Deriving Impervious Surfaces from Digital Orthoimagery

Summary

The purpose of this process is to create an impervious surface layer using automated geoprocessing methods derived from SWOOP2015 colour photography.
The Near Infra-Red (NIR) band in the 1km tiff files is exploited to assist with the image classification using Support Vector Machine classification.

Impervious surfaces are defined as any surface which water cannot infiltrate and are primarily associated with transportation (streets, highways, parking lots and sidewalks) and building rooftops (Bauer, 2004). A use case for these data is estimating water runoff which may affect flooding, water quality etc.

The Near Infra-Red (NIR) band was used to help differentiate water and vegetation from impervious surfaces as these three classifications have very different NIR values. Preliminary testing revealed that using the NIR, Blue and Red bands in the process produced an output most similar to the existing London impervious data.

Accuracy was determined by comparing the results to existing London impervious information. Automatic quality control process was introduced by using existing landcover, watercourse and waterbody layers to refine the results and increase accuracy.

What to do?

There are many ways to approach the digitization of impervious surfaces for the watershed. The table below shows the five methods that were considered and researched to conduct the digitization.

		Time	Quality	Overall Cost
1	Manual Digitizing	239 weeks	High	High
2	Outsourcing Digitizing	7.5 weeks	High	High
3	Automated Digitizing (No manual QC)	7.5 weeks	Moderate	Low
4	**Automated Digitizing (Moderate QC)**	**10 weeks**	**High**	**Low**
5	Automated Digitizing (High QC)	16 weeks	High	Moderate

1. **Manual digitization** will provide the highest quality of data, but it would take approxiamtely 4.6 years to complete, which in turn would have a high cost based on time.

2. **Outsourcing the digitization** through a consulting company has its benefits, but a prerequisite is to manually digitize a portion of the subject area, which is already done with the City of London impervious data. With a minor amount of quality control after the fact, it was calculated that the entire process would take about 8 weeks. The main drawback is the high cost, which makes outsourcing impractible.

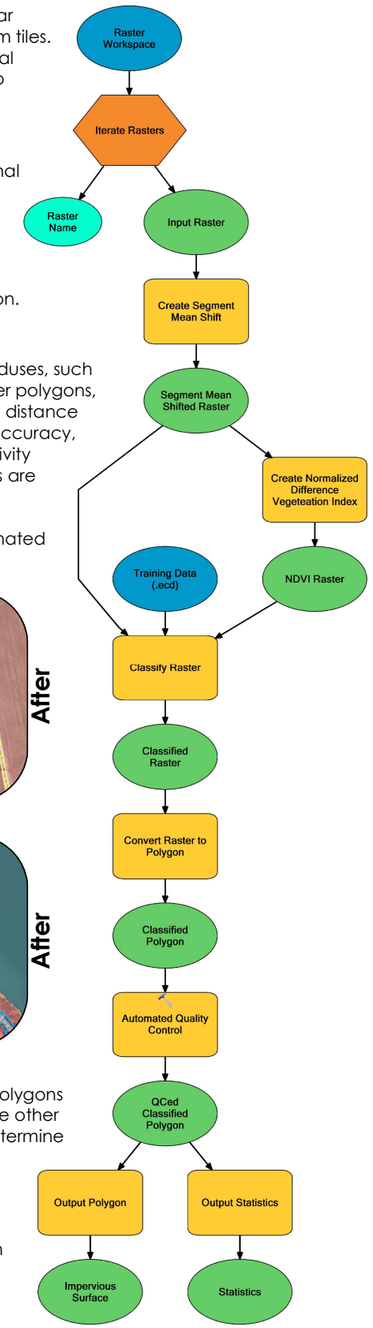
3. **Automated digitization with only automated quality control** for land use and waterbodies, and takes about 8 weeks to complete. There is no manual component to this method, so the quality varies based on the quality of the orthoimagery.

4. **Automated digitization with automated and moderate manual quality control.** There are many minor or major mistakes that have to be fixed manually to increase quality of the final results. ***This was the selected method.***

5. **Automated digitization with automated and high level of manual quality control.** High quality results, but only marginally better compared to the previous method.

Conceptual Model

The model iterates through all of the 1km tiles of a subwatershed. A segment mean shift using the Near InfraRed, Blue, and Red bands is applied to the 1km tiles. This groups adjacent pixels that have similar spectral characteristics to create a smoother image to help derive features of interest.



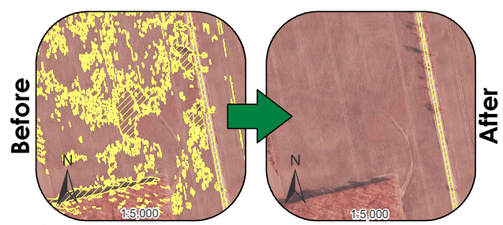
Raster Classification

There are two required components and an optional component: the training data, which was created from a diverse selection of tiles using Support Vector Machine classification, and the segment mean shifted raster. The optional component is an NDVI shift, which assists the classification process. The classified raster is then converted into a polygon.

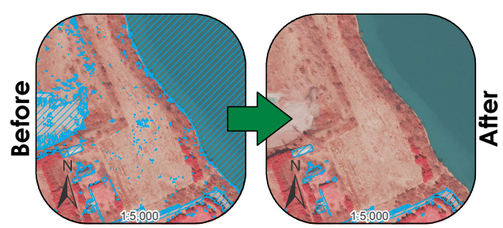
Automated quality control

Is conducted, including the removal of certain landuses, such as agricultural and woodland, the removal of water polygons, as well as any polygon completely within a ceratin distance from the water's edge. This process increases the accuracy, as bare soil or agricultural fields have similar reflectivity values as impervious surfaces, while some shadows are classified as water.

Below are examples of before and after the automated quality control process.



The removal of agricultural land.



The removal of waterbodies.

After the automated quality control process, the polygons are merged together with the other 1km tiles for the other subwatersheds. A statistics table is produced to determine the accuracy of the automated process.

Time

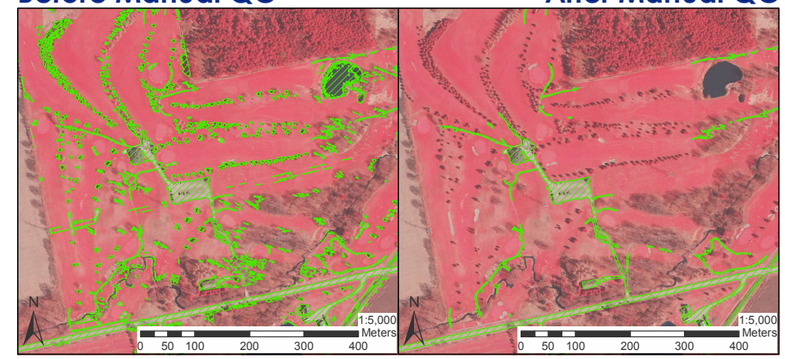
The model takes approximately 17 minutes to complete a tile. The majority of the time is spent on the segment mean shift process.

References

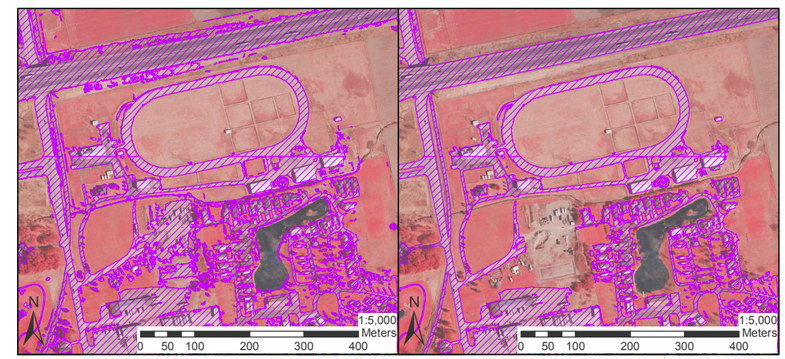
Bauer, M.E., Heinert N.J et al., 2004. Impervious surface mapping and change monitoring using Landsat remote sensing. APSRS Annual Conference Proceedings.
Online: https://land.rs.umn.edu/sites/land.rs.umn.edu/files/aspprs_2004i_bauer_impervious_mapping.pdf

Results of Manual Quality Control

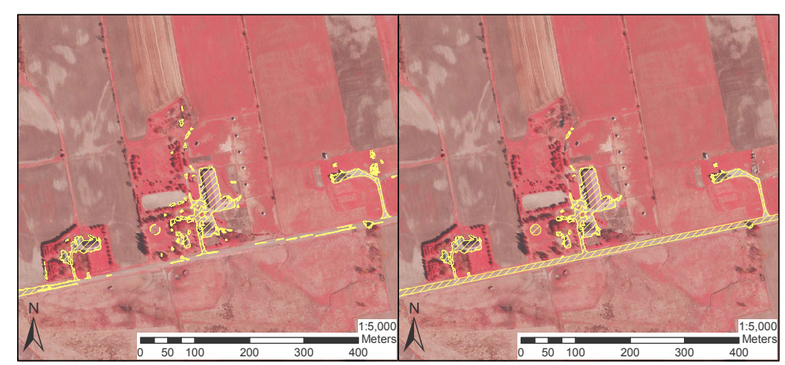
Before Manual QC | **After Manual QC**



Golf Course - The manual quality control helps with the removal of trees and waterbodies not removed with automatic quality control.



Trailer Park - The manual quality control helps with the removal of false positive impervious surfaces.



Rural Road/Residential - The gravel road which was not captured by the automatic digitizing process was digitized using manual quality control.

UPPER THAMES RIVER
CONSERVATION AUTHORITY
Adam Mikolajczak & Phil Simm, 2017