MACHINE LEARNING BASED MAXIMUM POWER POINT TRACKING

Kaluthara Wedage Canish Nauka Shalendra Fonseka

218523G

Master of Science in Artificial Intelligence

Department of Computational Mathematics
Faculty of Information Technology

University of Moratuwa
Sri Lanka

Apr 2024

MACHINE LEARNING-BASED MAXIMUM POWER POINT TRACKING

Kaluthara Wedage Canish Nauka Shalendra Fonseka

218523G

Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree
Master of Science in Artificial Intelligence

Department of Computational Mathematics
Faculty of Information Technology

University of Moratuwa
Sri Lanka

Apr 2024

DECLARATION

I declare that this is my own work and this thesis / dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 27th April 2024

The above candidate has carried out research for the PhD/ MPhil/ Masters thesis/ dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. (Mrs.) Thushari Silva, PhD

Signature of the Supervisor: Date: 27/04/2024

DEDICATION

I dedicate this thesis to the most remarkable persons who have played key roles in shaping my academic journey. First and foremost, I would like to convey my heartfelt gratitude to my dear beloved wife and cherished family members whose unwavering support and encouragement have been my constant motivation. Their belief in me during the challenging times has been a beacon of strength.

I extend my deepest appreciation to my esteemed supervisor, Dr. (Mrs.) Thushari Silva, PhD, and the academic faculty for their invaluable guidance, expertise, and mentorship. Their trust in my abilities, constructive feedback, and insightful critiques have significantly contributed to the refinement of my work and my growth as a researcher. I am also indebted to my friends whose friendship and unwavering support have been instrumental in keeping me inspired and focused throughout this journey.

Additionally, I express my sincere gratitude to the Sri Lanka Navy for providing me with the opportunity to pursue this degree while serving my nation. Their support and guidance have been indispensable in the completion of this research.

This thesis stands as a testament to the collective efforts of those mentioned above. I am indeed deeply grateful for their presence in my life journey and for their instrumental role in helping and supporting me to achieve this significant milestone.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to everyone whose steadfast assistance was necessary to finish this thesis.

First and foremost, my gratitude goes to the supervisor, Dr. (Mrs.) Thushari Silva, PhD, whose unwavering support, guidance, encouragement which have shaped the trajectory of this research. Her expertise and insights have significantly enhanced the quality of this work. I am indebted to the dedicated academic staff at the Faculty of Information Technology, University of Moratuwa, whose commitment to excellence has challenged me to grow as a Master's student. Their passion for their fields has served as a constant wellspring of inspiration.

I express sincere thanks to the Sri Lanka Navy for their invaluable support, understanding, and flexibility, enabling me to pursue this degree while fulfilling my duties to my country.

My heartfelt appreciation also goes to my beloved family members and friends, whose boundless love, care, encouragement and specially belief in me have been unwavering. Your sacrifices and encouragement have been the cornerstone of my journey, and I am profoundly grateful for your steadfast support.

Further, I extend my gratitude to all the participants whose contributions and willingness to share their experiences have made this research possible. I want to express my sincere gratitude and appreciation to each of you. I am honored to have had you by my side during this journey, and this thesis is a monument to your unfailing support and direction.

ABSTRACT

Origin of the solar cell dated back to 1883 when the first solar power generation was invented. A solar system converts sunlight into electrical energy through photovoltaic panels and known as solar power generation. At present solar power generation shows highest development of among all renewable resources. Maximum Power Point Tracking is a method of optimizing the solar panel in order to obtain maximum power output from the solar panel. Comprehensive literature review of MPPT systems, tracing their historical development and examining conventional and modern MPPT methods were carried out and observed existing MPPT methods often fail to capture the relationships between voltage, current, irradiance, and temperature parameters which directly affect the optimal operating point of a photovoltaic panel without disturbing the energy harvesting process, to deliver the maximum power output of the photovoltaic system. As a result, the overall efficiency and performance of the photovoltaic system may be compromised.

The proposed solution involves leveraging the capabilities of machine learning approaches to learn the complex relations between the voltage, current, irradiance and temperature paraeters using random forest regression and the proposed approach aims to overcome the limitations of traditional MPPT to obtain optimized output power from photo-voltic system. Developed MPPT model is tested using real-world data collected from PV installations under diverse environmental conditions. The tests evaluate the model's accuracy, adaptability, and performance compared to conventional MPPT techniques. Results demonstrate the effectiveness of the machine learning-based approach in improving energy harvesting efficiency and overall system performance. The findings suggest that machine learning-based VCIT-MPPT offers a promising solution for optimizing PV system performance and maximizing energy yields. In conclusion, this thesis presents a novel approach to MPPT leveraging machine learning techniques named as VCIT-MPPT, showing significant improvement in efficiency of energy harvesting and MPPT system performance. The findings contribute to the advancement of renewable energy technologies and pave the way for more efficient utilization of solar power resources.

Keywords: Maximum Power Point Tracking (MPPT), Photovoltaic (PV), Machine Learning (ML), Random Forest Regression (RFR) (RFR), Renewable Energy.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ABBREVIATIONS

Abbreviation	**Description**
CUR	Current
FFILL	Forward Fill
INC	Incremental Conductance
IPO	Input Process Output
IRR	Irradiance
MAE	Mean Absolute Error
MSE	Mean Square Error
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
PIP	Preferred Installer Program
PV	Photovoltaic
PWM	Pulse Width Modulator
P&O	Perturb and Observe
REF	Reference
RFR	Random Forest Regression
RMSE	Root Mean Square Error
STC	Standard Test Conditions
TEMP	Temperature
TVC	Temperature Voltage Converter
VOL	Voltage