Ein Bild, das Text, Schrift, Grafiken, Poster enthält.

Automatisch generierte Beschreibung

A Group Project Paper for the Digitalization Project for the Chair of Energy Network Technology at Montanuniversity Leoben

Forecasting Photovoltaic Power Generation using Machine Learning LSTM Models Trained on Simulated Data

**Authors**:  
Georg Gressl  
Christoph Rinnhofer  
Michael Grün

**Advisors**:  
Dipl.-Ing. Dr.mont. Julia Vopava-Wrienz

MSc. Ahmad Fayyaz Bakhsh

Kurzfassung

In Smart Grids ist die Kurzzeit-Lastprognose (STLF) von größter Bedeutung, insbesondere bei stark fluktuierenden Energiequellen wie Photovoltaik-Anlagen, bei denen eine direkte Reduktion der Leistung wirtschaftlich nicht sinnvoll ist. Zuverlässige Lastprognosen ermöglichen ein effektives Management und die Optimierung der Energiesysteme zum Ausgleich residualer Lasten. In dieser Arbeit wird ein datenbasierte Ansatz vorgenommen, der die Simulation eines Photovoltaiksystems unter Verwendung historischer Wetterdaten mit einem Deep-Learning-Modell zur Verbesserung der STLF-Genauigkeit kombiniert. Konkret wird ein Long Short-Term Memory (LSTM) neuronales Netzwerk eingesetzt, um zukünftige Lasten basierend auf Wettervorhersagedaten, die über eine Programmierschnittstelle (API) abgerufen werden, vorherzusagen. Durch die Integration der simulierten Photovoltaik-Systemleistung mit Wettervorhersagen erfasst der vorgeschlagene Ansatz die inhärente Variabilität erneuerbarer Energiequellen und verbessert dadurch die Qualität und Zuverlässigkeit der Lastprognose. Die nahtlose Integration von datengesteuerten Simulationen und fortschrittlichen Machine-Learning-Techniken zeigt das Potenzial für eine deutliche Verbesserung der STLF-Fähigkeiten und trägt letztendlich zu einem effizienteren und nachhaltigeren Energiemanagement in intelligenten Stromnetzen bei.

Abstract

In smart grid systems, accurate short-term load forecasting (STLF) is crucial, especially for highly fluctuating energy sources like solar photovoltaic (PV) systems where directly reducing the load profile is not economically viable. Reliable load predictions enable effective management and optimization of energy resources to meet demand. This paper proposes a novel data-driven approach that combines the simulation of a PV system using historical weather data with a deep learning model to enhance STLF accuracy. Specifically, a long short-term memory (LSTM) neural network is employed to predict future loads based on weather forecast data obtained from an application programming interface (API). By integrating the simulated PV system output with weather forecasts, the proposed method captures the inherent variability of renewable energy sources, thereby improving the quality and reliability of load forecasting. The seamless integration of data-driven simulations and advanced machine learning techniques demonstrates the potential to significantly enhance STLF capabilities, ultimately contributing to more efficient and sustainable energy management in smart grid systems.

Table of content (is completly freestyle adapt!)

[1 Introduction 1](#_Toc165715155)

[1.1 Basics Sun 2 Energy 1](#_Toc165715156)

[1.2 Pvlib and used methods 1](#_Toc165715157)

[1.3 LSTM 1](#_Toc165715158)

[2 Implementation of simulation and deep learning 2](#_Toc165715159)

[2.1 Simulation process 2](#_Toc165715160)

[2.2 LSTM approach 2](#_Toc165715161)

[3 Results 3](#_Toc165715162)

[3.1 Results of simulation 3](#_Toc165715163)

[3.2 Results and accuracy of deep learning 3](#_Toc165715164)

[3.2.1 ...Text... 4](#_Toc165715165)

[3.3 Example Forecast 4](#_Toc165715166)

[4 OPT: comparison to real data. 5](#_Toc165715167)

[5 Summary and outlook 6](#_Toc165715168)

List of Figures

[Figure 1: Possibilities of graphical representation of data 3](#_Toc130203293)

****List of tables****

[Table 1: xxxxx 2](#_Toc130202986)

List of abbreviations

STPF. Short-term Power Forecasting

PV Photovoltaic

LSTM Long Short Term Memory

API Application Programming Interface

The abbreviations given in this template are mainly important in connection with the citation of literature sources. They are for illustration purposes only and are not to be used for the list of abbreviations of the paper, as these are general known definitions for a scientific paper.

# Introduction

Introduction to the field of sun 2 energy conversion with PV systems, pvlib, single-diode-modell,   
  
Methods Literature review

## Basics Sun 2 Energy

Describe the way from sun to the energy production

## Pvlib and used methods

Describe how pvlib methods works and the basic modelling approach

## LSTM

Give a short introduction to neural networks and how the architecture of LSTM specifically works.

# Implementation of simulation and deep learning

Here we describe our approach of our simulation and our params and location etc.

Ein Bild, das Screenshot, Karte, Grafiksoftware, Multimedia-Software enthält.

Automatisch generierte BeschreibungProvide all data and assumptions.

Ein Bild, das Text, Screenshot, Schrift enthält.

Automatisch generierte Beschreibung

## Simulation process

## LSTM approach

# Results

Here we present our results.

Ein Bild, das Reihe, Diagramm, Screenshot, parallel enthält.

Automatisch generierte Beschreibung

Figure 1: PV simulation results

## Results of simulation

* Text
* Text
  + Text
    - Text

## Results and accuracy of deep learning

…Text….



Figure 2: Possibilities of graphical representation of data

....Text...

### ...Text...

Starting from headings of the fourth order, the numbering can be removed. These headings are usually used to briefly set off important sections. They are not to be included in the table of contents.

## Example Forecast

# OPT: comparison to real data.

If we can manage to get access to the Fronius WebApp we could compare to actual data.

# Summary and outlook

Summarize the complete process and write why this is important and that it will increase importance.

Bibliography