Title	Incorporating scale into Convolutional Neural Networks for use on aerial image interpretation
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Aims and Objectives

The aim expressed in the form of a research question is:

Does incorporating scale into Convolutional Neural Networks improve performance on aerial image interpretation?

The objectives are:

1. To establish potential scale methods to implement in a Convolutional Neural Network.
2. To implement scale based methods in a Convolutional Neural Network for high-resolution image interpretation (within the context of the ImageLearn project)
3. To evaluate the implementation against previous ImageLearn work and traditional scale methods.

Summary of Proposed Research and Analysis Methodology

This project will use an iterative process of implementing scale methods into a convolutional neural network (see PERT chart). Key to this method is defining the criteria with which we can measure how well the convolutional neural network is classifying objects. Percentage accuracy (the proportion of objects classfied correctly) will be used, however this is not very descriptive or useful when investigating the inner workings of algorithms. A better measure is the normalised discounted cumulative gain, which takes more than one 'correct' answer, in order, and scores based on the position of the true answer. This will be used together with the Cohen's Kappa statistic, which is an industry standard within remote sensing. Furthermore, a confusion matrix will provide an insight into errors of omission and commission. These statistics will be used to compare accuracy and provide a useful criteria for the classifier being 'good enough'.

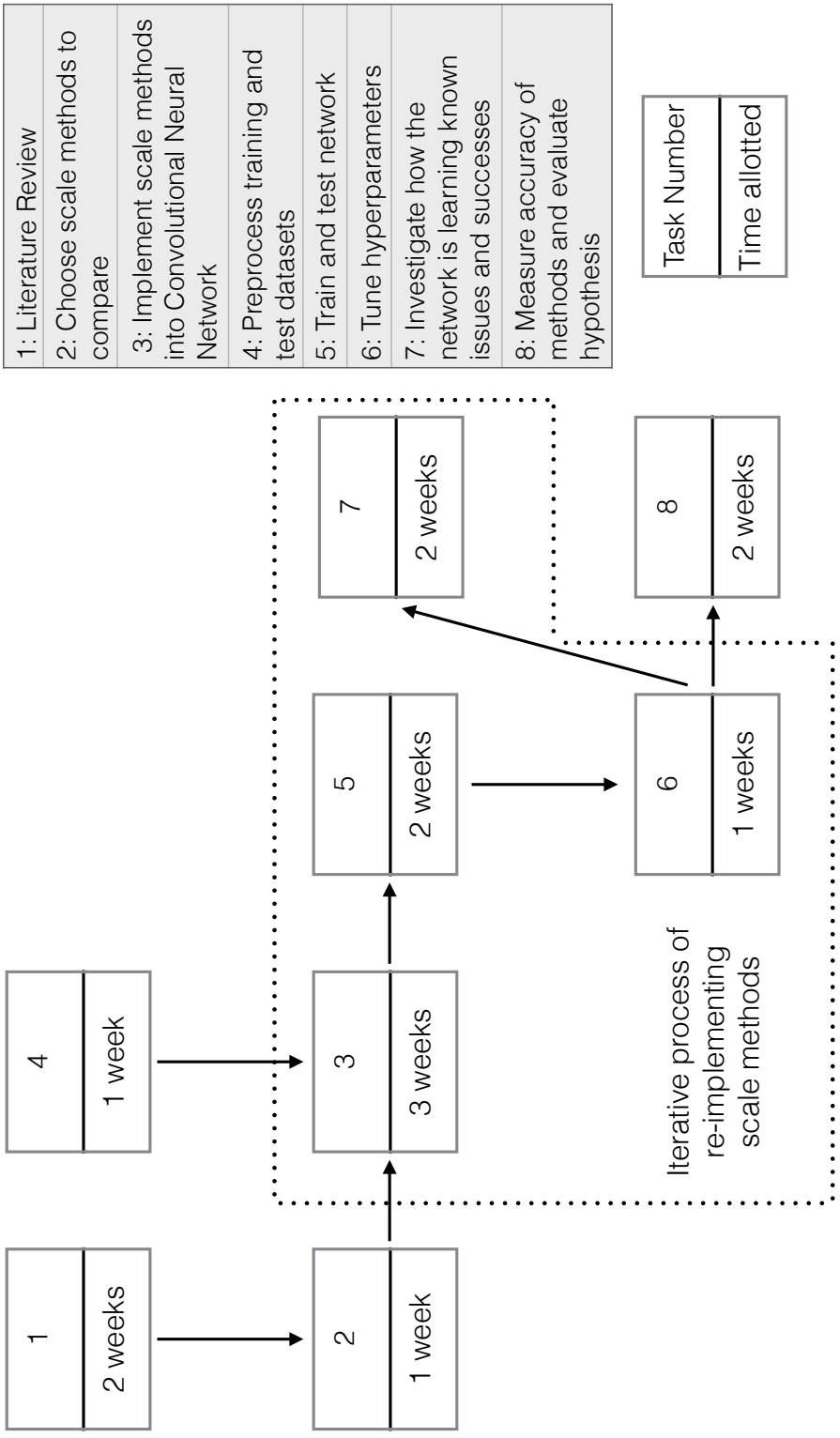
The data are being provided by Ordnance Survey and are already available along with labelled training data. The data were acquired by standard aerial cameras on Ordnance Survey's own plane. Data are available covering the whole of the UK with labelled training data for specific areas including Hull and Southampton.

The method will be implemented in the context of the ImageLearn project, which has already created CNNs for this work using the `neon` Python library. My extensions will build upon this library to ensure easy compatibility with the rest of the project.

Throughout the project I will use good software sustainability practices including version control, automated testing, and documenting code.

Research Plan

A PERT chart of the research plan, is included below. On the right hand side is shown the key for each task and the format of the boxes. All together the weeks add up to 14 weeks, the exact time between the end of exams and the hand-in date. There is a half a week slack period allowed in all estimations of time allotted.



Ethical Statement

This project aims to improve performance of recognising objects from aerial imagery, which could easily be used for 'good' or 'bad' purposes. As with most products or tools, everything *could* be used in an unethical or immoral way, but the tool itself is not unethical or immoral, and the ethics are a result of the people using it. Currently MapAction uses recognition of tents in aerial images to find and map refugee camps[1], this algorithm could automatically do this. However, with the same end goal of mapping tents in refugee camps, a group of terrorists could use it to identify targets. As discussed in the legal and commercial statement, this work will be the intellectual property of Ordnance Survey (OS) and therefore it is likely that it will only be used within OS, with OS imagery.

However, there are aspects of an ethical nature to do with the OS data that is being used. Aerial imagery can infringe on privacy, especially with such high-resolution imagery[2] which can discern levels of detail previously impossible. However these data are no more invasive than many other data, such as images from security cameras that reside in our day-to-day lives. None of these data will be used in an unethical way for this project.

[1] `http://www.mapaction.org/`

[2] E Terrence Slonecker, Denice M Shaw, and Thomas M Lillesand. "Emerging legal and ethical issues in advanced remote sensing technology". In: *Photogrammetric engineering and remote sensing* 64.6 (1998), pp. 589–595.

Legal and commercial aspects

This project has some interesting commercial and legal aspects, as it is sponsored by Ordnance Survey (OS) and using its data. Legally, as I am employed by Ordnance Survey, any of my work done on company time (including any work on my sponsored Masters) will be the Intellectual Property (IP) of Ordnance Survey. If the performance of the algorithm improves through this project it is likely that this technique could be used for creating new datasets of previously unmapped terrain. This is particularly useful for Ordnance Survey International who might use this to map countries that have no national mapping agency, to provide their version of MasterMap. This will provide more revenue for Ordnance Survey as well as fulfilling one of the corporate objectives to be able to expand into more markets than just Britain.

However, this does mean that publishing and advertising this method will need to be in done consultation with Ordnance Survey, as it may lead to copyright (for any data created) or Intellectual Property (for the implementation of the algorithm) infringement. Also any data created with this algorithm from OS MasterMap data will be under Crown Copyright, as Ordnance Survey only holds an exclusive license to use, manage and license this IP with permission from the Crown.