NowLagrangian: Short-term precipitation forecasting using Lagrangian Convolutional Neural Networks

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The high-resolution very-short-range forecasting (0–6 h ahead) of precipitation (nowcasting) is an essential component of severe weather and hydrological early warning systems. Timeliness and accuracy of such forecasts are essential for weather-dependent decision-making to guarantee infrastructure safety and socio-economic operations. State-of-the-art operational nowcasting methods typically advect precipitation fields with radar-derived displacement estimates, but they struggle to capture the initiation of new convective cells and the growth and decay of precipitation cells, especially in regions with complex orography.

In collaboration with MeteoSwiss, we established in the past year a framework to facilitate the design and training of autoregressive convolutional neural network (CNN) models for short-term precipitation forecasting over the Swiss territory. Based on the past observed evolution of precipitation, the CNN models learn in one-single-shot the future i) displacement and ii) the growth and decay of the precipitating cloud systems. In this project, the aim is to decouple the learning of the model in two separate components: an advection module and a “growth & decay” module.

To this end, the student is first expected to evaluate optical-flow estimation from various deep learning models (Sun et al., 2018, Teed et al., 2020, Hui et al., 2021). Subsequently, the optical flow fields will be used to advect the images (with the past observed evolution of precipitation) to the model prediction timestep. This will enable the “growth & decay” module to focus learning the precipitation increments in a Lagrangian frame, which means that the pixel-wise information across the time dimension in the Lagrangian tensor will provide the historical evolution of the precipitating cell along its trajectory over the Swiss complex terrain.

The accuracy of the precipitation forecasts of the newly redesigned model will be benchmarked against a comprehensive set of established nowcasting algorithms as well as the operational NowPrecip product of MeteoSwiss (Sideris et al., 2020). Simultaneously, the “growth & decay” model predicted patterns might offer the potential to shed new light onto complex precipitation processes occurring in the Alpine region.

Objectives
- Survey and benchmark of deep learning algorithms for optical flow estimation
- Development of a precipitation advection module in pytorch
- Design of a Lagrangian Convolutional Neural Network

Requirements
- Good programming skills in python
- Previous knowledge in deep learning and pytorch

References