Training a Segmentation Algorithm to Behave Like an Image Interpreter

Background: Geographic Object-Based Image Analysis (GEOBIA) is a widely-used alternative to pixel-based classification of very high resolution satellite imagery. The first stage of GEOBIA is image segmentation; delineating pixels into groups that represent real-world objects. Currently, the automated process does not perform as well as manual delineation by a skilled interpreter, particularly for natural objects.

Aim: Investigate the use of machine learning algorithms for automation of field parcel delineation, using very high resolution satellite imagery and manual interpretations of poppy and wheat fields in Helmand Province, Afghanistan.

Objectives:

Create a dataset from interpretations and imagery suitable for use with Machine Learning algorithms.

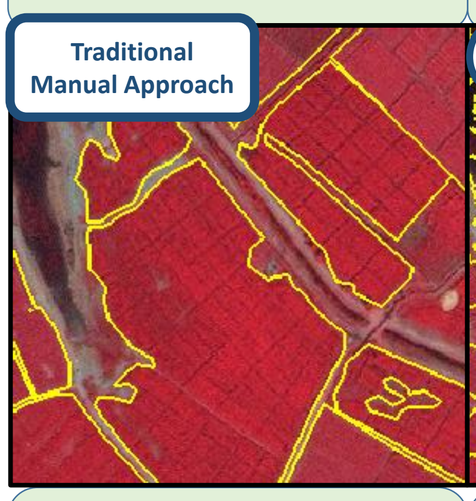
Test a range of Machine Learning methods for suitability for grouping superpixels into objects.

Evaluate the use of Machine Learning technologies for field parcel delineation and suggest a suitable implementation.

Method

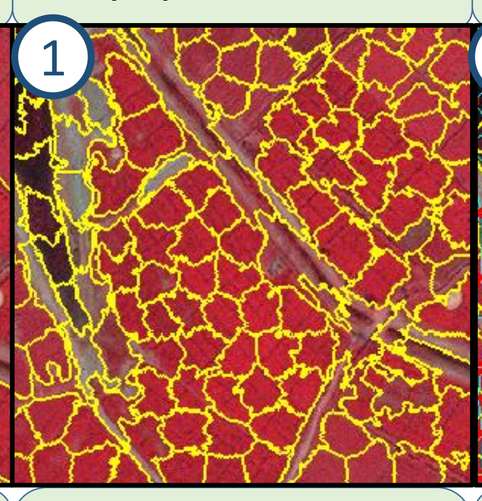
Dataset: 1m resolution satellite imagery and manual interpretations covering 280 km^2 of Helmand Province, Afghanistan

Manual Delineation



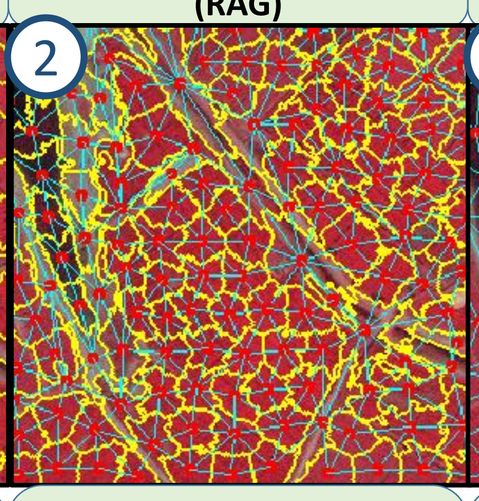
1km^2 sample images are split at random into 47 training and 32 testing images (3:2 ratio). The manual delineation is used as the true values.

1 Superpixel Generation



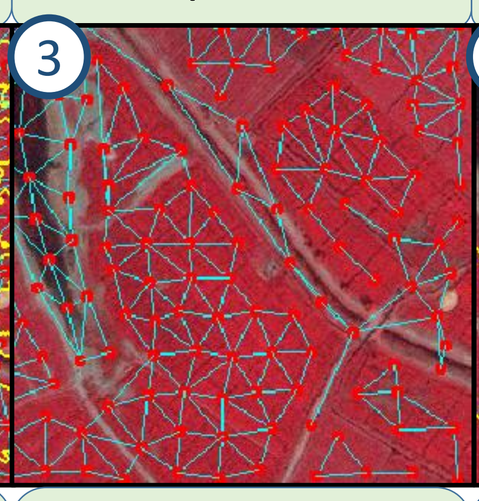
Autonomous segmentation of the image into superpixels (over segmentation into small groups of coherent pixels) using Simple Linear Iterative Clustering (SLIC).

2 Region Adjacency Graph (RAG)



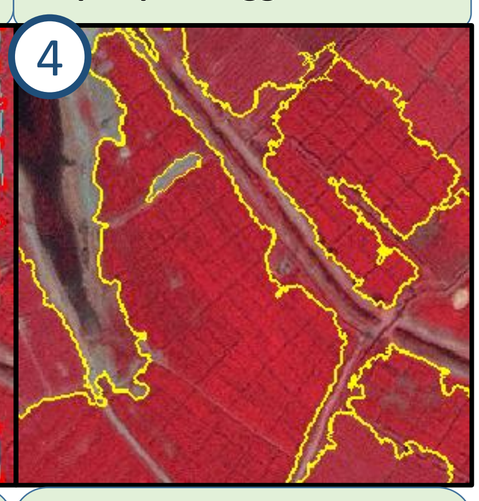
Generation of a RAG links each superpixel with every neighbour. A feature vector is assigned to each superpixel and a difference vector calculated for each pair.

3 Split RAG



Machine learning is used to train the classifier to make a decision on whether to merge each super-pixel pair. The result is a split RAG showing predicted merges.

4 Super-pixel Agglomeration

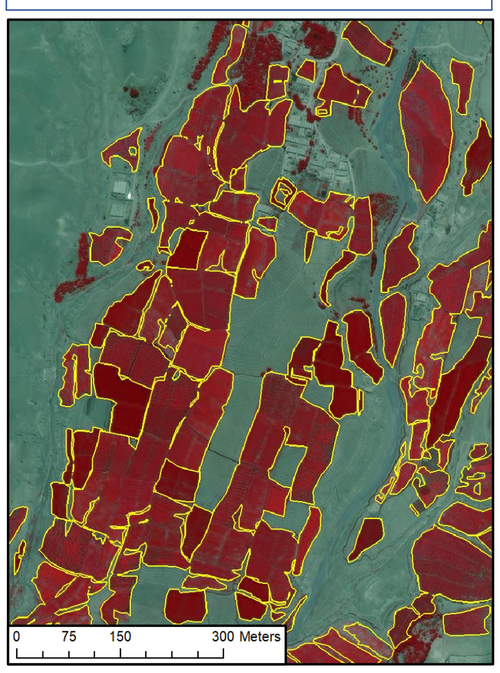


The final stage of autonomous delineation is visualising the boundary lines around the merged superpixels; meaningful objects (field parcels) are formed

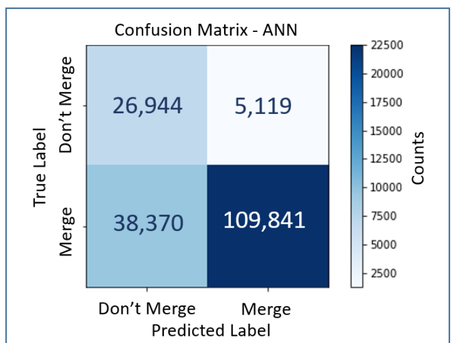
Machine Learning Classifier Performance

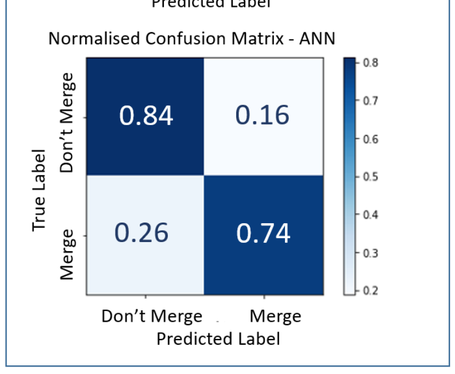
Automated Delineation

Manual Delineation



Accuracy Assessment (Full Dataset)





Results and Discussion:

- Autonomous delineation of entire field parcels has been demonstrated. Automated delineation of an example sample area shows field parcel delineation matching closely with the delineation from the manual approach (left).
- Where field parcel delineation has failed, the split RAG shows the field parcel still clearly identifiable and the only reason for the algorithm failing to delineate the parcel is often just one *Don't Merge* misclassification.
- There are 3 potential solutions proposed to removing under-segmentation: weighing the dataset in favour of *Don't Merge*; calculation of a confidence value with each prediction and a threshold set where uncertain *Merge* predictions are changed to *Don't Merge*; and development of a more sophisticated delineation algorithm to delineate field parcels that are not completely isolated.
- The algorithm performed poorly at delineating *Other* parcels of vegetation exhibiting high texture (woodland for example). This is due to the algorithm only considering spectral information and not textural information - a limitation of the current methodology.

Conclusions:

- A comprehensive dataset suitable for Machine Learning methods has been created through automated scripting processes.
- Machine Learning methods were successful in delineating agricultural field parcels in very high resolution imagery.
- Support Vector Classification was the best performing classifier demonstrating an overall accuracy of 82%.
- The limitation of the method was under-segmentation across the image area caused by a disproportional effect of a small error rate of superpixel agglomeration. Further development proposals are made to overcome the limitations of the method presented.
- Fully automated delineation using a superpixel merging method is achievable, but currently requires development for practical implementation.

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