THE MACAULAY INSTITUTE

Mapping Land Use in NE Scotland with Neural Networks from Remote Sensing Imagery

Matt Aitkenhead & Gary Wright

Presentation layout

- Introduction to the problem
- Data sets used
- Neural network methodology
- Initial results
- Method improvement
- Improved results
- Verification
- Discussion

Introduction

Landsat TM imagery can be used to classify land cover types based on reflectance characteristics in the seven wavelength bands.

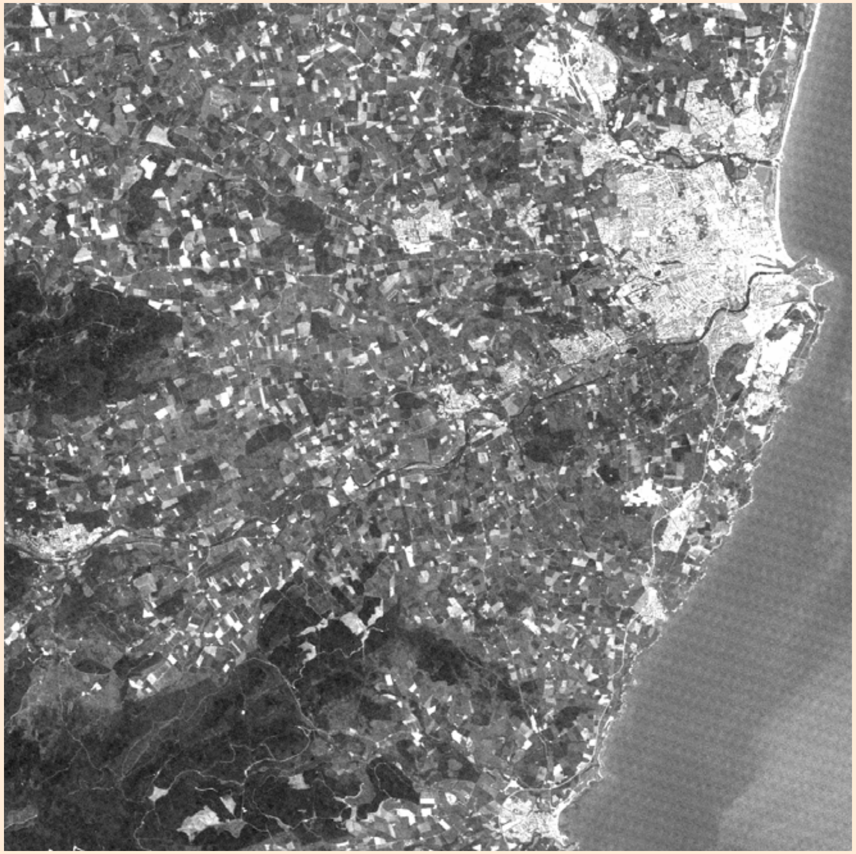
Various mathematical methods (e.g. NDVI), can be used to show strong variations in band reflectance ratios from different surfaces.

A neural network should be able to improve on these simple transformations by developing complex functions which allow recognition of different land cover or land use types.

Landsat imagery of the Aberdeen area is used to develop a land use map highlighting areas of residential, commercial and industrial land use, along with various natural and semi-natural land cover classes.

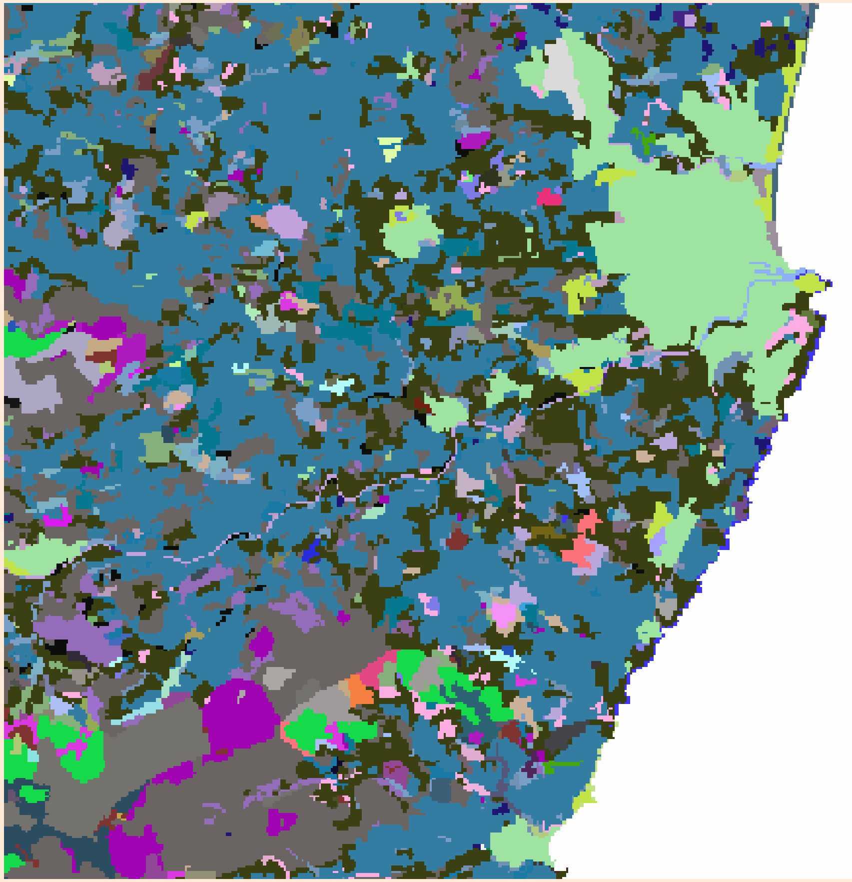
Data - Remote Sensing

- Landsat TM taken in June 1995
- Seven wavelength bands from 0.45-12.50 microns
- Resolution approx. 25m (120m for band 6)
- Study area 30x30km, with Aberdeen in North-East corner



Data – Land Cover of Scotland

- GIS layer extracted from LCS88
- Used for verification of predicted land cover map
- Necessary translation from original LCS legend into categories used here



Neural networks

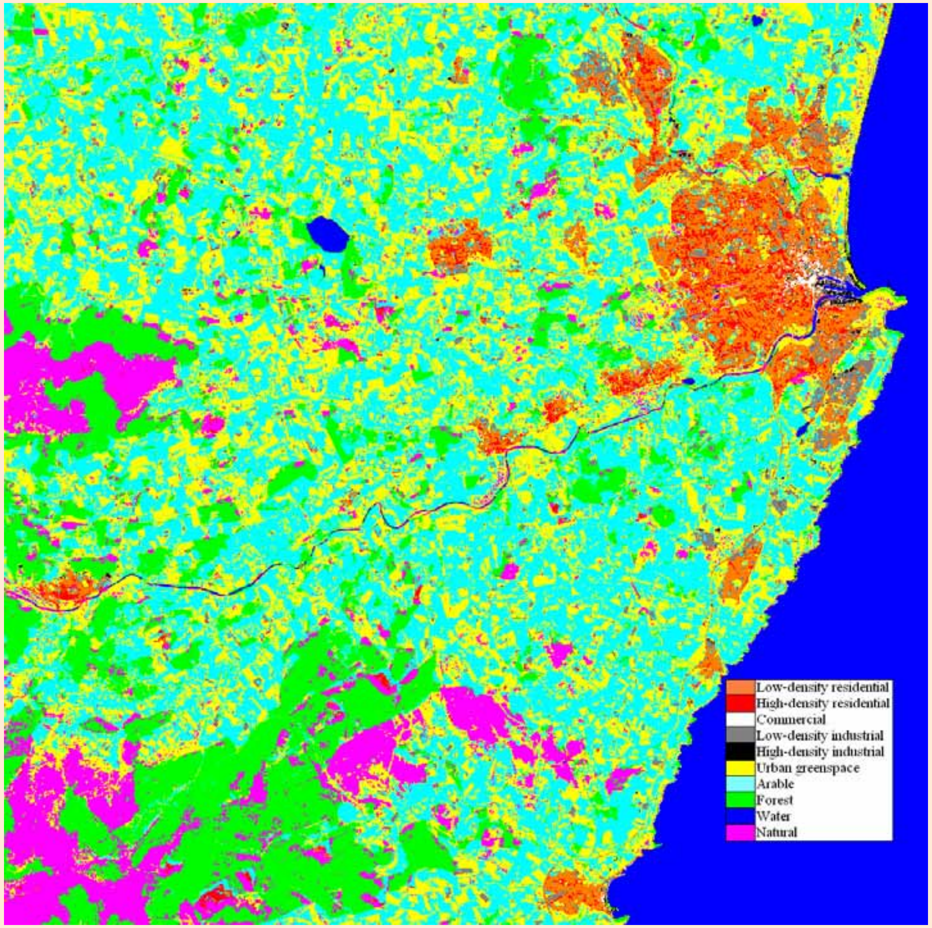
- Backpropagation neural network – an exercise in error minimisation
- Use of internal, hidden variables to develop transformation between input values (reflectance values) to output values (presence or absence of land cover types)
- Provides a method of developing complex, nonlinear mathematical relationships
- Requires training data

Neural networks

- Inputs – seven reflectance values each as (a) original value, (b) proportion of summed values (14 in total)
- Outputs – ten land cover classes chosen to reflect local area characteristics
  - low-density residential, high-density residential, commercial, low-density industrial, high-density industrial, urban greenspace, arable, forest, water, natural
- Training data obtained from Ordnance Survey 1:50000 map of the area
  - 5 locations for each land cover type, chosen for known continuous land cover
  - 4x4 pixels used from each location, giving set of 80 training points (800 in total)

Initial results

- First values show good general classification
- Several small areas misclassified, due to:
  - Poor selection of training areas
  - Poor selection of land cover categories
- Additionally, the colour scheme looks *awful*

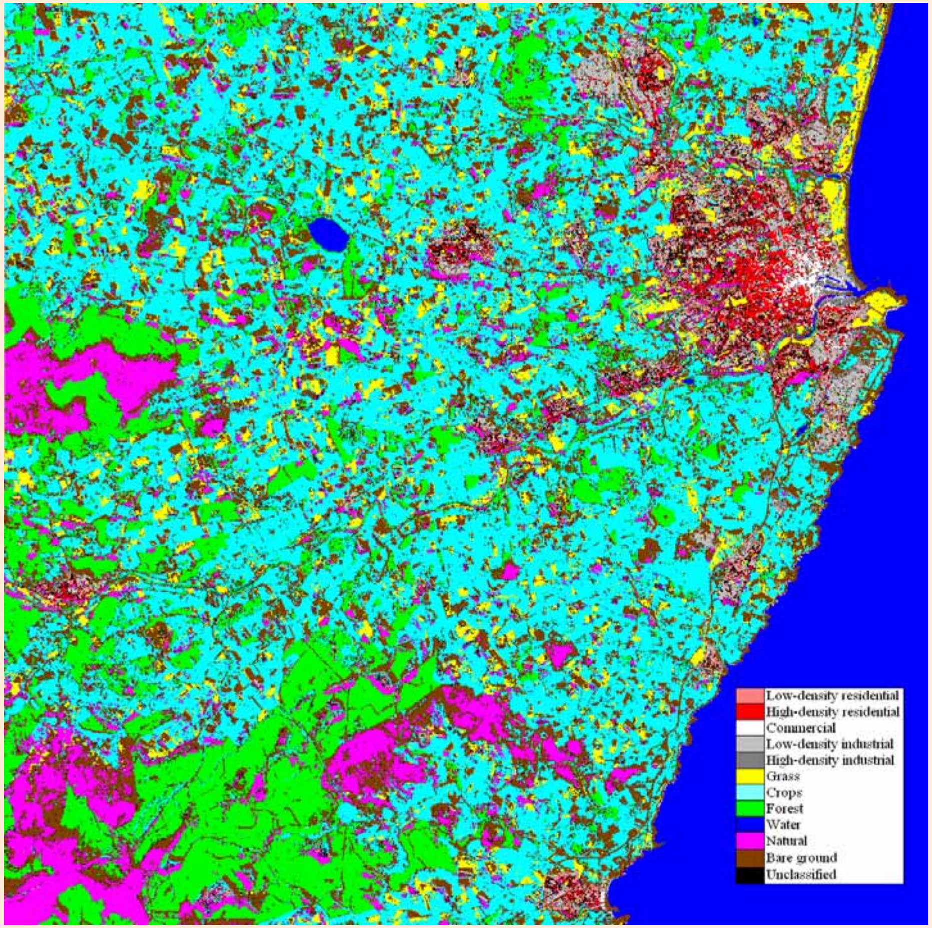


Improvement of initial methods

- Reselection of training area sites
- Redefinition of land cover classes used
  - Low-density residential
  - High-density residential
  - Commercial
  - Low-density industrial
  - High-density industrial
  - Grass
  - Crops
  - Forest
  - Water
  - Natural
  - Bare ground
- Requirement for clear classification – if no category is an obvious winner, then mark pixel as ‘unclassified’

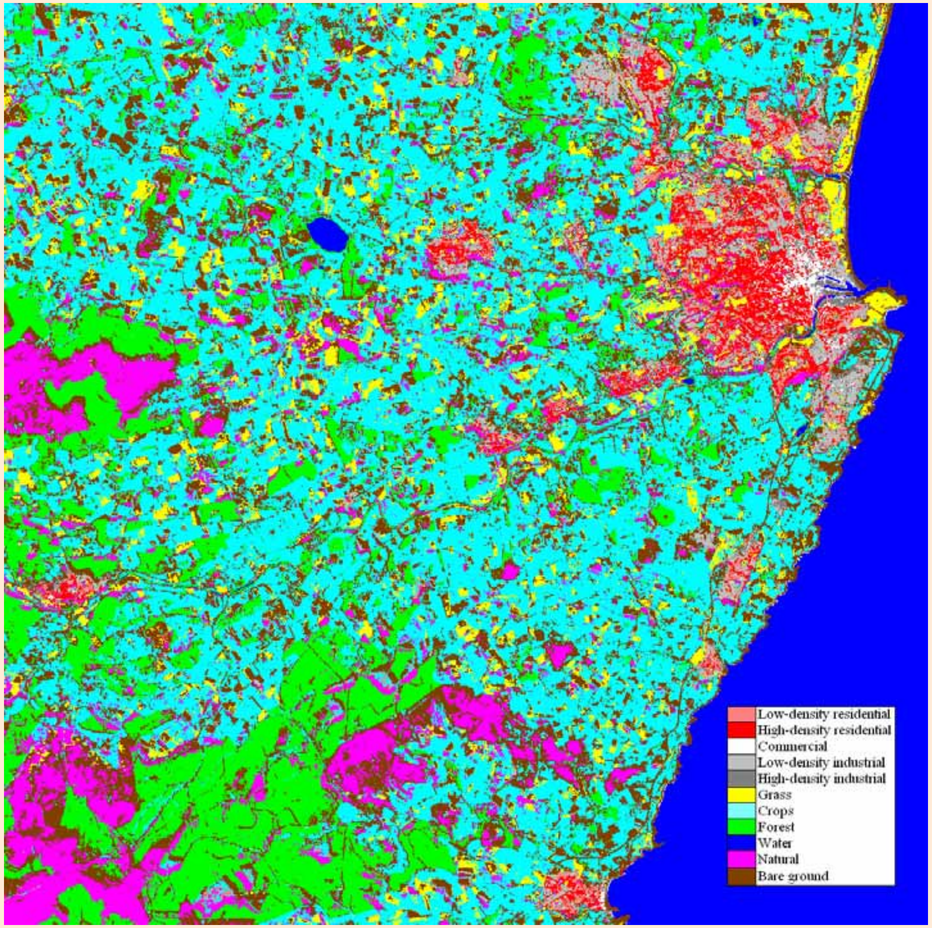
Improvement of initial methods

- Obvious improvement
  - No confusion between bare ground and industrial
  - Bare ground shows up in arable areas – ploughed fields?
  - Distinction between grass and arable crops, not between urban greenspace and rural grassland
- Unclassified land cover - 5.1% of total



Improvement of initial methods

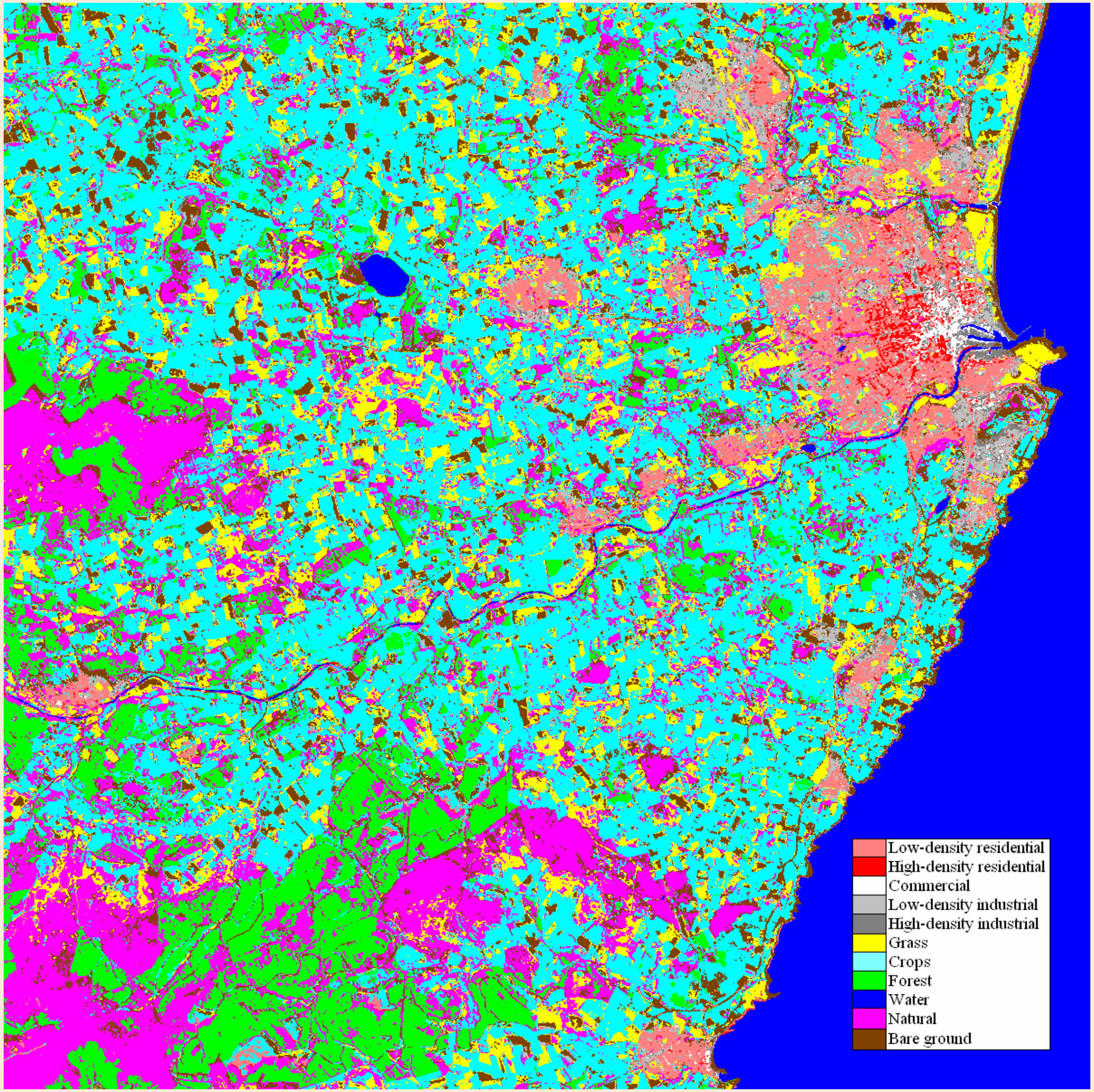
- Removal of unclassified pixels through comparison with neighbouring pixels
- Only 0.6% unclassified
- Uncertainty remaining with high/low density urban classes – too much high density



Final results

- Many of the problem pixels were originally unclassified
- Points to retraining of neural network as being necessary
- Longer training period, smaller training increments
- Validation still required

Final results



Prediction verification

- Twenty points sampled for each land cover type on the predicted map
- LCS88, field excursions and local knowledge used to provide verification of predictions

Land cover type	**Accuracy (%)**	**Mistaken for**
Low-density residential	75	High-density residential
High-density residential	75	Low-density residential, commercial, low-density industrial
Commercial	60	High-density residential, low-density industrial
Low-density industrial	80	Commercial, high-density industrial
High-density industrial	70	Low-density industrial
Grass	85	Low-density residential, natural
Crops	95	Grass
Forest	100	n/a
Water	100	n/a
Natural	90	Grass
Bare ground	90	Natural

Discussion

- Neural networks can provide effective land cover mapping capabilities if the following criteria are satisfied:
  - Suitable selection of classes
  - Accurate selection of training data
  - The network is not trusted too far; the ability to recognise that a pixel is unclassified is important
- Other work on using neural networks to map land cover show that multiband imagery is very useful – with greyscale imagery, textural measurements are scale-dependant and sensitive to image quality
- Require more sophisticated classification to provide meaningful results – division of ‘crops’, ‘forest’ and ‘natural’ into additional classes, if possible