FACULTY OF INFORMATION TECHNOLOGY CTU IN PRAGUE

Assignment of master's thesis

Title:	Incorporating Spatial Information in Deep Learning Models for Weather Prediction.
Student:	Bc. Dominik Chodounský
Supervisor:	Mgr. Petr Šimánek
Study program:	Informatics
Branch / specialization:	Knowledge Engineering
Department:	Department of Applied Mathematics
Validity:	until the end of summer semester 2024/2025

Instructions

Background:
Weather prediction is a critical aspect of numerous applications, from agriculture and disaster management to energy production and transportation. Accurate weather forecasting can help mitigate risks and optimize operations in these sectors. With the advent of machine learning and deep learning techniques, there has been significant progress in weather prediction accuracy. However, the incorporation of spatial information into these models remains a challenge. This project aims to explore and compare different deep learning models, for example the Temporal Fusion Transformer (TFT), Echo State Networks (ESN), DeepAR, and the Receptance Weighted Key Value (RWKV) model, for weather prediction using in-situ measurements from weather stations. The project will also investigate various ways to encode spatial information into the time series data.

Steps:
1. Literature review: Conduct a comprehensive review of the current state-of-the-art methods for weather prediction, with a focus on the use of deep learning models and the incorporation of spatial information.
2. Data collection and Preprocessing: Collect in-situ measurements from weather stations. This data will likely include variables such as temperature, humidity, wind speed, and pressure. Preprocess the data to handle missing values, outliers, and normalize the values if necessary.

Electronically approved by Ing. Magda Friedjungová, Ph.D. on 3 July 2023 in Prague.

3. Feature engineering: Incorporate spatial information into the data. This could involve encoding latitude and longitude information, or using more complex methods such as geospatial autoencoders or convolutional layers.
4. Model choice: Understand the deep learning models (e.g. TFT, ESN, DeepAR, RWKV) and suggest at least two models suitable for the present task.
5. Model implementation: Implement the chosen deep learning models in PyTorch. This will involve setting up the architecture of the models, selecting appropriate hyperparameters, and training the models on the preprocessed data. The student should investigate possible improvements to the model.
6. Model evaluation: Evaluate the performance of the models using metrics Mean Absolute Error (MAE), Root Mean Square Error (RMSE), or Mean Absolute Percentage Error (MAPE).
7. Model comparison: Compare the performance of the different models. This will involve not just comparing their prediction accuracy, but also considering other factors such as their computational efficiency and interpretability.
8. Incorporation of spatial information: Investigate different methods to incorporate spatial information into the models and evaluate how this affects their performance.
9. Conclusion and future work: Draw conclusions from the results of the project. Discuss the strengths and weaknesses of the different models and the effectiveness of the different methods for incorporating spatial information. Suggest areas for future research.

This project will provide valuable insights into the use of deep learning models for weather prediction and the incorporation of spatial information into these models. It will also contribute to the ongoing development of more accurate and efficient weather prediction systems.

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Department of Applied Mathematics
Supervisor: Mgr. Petr Šimánek

January 11, 2024

Declaration

I hereby declare that the presented thesis is my own work and that I have cited all sources of information in accordance with the Guideline for adhering to ethical principles when elaborating an academic final thesis.

I acknowledge that my thesis is subject to the rights and obligations stipulated by the Act No. 121/2000 Coll., the Copyright Act, as amended, in particular that the Czech Technical University in Prague has the right to conclude a license agreement on the utilization of this thesis as a school work under the provisions of Article 60 (1) of the Act.

In Prague on January 11, 2024

Czech Technical University in Prague
Faculty of Information Technology

Citation of this thesis

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Abstract

Once this thesis will be finished, it will be concerned with using deep learning architectures for the task of weather forcasting. It will also compare several methods of spatial representation to enhance the forecasting capabilities with additional data related to the location of weather stations.

Keywords deep weather forecasting, multivariate time-series forecasting, temporal fusion transformer, DeepAR, LSTM, spatial representation, hex2vec

Abstrakt

Po jejím dokončení se bude tato práce zabývat použitím architektur hlubokého učení pro úlohu předpovědi počasí. Dále bude srovnávat řadu metod prostorové reprezentace pro vylepšování predikcí pomocí dat extrahovaných z lokace meteostanic.

Klíčová slova předpověď počasí, hluboké učení, vícerozměrná predikce časových řad, temporal fusion transformer, DeepAR, LSTM, prostorová reprezentace, hex2vec

Chapter 1

TBD

Over the past few weeks, I have unfortunately encountered unforeseen challenges that have significantly impacted my ability to meet the winter semester deadline for submitting this thesis.

While a large portion of the work is already finished, the thesis as it stands now does not fulfil all of the requirements defined in the assignment. Due to personal and work-related reasons, I need to take the state exams during the winter period, so after careful consideration, I have decided to submit an "empty thesis" and forego my first attempt at defending it. I hope I will be allowed to continue with my chosen topic throughout the next semester, as I firmly believe, that this will leave me enough time to bring the work up to the expected standard.

I apologize for any inconvenience this step may cause; I have at least left out the chapters that have already been written so as to minimize the waste of time of everyone involved.

Appendix A

Contents of attachments

- `README.txt` ..... the file with attachment description
- `thesis` ..... directory with the thesis
  - `thesis.zip` ..... LaTeX source codes used in thesis text
  - `DP_Chodounsky_Dominik_2024.pdf` ..... PDF with thesis text