Background

In recent years, Recurrent Neural Networks (RNN) have become a popular focus of research topics in the areas of deep neural networks for both supervised and unsupervised machine intelligence tasks. RNNs use input sequences to solve both prediction and classification problems. Long Short-Term Memory (LSTM) neural networks are a special kind of RNN state-of-the-art architecture designed for a wide range of sequence modeling tasks and time series prediction models. Generative adversarial networks (GANs), on the other hand, are deep generative models that can generate realistic data samples following a given statistical distribution. Unsupervised and semi-supervised learning techniques using GANs have shown promising advancements in the areas of computer vision for image and video analysis, and text analysis in the area of natural language processing.

These thesis works are part of the H2020 project "**ExtremeEarth: From Copernicus Big Data to Extreme Earth Analytics**". To read more about the ExtremeEarth project, check out this link: http://earthanalytics.eu/.

Problem Statement

As the duration of the long sequence dependencies over the course of backpropagation increases, the derivatives of the gradient over many time steps may eventually vanish during the training of RNN networks. LSTM architectures are one of the most popular implementations introduced to address such critical challenges. We use LSTM when we train our model using long time-series data that contains both time and spatial dimensions. LSTM models are mainly used for analyzing and forecasting time-series inputs. However, we can also use it as an input for classification tasks. GANs, on the other hand, are used to learn and dynamically generate new data with the same statistical distributions and characteristics as the given training set. Hence, the main objective of these two thesis works is to develop a scalable model using LSTM and GAN-based approaches for geospatial data produced by satellites for the two use cases explained below.

Thesis Topics

- **Sea Ice Classification of SAR Images Using Recurrent Neural Networks**.
- **Semi-supervised Approach for the Classification of Multispectral Images of Crop Types Using GANs**.

These two thesis works are towards the polar and food security use cases in the context of the ExtremeEarth project. These two use cases are different based on the following main specifics.

- They use different types of input data. For example, in the Polar use case, we use Synthetic Aperture Radar (SAR) images acquired by satellites. However, in the case of food security use cases, we use mostly optical images.
- In the food security use case, we need to classify crop types and more precise maps of the crops. The input data for the crop type classification are quite dynamic even when the satellite moves on the same area for hours, it might capture different kinds of things. Such data are characterized by high spatial resolution and multisource nature. In the case of the Polar use case, we need to automatically classify sea ice types and the sources of data from the SAR satellites might also be dynamic but not so much as compared to the food security use case.

Tasks and Expected Results

- **Sea Ice Classification of SAR Images Using Recurrent Neural Networks**
  - Exploring state-of-the-art deep learning methods for the sea ice classification of SAR image classifications.
  - Improving the sea ice classification performance of the long-time series of multispectral images using an LSTM model.

- Designing and implementing a scalable LSTM-based classification model for automatic sea ice mapping tailored to Copernicus data for the Polar use case.
- Perform comparison of the proposed LSTM-based model with other state-of-the-art different algorithms for sea ice classification.

- **Semi-supervised Approach for the Classification of Multispectral Images of Crop Types Using GANs**
  - Exploring existing state-of-the-art crop type classification techniques for high-resolution multitemporal optical remote sensing data using GANs.
  - Designing and implementing a scalable GAN-based advanced crop type classification method tailored to the specific properties of the Copernicus data for the accurate crop type mapping of most widely planted crops.
  - Performing accuracy comparison with recent state-of-the-art crop type classification methods in the context of the food security use case using large-scale Earth Observation (EO) datasets.
  - Validating the scalability of the proposed GAN-based approach through experiments using different accuracy metrics.

Requirements

These thesis works will require a deeper knowledge of Python programming, machine learning, deep learning models, TensorFlow or PyTorch libraries, and a basic understanding of statistics.

Contact Details

If you are interested in working on one of these suggested thesis topics, feel free to send an email to the following contact details.

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