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Maximum Power Point Tracking Module for PV Systems Using Flower Pollination Algorithm

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Abstract - *Renewable energy sources have gained more attention due to increasing energy demand. For the maximization of solar photovoltaic system, The Maximum Power Point Tracking (MPPT) is used in various weather circumstances. To handle the MPPT problem, both traditional and soft computing approaches are commonly employed. Soft computing approaches are limited by insufficient randomness after reaching the region of maximum power, but the traditional method has limited performance owing to set step size.*
Flower Pollination Algorithm is the title of this project (FPA) based MPPT for Photovoltaic system is proposed. The FPA is an excellent technique in tracking of Maximum Power Point under uniform conditions. Optimization process in flower pollination algorithm performs a single-stage global and local search to reach the MPP. The solar panel voltage and current output is given to the boost converter (DC-DC), the reference voltage and current is given to the MPPT controller and the duty cycle generated is given to the boost converter in order to get the most power for different irradiances. The proposed system is established in MATLAB/ Simulink to evaluate the effectiveness of the system.

1. INTRODUCTION *(Size 11, Times New Roman font)*

With the energy issue and environmental pollution growing increasingly serious, major efforts have been made to explore new and green energy. Solar energy is widely recognised as a type of green energy because of its benefits of zero pollution, no regional restrictions, and ease of use [1].

In recent years, the world's attention has been drawn to limitless power generation due to rising energy consumption and the depletion of fossil resources. As an initial step toward pollution-free power generation, the government has increased subsidies and implemented tariff-free initiatives to stimulate renewable energy development. Solar energy is prioritized among the numerous types of renewable energy supplies because of its abundant availability and noteworthy attributes. Furthermore, massive Solar photovoltaic power parks have sparked interest of investors all over the world.

The most prevalent method of using solar energy is photovoltaic (PV) power generation. Solar photovoltaic (PV) technology collects photon energy from the sun and converts it to electricity. Because a single solar cell has a limited output power, many solar cells must be A basic PV module unit is made up of series and parallel connections.

Most power point tracking (MPPT) techniques are used to harvest the maximum possible power from a PV array and hence optimize its utilization. Because the array's P-V characteristics include several peaks, tracking the maximum power point (MPP) under partially shadowed circumstances is difficult.

Because of their potential to address huge and complex problems, nature-inspired algorithms are receiving a lot of attention. Genetic algorithms, swarm optimization techniques, harmony search algorithms, firefly algorithms, bat algorithms, and cuckoo search methods algorithms [2,3,4]are only a few examples. Recently, a few of these methods have been employed to monitor the MPP in partially darkened situations.

Flower pollination algorithm (FPA) is a modern nature-inspired algorithm. is used in this project. Xin - She Yang suggested this approach in the year 2012.[5]. This is based on blooming plant pollination.

2. Control Methodology

Multi-objective or multi-criteria design challenges are common in engineering and industry. These numerous goals frequently clash, making it hard to adopt a single design solution without making a compromise. Providing precise approximations to the true Pareto fronts of the topic of interest for example, a common strategy may rank various solutions based on their preferences or utility. Multi-objective optimization has extra challenges than single-objective optimization, such as temporal complexity, homogeneity, and dimensionality.

In recent engineering optimization literature, a family of nature-inspired algorithms has exhibited promising performance and result, they have become popular and frequently employed. The majority of these algorithms are based on swarm intelligence. Furthermore, the particle initialization process used makes it challenging to implement.

Bio-inspired approaches have recently been proposed as a viable a different approach to swarm tactics Some of the significant approaches proposed in the field of MPPT include Cuckoo Search (CS), Firefly Algorithm (FA), Random Search Method (RSM), Artificial Bee Colony Methods (ABC), Ant Colony Optimization (ACO), and Grey Wolf Optimization (GWO).

One of such algorithm is the Flower Pollination. Flowering plants make up more than a quarter of a million species in nature, accounting for over 80% of all plant species. A flower's primary function is to reproduce through pollination. Pollen transfer is commonly connected with flower pollination and Insects, birds, bats, and other creatures are commonly involved as pollinators. In actuality, a highly unique flower-pollinator interaction has arisen between some blooms and insects.

Pollination is the process of pollen being transferred from one species to another. Cross pollination and self pollination are two methods of pollination. This technique aids the emergence of new species of flowers.

Pollinators, also known as pollen carriers, come in a wide variety of shapes and sizes. Pollinators such as insects, bats, and birds are considered to number in the millions. Honeybees are an excellent example of pollinators, as they have evolved floral constancy.

Such floral constancy may have evolutionary advantages since it promotes flower pollen transmission to the same plants, hence promoting flower species reproduction.

2.1 Abiotic Pollination (Self)

This type of pollination occurs in the Pollen from the same plant species fertilize each other to produce new species. Abiotic pollination, which does not require pollinators, accounts for around 10% of pollination. Pollination such blooming plants is aided by wind and dispersion. Grass pollination is an excellent example of abiotic pollination. It is also called as Local Pollination.

2.2 Biotic Pollination (Cross)

In this type Pollen is transferred between two distinct species by pollinators such as honey bees, bats, and birds during pollination. Cross pollination accounts for around 90% of pollination. Cross-pollination across biotic species may occur over large distances. Bees, bats, birds, and flies are global pollinators because they can fly long distances.

Rules To Be Followed For Flower Pollination

The flow pollination mechanism of blooming plants was the inspiration for FPA. Multi-objective optimization has been added to FPA. The following four rules are employed for ease of use:

1. Pollen-carrying pollinators follow Lévy flights, hence global pollination processes include biotic and cross-pollination.

2. For local pollination, abiotic pollination and self-pollination are used.

3. Floral constancy is a reproduction chance proportional to the likeness of two flowers acquired by pollinators like insects.

4. The interaction or switching of local and global pollination can be governed by a switch probability p [0, 1], slightly tilted toward local pollination.

These guidelines must be turned into suitable equations to come up with the formulas..

2.3 Global Pollination

In the global pollination stage, pollinators such as insects deliver flower pollen gametes, and pollen may travel a long distance since insects can fly and move over a much greater area. As a result, the mathematical representation of rules (1) and flower constancy (3) is

$$X_{it}+1 = X_{it} + L(\beta)(X_{best} - X_{it})$$

where x_{it} is the pollen i or solution vector x_i at iteration t, and x_{best} at this iteration, the current best solution was discovered among all solutions.

L(β) is a step-size parameter that corresponds to the pollination strength, especially the Levy-flights-based step size. A Levy flight may be used to efficiently replicate insect behaviour since they can fly over long distances with varied distance steps.

$$L \sim ((\beta\Gamma(\lambda) \sin(\pi\beta/2)) / \pi) . 1/s1+\beta \quad (s >> s0 \quad >0)$$

This distribution is valid for big steps s > 0, where Γ(λ) is the usual gamma function. In theory, |s0| must be greater than 0, but in practice, s0 can be as low as 0.1.

2.4 Local Pollination

For local pollination, both Rule 2 and Rule 3 may be stated as $x_{it+1} = x_{it} + (x_{jt} - x_{kt})$, where x_{jt} and x_{kt} represent pollen from different blooms of the same plant species. This is similar to the flowery consistency of a small neighborhood. If is chosen from a uniform distribution in [0,1] this becomes a local random walk if x_{jt} and x_{kt} are from the same species or population**.**

STEPS INVOLVED IN FP ALGORITHM

The Flower Pollination Algorithm pseudo code is presented below.

Maximum f(x) goal, $x = (x_1, x_2, ..., x_d)$

Begin a population of n flowers/pollen gametes using random solutions.

Find the best solution among the original population x_{best}.

The probability of a switch is defined as p [0, 1].

while (t < MaxGeneration)

n = 1 for I (all n flowers in the population)

if rand p is true,

From a Levy distribution, create a (d-dimensional) step vector L.

Global pollination via $x_{it+1} = x_{it} + L(\beta)(x_{best} - x_{it})$

else

Draw ξ from a uniform distribution in [0,1]

Do local pollination via $x_{it+1} = xit + \xi(x_{jt} - x_{kt})$

end if

Evaluate new solutions

If new solutions are superior, the population should be updated.

end for

Find the current best solution x_{best}

end while`

Output the best solution found

Pollination of flowers may take place at many sizes, including local and international. However, nearby blossoms or flower patches in a close proximity Local flower pollen is more likely to fertilize them than pollen from further away. A proximity probability p or a switch probability (Rule 4) can be employed to alternate between widespread global pollination and intensive local pollination to imitate this characteristic. As a beginning point, a naïve value of p = 0.5 might be utilized. According to early parametric study, p = 0.8 could be better for most applications.

3. Result and Description

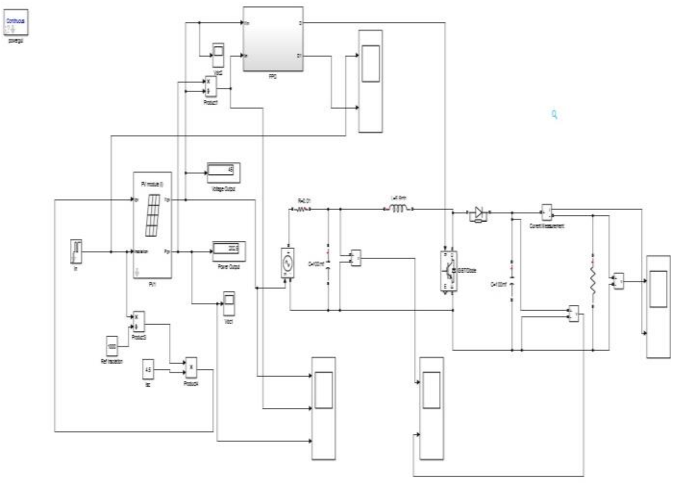

Figure.1. Simulation for Flower Pollination Algorithm

In this work, MPPT algorithm with flower pollination optimization (FPO) is presented for PV systems. The terminal voltage, current, and duty-cycle at which the DC/DC converter should be switched to achieve maximum power production are calculated. The work is carried out in Matlab / Simulink environment.

Solar Output

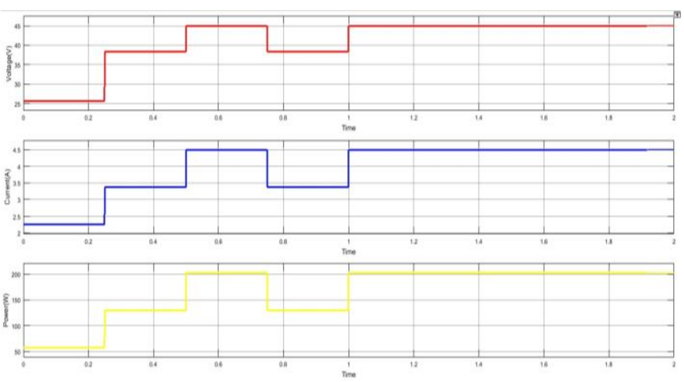

Figure 2. Solar PV voltage, current and power output

The output for the voltage, current and power for the solar PV is obtained.

Boost Converter Output

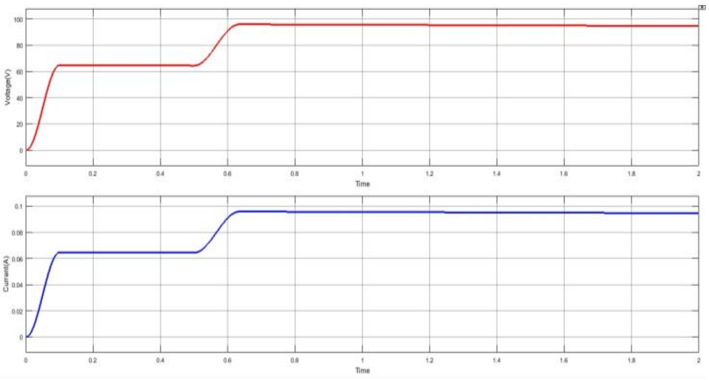

Figure.3. Boost converter voltage, current output

The output for the voltage and current of the boost converter is obtained.

Comparison Table For P&O Mppt And Fpa Mppt:

Table.1.Comparison table for P&O MPPT and FPA MPPT

	P&O based MPPT			FPA based MPPT		
Irradiance(W/m^2)	500	750	1000	500	750	1000
Duty cycle(D)	0.25	0.39	0.45	0.3	0.44	0.5
Voltage(V)	106	135	160	114	139	165
Current(A)	1.2	1.3	1.4	1.3	1.42	1.50
Power(W)	127	175	189	148	191	200

From the simulation results of voltage, current and power P&O MPPT and FPA MPPT for different irradiance shown in Table 5.1, it is concluded that, FPA based MPPT performs better when compared with P&O based MPPT.

4. Conclusion

FPA provides benefits such as simplicity and flexibility, and it is similar to CS and other algorithms using Levy flights in many aspects. FPA includes just two important parameters: p and a scaling factor, which makes the method easy to implement. However, the nonlinearity of Levy flights makes mathematical analysis challenging. FP algorithm requires less parameter to be adjusted, which simplifies the complexity of the method.

The FPA is unique in MPPT research since every iteration, the duty cycle is updated by cross or local pollination, resulting in speedy convergence and excellent accuracy.

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