A ROUGH SET DECISION TREE BASED MLP-CNN FOR VERY HIGH RESOLUTION REMOTELY SENSED IMAGE CLASSIFICATION

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ABSTRACT:

Recent advances in remote sensing have witnessed a great amount of very high resolution (VHR) images acquired at sub-metre spatial resolution. These VHR remotely sensed data has post enormous challenges in processing, analysing and classifying them effectively due to the high spatial complexity and heterogeneity. Although many computer-aid classification methods that based on machine learning approaches have been developed over the past decades, most of them are developed toward pixel level spectral differentiation, e.g. Multi-Layer Perceptron (MLP), which are unable to exploit abundant spatial details within VHR images.
This paper introduced a rough set model as a general framework to objectively characterize the uncertainty in CNN classification results, and further partition them into correctness and incorrectness on the map. The correct classification regions of CNN were trusted and maintained, whereas the misclassification areas were reclassified using a decision tree with both CNN and MLP. The effectiveness of the proposed rough set decision tree based MLP-CNN was tested using an urban area at Bournemouth, United Kingdom. The MLP-CNN, well capturing the complementarity between CNN and MLP through the rough set based decision tree, achieved the best classification performance both visually and numerically. Therefore, this research paves the way to achieve fully automatic and effective VHR image classification.

1. INTRODUCTION

Over the last decade, ground-based, airborne and satellite sensors and platforms have evolved dramatically, of which a major achievement is the acquisition of very high resolution (VHR) remotely sensed imagery. These VHR images provide sub-metre ground resolution at an increasing level of spatial details, facilitating a wide range of geospatial applications such as urban land use retrieval, precision agriculture, and tree delineation etc. However, the increase of spatial resolution does not signify the increase of accuracy for processing, classifying and labelling such kinds of data, mainly because of spectral variations within class and similarity between class occurred within VHR imagery. Therefore, it is of necessity and urgent to develop robust and accurate image classification methods that are able to address the challenges from VHR imagery.
Researchers and practitioners have developed numerous computer based classification methods, ranging from unsupervised K-mean clustering, supervised parametric methods such as Maximum Likelihood, and non-parametric machine learning algorithms e.g. Multi-layer Perceptron (MLP), Support Vector Machine and Random Forest etc. MLP, as a classical non-parametric machine learning approach, has been widely used in remote sensing domain including VFSR-based land cover classification (e.g. Del Frate et al., (2007), Pacifici et al. (2009)). It was invented to mimic the human brain through layer-wised information processing (Atkinson 1997) with nonlinearity to handle the spectral features irrespective to its statistical characteristics. However, the MLP model was difficult to go deep with typically shallow model structure due to its full connection properties that involve a large amount of parameters, and its intractable "black-box" machine learning characteristics. The MLP is essentially a pixel-based classifier with shallow architectures that predicts the membership association of each pixel to a particular land cover type.
Recent advances in machine learning and computer vision inspired that the deep feature representations can be learnt hierarchically at multiple levels through deep machine learning methods (LeCun et al. 2015). These deep learning methods represent the state-of-the-art in a variety of domains, including object detection, information retrieval, image recognition and robotics etc. The convolutional neural network (CNN), as a well-established deep learning approach, has widely recognized as one of the best deep neural networks in pattern recognition and computer vision. Its popularity is largely related to the success in the ImageNet Large Scale Visual Recognition Challenge at 2012 where 11% less error rate was achieved by CNN in comparison with several contestants. Since then, the CNN remained active in multiple domains, and introduced to the remote sensing domain. The considerable majority of researches in remote sensing were focused on object detection and scene classification. Recent researches also show the possibility of CNNs for the remote sensing image classification task. For example, Chen et al. (2016) introduced a 3D CNN to jointly extract spectral–spatial features, thus, making full use of the continuous hyperspectral and spatial spaces. Zhao and Du,

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