Performance Analysis of Solar Health Monitoring by Spider Monkey Optimization (SMO)

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ABSTRACT

In real life, human dependency on electricity is increasing regularly. Research focuses on increasing the energy efficiency of renewable resources such as solar and wind energy.

As India is situated within the solar belt region, Solar electricity can act as a great solution for the electricity demand in the urban and rural areas of the developing countries such as India. In the proposed research, we submit an automated health monitoring model for photovoltaic (PV) solar cells utilizing Spider Monkey Optimization (SMO) method. The fission-fusion food search behavior of spider monkeys served as the inspiration for Spider Monkey Optimization, an evolutionary optimization method inspired by nature.

In the presented model, every array of the photovoltaic (PV) cell is linked to separate Solar Monitoring Unit (SMU). After completing this installation, centralized data from each Solar Monitoring Unit via micro-controllers enables autonomous health monitoring. Additionally, a device that uses SMO-based data processing to derive health information from each PV array is attached to this system.

Keywords: *Photovoltaic (PV) cells; Spider Monkey Optimization (SMO); Solar Monitoring*

INTRODUCTION

Maximizing power generation is crucial in emerging nations like India to support the fast expansion of several sectors, including industry, rural areas, and urban areas.

In India, the installed power generation capacity currently stands at approximately 300GW. S. Kumar, B. Bhattacharya, and V.K. Gupta examined contemporary and prospective energy considerations in 2014.

The reliance of India on fossil fuels for power generation is significant, with around 72% of its capacity being fossil fuel based which is shown in following figure: -

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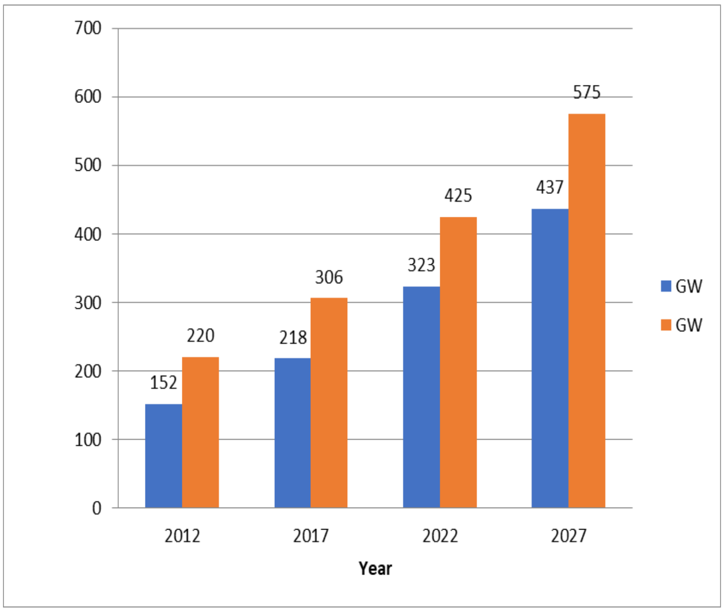

Figure. 1.1

The maximum electricity consumption is consistently rising and is projected to approach around 437 GW by 2027, as illustrated in Figure 1.1.

Solar modules can be connected in parallel or series, depending on the appropriate voltage and current. There is an increase in voltage when modules are joined in series and if it is connected is parallel it provided the increase in current.

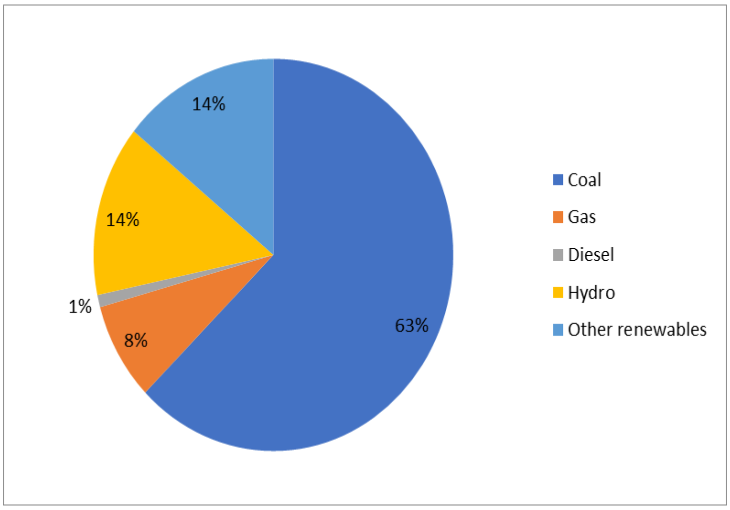

Figure. 1.2

Solar energy was created in 2014 by Jagar K. Isabella, O., Smcts A.H.M., et al. In India, coal is the most common fuel used to generate power (62%), followed by natural gas and other renewable energy sources.

The rural-urban divide in electricity access is evident as According to estimates from the International Energy Agency (IEA), 96% of households in metropolitan areas have access to electricity, compared to only 75% in rural areas. The rural communities commonly experience prolonged and frequent disruptions to their power supply.

India, the seventh largest country in the globe spans 328 million hectares of renewable sources of energy, offering immense potential for sustainable power generation. The on-grid system, which works in conjunction with the utility power grid, is the first framework. This technology ensures a reliable and synchronized supply of electricity by producing power only when the utility power grid is available. By returning excess generated electricity to the grid, these devices can optimize energy usage.

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The off-grid system serves as the second framework which enables the storage of excess solar energy in batteries making it reliable and consistent source of energy well suited for remote areas.

A hybrid system, which provides a cutting-edge approach to the renewable energy management, serves as the third framework.

In addition to sending excess electricity back to the grid for credits that can be used later, it supplies power to balance the grid energy whenever the sun shines.

The smallest component of a PV array is the solar cell. When placed with care, these cells forms a larger structure known as solar PV module. These solar panels are designed and arranged and is known as solar PV array using the algorithm which minimizes the tracing time with small no. of perturbations without utilizing any specialized equipment.

In 2017, S. Daliento, A. Chouder,P. Guerriero, A. Massi et.al. developed Monitoring Diagnosis and power face casting for photovoltaic (PV) fields.

RESEARCH METHODOLOGY

In this section we shall discuss research methodology and overview:

A. Research Methodology Overview

This research aims to design and develop a solar health monitoring system, leveraging the optimization capabilities of the Spider Monkey Optimization (SMO) technique.

Based on how spider monkeys forage, Spider Monkey Optimization (SMO) is an algorithm inspired by nature. The SMO algorithm's pseudo code, which illustrates the suggested algorithm's process flow, is shown in figure 1.2.

Flow Chart of the SMO Algorithm

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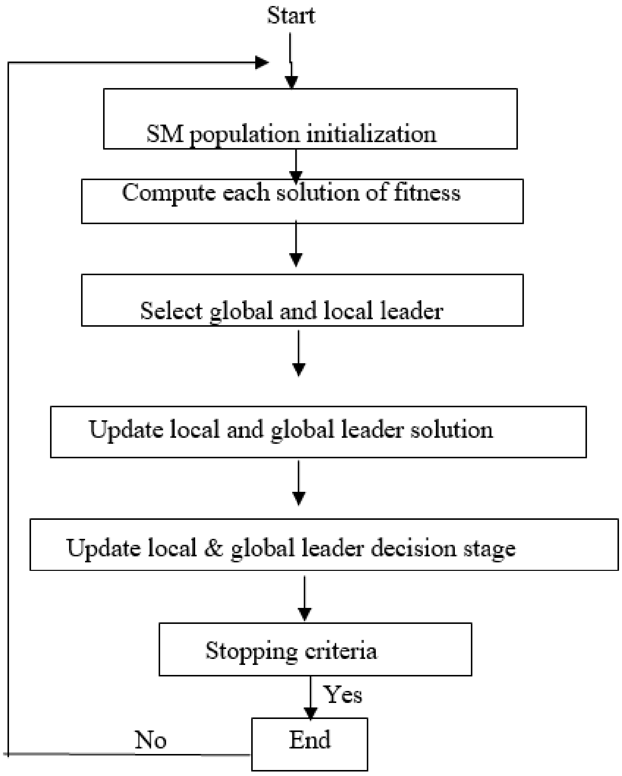

Chart 1.1

Spider Monkey Optimization (SMO)

Jagdish Chandra Bansal proposed the new swarm intelligence-based method that is being presented in 2014. The social behaviour of spider monkeys serves as the model for the population-based technique known as SMO. SMO allows the optimization process to strike a balance between intensification (local search) and diversity (global search) by imitating social behaviour, which results in an efficient solution to the challenges at hand.

Spider monkeys' social behaviour exemplifies a fission-fusion system. These primates reside in large communities, known as 'unit groups.' Spider monkeys deliberate group division into smaller subgroups to reduce foraging rivalry among group members.

Fission-Fusion social behavior

Spider monkeys' parent groups forage (hunt) by splitting out into smaller groups, each of which forages in a separate location (fission). The subgroups rejoin the parent group (fusion) around dusk to partake in social activities and share meals.

In order to get food, spider monkeys use a dynamic foraging method, moving in various directions. Group members maintain contact through visual and vocal communication, ensuring coordination and cooperation.

The parent group is led by a dominant female, who serves as the global leader. If food scarcity arises, the leader adapts by dividing the group into even smaller involving 3-8 members in each subgroup, optimizing foraging efforts and enhancing resource acquisition.

These subgroups, in turn, are led by secondary female leaders, who assume responsibility for selecting the most efficient foraging route each day, ensuring survival and success.

The Standard SMO

In this section we develop standard monkey optimization.

Population Initialization

$$SM_{ij} = SM(0,1)\left(SMjmin_{jmax}\right)_{jmin} \tag{1}$$

where SM_{jmin} and SM_{jmax} are bounds of SM_i and $U(0,1)$ is a uniformly distributed random number.

$U(0,1) \in [0,1]$.

Local Leader (LLP) Phase

SMijnew = SMij + U[0,1] X (LLkj –SMij) + U[- 1,1] X (SMrj – SMij) -------------------(2)

The Global leader phase (GLP)

SMijnew = SMij + U(0,1)X (Glj –SMij) + U(- 1,1)X (SMej – SMij), -------------------(3)

SOLAR PHOTOVOLTAIC (PV) MODEL

In 2014, Borhanazad, H., and H. Mekhily proposed the power of the photo voltaic (PV).

Two major environmental elements have a direct impact on the energy generation of the solar photovoltaic (PV) system: solar irradiance and atmospheric temperature. The amount of solar radiation received by the PV panels determines the system's power output, while temperature fluctuations impact the panels' efficiency and overall performance

At any given time PV power out is given by the following equation.

$$PV_{power.out} = P_{PV}.\frac{A}{Z_{ref}}\left[1 + K_{temp}\{Tamb + (0.0256z)\}\right] - T_{ref} \tag{4}$$

where

P_{PV}: Rated PV power, Kilowatt
Z: Solar Radiation W/M^2
Z_{ref} : Solar Radiation of standard radiation
$T_{amb.}$: Ambient Temp. of the Solar Panel
T_{ref}: Standard Temperature

Applications of SMO:

Numerous academic, professional, and research domains have made use of Spider Monkey Optimization (SMO). It can be used in a variety of fields, including "Biomedical Engineering, Computer Science and Networking, Cryptography, Electrical and Electronic Engineering, and Queuing Systems, especially delay systems in queues." Fuel, energy, agriculture, and so on.

The graph below displays SMO and Modified SMO by year.

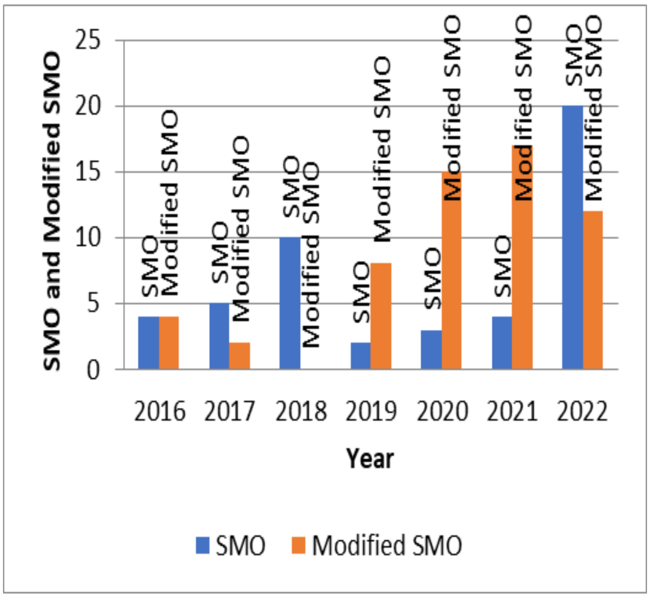

Figure 1.3

Usage of SMO and Modified SMO

In the next graph, we shall show the usage of simple SMO by year in research.

Simple SMO in the field of research.

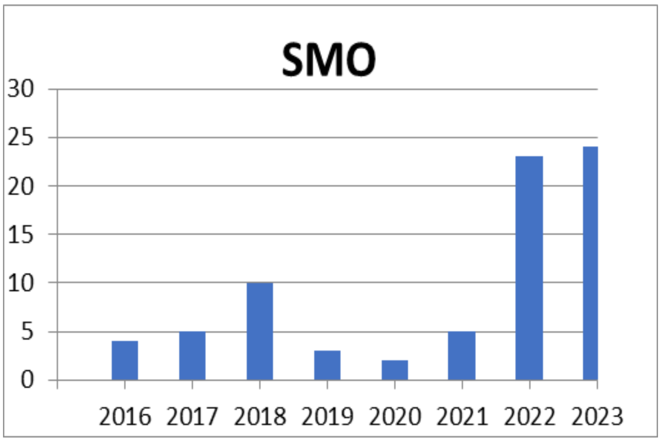

Figure 1.4

Mechanism for Simulating a random variable.

That mechanism is driver by the simulation of pseudorandom U (0,1) random variable. Once the random variables are created the they can be transformed into any desired univariate random variable.

The trans for motion applies to univariate random variables that are defined by a probability destitution function. Univariate means that distribution pertains to single independent random variables. rather than pairs, triplets etc. of dependent random variables.

All probability distribution function must be non-decreasing and have the range $[0.1]$.

The likelihood that the random variable is less than a very tiny value is the lower constraint on the grange. The likelihood that the random variable is less than a very big value x is represented by the value x and upper bound.

Mathematical modeling of PV cell using MATLAB SIMULINK.

Among various photovoltaic (PV) cell models, including single cell, dual cell, three diode, double diode, and single diode models, the single diode model stands out as the most widely adopted. Its popularity stems from its optimal balance between simplicity and accuracy, making it a reliable choice for PV cell simulations and analyses.

Photo Current (Iph), Shunt Resistance (Rsh) and Diode Series Resistance (Rs) represents single diode model of the Photo Voltaic cell which is shown in table 1.

Practical PV cell equipment circuit Figure 1.4

According to the Kirchhoff's Current Law (KCL), the output current equation can be given by the diode equation.

$$I = I_{ph} - Io\left[exp\left(\frac{q(v+IRs)}{nKNT}\right) - 1\right] - I_{sh} \quad (5)$$

where

Photo Current is denoted by I_{ph}
Saturation Current is signified by I_o
Reverse Saturation Current is signified by Irs
Current through Shunt Resister is denoted by Ish

$$I_{ph} = [I_{sc} + K_i(T - 298)]\frac{G}{1000} \quad (6)$$

$$I_o = I_{rs}\left[\frac{T}{T_n}\right]^3 exp\left[\frac{qEgo\left(\frac{1}{T_n} - \frac{1}{T}\right)}{nk}\right] \quad (7)$$

$$I_{rs} = \frac{I_{SC}}{exp\left(\frac{qV_{OC}}{nNsKT}\right)} - 1 \quad (8)$$

$$S_{sh} = \left(\frac{V+IRs}{R_{sh}}\right) \quad (9)$$

The following table gives the values

I_{ph}	Photocurrent (A) (Ish)
Isc	Short Circuit current (Isc)
Ki	Short Circuit currently Cell at 25^0C & 1000 w/m^2
T	Operating Temp. (K)
T_n	Normal temp (K)
G	Solar irradiance (w/m^2) (G)
Q	Electron Charge (C) 1.6×10^{-19}
Voc	Voltage of Open Circuit (V): Voc.
N	Ideality factor of diode: 1.3
K	Constant of Boltzmann (J/K) : 1.38×10^{-23}
Ego	Band gap Energy (ev) : 1.1
NS	# of PV Cells Connected in series: Ns
Np	# of pv Cells connected in parallel: Np
Rs	Series resistance (Ω): 0.221
RsR	Shunt resistance (Ω): 415.405
Vs	Diode thermal Voltage (V)

PV Panel Specification

Rated power (Vamp)	200 W
Voltage at max. Power (Vamp)	26.4 V
Current at max. power (Vamp)	7.58A
Open Current Voltage (Voc)	32.9
Short Circuit Current (VSc)	8.21A
Total # of Cells in series	54
Total # of cell in parallel	1

Table 1

The single diode models current voltage and power voltage characteristic can be described using above (5) to (9) equations.

In the following equation MATLAB SIMULINK is given as follows:

$$I_{ph} = [I_{Sc} - K_c(T - 298)]\frac{G}{100} \quad (10)$$

Nigam Sandeep gave introduction to MATLAB for engineers and scientists and provided solution for numerical computation and modeling.

In 2016, Oge well rerdi studied math works and presented product digitization is a boost for smart algorithm and simulation.

CONCLUSION

In this work, we have analyzed and studied performance analysis of solar health monitoring by Spider Monkey Optimization (SMO) technique. The fission-fusion food search behaviour of spider monkeys served as the inspiration for Spider Monkey Optimization, an evolutionary numerical optimization system.

If a separate solar monitoring unit (SMU) is linked to each array of photovoltaic (PV) cells and if this system is connected to a computer. and using MATLAB-SIMULINK; SMO based data analysis takes place and health of each for array is obtained.

Computer simulation begin by creating pseudo-random variables with uniform [0,1] distribution.

The Spider Monkey Optimization (SMO) algorithm holds tremendous promise, and its overall potential is vast. As a meta-heuristic approach, SMO has the capacity to emerge as a highly effective tool for tackling complex optimization problems. With ongoing developments and variations, SMO is poised to become a go-to framework for addressing a wide range of optimization challenges.

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