Partial Shading Conditions for Photovoltaic System using MPPT Techniques

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Abstract—This paper introduces a most extreme power point following (MPPT) plan for a photovoltaic (PV) framework utilizing a grey wolf improvement (GWO) procedure, and shuffled frog leaping algorithm (SFLA). The GWO is another advancement strategy which conquers the constraints, for example, bringing down following productivity, enduring state motions, and drifters as experienced in annoy and watch (P&O) and enhanced PSO (IPSO) strategies. And also by using SFLA, this paper presents a novel approach using the shuffled frog leaping algorithm (SFLA) to determine the issue of following the global peak (GP) of a PV cluster under partial shading conditions (PSCs). The proposed plan is contemplated for a PV cluster under PSCs which displays various pinnacles and its following execution is contrasted and that of two MPPT calculations, in particular P&O-MPPT and IPSO-MPPT. The proposed GWO and SFLA MPPT calculation is actualized on a PV framework utilizing MATLAB/SIMULINK.

Index Terms—Grey wolf optimization (GWO), shuffled frog leaping algorithm (SFLA), maximum power point tracking (MPPT), partial shading conditions (PSCs), photovoltaic (PV).

1. INTRODUCTION

VARIOUS greatest power point following (MPPT) calculations were examined in writing [1] about the event of confounded non uniform insolation bringing about abatement in photovoltaic (PV) yield control, and the problem area created harms the PV cells. Since the flow of the PV framework under incomplete shading is time shifting, MPPT plan for PV control framework ought to be outfitted with elements, for example, following worldwide greatest power point (GMPP) at various conditions, e.g., shading, corruption of PV cell, and versatility to P–V qualities change in PV exhibit, smooth, and consistent following conduct. Various MPPT systems, for example, slope climbing (HC) [2], irritate and watch (P&O) [2]–[4], and incremental conductance (IC) [5] have been proposed for enhancing the Productivity of the PV framework. The HC technique utilizes an annoyance in the obligation proportion of the power converter and the P&O strategy utilizes an irritation in the working voltage of the PV framework [2]–[4]. Both these techniques yield motions at greatest power point (MPP) inferable from the way that the annoyance constantly changes in both headings to keep up the MPP bringing about power misfortune. The two impacting parameters in P&O calculation, to be specific irritation rate and bother size, are talked about in [4]. To lessen these motions and enhance the module effectiveness, the IC technique was proposed [5] which diminished the motions however not totally. Both P&O and IC techniques fizzle amid those time interims portrayed by changing environmental conditions [6], [7]. The concentration of the exploration here is to decide the worldwide pinnacle (GP) amid PSCs; with a specific end goal to reduce a portion of the issues like lower following productivity and motions created in the PV yield control, an option approach is to utilize transformative calculation (EA) systems, which has the capacity to deal with nonlinear target capacities. Metaheuristic improvement philosophies, for example, molecule swarm enhancement (PSO) [8], and firefly have
been widely utilized for different designing applications. As of late, Mirjalili have built up a metaheuristic calculation known as dim wolf streamlining (GWO).

This calculation is motivated by dark wolves to assault preys for chasing reason. Further, a few works are accounted for in writing on an option delicate processing strategy known as dark wolf enhancement which is pulling in significant interests from the examination group contrasted with other advancement systems since it is more vigorous and shows speedier joining. Besides, it requires less parameters for change and less administrators contrasted with other developmental methodologies, which is leeway when fast outline process is considered. After a careful writing overview, it is watched that GWO has not been abused for outlining a MPPT. Subsequently, this work endeavors to abuse the GWO for planning a MPPT to get productive following execution under PSCs. This paper is sorted out as takes after. Segment II portrays about the attributes of the PV framework under PSCs and the framework depiction demonstrating I–V and P–V bends of incompletely shaded modules. Segment III depicts the proposed GWO-based MPPT calculation to track the GP and Sections IV exhibits the reenactment and exploratory outcomes. At last, conclusion is given in Section V.

II. GWO AND ITS APPLICATION IN MPPT DESIGN

A. Grey Wolf Optimization

The GWO algorithm imitates the leadership hierarchy and hunting mechanism of grey wolves in nature. Grey wolves are considered to be at the top of food chain and they prefer to live in a pack.
Four types of dark wolves, for example, alpha (α), beta (β), delta (δ), and omega (ω) are utilized for mimicking the administration chain of command. So as to numerically display the social pecking order of wolves while planning GWO, we consider the fittest arrangement as the alpha (α). Therefore, the second and third best arrangements are named as beta (β) and delta (δ), individually. Whatever is left of the hopeful arrangements are thought to be omega (ω). three principle ventures of GWO calculation, to be specific chasing, pursuing,

Fig. 2. 2S2P configuration under different shading patterns. (a) Pattern 3. (b) Pattern 4. (c) P–V curves under PSCs.

Fig. 3. Hunting behavior of grey wolves: (a)–(c) chasing and tracking prey; (d) Encircling prey; and (e) attacking prey.
furthermore, following for prey, enclosing prey, and assaulting prey which are executed to outline GWO for performing improvement. Dim wolves surround a prey amid the chase and the enclosing conduct can be demonstrated by the accompanying conditions:
\[
\mathbf{r}_t = [\mathbf{c}_t \cdot \mathbf{X}_p(t) - \mathbf{X}_p(t)] \\
\mathbf{X}(t+1) = \mathbf{X}_p(t) - \mathbf{A} \cdot \mathbf{D}
\]
where \( t \) signifies the present cycle, \( \mathbf{D} \), \( \mathbf{A} \), and \( \mathbf{C} \) mean coefficient vectors, \( \mathbf{X}_p \) is the position vector of the prey, and \( \mathbf{X} \) shows the position vector of dim wolf. The vectors \( \mathbf{A} \) and \( \mathbf{C} \) are calculated as follows:
\[
\mathbf{A} = 2\mathbf{r}_1 - \mathbf{r}_2 \\
\mathbf{C} = 2\mathbf{r}_2
\]
Where segments of a straightly diminishes from 2 to 0 over the span of cycles and \( r_1 \), \( r_2 \) are arbitrary vectors in \([0, 1]\). The chase is typically guided by alpha called pioneers taken after by beta and delta which may likewise take an interest in chasing infrequently. Delta and omega deal with the injured deceivers. In this manner, we allude alpha as the applicant arrangement having better information about the area of prey. The dark wolves complete the chase by assaulting the prey when it quits moving.

B. Application of GWO for MPP Tracking
Fig. 4 demonstrates the piece chart of the proposed MPPT conspire for the PV framework. For number of dim wolves, i.e., obligation proportions, the controller measures \( V_{pv} \) and \( I_{pv} \) through sensors and processes the yield control. The flowchart of the proposed GWO-based MPPT calculation is appeared in Fig. 5.

Amid halfway shading, the P–V bend is arranged by different pinnacles having different nearby pinnacles (LPs) and one GP. It is to note that when the wolves discover the MPP, their associated coefficient vectors turn out to be about equivalent to zero. In the proposed strategy, an endeavor has been made to join GWO with direct obligation cycle control, i.e., at the MPP, obligation cycle is managed at a consistent esteem which thusly lessens the relentless state motions that exist in traditional MPPT methods and ultimately, the power misfortune because of wavering is decreased bringing about higher framework effectiveness. To actualize the GWO-based MPPT, obligation

![Fig. 4. Block diagram of the proposed MPPT method.](image)

Cycle \( D \) is defined as a grey wolf. Therefore, (3) can be modified as follows:
\[
D_t(k +1) = D_t(k) - \mathbf{A} \cdot \mathbf{D}.
\]
Thus, the fitness function of the GWO algorithm is formulated as
\[
P(d^t) > P(d^{t-1})
\]
Where \( P \) represents power, \( d \) is duty cycle, \( t \) is the number of current grey wolves, and \( k \) is the number of iterations.
Fig 5. Flow chart of the proposed algorithm
III. SFLA

The populace in the SFLA, all in all, comprises of an arrangement of frogs that is subdivided into various gatherings alluded to as memeplexes which have diverse societies of frogs. Each memeplex plays out a neighborhood look. The individual frogs inside Eachmemeplex hold thoughts that are affected by the thoughts of different frogs and create amid a memetic advancement handle. The memetic calculation depends basically on the standard of 'survival of the hereditarily fittest and generally experienced'. After a characterized number of memetic advancement steps, thoughts are transmitted between memeplexes in a rearranging procedure. Both of the neighborhood hunt and rearranging process proceeds until the required union criteria are accomplished. The flowchart of the SFLA approach is appeared in Fig. 6.

In the wake of making the wellness work, the number of inhabitants in P frogs is at first delivered in arbitrary positions inside the pursuit space. In the SFLA, the frog position is the hopeful arrangement. Each frog is corresponded with a position vector, \( X_i = [x_{i1}, x_{i2}, \ldots, x_{iN}] \), where \( N \) is the quantity of outline factors. The frogs are sorted in a dropping request as per their wellness. At that point, the entire populace is separated into \( m \) memeplexes, each including \( n \) frogs (\( P = m \times n \)). In the key association of this procedure, the primary frog goes to the principal memeplex, the second frog goes to the second memeplex, frog \( m \) goes to the \( m \)th memeplex, frog \( m + 1 \) backpedals to the main memeplex, etc. In each memeplex, the frogs position with the best and most exceedingly bad finesses are spoken to as \( X_b \) and \( X_w \), separately. Besides, the frog position with the worldwide best wellness is recognized as \( X_g \). At that point, in each memeplex, a specific procedure like the PSO approach is connected to upgrade just the frog with the most exceedingly terrible wellness. Along these lines, the position of the frog with the most exceedingly terrible wellness can be refreshed as takes after:

\[
D_{i1} = \text{random} \times (X_b - X_w) \quad \ldots \ldots \quad (8)
\]

\[
X_{\text{new}}^w = X_{\text{old}}^w + D_i \quad (D_{i \text{min}} \leq D_i \leq D_{i \text{max}}) \quad \ldots \ldots \quad (9)
\]

Where \( D_i \) is the change of the frog position; \( \text{Rand} \) is a random Number between 0 and 1; and \( D_{i \text{min}} \) and \( D_{i \text{max}} \) are the minimum and maximum step sizes allow for the frog position, respectively. If this process leads to a better solution, it will replace the worst frog. Otherwise, the calculations of equations (8) and (9) are repeated, but in this case \( X_b \) is replaced by \( X_g \). If no improvement takes place, a new solution will be randomly produced to replace that frog. Then, the calculations continue for a specific number of iterations.
Fig. 6 flow chart of SFLA
IV. SIMULATION STUDY CASE

For number of grey wolves, i.e., duty ratios, the controller measures $V_{pv}$ and $I_{pv}$ through sensors and computes the output power. During partial shading, the $P-V$ curve is categorized by multiple peaks having various local peaks (LPs) and one GP. In the proposed method, an attempt has been made to combine GWO with direct duty-cycle control, i.e., at the MPP, duty cycle is sustained at a constant value which in turn reduces the steady-state oscillations that exist in conventional MPPT techniques and lastly, the power loss due to oscillation is reduced resulting in higher system efficiency. To implement the GWO-based MPPT

![Tracking Curves Of Proposed MPPT](image)

**Fig. 7** shows the Simulation of the proposed MPPT scheme for the PV system.
TABLE I: QUALITATIVE COMPARISON OF THE PROPOSED WITH OTHER FAST-CONVERGING MPPT TECHNIQUES

<table>
<thead>
<tr>
<th>Type</th>
<th>P&amp;O</th>
<th>IPSO</th>
<th>[9]</th>
<th>[13]</th>
<th>Proposed</th>
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<tr>
<td>Tracking speed</td>
<td>Slow</td>
<td>Medium</td>
<td>Fast</td>
<td>Fast</td>
<td>Very fast</td>
</tr>
<tr>
<td>Transient power fluctuation</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Tracking accuracy</td>
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<td>Accurate</td>
<td>Highly accurate</td>
<td>Highly accurate</td>
<td>Highly accurate</td>
</tr>
<tr>
<td>Convergence to GP</td>
<td>Tracks which comes in contact first (LP or GP)</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of tuning parameters</td>
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<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
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<td>Zero</td>
<td>Zero</td>
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<tr>
<td>Power efficiency</td>
<td>High (uniform insolation) low (PSCs)</td>
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<td>High</td>
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</tr>
<tr>
<td>Implementation complexity</td>
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<td>Medium</td>
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<tr>
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</table>

VII. CONCLUSION

This paper proposed another transformative registering approach called dark wolf advancement to outline a most extreme power extraction calculation for PV frameworks to work under PSCs. In perspective of evaluating the adequacy of this new MPPT (greywolf-based MPPT), its execution was contrasted and two existing MPPTs, in particular P&O and IPSO-based MPPT techniques and from the got comes about, it was discovered that the GWO-based MPPT shows better execution looked at than other two MPPTs.

REFERENCES