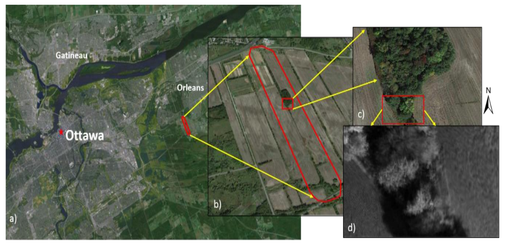
Airborne Multispectral Sensor Data and Object-based Image Analysis for Improved Forest Classification

Steven E. Franklin, Oumer Ahmed, Griffin Williams, Rachel Wasson, and Michael Stefanuk
School of the Environment, Trent University, Ontario, Canada

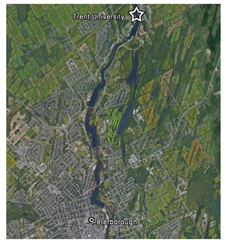
Summary

The acquisition and use of multispectral UAV imagery in mapping and forest management applications is increasingly considered a viable approach in Canada. Object-based image analysis (OBIA) and machine learning are an ideal application for this type of data and have now been extensively tested in two study sites. Land cover and forest tree species were classified based on a combined field- and visually-based training sample and validation procedure. Overall classification accuracies were greater than 76% for the major land cover classes and forest tree species.

Study Areas



a) Orleans, eastern Ontario



b) Peterborough, central Ontario

c) UAV platform (eBee)

Study sites: a) located near Orleans in eastern Ontario, Canada. Mature and immature species of interest include: Sugar maple (Acer *saccharum*), Aspen (Populus *tremuloides*), Birch (*Betula*), and Red maple (Acer *ruburm*). Study area b) located at Trent University, Peterborough, in central Ontario, Canada. Tree species of interest include Eastern White Cedar (Thuja *occidentalis*), Eastern White Pine (Pinus *strobus*), Hemlock (Tsuga *canadensis*),Juniper (Juniperus *communis*), Red maple (Acer *ruburm*), Basswood (Tilia Americana), and Aspen (Populus *tremuloids*).

Remote Sensing Image Data and Features

Multispectral Sequoia image Peterborough

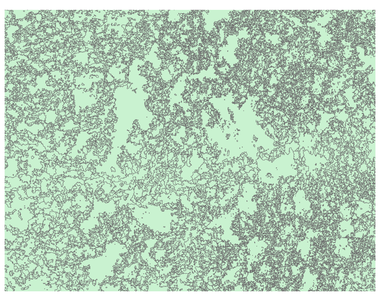
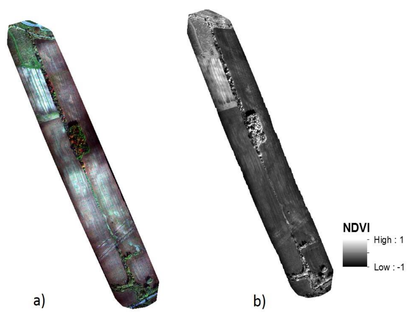
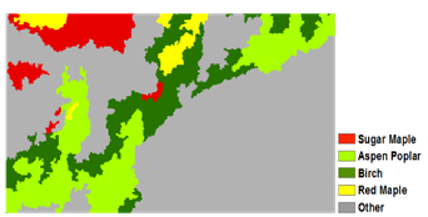


Image segments Peterborough RGB



NDVI at Orleans site

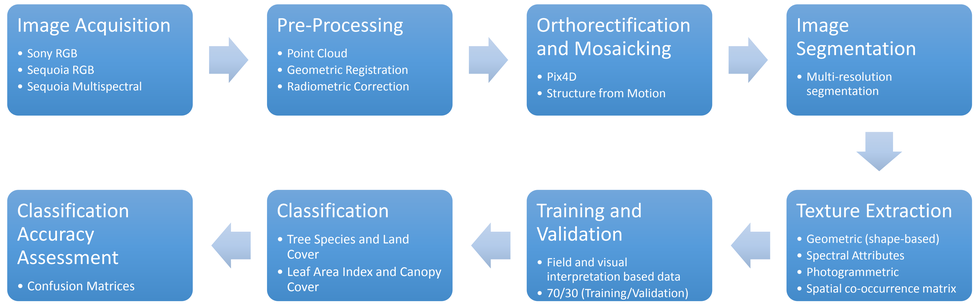
Close-up coniferous canopy at Trent University Peterborough



Species classification objects Orleans

Collection of reference reflectance spectra Trent University Peterborough site

Methods



Classification Accuracy

Table 1. Orleans study area. RF classification of four land cover classes based on 67 field-based training samples and validated with 29 independent field samples.

	Reference					
	Forest	herbaceous	Shrub	Other	Total	Commission error (%)
Forest	8	0	0	0	8	0.0%
herbaceous	0	6	1	1	8	25.0%
Shrub	1	0	4	1	6	33.3%
Other	0	1	1	5	7	28.6%
Total	9	7	6	7	29	
Omission error (%)	11.1%	14.3%	33.3%	28.6%	Overall accuracy = 79.3% Kappa = 0.79	

Table 2. Trent University study area. RF classification confusion matrix for land cover using Multispectral Sequoia sensor at 400ft with ground sampling distance of 12.9cm

	REFERENCE											
	Maple	Ash	Aspen	Basswood	Tall Shrub	Short Shrub	Crop	Alfalfa	Gravel	Asphalt	Sum	User's Accuracy (%)	Commission error (%)
Maple	9	0	1	1	0	0	0	0	0	0	11	0.81	0.18
Ash	0	6	0	0	0	0	0	0	0	0	4	1	0
Aspen	1	1	7	0	0	0	0	0	0	0	5	0.6	0.4
Basswood	1	1	2	15	0	0	0	0	0	0	18	0.83	0.167
Tall Shrub	0	0	0	0	9	0	0	0	0	0	9	1	0
Short Shrub	0	0	0	0	2	5	2	1	0	0	10	0.5	0.5
Crop	0	0	0	0	1	2	10	2	0	0	15	0.66	0.333
Alfalfa	0	0	0	0	0	1	3	17	0	0	21	0.80	0.19
Gravel	0	0	0	0	0	0	0	0	12	0	12	1	0
Asphalt	0	0	0	0	0	0	0	0	0	8	8	1	0
Sum	11	8	10	16	12	8	15	20	12	8	113		
Producer's accuracy (%)	0.81	0.75	0.7	0.93	0.75	0.62	0.66	0.85	1	1	Overall accuracy		0.82
Omission error (%)	0.18	0.25	0.3	0.06	0.25	0.37	0.33	0.15	0	0	Margin of error		± 1.94

Table 3. Random Forest classification confusion matrix for Coniferous tree species using Multispectral Sequoia sensor at 400 ft with GSD 12.9cm, using 120 field samples.

		REFERENCE									
	Class name	Cedar	Pine	Spruce	Juniper	Other Species	Trail	Open Field	Sum	User's Accuracy (%)	Commission Error (%)
PREDICTED	Cedar	17	2	0	1	0	0	1	21	80.95%	19.05%
	Pine	4	17	1	0	0	0	0	22	77.27%	22.73%
	Spruce	0	0	15	0	1	0	0	16	93.75%	6.25%
	Juniper	0	1	0	15	0	0	0	16	93.75%	6.25%
	Other	0	0	0	0	15	0	0	15	100.00%	0.00%
	Trail	0	0	0	1	0	14	1	16	87.50%	12.50%
	Open Field	0	0	0	0	0	1	13	14	92.86%	7.14%
	Sum	21	20	16	17	16	15	15	120		
	Producer's accuracy (%)	80.95 %	85.00 %	93.75%	88.24%	93.75%	93.33%	86.67%	Overall accuracy		88.33%
	Omission error (%)	19.05 %	15.00 %	6.25%	11.76%	6.25%	6.67%	13.33%	Margin of Error ±		0.057

Table 4. Random Forest classification confusion matrix for Coniferous tree species using Sony DSC-WX220 RGB camera at 400 ft with GSD 3.52cm, using 120 field samples

		REFERENCE									
	Class name	Cedar	Pine	Spruce	Juniper	Other Species	Trail	Open Field	Sum	User's Accuracy (%)	Commission Error (%)
PREDICTED	Cedar	14	4	0	1	0	0	1	20	70.00%	30.00%
	Pine	4	12	4	0	2	0	0	22	54.55%	45.45%
	Spruce	0	4	9	0	0	0	0	13	69.23%	30.77%
	Juniper	0	0	0	15	0	0	0	15	100.00%	0.00%
	Other	2	0	3	0	14	0	0	19	73.68%	26.32%
	Trail	0	0	0	0	0	15	1	16	93.75%	6.25%
	Open Field	1	0	0	1	0	0	13	15	86.67%	13.33%
	Sum	21	20	16	17	16	15	15	120		
	Producer's accuracy (%)	66.67 %	60.00 %	56.25%	88.24%	87.50%	100.00%	86.67%	Overall accuracy		76.67%
	Omission error (%)	33.33 %	40.00 %	43.75%	11.76%	12.50%	0.00%	13.33%	Margin of Error ±		0.075

Conclusion

Spectral, textural and point cloud (height) UAV-based data are used to improve forest and land cover classification accuracy. Multispectral UAV imagery classified land cover types and major trees species in an object based image analysis approach with >76% overall accuracy. These results confirm that UAV-based RGB and multispectral image sensors are an effective data source to classify land cover types and tree species.

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