CA 400 - Functional specification

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Smart City

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1. Introduction

1.1 Overview

For our project we plan to create an image recognition system for buildings where a user can take a photo of a building or landmark, our system will then identify what building it is using a convolutional neural network search system that will test its features against a database of photos. The system will then display information relevant to the building, eg. The address, why is was constructed and any historical data.

The app will also contain several predesigned routes between buildings and landmarks. The user can use these routes as a tour guide. Once they get close enough to a building or landmark the user will be able to click a button to bring them to the camera screen.

Another function of the app will be to display all buildings and landmarks nearby. The user can then click on a nearby building or landmark and be directed towards it. When the user is close enough to their chosen building or landmark they will be able to use the camera to find out information on it.

This system will be built and tested using android software. The application will also contain several possible routes to notable building/landmarks which can be used by the user as a tour.

1.2 Business Context

There are many possible business applications for our project. The application itself can be used as a product that a person or organisation may purchase to detect nearby landmarks they are interested in. This application can also be used by those who are visually impaired or have learning disabilities to help them gain a better understanding of their surroundings. This is another crucial application we would like to include in our final design

The function of adding certain routes and GPS location to the application also leads to the possibilities of selling ad space to companies that may be close to a specific route or area. This also includes an opportunity for groups and organisations to create their own routes to follow for any type of event.

This function also adds opportunity for Geo-Locational based advertisement. The ability to tell where a person is travelling is very important to local businesses such as restaurants, stores and tourist offices in the area.

1.3 Glossary

Convolutional Neural Network

a convolutional neural network is a class of deep neural networks, most commonly applied to analyzing visual imagery.

Python

Python is an interpreted, high-level, general-purpose programming language. Used for creating our neural network.

Android

Android is a mobile operating system based on a modified version of the Linux kernel and other open source software, designed primarily for touchscreen mobile devices such as smartphones.

Google Cloud

Google Cloud Platform, offered by Google, is a suite of cloud computing services where we intend to store our photos

React

React is a JavaScript library for building user interfaces.It can be used as a base in the development of single-page or mobile applications

Tensorflow

TensorFlow is a free and open-source software library for dataflow and differentiable programming across a range of tasks. It is primarily used for machine learning.

2. General Description

2.1 Product / System Functions

The system is a complex integration of several technologies to achieve the goal of identifying nearby building and landmarks using a smartphone camera and mobile application.

The system includes the main areas of the android app, the machine learning algorithm and the database.

The android application will be creating using React and tested on several applications that allow for mobile testing such as Explo. This app will allow a user to access their camera and take a photo of the nearby landmark or building of interest.

From here the image will be passed to our machine learning algorithm where we have a trained convoluted neural network to test the image against thousands of other images in a set database.

The database will be set up on Google Cloud, we intend to collect all of our images from Google Images and Google Streetview. This database will contain thousands of images that are all tagged relating to the building or landmark in the photo.

2.2 User Characteristics and Objectives

This application is intended to be used by people with a technical background as well as those who are new to using technologies. It will have a clear and easy to use interface at every point of design.

The objectives we intend to tackle is to successfully create an application that can access the camera of a smartphone and take a series of photos or nearby landmarks. We then intend to create a convoluted neural network that can test this image against thousands of images in a database and will return the most likely outcome. Another objective for the system is to create an easy to navigate database that will serve as a reference point for the neural network.

From a business perspective we would like to include several routes that a user or group can take. This will allow for targeted advertisement in the specific area as well as sponsored walks that include aspects of landmark discovery.

The application is also intended to help those with disabilities such as visual impairment and learning disabilities. We intend to keep this as a key aspect in the production of our product.

2.3 Operational Scenarios

Scenario 1

- The User opens the app and is presented with a home screen containing three buttons.
- The user clicks the first button which brings them to the camera screen.
- The user then uses this camera to take a picture of a building or landmark.
- The app then displays information relevant to the building or landmark in the picture.
- The user also has the option to click a link which brings them to a google search for more information on the building or landmark.
- The user can then return to the home menu or close the app.

Scenario 2

- The User opens the app and is presented with a home screen containing three buttons.
- The user clicks the second button which brings them to a page with a list of predesigned routes between buildings and landmarks.
- The user selects a route they wish to take, and the app displays this route on screen.
- When the user gets close to one of the buildings or landmarks, they can click the button which brings them to the camera.
- The user then uses this camera to take a picture of a building or landmark.
- The app then displays information relevant to the building or landmark in the picture.
- The user also has the option to click a link which brings them to a google search for more information on the building or landmark.

- The user then clicks the button to bring them back to the screen displaying their route.
- When the user reaches the end of the route, they can either return to the home menu or close the app.

Scenario 3

- The user opens the app and is presented with a home screen containing three buttons.
- The user clicks the third button which bring then to a page with a list of all the nearby buildings and landmarks.
- The user selects which building or landmark they would like to visit and the app will direct them to it.
- When the user gets close to their chosen building or landmark, they can click a button which brings them to the camera.
- The user then uses this camera to take a picture of a building or landmark.
- The app then displays information relevant to the building or landmark in the picture.
- The user also has the option to click a link which brings them to a google search for more information on the building or landmark.
- The user can then decide to return to the nearby menu, the home screen or close the app.

Scenario 4

- The user opens the app and is presented with a home screen containing three buttons.
- The user clicks the first button which brings them to the camera screen.
- The user takes a picture of a building or landmark using the camera in the app.
- The system could not find a match in the database for the picture taken by the user. (eg. due to low resolution)
- An error is displayed on screen for the using to see. This error prompts the user to retake the picture.
- The user then retakes the picture and a match is found in the database.

- The app displays all relevant information for the building or landmark in the picture.
- The user also has the option to click a link which brings them to a google search for more information on the building or landmark.
- The user can then return to the home menu or close the app.

2.4 Constraints

Mobile Operating System

One constraint we face is that we will only be able to produce this system using android as to create such an app on iOS would require a Developer License which costs each user $99/per year.

Processing Speed

Another constraint the project faces is processor speed, given that the system will have to scan through thousands of images, the application will have to pass the neural network processing to a server to handle the amount of data. This is a major obstacle the operation faces as we must have.

Design Related Constraint

Given the application is also intended to help those who are visually impaired it is another challenge we face as we have little experience in designing interfaces for those with these types of disabilities.

Database Sizing Constraint

From an implementation standpoint another constraint we face is that databases can only be a certain size on Google Cloud, we intend to keep a large data size for training and testing our algorithms. However, we will not be able to include everything we would like to.

3. Functional Requirements

3.1 Taking a photo on the mobile application

Description

The user must be able to take a photo of the point of interest on the application through the application.

Criticality

This function of the application is critical as it is the first step a user must take in the process of identifying the building. This photo will be the one that is passed to the convoluted neural network so it is very important that these feature works flawlessly.

Technical Issue

We believe there are several functions and API's in React that can help us with this issue.

3.2 Accessing Camera Gallery

Description

The user must be able to access their current smartphone camera gallery to select previous photos.

Criticality

This function of the application is another feature that we believe to be important. The action allows users to select from previous photos they may be interested in learning more about.

Technical Issue

We believe there are several functions and API's in React that can help us with this issue.

3.3 Landmark Recognition System

Description

The system must be able to take in the image and process it by comparing it to other photos in our dataset. It also must return the most probable solution to the building or landmark in question.

Criticality

This function of the application is another feature that we believe to be important. This action is essentially the process that relates most to what we are trying to achieve in this project. The image must be able to be read correctly using softwares such as TensorFlow.

Technical Issue

This will be one of the most challenging tasks throughout the project. It will involve creating a convoluted neural network, receiving and outputting information for the user to see.

Dependencies with other requirements

This section will involve constant information sharing between the application, the neural network and our database of images.

3.4 Training Neural Network

Description

Training our neural network is another functional challenge we look to overcome. This includes training initial data and then testing the accuracy of our system many times to find the most accurate results

Criticality

This is another important feature of our application, although it will be in the backend and the user will not interact with it directly. It is the core process that our program looks to deal with

Technical Issue

Using technologies such as TensorFlow, training and testing datasets and interacting with databases for clearer results will be the many challenges.

Dependencies with other requirements

This section will involve interaction with both the photo taken from the camera and with the neural network algorithms

3.5 Creating Dataset

Description

Creating a dataset large enough to contain several thousand photos that are all sorted and tagged correctly is another challenge we face.

Criticality

This is another important feature of our application, although it will be in the backend and the user will not interact with it directly. It is the core process that our program looks to deal with

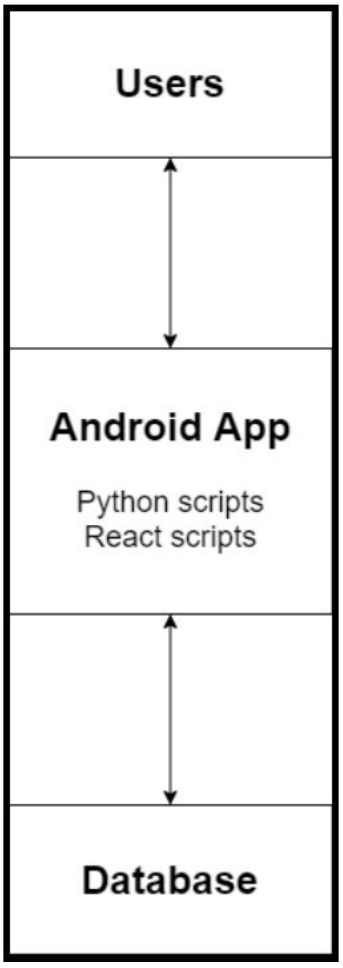
Technical Issue

Using technologies such as Google Cloud to store our data is a new functional challenge we look to overcome

Dependencies with other requirements

This section will involve interaction with both the photo taken from the camera and with the neural network algorithms.

4. System Architecture



Users

The user is someone who uses the app to take a picture of a building or landmark and find out all relevant information on this building / landmark.

Android App

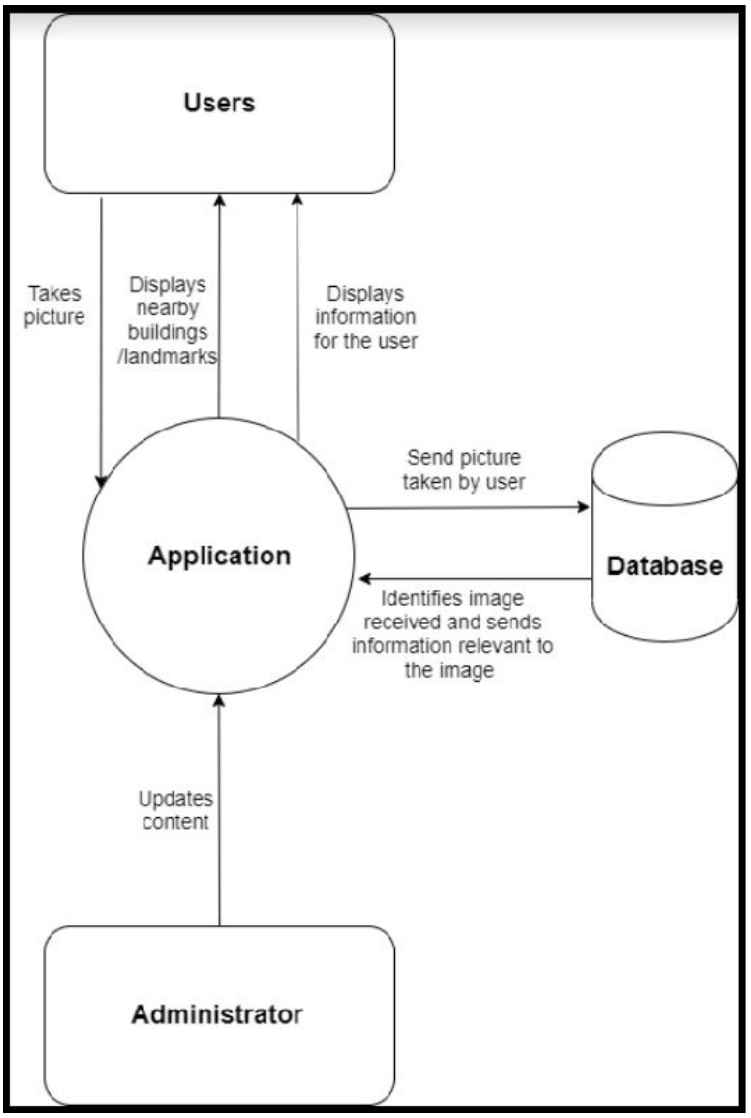
The android app links the python scripts with the react scripts. The python scripts are responsible for sending queries to the database and when it receives a response the app displays the information taken from the database.

Database

The database is used to store all images of the buildings and landmarks that the app will support. It will also contain information about these buildings and landmarks. The database will be queried when the user takes a picture of the building / landmark and find the relevant information to send back to the user.

5. High-Level Design

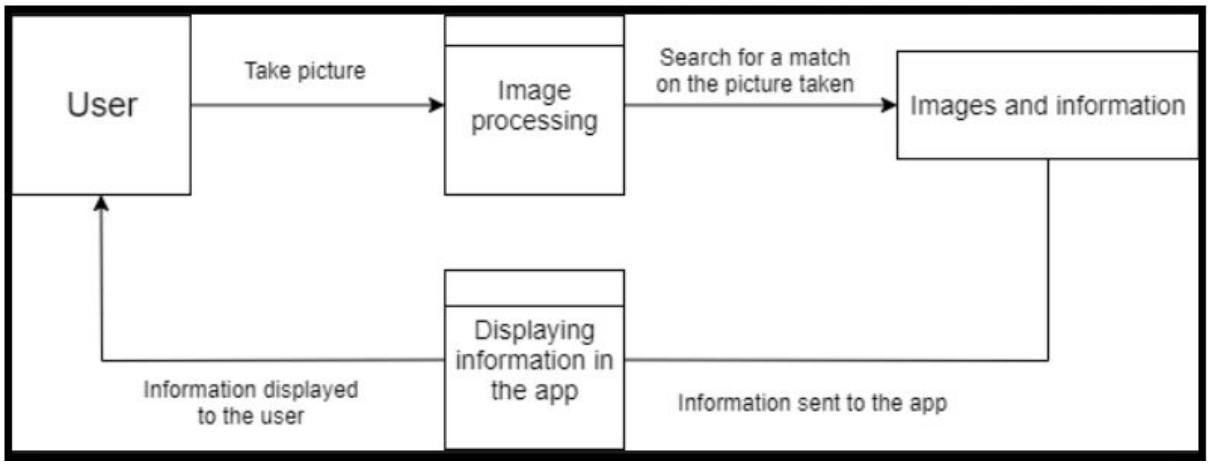
Context diagram



The diagram above shows the interaction between the users, administrator, database and the android application. The user takes a picture of a building or landmark using the camera on the app. This picture is then processed and the database is queried using this picture. When a match is found in the database the information associated with it is displayed on the app for the user to see. The app also displays a route planner between between buildings and landmarks which can be used by the user as a tour guide. The app also displays all nearby buildings and landmarks.

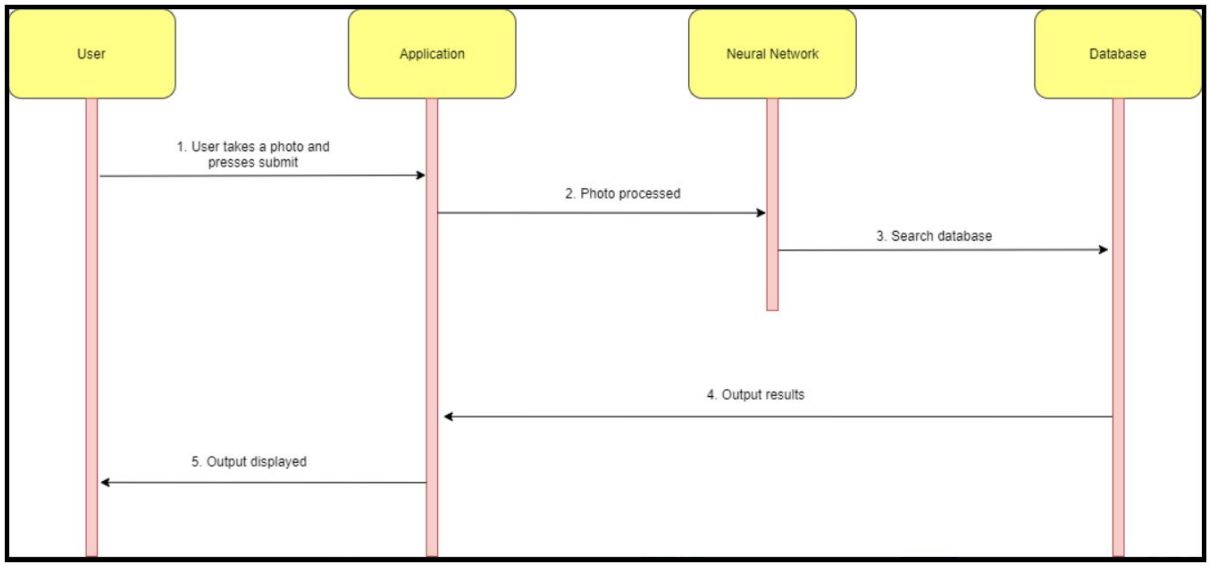
The administrator also connects with the app to be able to update and improve the content of the application.

Data Flow Diagram



The data flow diagram above illustrates the interaction of the user with the application when they take a picture using the app. The image taken is processed in the app and a query is sent to the database. When the database finds a match the relevant information is sent back to the app to be displayed for the user.

Sequence Diagram



1. **User Takes A Photo and presses submits**

The User must first use the application to take a photo of the point of interest they would like to identify**.**

After the photo is taken the user must then select to use this particular photo or take a new one if it is not clear or precise enough for the application to work.

2. **Photo Processed**

The photo is then passed to the neural network to decide which point of interest resembles the photo taken

3. **Search Database**

The neural network is trained that it will then search the database of tagged photos to find the best match. This section will most likely take the most time to complete given the amount of computing that needs to be done before an accurate answer can be given.

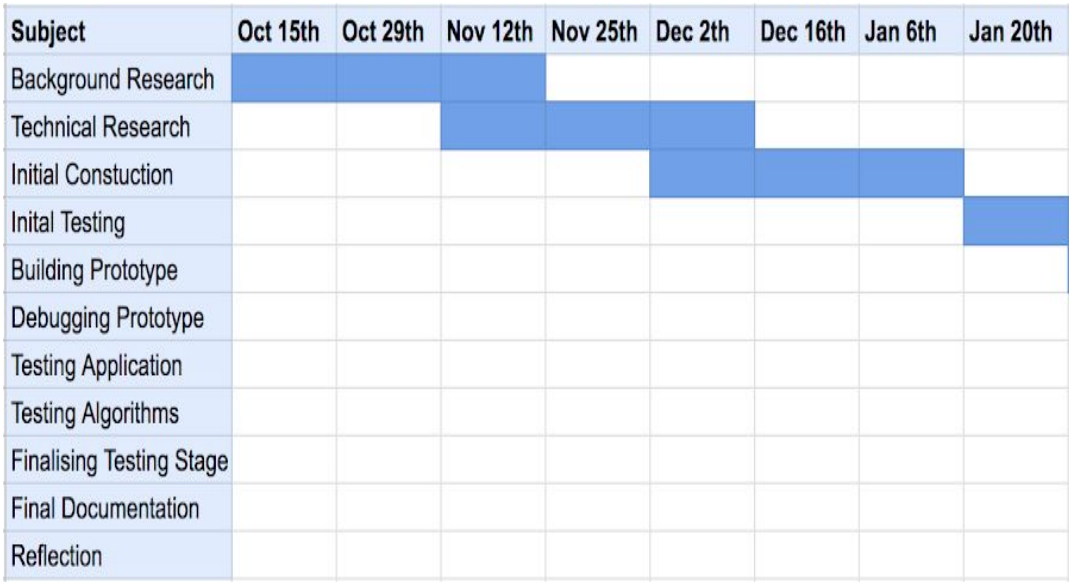
4. **Output Results**

The results from the photo being process and databased being searched are passed back to the device. Ideally only one, correct result will be passed to the device

5. **Output Displayed**

The result is then displayed to the user along with a small section of information relating to the building or landmark. The application will then complete this cycle.

6. Preliminary Schedule



Subject	Oct 15th	Oct 29th	Nov 12th	Nov 25th	Dec 2th	Dec 16th	Jan 6th	Jan 20th
Background Research								
Technical Research								
Initial Constuction								
Inital Testing								
Building Prototype								
Debugging Prototype								
Testing Application								
Testing Algorithms								
Finalising Testing Stage								
Final Documentation								
Reflection								

Background Research

This section will include looking into several technologies for our future project brainstorming different systems we could possibly use. This is the first step towards our full idea.

Technical Research

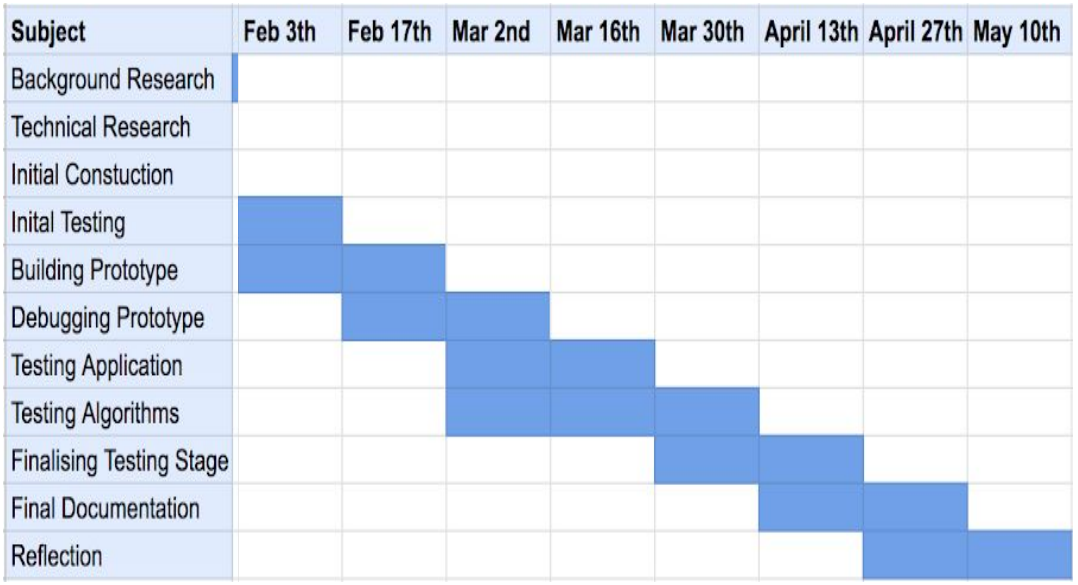
Here we intend to look in further details about which exact technologies and the basic data flows we will look to implement at each stage. We will have a full idea of each step we need to take by the end of each stage. This includes the development of our functional specification.

Initial Construction

In this section we will look to begin our first draft of each stage of our project. We will allow 3 weeks for this as we predict some initial struggles with adapting to new technologies such as React, TensorFlow and Google Cloud.

Initial Testing

We intend to use this period as a brief testing of our initial construction. This is also a time to reflect on the work we've done and how we can possibly improve our workrate for the future.



Building Prototype

After our period of reflection on our work at this time we begin to solidify all working sections of our project and improve on those parts that need improving. This will be a close resemblance of how our final product will look without that much functionality.

Debugging Prototype

From here we will begin debugging our system at the stage that it is at. This stage is where we add certain functionalities and debug certain issues in the application.

Testing Application

At this stage we will test the existing application and see if there are any issues surrounding the mobile application. We will also add any missing functionalities to the application

Testing Algorithm

Here we will test the backend of our application and see if there are any issues surrounding the servers or neural network. Once this stage is complete we should be ready for our final stage of testing.

Finalising Testing Stage

At this stage we intend to create final tests for our application and test its limits in terms of robustness and speed. We will also release it to the public to test at this stage once we are ready.

Final Documentation

From this stage onwards we look to only make very minor changes as we begin finalising our documentation and preparing for our final submission. Checking every file is clear and precise in nature and filling out any necessary requirements for the project submission

Reflection

We have left our final week to reflect on the work we did. Here we will create a list of things that we felt worked well for us and areas we could have improved on throughout the project

7. Appendices

Specifies other useful information for understanding the requirements.

https://www.tensorflow.org/resources/libraries-extensions

https://reactjs.org/

http://flask.palletsprojects.com/en/1.1.x/

https://cloud.google.com/