Convolutional LSTM Network: A Machine Learning Approach for Precipitation Nowcasting

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Abstract

The goal of precipitation nowcasting is to predict the future rainfall intensity in a local region over a relatively short period of time. Very few previous studies have examined this crucial and challenging weather forecasting problem from the machine learning perspective. In this paper, we formulate precipitation nowcasting as a spatiotemporal sequence forecasting problem in which both the input and the prediction target are spatiotemporal sequences. By extending the *fully connected LSTM* (FC-LSTM) to have convolutional structures in both the input-to-state and state-to-state transitions, we propose the *convolutional LSTM* (ConvLSTM) and use it to build an end-to-end trainable model for the precipitation nowcasting problem. Experiments show that our ConvLSTM network captures spatiotemporal correlations better and consistently outperforms FC-LSTM and the state-of-the-art operational ROVER algorithm for precipitation nowcasting.

1   Introduction

Nowcasting convective precipitation has long been an important problem in the field of weather forecasting. The goal of this task is to give precise and timely prediction of rainfall intensity in a local region over a relatively short period of time (e.g., 0-6 hours). It is essential for taking such timely actions as generating society-level emergency rainfall alerts, producing weather guidance for airports, and seamless integration with a longer-term numerical weather prediction (NWP) model. Since the forecasting resolution and time accuracy required are much higher than other traditional forecasting tasks like weekly average temperature prediction, the precipitation nowcasting problem is quite challenging and has emerged as a hot research topic in the meteorology community [22].

Existing methods for precipitation nowcasting can roughly be categorized into two classes [22], namely, NWP based methods and radar echo[1] extrapolation based methods. For the NWP approach, making predictions at the nowcasting timescale requires a complex and meticulous simulation of the physical equations in the atmosphere model. Thus the current state-of-the-art operational precipitation nowcasting systems [19, 6] often adopt the faster and more accurate extrapolation based methods. Specifically, some computer vision techniques, especially optical flow based methods, have proven useful for making accurate extrapolation of radar maps [10, 6, 20]. One recent progress along this path is the *Real-time Optical flow by Variational methods for Echoes of Radar* (ROVER)

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[1]In real-life systems, radar echo maps are often constant altitude plan position indicator (CAPPI) images [9].