An Adaptive PSO-Based Approach for Optimal Energy Harvesting in PV Systems

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Motivation
Energy harvesting for PV systems must be done efficiently, accurately and fast under continuous and sometimes rapid changes in ambient environmental conditions like irradiation and temperature fluctuations. There exist a number of methods for energy harvesting of PV systems in literatures. Amongst the widely used methods is maximum power point tracking (MPPT). Two important issues in energy harvesting are efficiency and speed of the implemented method.

Research Goal
A PSO-SG (particle swarm optimization - subgradient) MPPT algorithm is proposed in this study, which is shown to work accurately and fast. This PSO-based algorithm shortens the MPP tracking time by using the sub-gradient method to update the algorithm parameters at each iteration.

Sub-gradient method
For a convex function of \( f : \mathbb{R}^n \to \mathbb{R} \) to find the maximum point of \( f \), the following iterative algorithm is used:

\[
x^{k+1} = x^k - \beta_k \delta_k
\]

where \( x^k \) is the \( k \)th iterate, \( \delta_k \) is sub-gradient of \( f \) at \( x^k \), and \( \beta_k \geq 0 \) is the \( k \)th sub-gradient step size.

\[
\beta_k \geq 0, \lim_{k \to \infty} \beta_k = 0
\]

Regarding the sub-gradient method:

\[
\forall k \in \mathbb{N}, k = k_{\max} = \max\{f(x^{k-1} - f(x^{k}))\}
\]

The performance of PSO-based MPPT methods depends on the following factors: (i) the number of particles used, (ii) tuning of the design parameters, \( \omega \), \( c_1 \) and \( c_2 \), and (iii) sampling time (Tsamp), which is calculated considering the system model and settling time.

Results
Static-

- Three possible case studies (three different partial shading patterns) are shown in Figure (1) global maximum (GM) is located in three different places. PV outputs and updating inertia weights are shown in Figure(2) and Figure(3) respectively. Results shows that in all three cases the MPPT algorithm track the GM and does not stick at local maximum.

Dynamic-

- A trapezoidal irradiance is used to simulate a dynamic irradiation variation. Figure (4) b shows PV outputs while the proposed method is used under the dynamic irradiance variation. It shows tracking is fast and accurate in dynamic irradiation variation.

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