Developing Deep Learning Techniques towards fusing optical and SAR images for remote sensing applications

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Description:

Deep learning is a subset of machine learning approach that is capable of learning from data. Deep learning has received a lot of attention in recent times due to its ability to achieve high levels of performance in terms of accuracy and speed, where deep learning algorithms can simply outperform humans and other machine learning techniques at decision making, and tasks such as classifying images, and real-time detection.

The fusion of data available from different remote sensing missions can aid towards accurately determining land use and quantifying subtle changes in land use management activities. In general, fusion refers to a formal concept for combining data from different sources, with the aim of generating information of "better quality" than the individual input datasets. The methods of image fusion can be grouped into three categories depending on the level at which the integration is performed:

- pixel-level fusion (data fusion);
- feature-level fusion; and
- fusion in decision making.

Remote sensing application such as Land Cover Land Use (LCLU) mapping and monitoring can get huge benefits from fusion of optical and synthetic aperture radar (SAR). While the complementarity of data from both optical and radar sensors for the characterization of LCLU has been put to use in many of the recent studies, the development of adequate data fusion techniques is still an important ongoing field of research with deep learning.

To overcome the limitation of individual datasets and improve the identification of land use dynamics specifically, fusing datasets acquired from remote sensors that operate on different fundamental physical principles helps towards providing synergistic information on land surface and its properties. Particularly with the prospects of multi-sensor datasets, fusion brings the benefits of higher spectral resolution, compensating for the limitations of using single dataset alone.

Optical products are commonly available as multispectral images (ranging from visible to infrared wavelengths) or hyperspectral images (consisting of continuous bands from visible to infrared wavelengths) consisting of several bands of data, which can offer different information on land properties based on its spectral reflectance. In contrast, radar signals are typically only generated at a single wavelength for each sensor, and interact in a characteristic way with structural land properties.

Data fusion of Optical and SAR images can be complex, noisy and imbalanced. Therefore, there is a significant challenge to create deep learning models that can classify these multi-sensor datasets using different fusion methods defined above. Machine learning models designed to classify imbalanced data are biased toward learning the more commonly occurring classes.

Such bias occurs naturally as the models tend to learn classes better which contain more records, a similar process that would occur with human learning behavior.

Hence, the main objectives of this research are:

1. **devise feature engineering approaches for fusing Optical and SAR data**
2. **develop computational approaches and methods for fusing imbalanced multi-sensor data.**
3. **identify whether fusing these multi-sensor data improves results as opposed to using single dataset in specific machine learning tasks**