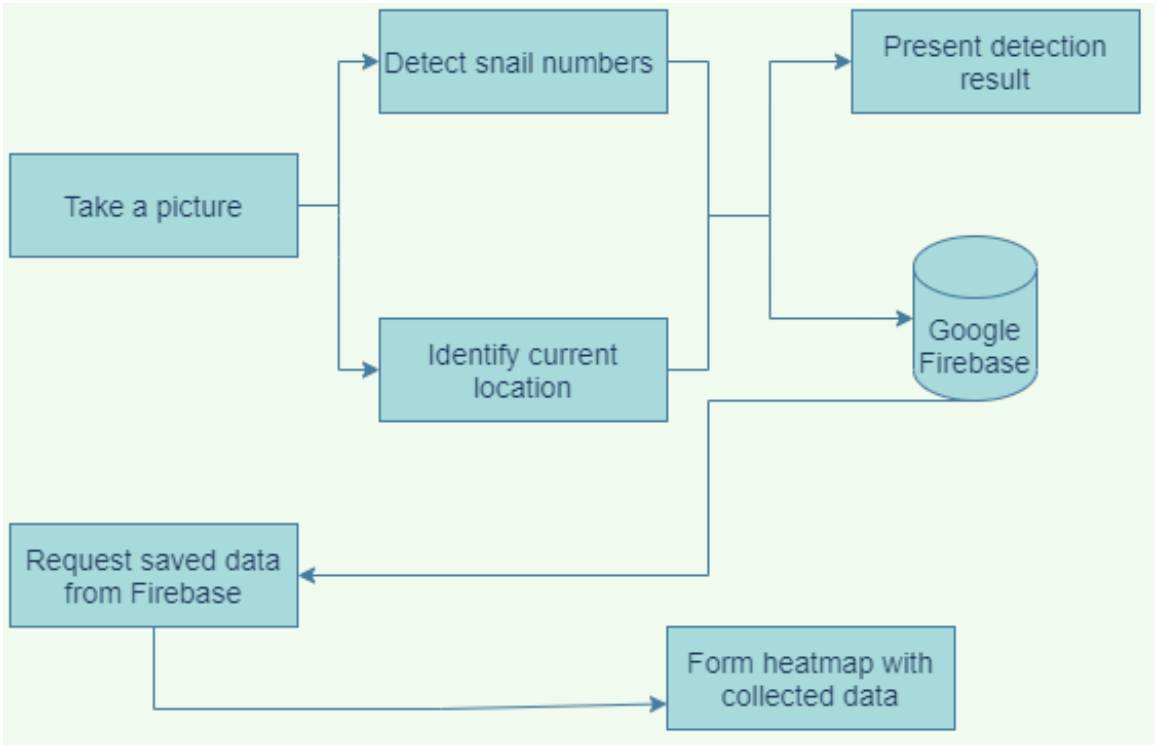








6 Description of System's Workflow



The above flowchart shows the workflow of this app:

1. At the "home" page of this app, the user clicks "Camera" button to take a picture, then the app will abstract desired information from the confirmed picture.
2. At the app background, it will automatically obtain the location of where this picture is taken and also detect how many snails in this picture by utilizing deployed AI model.

3. When the snail numbers and location information are obtained, the app page will display how many snails are detected in this picture and the latitude and longitude of this location. At the same time, this information automatically be sent to the deployed Google Firebase and recorded at the "notification" page. The taking picture functions can be repeated multiple times to form a more useful heatmap later.
4. When the user wants to form a heatmap after taking at least one picture, the user can click into the "dashboard" page and there will present a heatmap based on the abstracted data from Google Firebase. There is a "Reload" button at the dashboard page which the user can refresh the heatmap if more pictures' data is added after the first-time heatmap formation.

7 Functional and Non-Functional Requirements

7.1 Functional Requirements

7.1.1 Content of Functional Requirements:

The functional requirements of this application, and associated use-cases identified, will be discussed here.

Actors

The actor has been identified for this application:

1. User(farmer)

The farmer actor represents a user wanting to use the system to find the snails in the paddocks.

1. Visibility
    1.1 The home screen provides the quick view of camera button which is used to take pictures and displays the latitude, longitude and count of snails in that particular picture.
    1.2 The dashboard screen provides the heatmap visualization of the snails in the paddock.
    1.3 The notifications screen provides the information such as the history of latitudes, longitudes and number of snails for each log.
2. Data Analysis
    2.1 The user can view the heatmap patterns for each picture taken.
    2.2 The user can manually view the records i.e., latitudes, longitudes and count of snails.
3. Camera Function
    3.1 The user can take pictures of the paddocks to detect the snails.
4. Download Mobile Application
    4.1 The user can able to download the application from store in Android mobiles.
5. Data Storage
    5.1 The user can store the data in cloud (mobile application is connected to the cloud platform)

7.1.2 Use Cases

All the identified use cases for actor are identified and discussed below. A typical workflow is presented for each use-case. Each use-case is linked to its associated functional requirement.

- Download the Mobile Application

Identifier	4.1 Download Mobile Application
Goal	To download the agriculture pest control application into Android mobile.
Flow of Events	1. User needs to connect to internet 2. User opens the play store to download the application 3. The user search for agriculture pest control application and click on download button
Preconditions	The user needs to have android mobile application and internet in his/her phone.
Post Conditions	Connect to internet while using the application
Notes	

- Camera

Identifier	3.1 Camera Function
Goal	To take the picture of the paddocks for detecting the snails in the picture
Flow of Events	1. User opens the application. 2. User clicks the camera button in the home page. 3. Application asks permission to access the camera present in the mobile. 4. User gives permission to access camera 5. User takes picture of paddocks containing snails.
Preconditions	The phone needs to have the built-in camera
Postconditions	The picture taken is visible to the user
Notes	

- Count of Snails

Identifier	1.1 Camera Function
Goal	To take the picture of the paddocks for detecting the snails in the picture
Flow of Events	1. User takes the picture using camera. 2. The deep learning model detects the snails in the pictures 3. The algorithm in deep learning model counts the number of snails 4. Count of snails is then displayed on the home screen
Preconditions	
Postconditions	
Notes	

- Heatmap

Identifier	2.1, 2.1 Heatmap
Goal	To create a heatmap using picture taken from camera
Flow of Events	1. User opens dashboard screen in application 2. Dashboard screen contains heatmap for that particular picture 3. The user can able to find the are which has more snails.
Preconditions	The picture of paddock needs to be taken for heatmap visualization.

Postconditions	
Notes	

- Location Logs

Identifier	1.3, 2.2 Latitude and longitude of snails
Goal	To find the location of the snails in paddocks
Flow of Events	1. User opens the notifications screen 2. User can see the time and the location for each picture taken
Preconditions	
Postconditions	
Notes	

7.2 Non-Functional Requirements

The proposed system has several non-functional requirements, each of which is presented and discussed below.

Security

This application is only intended for the use of the client. Thus, proper authorization mechanisms should be established and the security of these mechanisms ensured, to prevent unauthorized usage of the system.

Accuracy

The data reported must be accurate and meaningful, else any analysis built on it is flawed. The analysis itself should account for potential inaccuracies, and transparency provided where there is a lack of confidence in the validity of a conclusion inferred by the system.

Obscurity of Data/Privacy

The goal of the system is to provide users with high-level analysis tools and visualize high-level snail patterns in paddocks. The GPS traces of individual users should not be visible. It is required of the system to protect any potentially harmful/confidential user/trace information.

Intuitive Visualization and Reporting

The visualization of the data, and any metrics reported to end-users, should be intuitive, meaningful, and easily understood and comprehended. They should not be overly complex, or lacking in tangible meaning. They should have a traceable contribution to the provision/derivation of significant conclusions/inferences made using the platform.

Power Efficiency

As the system will rely primarily on GPS polling, the system must have measures/work-arounds in place to minimize the extent to which it impacts on the user's battery life. Again, users cannot

be expected to have much willingness to use the application if it significantly deteriorates the battery performance of their smartphones.

Privacy

User privacy is a crucial concern for this application. As user locations are being tracked and transmitted, the privacy of the users is paramount. All data should be anonymized before transmission from the smartphone. In addition, there must be some level of obscurity (so long as the utility of the data is not impacted) to impede any attempt to derive identify/understand specific user's snail patterns. Data stored on the cloud must absolutely not have any link to individual user identities.

8 Design Constraints

Here are some listed constrains which should be adhered to for further development including hardware and software infrastructure and applied technologies.

Constraint Name	Description
Android Mobile Phone	This project is specifically designed for Android mobile phone, its installation cannot be achieved on other operating systems such as Apple's iOS.
Android 10 (API level 29 or higher)	This project uses Android SDK Build-Tools 29, all the functions are built and tested at this level, lower version of Android operating system may run this app successfully but cannot be guaranteed.
Java Android Development Environment	The project is implemented with Java-based Android Studio, other Android development programming languages are not supported.
GPS embedded	To make sure the app can identify the user's location and form the heatmap properly, the mobile phone must be embedded with a functional GPS.
Reliable Network	As the app will send the collected data to the cloud instantly after taking the picture, a non-stop network is indispensable.
Camera	The snail detecting accuracy is related to the quality of the picture, fuzzy pictures may affect the detection result.
Google Firebase	The cloud storage right now only supports Google Firebase Service as this function is deployed by following the Google Firebase tutorial. Code modification needed for using other cloud storage services.
TensorFlow Lite	This app uses TensorFlow Lite to make use of the trained AI model which only supports. tflite format, not all AI model trained on PC can successfully be transformed into .tflite format.

9 Conclusion

The Pest control application is a good way to minimize the damage which is done to the crops due the increasing numbers of snails. It will easily detect the parts which need to be focused more so that there is no loss to the crops. It can provide a long-term solution to the problem faced by the farmers as they can now know the hottest part and have the co-ordinates for it which eventually will lead to the less economic hardship. The farmers can concentrate on getting rid of the snails rather than looking for the snails and then trying to eliminate it. Hence, it will save ample amount of time and the job can be done efficiently.