**Project Title: Identifying Aircraft from above**

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# Background reading

## Abstract

We all know what an aircraft looks like from above...but this turns out to be a difficult problem to solve by computer. This project will first capture a database of aircraft and then use machine learning to develop recognisers for aircraft.  The project will compare the effectiveness of deep learning (a convolutional neural network) with an approach based around genetic programming.

## Approaches

Computer vision is the process of extracting information from an image or images using intelligently designed algorithms and recognisers to give computers an accurate understanding of the world. As a human being, recognising objects in the real world is a simple task often requiring minimal effort. This is down to years of practice. There has been little development of computer vision even though image recognition is such a crucial part of human life. However, over the last few years, as technology has improved drastically, there has been huge advancements in the machine learning field thus helping computer vision hugely [1].

To create a program capable of recognising objects in images, there are several approaches. The approach I am going to use in this project is construction of a convolutional neural network with genetic programming. Images of aircraft will be collected from a source such as Google Maps to develop recognisers using machine learning. Once recognisers are developed, the program should be able to identify aircraft in an image.

## Imagery

### Overview

The images collected to create recognisers must be of a high quality to aid the recognition process. If low quality images are used, the computer may struggle to identify key parts. The image format favoured in image recognition is PNG as it uses a losses compression algorithm meaning no part of the image is lost during the compression process.

To increase the probability of successful recognition, the images must be cropped, resized, rotated and segmented. Cropping decreases the chance that irrelevant parts of the image aren’t recognised instead of the main subject. Resizing is carried out to minimalize CPU usage by using images of the same size. Rotation is used to normalise all images.

### Segmentation

Image segmentation is the process of partitioning an image into multiple segments. This is typically used to simplify an images representation to something more identifiable/ recognisable [2]. There are several image segmentation techniques;

* Colour based segmentation such as K-means clustering assumes that homogeneous colours represent different objects within an object.
* Thresholding methods such as Otsu’s method are used to remove an images nonuniform background so that objects in the foreground can easily be identified.
* Transform methods such as Watershed segmentation are used to separate objects that are near each other or touching.
* Texture filters can help to identify objects in an image by comparing the textures of objects present in an image.

## Neural Networks

To create recognisers, neural networks must be utilized. A Neural Network is a like a human brain with thousands of connections between neurons stacked layer upon layer. A Neural Network consists of an input layer, hidden layer and an output layer. Each layer has no limit to the number of neurons it can have. Smaller networks can have a few dozen neurons whereas larger networks can have millions [3]. The input layer can take various forms of data from the outside world to be learnt, recognised or processed later in the network. The output layer signals how the network has responded to data it has received.

The hidden layer forms most of the network. In most neural networks, the hidden layer connects the nodes of the input layer to each other and the output layer thus making it a fully connected network. The connections between neurons is represented by a number called weight. This determines the effect one unit will have on another. The higher the weight, the more influence a neuron will have. The weight can be a positive or negative number.

Neural networks learn just like we do. For example, when learning a skill, mistakes commonly occur. To avoid making the same mistake again, you make changes. This process is referred to as back propagation. Back propagation is the process of making changes to neurons weights by initially comparing expected and actual output.

Once a network has been trained with enough information, you can present it with new information. For this project, I will present it with many images of aircraft for training. After the training phase is completed, it will be provided with new images of aircraft to test its reliability. It may recognise the aircraft depending on how well the training was performed or may try to categorize the image as an entirely new object. If the network cannot recognize the new aircraft, further training will be performed until it reaches the correct level of reliability.

### Convolution

Convolutional Neural Networks are very similar to ordinary Neural Networks [4]. They are developed to specifically to work with image recognition. The hidden layer of convolution neural networks is 3-Dimensional allowing an images Red, Green and Blue values to be processed separately.

## Genetic Programming

The Neural networks come from the idea of genetic programming. “Genetic programming is a model of programming which uses the ideas (and some of the terminology) of biological evolution to handle a complex problem” [5]. Genetic programming is an appropriate approach to problems that require a large amount of constantly fluctuating variables. Human brains are constantly processing thousands of pieces of information at once. Neural networks were developed after direct study of the human brain.

## Programming language

Python is the language I have selected for the project as it has several purpose-built image recognition libraries available for it. It’s also a great language to learn image processing with because of its simplicity and moderately fast run times.

## Libraries

TensorFlow is an open source machine learning framework [1] that allows the construction of a neural network with the help of a neural network library. TensorFlow allows users to represent computation as a graph of data flows. Mathematical operators in the graph are represented as nodes and edges between nodes represent communication between them. Keras is a Neural network library that allows construction of neural networks with minimal lines of code. Its user-friendly design allows easy integration with Python and TensorFlow.

GoogLeNet is a convolutional neural network that has already been trained on thousands of different image categories, aircraft being one of them. The reason I have chosen to use a pre-trained neural network is that training times on an untrained network will be extremely high (a few days minimum) therefore hindering my progress developing a solution.

# Project Goals

During this project I will complete the following set of goals;

## Primary goals

1. To gather a sample set of images
2. To normalise a sample set of images
3. To construct a convolutional neural network
4. To train a convolutional neural network with images of aircraft
5. To use deep learning to attempt to recognise commercial aircraft from above
6. To apply image segmentation techniques to differentiate between aircraft and other parts of an image.
7. To highlight aircraft fuselage after the recognition process is complete
8. To create tests to ensure recognition is accurate

## Additional goals

1. To attempt to recognise non-commercial aircraft such as private aircraft and helicopters.

Primary goals 1-5 are to be completed by the interim oral review.

# Project planning

## Summer planning

During the summer, I used CSEE Taiga to record my work, so I had a log of everything I had done. Once CSEE Jira was released, I migrated my log to CSEE Jira so that I could use one platform to complete the remainder of my initial report.

## Current planning

The planning tool I will be using throughout this project to document stories and other related tasks such as bug reporting and work flow is CSEE Jira. I will be using the Kanban methodology to plan my work. The Kanban methodology focuses on visualising workflow and by attempting to limit the amount tasks in progress at once. This allows for incremental improvements.

Jira has several features to help project management. Each type of issue (task, epic, story, bug, supervisor or risk) can be assigned a priority level. Highest priority means an issue will block progress, and on the opposite end, lowest priority has little or no effect on progress. All issues are placed on a Kanban board under sections to do, in progress and done.

During the development of version one, all tasks and work completed will be well documented on Jira. This will help to me focus on current work instead of rushing to the next piece.

Version one of my system is set to be completed by the interim oral review if training times of the neural network do not take longer than estimated in the Gantt chart. After the interim oral review is complete, I shall work on the remainder of the project goals and work towards version two of my system. Version two will be more efficient and accurate when identifying objects and will be delivered before the final report is due.

## Gantt Chart

Gantt chart for version 1 of aircraft recognition system

A screenshot of a cell phone

Description generated with very high confidence

A screenshot of a social media post

Description generated with very high confidence

# References

[1]"Image Recognition | TensorFlow", *TensorFlow*, 2018. [Online]. Available: <https://www.tensorflow.org/tutorials/images/image_recognition>.

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[3]"How neural networks work - A simple introduction", *Explain that Stuff*, 2018. [Online]. Available: https://www.explainthatstuff.com/introduction-to-neural-networks.html

[4]"CS231n Convolutional Neural Networks for Visual Recognition", *Cs231n.github.io*, 2018. [Online]. Available: http://cs231n.github.io/convolutional-networks/.

[5]"What is genetic programming? - Definition from WhatIs.com", *WhatIs.com*, 2018. [Online]. Available: https://whatis.techtarget.com/definition/genetic-programming