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Forecasting River Flow in the Tejo River Basin Utilizing Deep Learning Models

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Effective water resources management depends on accurate river flow forecasts, which affect hydroelectric power generation, flood control, and agriculture, among other sectors. Achieving consistent projections is challenging, though, because the complex characteristics defining the river flow—which are influenced by factors including precipitation, reservoir management, and changes in land use—are tough. Given the increasing frequency of extreme weather events linked to climate change, our research emphasizes the importance of applying deep learning in river flow forecasting for operational decision-making and public safety. This has a significant impact on public safety.

Deep learning algorithms are particularly well-suited for river flow prediction because they attract more attention in the application of time series forecasting. These models are good at identifying complex patterns across enormous amounts of data. This work evaluates various models multilayer perceptrons (MLPs), support vector machines (SVMs), recurrent neural networks (RNNs), long short-term memory (LSTM), gated recurrent units (GRUs), and hybrid models. We evaluated each model based on its potential to improve river flow forecasting accuracy. MLP emerged as one of the best models.

Using data from Portugal's National Water Resources Information System (SNIRH), our analysis currently emphasizes the Tejo River watershed from October 1, 1984, until September 26, 2023. The used dataset comprises daily data on river discharge, water levels, and precipitation. In terms of model construction, given that we used a supervised learning approach, we prepared different training, testing, and validation datasets. We followed typical deep learning model construction steps, which include data preprocessing, training and validation, and application deployment. The data preprocessing step includes feature selection, missing data management, resampling, and time series data conversion into a supervised learning form. Additionally, we combine common periods and interpolate terms, selecting common periods with a maximum of 10 missing values to ensure data consistency. The training phase ensures that the models train on past data, and we apply grid search to refine the hyperparameters. We use the root mean squared error (RMSE) loss function and the Adam optimizer throughout the training process. The deployment or forecasting process consists of generating projections for the next three days, and, for the time being, we verify these forecasts with real data when they are obtained.

The models created with the SNIRH dataset demonstrate promising results. Through comparison with similar approaches, we can conclude that the models clearly capture temporal dependencies and generate valid river flow predictions according to the performance metrics. The findings show that deep learning methods provide important new perspectives for water resource management and decision-making since they can increase the accuracy and dependability of river flow estimates under emergency conditions.

Future activities will include assessing the performance of these models in related basins and developing a customized tool that enables hydrologists to build AI-driven models for variable construction within the SNIRH dataset.

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