HSLU Hochschule Luzern

Technik & Architektur
Master of Science in Engineering Data Science

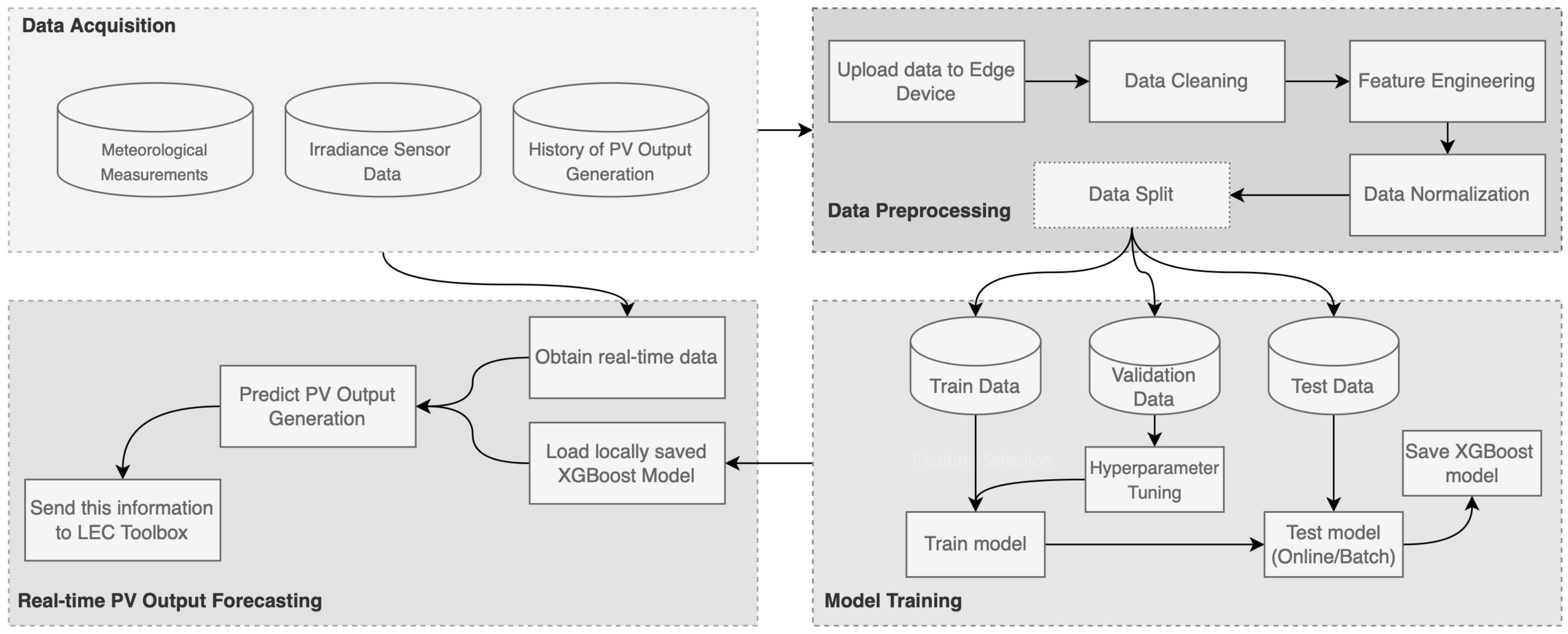
Master Thesis

Advanced Energy Forecasting for Local Energy Communities Based of AI Techniques

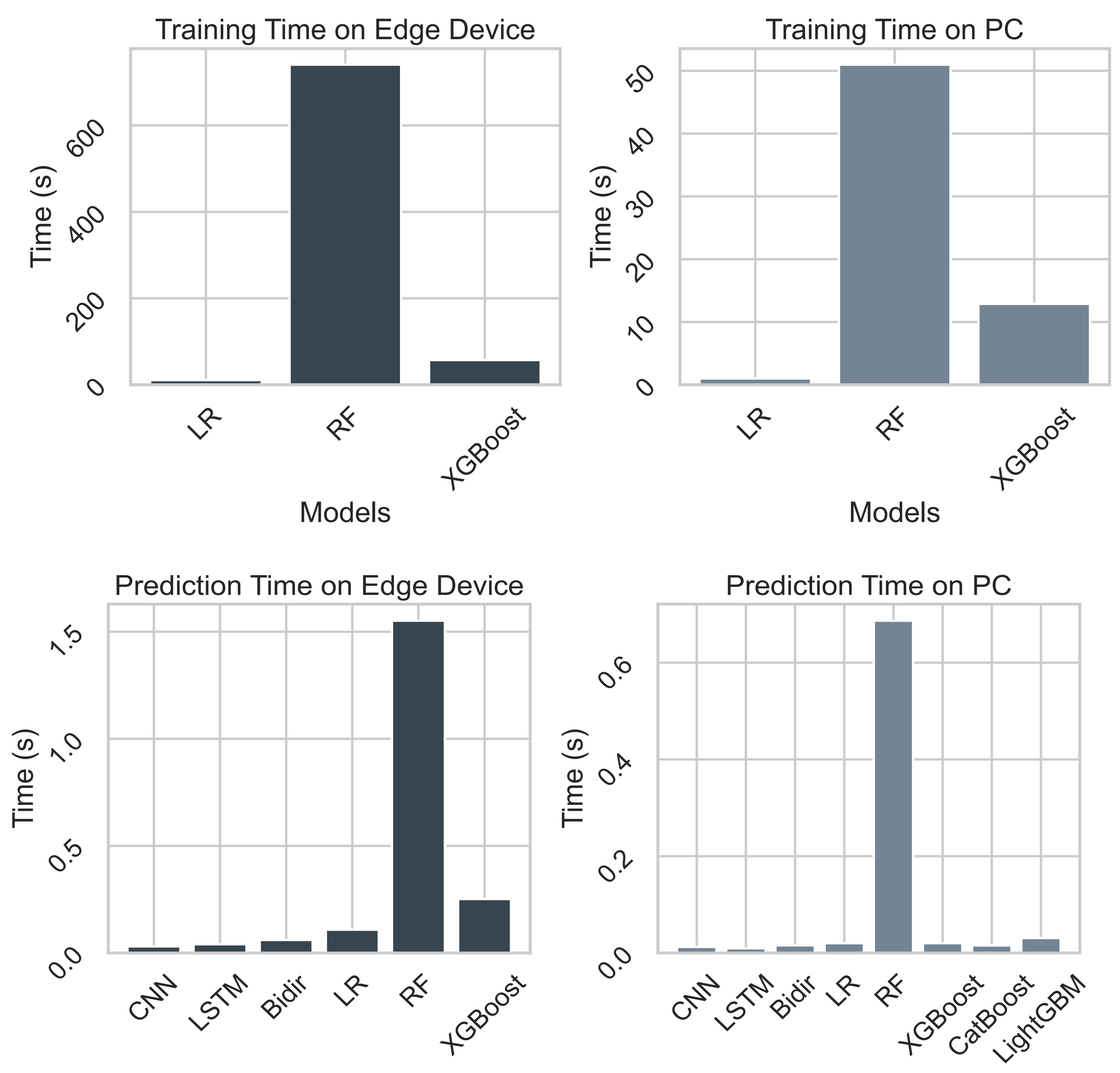
Objectives

- Investigating the current state of art in solar PV generation forecasting approaches have been already applied
- Learning about Local Energy Communities and their characteristics, understanding the need
- Reviewing possible forecasting approaches by constructing data and developing a framework
- Implementing selected models with the developed framework on an edge device

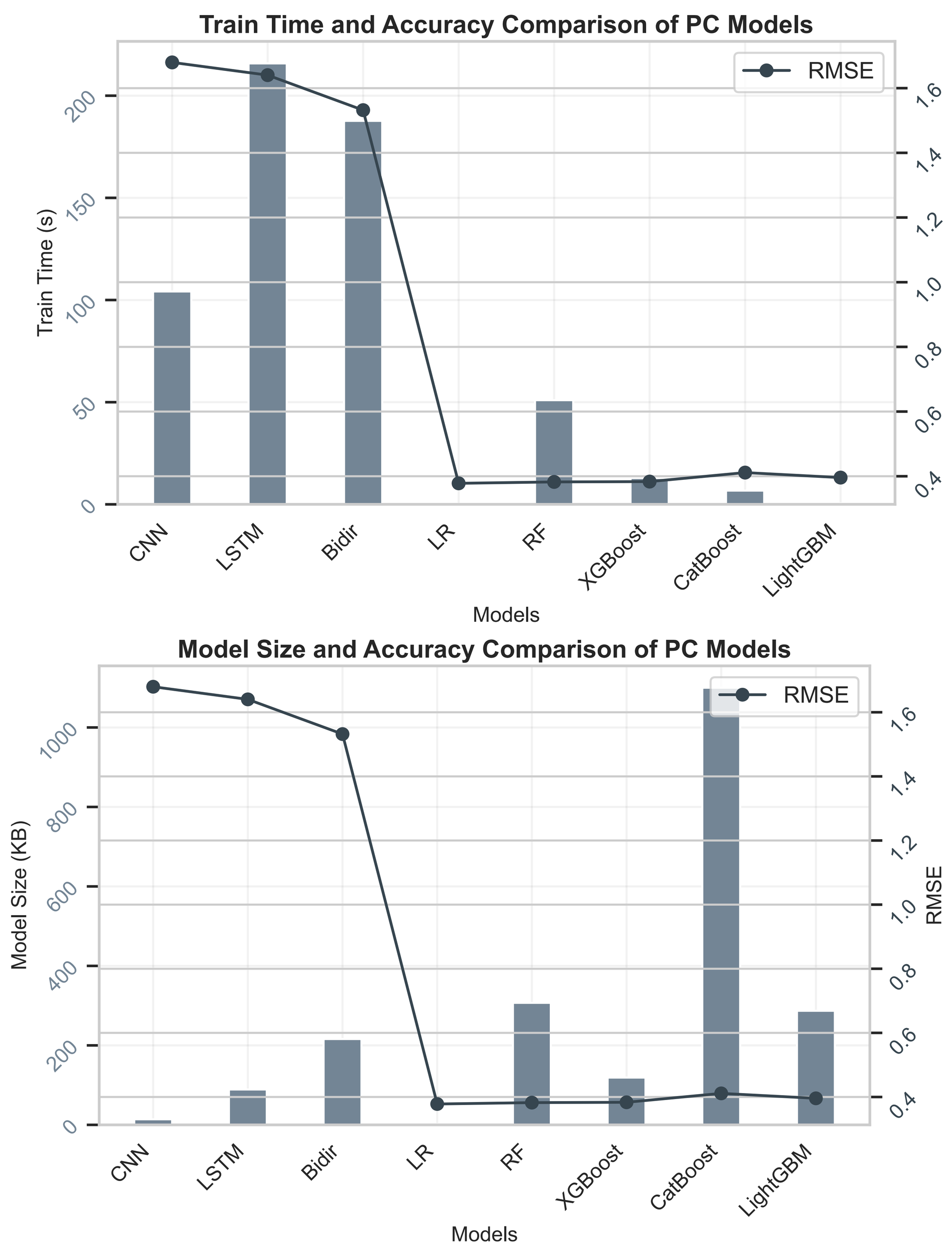
Methodology



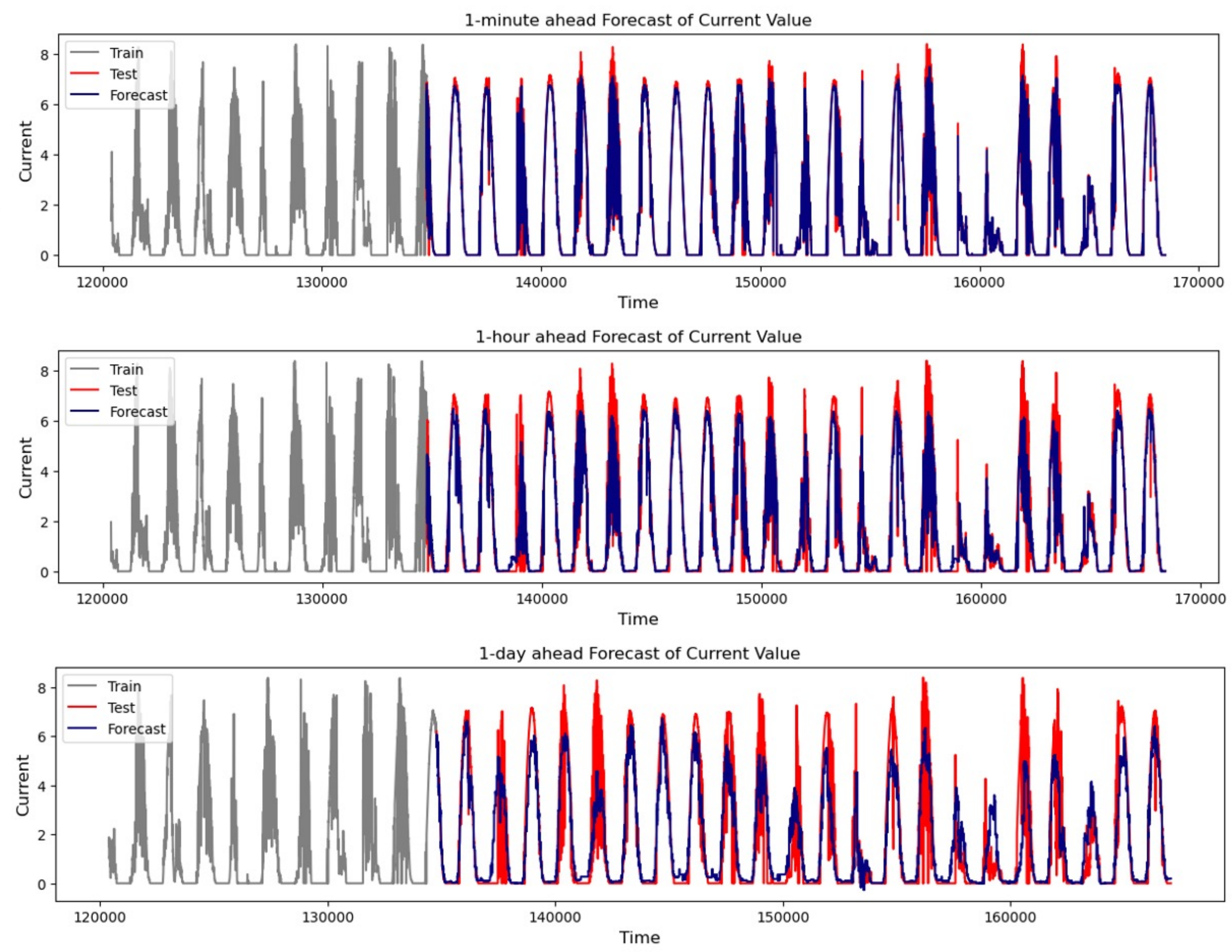
Training and Prediction Time of Models on Edge and PC



Comparing Models on PC



Very Short/Short Term Forecasting of PV Output



Introduction and Problem Definition

The use of solar energy is gaining increasing popularity as a means to reduce dependency on fossil fuels and address the impacts of climate change. **Solar Photovoltaic (PV) technology**, in particular, has become an economical and appealing option for individuals and businesses looking to generate their own energy. As a result, **local energy communities (LECs)** have formed, consisting of groups of individuals and organizations that come together to own, operate, and use solar PV systems. The volatile nature of solar energy presents a significant challenge for accurately **forecasting solar PV generation**. This is crucial for the transition from non-renewable energy sources to solar energy, as it affects the reliability of the energy system. This thesis aims to investigate the current state of the art in solar PV generation forecasting, focusing on **machine learning methodologies** and their potential use in local energy communities. Also, to review the literature on solar PV forecasting techniques and assess the potential for applying these methods in local energy communities, specifically through the implementation of machine learning technologies on **edge devices**. The challenges and limitations of these implementations also discussed and potential directions for future research suggested.

Overview

The forecast horizon is classified into long-term (1 to 10 years ahead), medium-term (1 month to 1 year ahead), short-term (1 hour to 1 week ahead), and very short-term (1 minute to several minutes ahead). The focus of the study is on very short and short-term forecasting for its importance in smart grid implementations. The study evaluates the performance of 3 deep learning models (CNN, LSTM, and Bidirectional LSTM) and 3 machine learning models (Linear Regression, Random Forest, and XGBoost) on a PC and edge device. The input data for the forecasting model includes time series data on weather conditions and solar panel readings. The selected model was trained on a set of input features which were chosen for edge device implementation based on the type of output and the forecast horizon.

Conclusion

The use of machine learning on edge devices is crucial in solar PV output forecasting as it enables real-time decision-making and integration of local data and forecasts. This is important for local energy communities without access to centralized servers. **XGBoost Regressor** was found to be one of the most accurate machine learning models, with the added benefit of **running on edge devices, providing real-time forecasting**.

Futurework

The accuracy and efficiency of the solar PV output forecasting model can be improved by implementing MLOps practices during development and deployment, and by exploring alternative machine learning algorithms. The study can also be enhanced by integrating the models into the Local Energy Community toolkit, evaluating different feature selection methods, and creating an API for training and prediction tasks.

Nur Sinem Dere
sinemderee@gmail.com

Advisor
Prof. Mirko Birbaumer
Expert
Benjamin Bowler

FH Zentralschweiz

MSE MASTER OF SCIENCE IN ENGINEERING