Effective Battle Royale Algorithm For MPPT Tracking Of PV System Under Partial Shading Condition Integrating With LF-HVAC System

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Abstract
As of late, a few memetic streamlining approaches have been created for tackling numerous unpredictable issues in different regions. The vast majority of these improvement calculations are propelled naturally or the social conduct of certain creatures instead of some games. This proposed algorithm is inspired from a famous game Battle Royale which is also based on population algorithm which has been implemented in MPPT tracking of PV Array cells. Several other algorithms have been compared with this proposed algorithm in PV Array to find its accuracy of results and efficiency increaser of circuit and also best convergence with DGs integrated in it. The proposed system has been connected to Low frequency HVAC system for checking stability of system with proposed algorithm. The proposed algorithm is implemented in MATLAB / SIMULINK Environment

Keywords: Battle Royale Optimization, PSO optimization, Cuckoo optimization, LF-HVAC, Array

1. Introduction
The high investment cost of photovoltaic (PV) panels formerly hampered the use of solar energy. However, in recent years, substantial reductions in the manufacture and installation costs of PV panels have sparked a trend of large-scale PV system installation in many nations across the world, in addition to solar energy farming through rooftop PV panel systems. In particular, a distributed

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maximum power point tracking architecture must be used in urban areas in which the photovoltaic sources control increases energy production in relation to a centralized MPPT and gives extra protective features, notably in the case of fire and diagnostics. In comparison to the centralized MPPT the benefit of solutions based on MPPT distributed with dc/dc is around 5 %. The MPPT function of each PV source control is supported by a dc/dc converter. Many aspects influence the overall performance of the system, but the presence of shadowing phenomena influencing the PV generators, the dc/dc converters' allowed conversion ratios, and the inverter's dc bus voltage control are the most important.

People have known since the dawn of time that handling a problem with numerous options is nothing more than selecting the solution with the most positive and least negative effects. Optimization is the process of determining the "optimal" solution. The transition between the actual issue and its mathematical model is one of the most difficult aspects of using optimization approaches. Mathematical equations can't adequately explain any natural occurrence or practical scenario. This is due to the fact that each model has a set of limitations and assumptions that do not apply to genuine systems. As a result, using mathematical models to simulate natural systems must be done with considerable caution.

One of the primary benefits of the series connection is that each converter only needs to withstand a portion of the dc bus voltage at its output, eliminating the need for a HV boost ratio and allowing the use of simple and efficient converters.

A number of global search methods for MPP tracking were suggested for the treatment of non-uniform irradiation. They are based on teaching, learning-based optimization, genetic algorithm, PSO, Cuckoo, Swarm, Monkey, Ant Colony optimization and conventionally and artificially hybrid and conventionally and meta-heuristically optimized hybrid ways[1-6].

Partial shading is a common yet challenging challenge in the installation of a PV system. A partial shading problem is unavoidable, especially with a big PV system. Because of overshadowing induced by clouds or surrounding objects, PV arrays struggle to maintain uniform solar irradiation. When a PV cell is shaded, the current is limited and the power provided by the entire PV panel is greatly reduced.

The HVAC system has different frequencies all over the world so to normalize different frequency many converters are used. Previously Cycloconverter had been used for changing frequencies but now a days Back to back converters have been used for doing the same conversion. With integration of renewable sources make it more complex so to visualize it outcomes many algorithms have been used for MPPT with different cases.

While many optimization algorithms are motivated by the ways in which the game strategy has been developed, society, culture, politics, humanity, and so on. A novel Battle Royale Optimization (BRO) method is suggested in this work. The approach presented is influenced by the royal video games strategy. BRO is also a population based company like other previous swarm-based techniques; it employs a population of potential solutions to find the optimal answer. Every
solution is termed a soldier who tries to overthrow his nearest neighbour. A soldier better situated can thus beat other soldiers. Therefore, everyone tries to shift to a better location to have a greater chance of surviving. The best soldier will be the winner at the conclusion of the iteration[10-19]

1.1. Related Works

The Genetic Algorithm (GA) is one of the most commonly used and oldest evolutionary optimization algorithms, based on simulations of reproductive processes and Darwin's theory of evolution. Chromosome alterations occur in the GA during the reproductive process. A selection operator identifies the parents' chromosomes, which are subsequently randomly exchanged in a process known as crossover. As a result, children acquire some of their father's qualities and some of their mother's traits and features. Mutation is an uncommon phenomenon that produces changes in the properties of living organisms.[15-20]

Particle Swarm Optimization (PSO) is a well-known and frequently used optimization approach based on the natural behaviors of birds and their interactions. Each member of the population's location is updated at any point in time in PSO due to three factors.[10-22]

The Gravitational Search Method (GSA) is a physics-based optimization algorithm that works by simulating the gravitational attraction between two objects. Members of the population in the GSA are objects that are separated from one another in the problem-solving area. The gravitational pull attracts things that are in a better location in the search space.

The Whale Optimization Method (WOA) is a nature-inspired meta-heuristic optimization algorithm that is inspired by humpback whale social behavior. The bubble-net hunting technique is reproduced in the WOA in three stages: surrounding prey, spiral bubble net feeding maneuver, and prey search.

2. PV Array and Partial shading

PV modules are made by connecting a specified number of PV cells in a serial fashion. PV modules are linked in series to attain greater voltage levels, and the PV array is constructed. Each PV module in a PV array has a bypass diode linked in parallel to itself. The PV array in this research is made up of four parallel-connected PV modules, each of which has twenty-one PV cells linked in series.
Fig. 1. PV cell structure

\[ I = I_L - I_D - I_{SH} \]  \hspace{1cm} (1)

\[ V_j = V + IR_S \]  \hspace{1cm} (2)

\[ I_D = I_0 \left\{ \exp \left[ \frac{V_j}{nVT} \right] - 1 \right\} \]  \hspace{1cm} (3)

Where \( I_0 \), reverse saturation current (ampere) \( n \), diode ideality factor (1 for an ideal diode) \( q \), elementary charge \( k \), Boltzmann's constant \( T \), absolute temperature \( \text{V}_{\text{T}} = kT/q \), the thermal voltage. At 25 °C, \( V \approx 0.0259 \text{volt} \).

Partial shading has a significant impact on a PV module's output power, it's critical to assess the module's performance under these circumstances. Bypass diodes are usually used to decrease losses caused by partial shading. However, because the bypass diode can assist save the operation of the unshaded solar cells while also introducing another power peak in the lower voltage area under partial shading situations, the module behavior will become more complicated. As a result, predicting the highest power point when partial shade is present is critical.
When the PV array is partially shaded, the unshaded modules receive a specific amount of solar irradiation, while the shaded modules receive less. The shading factor and number of shaded modules define the partial shading working state. In this article, the shade factor is defined as the irradiation ratio comparing colored modules to unshaded modules. All modules are expected to function at the same temperature. The temperature differential between shaded and unshaded modules is unlikely to be significant when partial shading is used.
This section will discuss BRO's inspiration in order to better understand the suggested technique. Some battle royale games start with people jumping off a cliff. Jump out of an aircraft and land on the map. Moreover, similar to BRO, like other swarm-based algorithms, starts with a random number. Population, which will be evenly dispersed across the country the issue domain after then, each person (soldier/player) is evaluated. Attempts to harm a nearby soldier by firing a weapon. As a result, soldiers in superior locations inflict harm on their opponents. Next-door neighbors when one soldier is injured by another, it causes a chain reaction. The damage level rises by one. These interactions are determined using the formula $y_i^{*\text{damg}} = y_i^{*\text{damg}} + 1$, where $y_i^{*\text{damg}}$ is the damage level of the population's $i_{th}$ soldier. Furthermore, soldiers seek to change positions as soon as they are damaged, allowing them to assault opponents from a different direction. As a result, in order to concentrate on exploitation, the injured soldier shifts to a place halfway between the prior position and the best position discovered thus far (elite player). These interactions are determined theoretically as follows:

$$y_{\text{damg},d} = y_{\text{damg},d} + r(y_{\text{best},d} - y_{\text{damg},d})$$

$Y_{\text{damg},d}$ is the position of the injured soldier in dimension $d$, and $r$ is a randomly generated value evenly distributed in the range $[0,1]$. Furthermore, $y_i^{*\text{damg}}$ will be reset to zero if injured troops may injure their opponent in the following iteration. In order to keep the focus on exploration, if a soldier's damage level exceeds a predetermined threshold number, the soldier dies and respawns at random from the viable problem space, with $y_i^{*\text{damg}}$ reset to zero. We discovered that a threshold value of 3 was appropriate after much trial and error. This operation prevents early convergence and allows for further exploration. After being slain, a soldier returns to the problem space as follows:
\[ y_{\text{damg},d} = r(\text{ub}_d - \text{lb}_d) + \text{lb}_d \]

Where the lower and upper limits of dimension \( d \) in problem space are \( \text{lb}_d \) and \( \text{ub}_d \), respectively. Furthermore, the problem's viable search space is expanded by \( D \) iterations begins to condense down to the most optimal answer. The \( D = \log_{10}(\text{MaxCicle}) \) was the initial value, and \( D = D + \text{round} \left( \frac{D}{2} \right) \). \( \text{MaxCicle} \) is the maximum number of cycles of successive generations.

Exploration and exploitation are both aided by this relationship. As a result, the lower and upper bounds will be adjusted in the following manner.

\[
\begin{align*}
\text{lb}_d &= y_{\text{best},d} - \text{SD}(\bar{x}_d) \\
\text{ub}_d &= y_{\text{best},d} + \text{SD}(\bar{x}_d)
\end{align*}
\]

The standard deviation of the entire population in dimension \( d \) is \( \text{SD}(\bar{x}_d) \), and the location of the best solution discovered so far is \( y_{\text{best},d} \). As a result, if the \( \text{lb}_d/\text{ub}_d \) is greater than the initial lower/upper bound, it returns to the original \( \text{lb}_d/\text{ub}_d \). Furthermore, in order to emphasize elitism, each iteration's greatest player/soldier is retained and designated an elite.

The computational cost of the suggested technique is determined by the population size and the maximum number of iterations, in addition to the issue dimensions. Given the population size \( n \), the complexity of calculating for all solutions is \( O(n^3) \) since each answer must be compared to all others in order to determine its Euclidean distance from all other solutions. As a result, the computational complexity of BRO is \( O(n^3) \) when \( m \) is the number of iterations.
START

Set all parameters and initialize Population

Match $i$th soldier with nearest one ($j_a$)

$\text{dam} =$ index of damaged soldier

$\text{vic} =$ index of victorious soldier

if ($\text{y}_{\text{damg}} \cdot \text{damage} <$ Threshold)

Relocate $\text{y}_{\text{damg}}$ based on Eq. (1)

$\text{y}_{\text{damg}} \cdot \text{damage} = \text{y}_{\text{damg}} \cdot \text{damage} + 1$

$\text{Relocate } \text{y}_{\text{damg}}$ based on Eq. (2)

$\text{y}_{\text{damg}} \cdot \text{damage} = 0$

$\text{y}_{\text{vic}} \cdot \text{damage} = 0$

update ($f(\text{y}_{\text{damg}})$)

Shrink down problem space based on Eq. (3)

Termination criterion is met

Select the best soldier as the solution

END

Fig. 5. BRO Algorithm
5. Simulation Results and Discussions

In this paper, simulations are implemented in MATLAB 2020a. The TP250MBZ PV cell module has been used for modelling, simulation of model of the PV system with the proposed MPPT technique. The major parameters for the converter (boost) circuit are: C1 = 10 μF, C2 = 47 μF, L = 0.1 mH, f = 50 Hz, and R = 53 Ω. Table 2 represents the major parameters of PSO, Cuckoo and BRO algorithms. The sampling interval for the MPPT controller is chosen as 0.27 s.

TABLE 1 PARAMETERS OF OPTIMIZATION ALGORITHM

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PSO</th>
<th>Cuckoo</th>
<th>BRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>population</td>
<td>100</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>Maximum Iteration</td>
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<td>300</td>
<td>300</td>
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<td>C1max, min</td>
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<td>-</td>
</tr>
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<td>C2max.min</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>[10, 500]</td>
<td>[0-1]</td>
</tr>
<tr>
<td>No of nests</td>
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<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Step size</td>
<td>0.01</td>
<td>0.01</td>
<td>-</td>
</tr>
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</table>

The proposed algorithm BRO is compared with PSO & Cuckoo algorithm of optimization for MPPT tracking to get best results. Table 1 shows the parameters of different algorithms taken for optimization to get maximum power under partial shading conditions. From Fig. 6. We can see the...
Duty cycle of BRO algorithm which converges more fastly than other algorithms. So we can conclude the BRO algorithm gives the best MPPT Tracking than PSO and Cuckoo-based algorithms. From Fig. 7. The power output of PV array connected with LFHVAC system with proposed algorithm and comparison have been shown. Fig. 8. Shows the overall efficiency of the system in terms of power output with the proposed and other algorithms.
5.1. Experimental Results

Fig. 6. (a) Duty cycle of BRO Algorithm (b) Duty Cycle of Cuckoo Algorithm (c) Duty Cycle of PSO
6. Conclusions

The proposed BRO algorithm for MPPT tracking with Partial shading gives the best results among the other MPPT techniques. On 19 benchmark test functions, BRO and the other algorithms were tested. As previously stated, the effectiveness of metaheuristic techniques is contingent on a balance between exploitation and exploration. The players' deaths force them to flee from the local optima, and their respawn in a random location prompts them to explore. Moving the players toward the greatest player while narrowing the problem space, on the other hand, has resulted in exploitation. Based on the numerical data and analyses shown above, BRO exceeds all other algorithms in terms of accuracy convergence rate. The integration of LF-HVac system with proposed controller makes the new system and stable system with better power outcomes and less voltage fluctuations.
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References


