CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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S0802

Project Title

Constructing Vegetation-Health-Map Image Forecasts Using a Novel Variable Length Attention ConvLSTM Network

Abstract

Objectives

Vegetation health forecasting is an important field of research that involves predicting annual crop growth patterns in order to provide information to humanitarian aid agencies, government crop monitors, and famine warning systems. We propose and develop a novel algorithm to construct accurate 32-day-ahead image forecasts of vegetation health, as measured by NDVI (Normalized Difference Vegetation Index), over a 100 km by 100 km crop region in Ethiopia.

Methods

The vegetation health data was obtained from NASAs MODIS satellites. To improve our models ability to learn the annual patterns of crop growth, we developed a modification to the standard method of spatiotemporal forecasting, the ConvLSTM. Our proposed model, the Annual Gate ConvLSTM, introduces attention-network-weighted data from previous years into the memory cell of each recurrent unit. Furthermore, our variable length attention network improves upon the standard attention network by ensuring a constant standard deviation of weights for sequences of different lengths. This is achieved by multiplying all unnormalized terms by a value k, determined by a regula falsi approximation, before feeding the terms into the softmax normalization function. We measure the accuracy of the standard ConvLSTM and the Annual Gate ConvLSTM using Root Mean Square Error (RMSE, 0 is perfect, 1.3 is worst) on a common testing dataset of 70 sequences of 10,000 sq km NDVI data.

Results

Our Annual Gate ConvLSTM achieves RMSEs of 0.0852, 0.0834, 0.0882, and 0.0911 for the 8, 16, 24, and 32 day ahead predictions of NDVI values over the 10,000 square km region. The standard ConvLSTM achieves higher, less accurate RMSEs of 0.1005, 0.1135, 0.1218, and 0.1412 for the four respective timesteps. Furthermore, our network outperforms baseline models and existing methods of NDVI forecasting.

Conclusions

The superior performance achieved by the Annual Gate ConvLSTM in comparison to the standard ConvLSTM suggests that the usage of a variable length attention network in a Recurrent Neural Network helps to discover and utilize periodic trends in sequential datasets. Furthermore, the best existing algorithm for large scale NDVI forecasts only provides 8 day, 10 km by 10 km forecasts of 1 square km resolution at an RMSE of 0.09 - performing fewer steps ahead, smaller scale, and less accurate forecasts.

Summary Statement

We develop a novel, period-aware modification to the ConvLSTM to construct accurate, long-term, large-scale image forecasts of vegetation health captured by NASAs MODIS satellites over a 10,000 square km region in Ethiopia.

Help Received

We designed, developed, and tested our algorithm entirely on our own. However, we obtained our data from the repository of NASAs MODIS satellite imagery. Furthermore, we would like to thank Dr. Wassila Thiaw & Dr. Pablo Bocca for their advice pertaining to the importance of NDVI forecasting.