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Editorial

Deep learning for remotely sensed data

Remotely sensed data have exploded in the past two decades. The new availability of a number of medium resolution sensors is complemented by commercial high-resolution satellites that provide unprecedented monitoring opportunities. Geospatial imagery is only expected to increase with the proliferation of unmanned aerial vehicles.

Converting these vast, diverse datasets into usable information is a significant theoretical and computational challenge. In the past decade, computational and theoretical advances, coupled with big dataset availability, have brought to the foreground a promising family of new algorithms, collectively known as deep neural networks (DNNs). DNNs model high-level abstractions in complex data by adopting a deep and hierarchical graph with multiple layers of non-linear information processing. Due to this big data availability, together with efficient parallel processing hardware architectures and effective large-scale parameter optimization techniques, DNNs have shown promising potential in a variety of machine learning tasks, such as pattern recognition and data mining.

Recognizing the natural match of DNNs and remote sensing data characteristics, this special issue concentrates on reporting the latest advances and trends in the field of deep learning for remote sensing data analysis. A promising implementation area for DNNs is the manipulation of hyperspectral images, due to the large dimensionality of these data. Three such examples are included in this special issue. Pan et al. (2018) proposed a small-scale data based method, i.e., multi-grained network (MugNet), that investigated the application of deep learning in hyperspectral image classification problems. Paoletti et al. (2018) presented a new CNN architecture for hyperspectral image classification that combined spectral and spatial information. Lastly, Xu et al. (2018) developed a new Random Patches Network for hyperspectral image classification that combined both shallow and deep convolutional features, resulting in a multi-scale approach.

Another popular topic of DNN understanding in remote sensing problems relates to scene classification, as opposed to individual pixel labeling. The special issue includes four promising methods starting with Liu et al. (2018) that introduced a CNN-based end-to-end self-cascaded network (ScasNet) for image scene classification using sequential global-to-local context aggregation. In another work, Han et al. (2018) tackled the problem of image scene classification and proposed a semi-supervised generative framework that combined deep learning features, a self-labeling technique, and a discriminative evaluation method. Deng et al. (2018) adapted faster region-based convolutional neural networks for multi-class object detection addressing scaling issues and annotation limitations. Lastly, Zhou et al. (2018) introduced a new large-scale remote sensing dataset called "PatternNet" and evaluated the performance of 35 popular algorithms for scene recognition, a particularly helpful activity to guide further advancements.

In addition, a traditional pixel-based classification task was investigated by Marcos et al. (2018), who proposed a new method to encode rotation equivariance inside a CNN's architecture for image classification. The special issue also showcases a broader breadth of DNN implementations, for example related to registration, compression and pan-sharpening. Wang et al. (2018) applied deep learning to address image registration issues using transfer learning to reduce computational speed and increase registration accuracy. Zhang et al. (2018) developed an end-to-end one-two-one network that integrated different deep models to reduce complicated image compression artifacts. Finally, Xing et al. (2018) proposed a deep metric learning method capturing the hierarchical features of patches via multiple nonlinear deep neural networks to improve image pan-sharpening task.

The special issue also covers aspects related to non-traditional remote sensing geometry through Kang's et al. (2018) work, who investigated the application of CNNs for individual building extraction from side-looking images extracted from Google StreetView. Finally, bearing in mind the upcoming proliferation of unmanned aerial platforms, an example implementation was also included in the special issue. Specifically, Kemker et al. (2018) used synthetic multispectral imagery to initialize a CNN and evaluated the method with very-high resolution data collected by an unmanned aircraft system.

There is clear evidence that deep learning can further advance image manipulation and understanding. This special issue presents a broad range of examples to guide future advancements in this field. While these advancements are clear from an algorithmic standpoint, there is a certain lack of coordination in the remote sensing community regarding the development of unified benchmarking datasets designed to harness DNN's potential. We would encourage a collective effort to create those necessary training datasets, especially in the area of pixel-based classification.

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