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A SMALL-PATCHED CONVOLUTIONAL NEURAL NETWORK FOR MANGROVE MAPPING AT SPECIES LEVEL USING HIGH RESOLUTION REMOTE SENSING IMAGE

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ABSTRACT

The understanding of mangrove forest structure and dynamics at species level is essential for mangrove conservation and management. To classify mangrove species, spatial structure is usually viewed as an effective complementary information to improve classification accuracy using remote sensing images with high spatial resolution. Recently, the Convolutional Neural Networks (CNNs) show great advantages in abstract feature exploitation. To apply the CNNs to mapping at species level, a small patch based CNNs tailored for fringe mangrove forests is proposed to overcome the difficulties in the applicability of mangrove species mapping using conventional CNNs with fixed and large input. Compared to the features of grey level co-occurrence matrix with support vector machine, our proposed CNN shows better performance in classification accuracy.

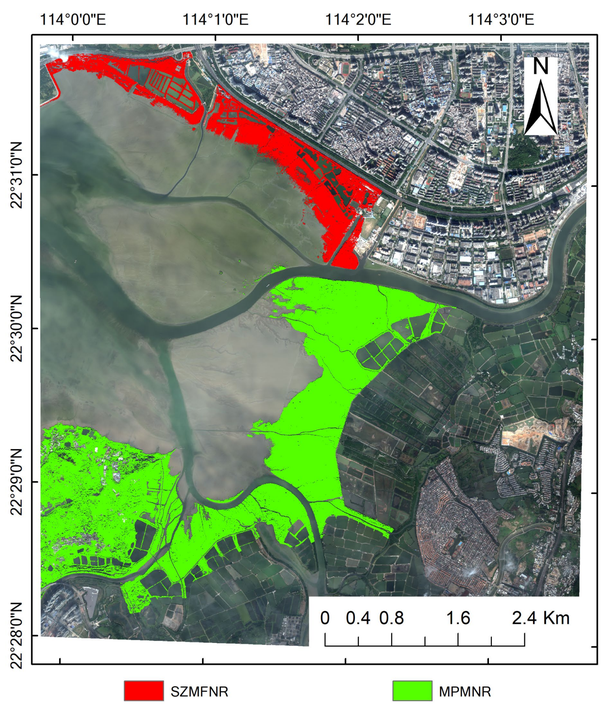
INTRODUCTION

Mangrove forests are the most productive ecosystems in the world with providing essential and unique ecological goods and services to human beings and adjacent systems including coastline and flood protection, shrimp farming and habitat provision for various terrestrial, estuarine and marine species. Mangrove forests monitoring at species level can help understand their structure and dynamics, and then offer guidance for the management, such as conservation, assessment of mangrove reconstruction, and invasive species monitoring etc.

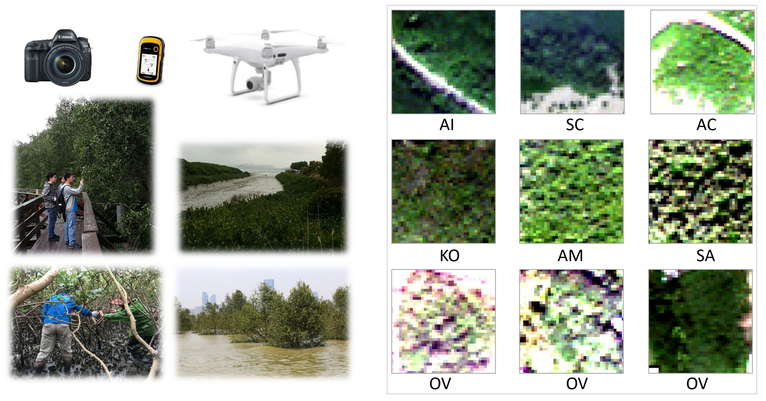
Remote sensing images with high resolution offer a cost-efficient way with more detailed spatial information for mangrove monitoring over a large scale. The spectral similarity of mangrove and associate species, unclear zonation boundaries, and vast variance of inter-class make it challenging only with the designed texture features. Compared to conventional texture metrics, CNNs show great advantages in abstract features extraction which are robust and effective for mapping.

OBJECTIVE

1. To apply CNNs to mangrove mapping at species level, a novel CNNs is designed to solve the need of smaller input patch in conventional CNNs for mangrove species classification;
2. To investigate the ability of CNNs in feature representation of mangrove.



A WorldView 2 image (true color) of Study site - DeepBay with two famous mangrove reservation zones, Shenzhen Mangrove Forest Nature Reserve (SZMFNR) and Mai Po Marshes Nature Reserve (MPMNR) .



Field survey and dominant samples, AI= Acanthus ilicifolius, SC= Sonneratia caseolaris, AC= Aegiceras corniculatum, KO= Kandelia obovate, AM= Avicennia marina, SA= Sonneratia apetala, OV*=other vegetation (non-mangrove)

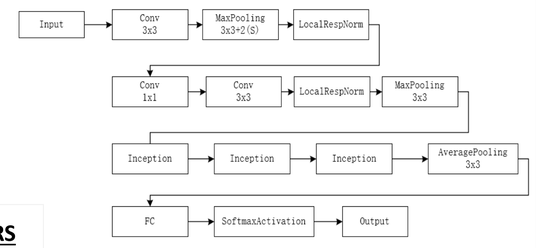
METHODS

1. POOLING LAYERS

1. All are set to 3 x 3 with a stride of 1

2. CONVOLUTION LAYERS

1. All kernel size are set to 3 x 3
2. Inception with dilated / atrous Convolution



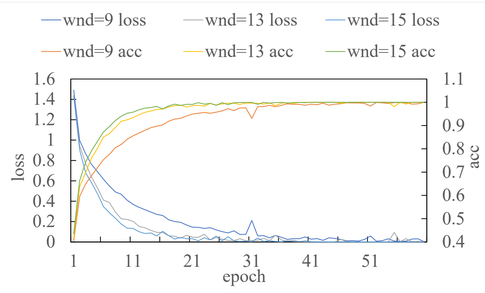
Architecture of small patched CNNs

3. REDUCE OVERFITTING

1. Data augmentation
2. Dropout
3. Light weight

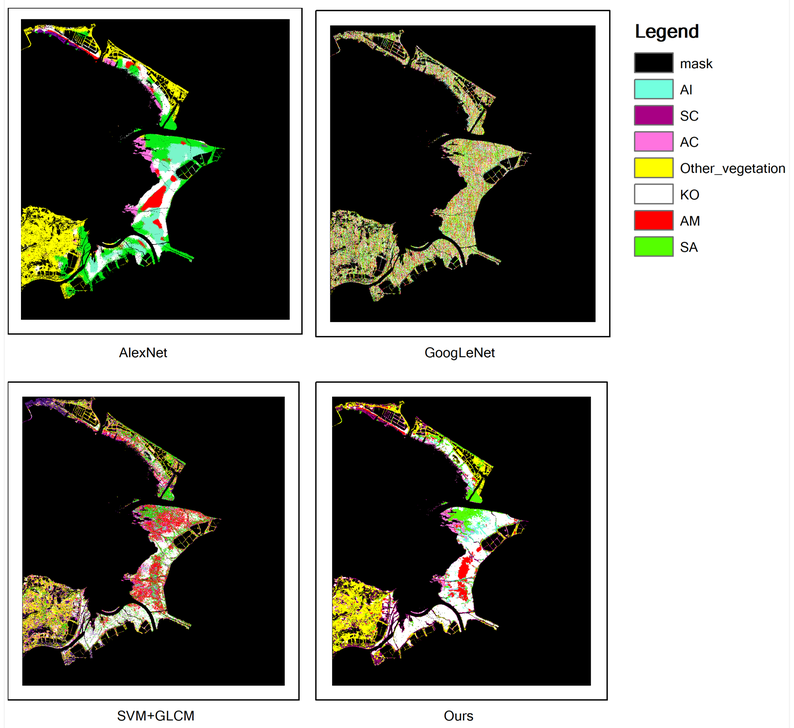
RESULTS

1. Select patch size



Patch size selection

2. Comparison

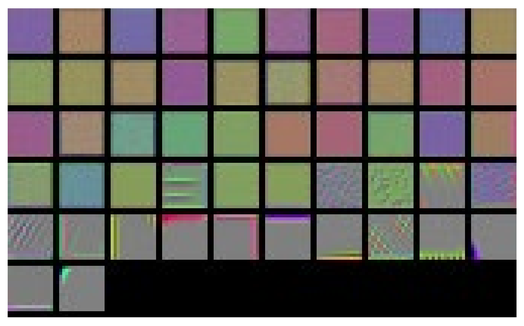


Mangrove species classification using different methods

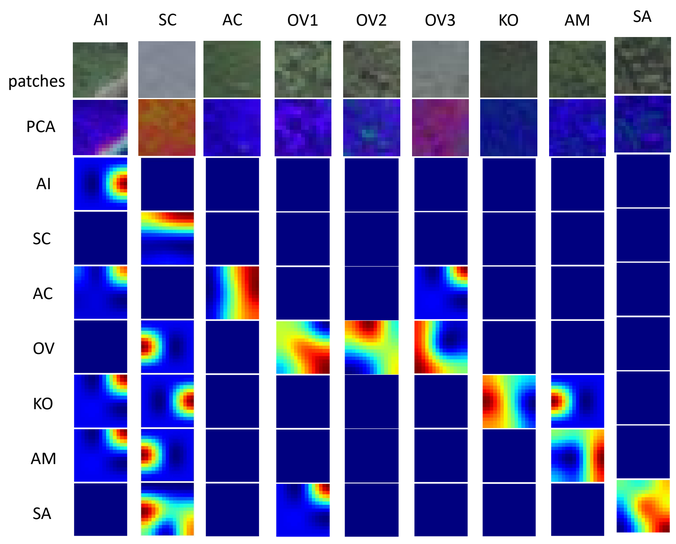
Classification accuracy for different methods

	AlexNet	GoogLeNet	SVM+GLCM	Ours
Overall accuracy	99.52%	17.17%	65.34%	98.81%
Kappa Coefficient	0.9944	0.0295	0.5952	0.986064

3. Visualization



Visualization of first conv layer (only 64 filters were listed) in the small patched CNNs



Attention maps of the filters in the final layer for different mangrove species

DISCUSSION

1. High classification accuracy for CNNs does not mean better result. The effect of dilation is very clear for AlexNet, since severe overlap happens between adjacent patches. The effect of 'dilation' can also be found in texture extraction when the moving window was set to be larger.
2. For GoogLeNet, the effect of noise rather than dilation is due to valid information loss.

CONCLUSIONS

1. the small patched CNNs can give an acceptable classification than the result with handcrafted features;
2. Because of the characteristic of small patch for input, the stripe region can be well detected;
3. The multi-scale feature extractor helps with the fragmentation reduce.
4. our model can capture many distinguished low-level features including colours, dot patterns and directionalities, and high-level statistical features.

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