Abstract

ANN Based Maximum Power Point Tracker for a Standalone PV System

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Highlights

- We are using an Artificial Neural Network(ANN) for maximum power point tracking using Tensor Flow.
- Standalone PV system has been mathematically modelled and simulated using SciPy
- Training data was taken from experimental results carried out on solar panels mounted on roof top.
- The complete working of the system is analysed and simulated using Python stack.

Introduction

Solar being an intermittent source of renewable energy, it is important to completely utilize the available free resource in a systematic way. Therefore, we implement maximum power point tracking controllers in order to save energy & improve efficiency of the system. The following block diagram gives a brief idea about the PV system under consideration:

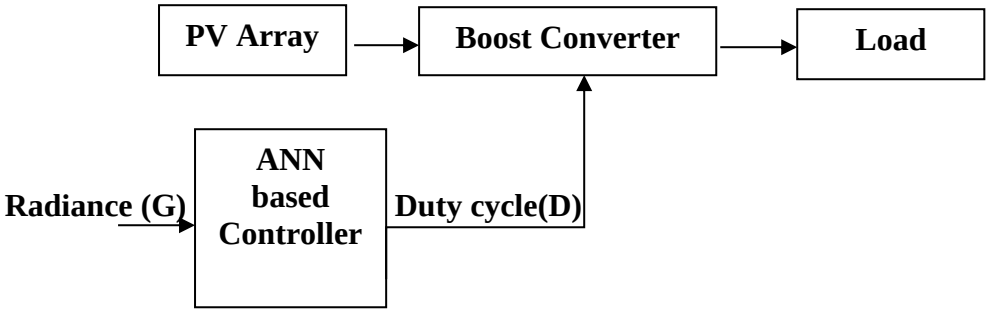


Fig 1: ANN based MPPT controller utilizing G & D as inputs.

System Equations:

- PV array: Voltage and Power

$$V_{array} = 54.68 \ln\left(\frac{I_{ph} - I_{array} + 0.005}{0.005}\right) - 3.74 I_{array}$$

$$P_{array} = 54.68 I_{array}\, ln\left(\frac{Iph - Iarray + 0.005}{0.005}\right) - 3.74 I_{array}^2$$

- Boost-Converter Equations:

$$\begin{pmatrix} \dot{il} \\ \dot{vc} \end{pmatrix} = \begin{pmatrix} 0 & -(1-s)/L \\ (1-s)/C & -1/RC \end{pmatrix} \begin{pmatrix} il \\ vc \end{pmatrix} + \begin{pmatrix} 1/L \\ 0 \end{pmatrix} (\mathrm{Vs})$$

Where,

V_{array}=array output voltage

I_{array}=array output current

P_{array}=array output power

I_{ph}=Variable photo-current proportional to solar insolation

s=Switching state

V_s=Input to boost converter

R=Resistance

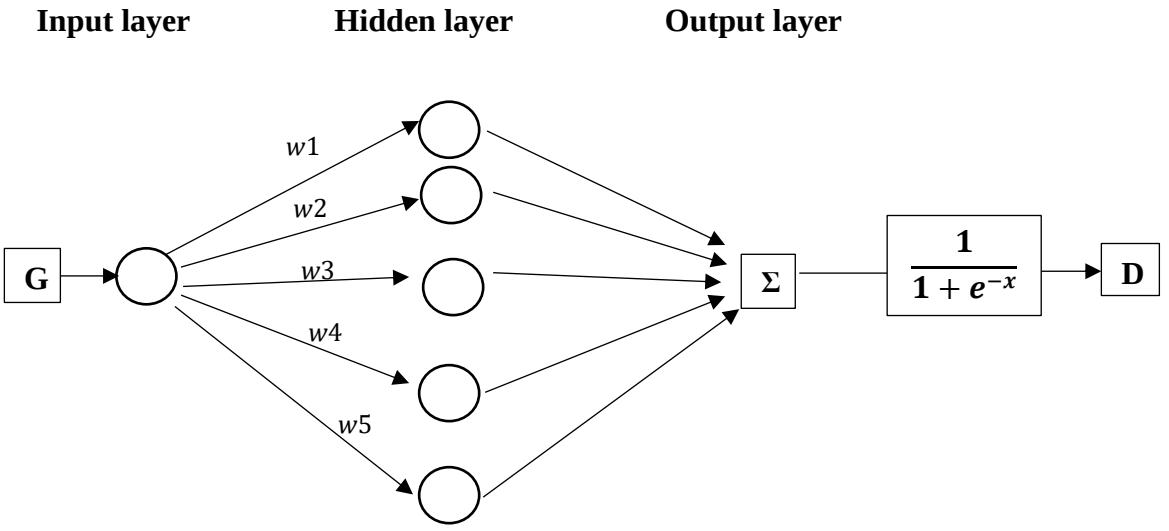
L=Inductance

C=Capacitance

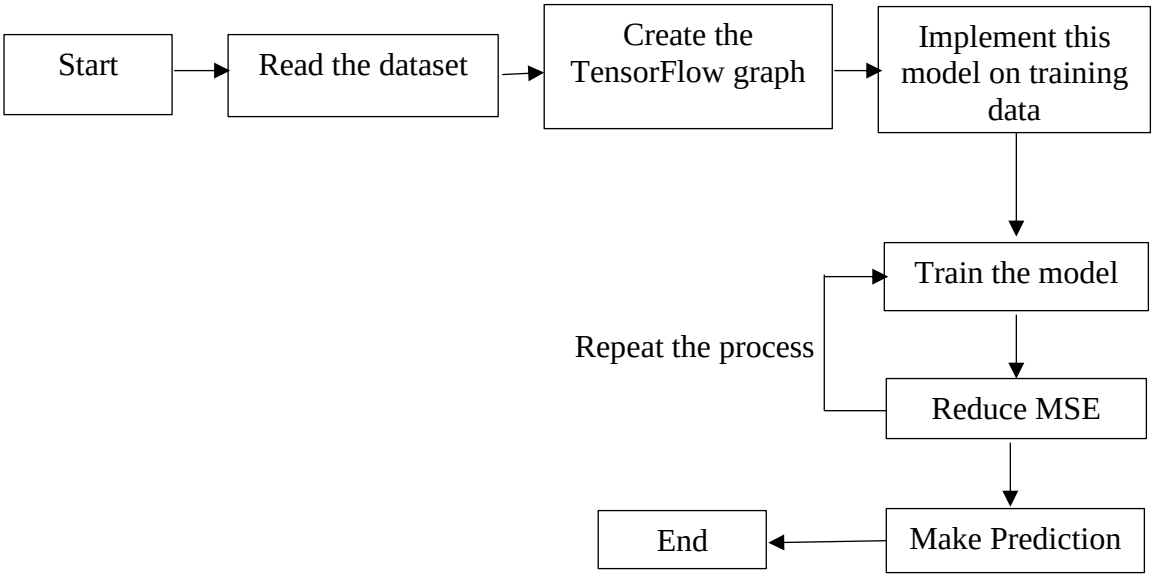
Referring to Fig. 1, PV panel output is connected to a boost type dc-dc converter which feeds a load. The power delivered by the PV array depends on the duty cycle of dc-dc converter and load. It is known that the power output of PV panel varies with solar radiation, ambient temperature and solar cell temperature. Taking these conditions into account, ANN based model is developed which takes input as solar insolation (radiance) and gives duty cycle as the output which acts as the control signal to the boost converter so as to draw maximum power from PV array. Accordingly, the dc-dc converter draws maximum power from the PV panel.

ANN structure:

ANN structure used for prediction of duty cycle is as shown below:



Duty cycle prediction for Boost Converter:



The results obtained from the ANN model are fed to the boost dc-dc converter so as to track maximum power from PV array. Following are the results obtained.

Results:

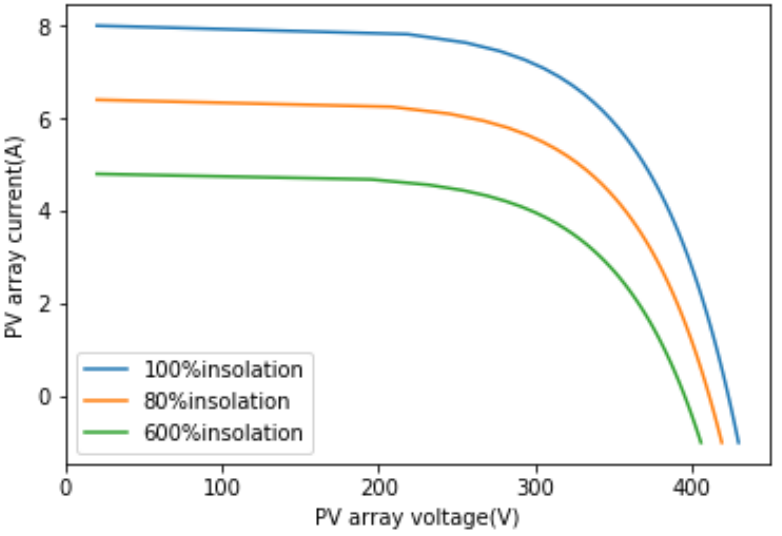


Fig. 2. VI characteristics of PV panel for different insolation levels

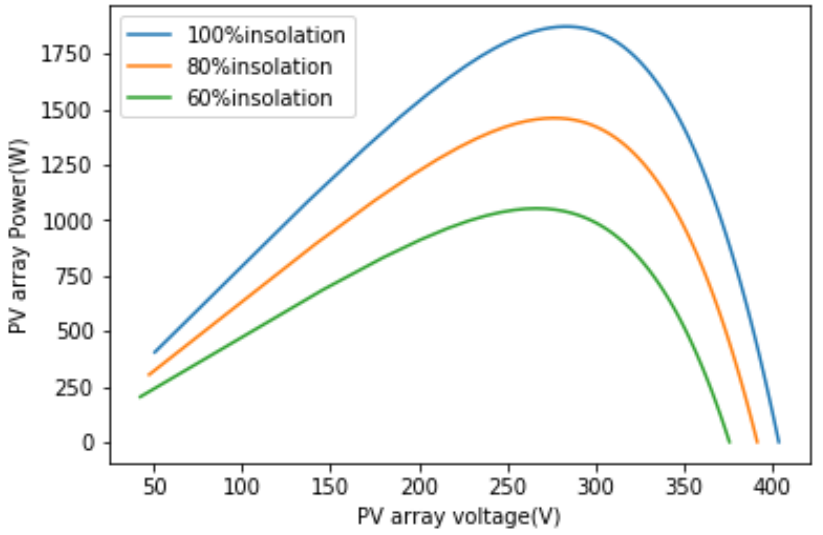


Fig. 3. PV characteristic of solar panel for different insolation levels

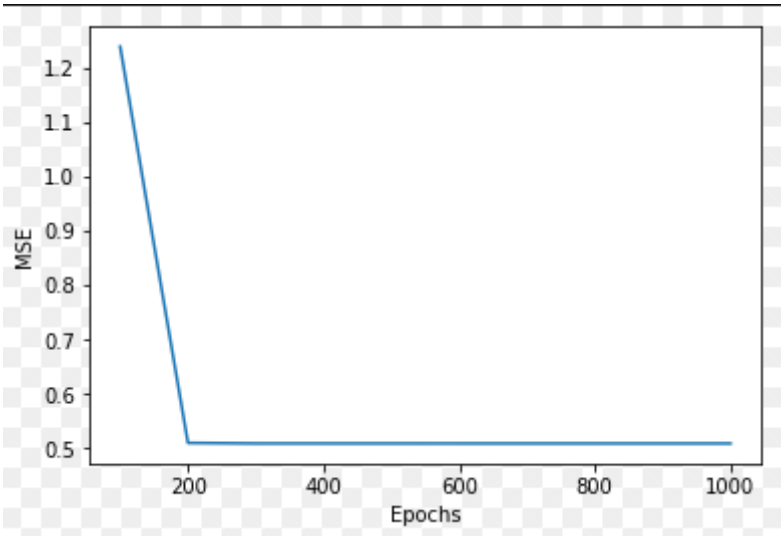


Fig. 4. Epochs Vs Mean Square Error

Boost converter output at 80% insolation:

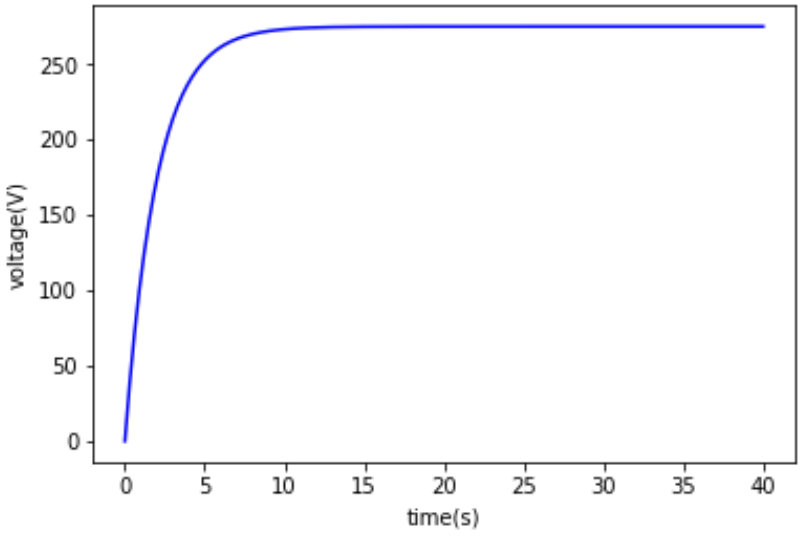


Fig. 5. Output voltage of boost converter in Volts

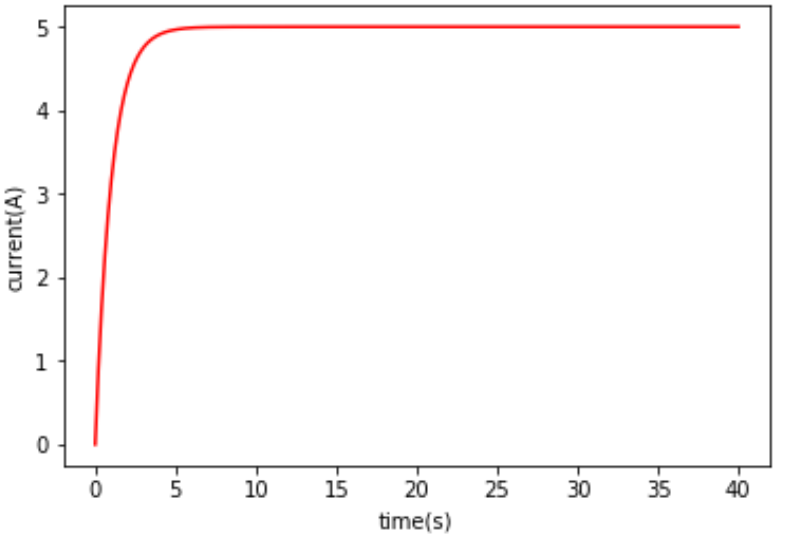


Fig. 6. Load current in Amperes (A)

Learning Experience:

- ✓ Simulation of Boost converter involves solution of simultaneous differential equations which is implemented using ODE solver available in SciPy module.
- ✓ Feed Forward Neural Network model is used to implement MPPT controller for PV array using Tensor Flow library.
- ✓ Graphical results are obtained using Matplotlib.
- ✓ The complete mathematic model representing PV array feeding a boost converter with MPPT controller is analysed using Python.
- ✓ Hence, Python is successfully used for scientific computing involving simulation of a standalone photovoltaic system.

References:

[1] S. Leva, A. Dolara, F. Grimaccia, M. Mussetta, E. Ogliari, "Analysis and Validation of 24 hours Ahead Neural Network Forecasting of Photovoltaic Output Power", Int. Rev. Electr. Eng. 7 (1) (2014), pp. 3454–3460.

[2] Bastidas-Rodriguez, J.D., Franco, E., Petrone, G., Andrés Ramos-Paja, C., Spagnuolo, G., "Maximum Power Point Tracking Architectures for Photovoltaic Systems in Mismatching Conditions: A Review', IET Power Electron., 2014, 7, (6), pp. 1396–1413.