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An Advanced Solar Tracking System with Computational Optimization

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Abstract. The carbon-emitting fuel reduction leads us to Solar power and its possible way of maximum availability. Solar energy is one of the most copious energy resources in nature. This can be received using receptors and converted into electrical energy by photovoltaic cells. The receiving method of energy is an important phase and it should be one of the best efficient methods. This paper follows the Sun positioning algorithm to get the exact location of the Sun over a period of years. In this system, the tracker movement mechanisms are controlled by PID controllers with an advanced, optimized chimp optimization algorithm.

Keywords: Renewable energy, Solar tracking system (STS), Optimization, PID tuning, Computation.

1. Introduction

The continued use of fossil fuels and the increased impacts of climate change caused by traditional energy resources have elevated interest in exploiting sources of Solar energy, this can respond to present global energy needs and integrate several benefits [1].In the case of an integrated energy system, the difference between energy consumption and power generation leads to many problems like grid stability [2], Solar system has the advantage of being able to be installed on a small scale, allowing them to use for both heat and electrical energy production in many buildings [3]. It's worth noting that advanced areas (geothermal, wind, hydro, and solar power) have been made for renewable energy sources, even in high fuel stocks. The contribution to the global renewable energy model is the most rapid one in growth [4]. The photovoltaic module is a type of energy collector which converts sunbeam into electrical energy [5].

PV cells have been utilized to control little gadgets or can be wired together to make sun-oriented panels for bigger loads. The panels may connect to make a large-scale solar power generation [6]. The ideal point for a sun-powered con trol framework depends on the scope of the location and the reason for which the PV must be utilized [7].

Sun-powered following frameworks are categorized into five sorts of concurring as per the advances, specifically, manual following, detached following, semi-passive following, chronological following, and dynamic following [8]. The major problem with solar energy lies in its diluted nature. Even in the world's hottest places, available

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solar radiation flux seldom reaches 2 Praveen P N and Dr. D Menaka

1 kW/m, which is insufficient for technological use [9].To reach the maximum capacity of the system, a proper optimization approach with flawless precision and fast convergence are required[10]. It would be good enough,if PV modules made up of solar cells that can deliver good performance also incorporates with it. To get the best results, each solar cell must be precisely designed[11]. For ideal control point following and subsequently most extreme control extraction from sun-oriented photovoltaic frameworks, a basic and viable control using the dc-dc converter is utilized [12]. In this case, the panel exhibits the non-linear current voltage characteristics with maximum power point tracking (MPPT) and results in problematic solar output because energy consumption is a time-variant one [13] [14]. The system here will convert the incident energy at its maximum ef ficiency and the PID controller will help to track the Sun path based on the optimization algorithm.

2. Sun Position Algorithm

There are various methods/algorithms to find out the solar positioning such as Astronomical Almanacs (AA) [13], Position Solar Algorithm (PSA) [14], Solar Positioning Algorithm (SPA) [15], etc.

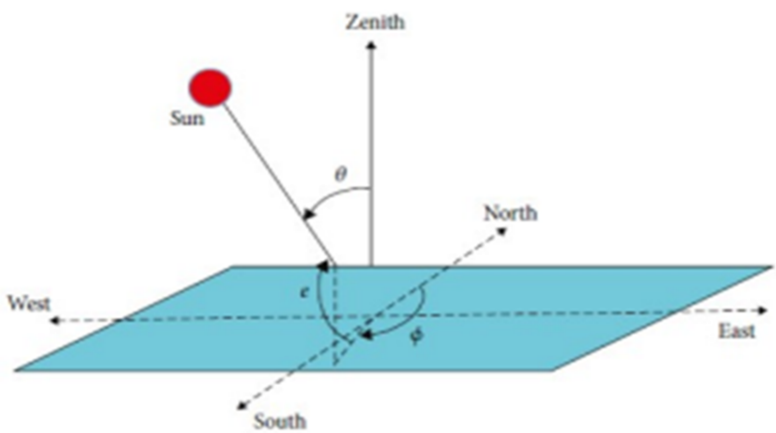

Figure 1. Parameters of Solar position algorithm

The characteristics connected with the measurement of the Sun's location are shown in Figure 1. The rising angle (e) is calculated, using one of the expressions. An advanced Solar tracking system with computational optimization 3 underneath (depending on the calculation, for illustration, eSPA is the rise point calculated utilizing the SPA calculation, eAA [14] is the height point calculated utilizing the AA calculation, and e ENEA is the rise point calculated utilizing the Roberto Grenas Energy and Sustainable Economic Development algorithm (ENEA), which is more exact to measure the sun based position than the sensor based sun based positioning framework.

$$eAA = asin(sin\psi sin\delta_t + cos\psi cos\delta cosh_a) \quad (1)$$

This paper follows the method, AA algorithm (Astronomical Almanac's algo rithm) to find solar positioning because this is the most efficient method, which provides the exact position of the Sun from the year 1950 to 2050. Moreover, the azimuthal angle can also be calculated using the AA algorithm.

3. Implementation PID Controller

To get constant and sustained output from a photovoltaic cell, need to implement an algorithm for the tracking of the panel. The parallel processing of signals will provide faster accuracy in tracking. That is the signal obtained by comparing the input of the cell and the YAW (rate of change of the heading point when the panel is horizontal. It is commonly measured in degrees per second or radians per second) signals from the reference given by AA algorithm. This gives the precise and perfect values for controller inputs. Now the present system will work smoothly but the convergence time to stability and efficiency is more. The Implementation can be done as below.

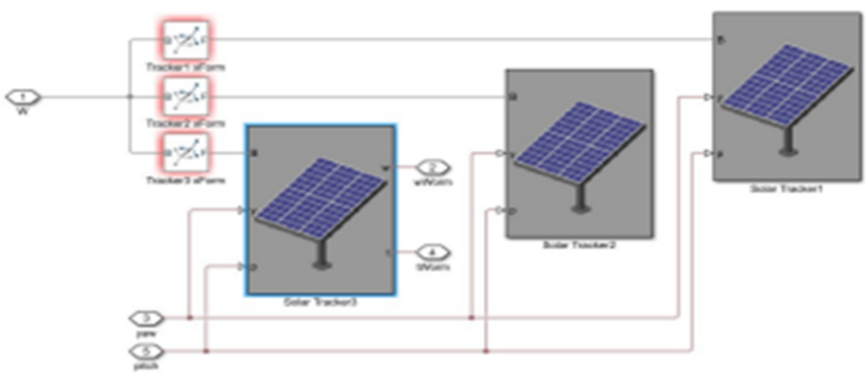

Figure 2. Implementation of PID in solar tracker

4. Implementation of Chimp Optimization algorithm as computational algorithm

In general, the starting population for all evolutionary algorithms is produced at random, and in following iterations, they gradually find the best solution and re sult at the predefined condition. The gaps between these initial estimations and the best solution affect the algorithms' convergence time. It focalizes rapidly in the case the introductory arrangement is near to the ideal arrangement, some thing else; it takes a longer time to merge. Opposition-based learning (OBL) [15] is one of the foremost efficient techniques for progressing the primary arrange ment by dissecting the current candidate arrangement. At the same time,Its inverse solution which selects the one, that's best suited to the past. The es sential principle is that each anticipated answer is 0.5 times farther away from the real solution than its inverse solution, according to probability theory. The method is important not only for the initial population but for improving the ultimate result also with each repetition. In an optimization problem, the con cept of OBL is based on evaluating both the present candidate solution and its inverse solution at the same time.

5. Mathematical modeling in computational algorithm

This algorithm contains mathematical modeling methods of a self-contained group or grouping, driving, blocking, chasing, and assaulting. The ChO algo rithm that corresponds is then provided.

Driving and chasing the prey The prey is getting hunted during two phases, one is in exploration and another is in exploitation phase. The Equations (2) and (3) are proposed for the mathematical modeling of driving and chasing the prey.

$$d = | c.x_{prey}(t) - m.x_{chimp}(t) \tag{2}$$

$$x_{chimp}(t+1) = x_{prey}(t) - a.d \tag{3}$$

The t denotes the present iteration number, a, m, and c denote the coefficient vectors, Xprey denotes the prey location vector, and Xchimp denotes the vector of chimp position. The Equations calculate a, m, and c vectors. (4), (5), and (6), respectively.

$$a = 2.f.r_1 - f \tag{4}$$

$$c = 2.r_2 \tag{5}$$

$$m = chaoic\ \underline{v}alue \tag{6}$$

Through the iteration process, f is reduced non-linearly from 2.5 to 0. This idea can be used for n-dimensional search space. The chimps, as described in the preceding section, use a chaotic technique to attack their victim. In the following part, this approach is mathematically formulated.

An advanced Solar tracking system with computational optimization 5 Attacking method (exploitation phase) Two ways have been formulated to scientifically show chimp assaulting conduct: The chimps can identify the po sition of the prey before encompassing it. Attacker chimps are normally hunters. Driver, barrier, and chaser chimps are all involved in the hunting procedure on occasion. As a result, four of the leading arrangements so distant are spared, and other chimps are pushed to adjust their positions in agreement with the most excellent chimps' arrangements. The equations are utilized to specify this relationship. (7) - (9)

$$d_{Attacker} = | c_1 x_{Attacker} - m_1 x |,\ d_{Barrier} = | c_2 x_{Barrier} - m_2 x |,\ d_{Chaser} = | c_3 x_{Chaser} - m_3 x |,\ d_{Driver} = | c_4 x_{Driver} - m_4 x |. \tag{7}$$

$$x_1 = x_{Attacker} - a_1(d_{Attacker}),\ x_2 = x_{Barrier} - a_2(d_{Barrier}),\ x_3 = x_{Chaser} - a_3(d_{Chaser}),\ x_4 = x_{Driver} - a_4(d_{Driver}). \tag{8}$$

$$x(t+1) = x_1 + x_2 + x_3 + x_4 \tag{9}$$

The prey area is assessed by four of the finest bunches, whereas other chimps within the range overhaul their positions at random.

Prey attacking (utilization) Prey attacking is the third stage as already expressed, the chimps will assault the implore within the last arrange and con clusion the chase before long as the prey stops moving. The esteem of fought can be reduced to show the assaulting process mathematically. This variation range will be brought down by f. In other words, the chance of an irregular variable within the extend [2f, 2f], though f diminishes from 2.5 to throughout the course of reiterations. When the irregular values lie within the extent [1, 1], a chimp's other position can be anyplace between its current position and the prey's position. ChOA permits the chimps to overhaul their area based on the positions of the attacker, barrier, chaser, and driving chimps and attack the prey, concurring with the administrators who have as of now been given.

Searching for Prey (exploration) As stated before, the chimps' exploration procedure is initially based on the location of the categories of chimps. The chimps will be divided into groups for haunting the prey. This divergence be havior can be shown by the inequality $| a |> 1$ as per this algorithm. This causes the chimps to scatter around the surroundings in search of better prey. This part was influenced by GWO [16-17].

The value of the c vector is another ChOA factor that influences the exploration part. The 'c' vector members are arbitrary variables in the interval [0, 2], as in Eq. (4). This component assigns random weights to prey to enhance ($c > 1$) or suppress ($c < 1$) the impact of the prey area in deciding the distance in Eq (5).

It also helps ChOA in moving forward with its stochastic behavior during the optimization process and diminishing the chance of nearby minima catching. This makes the chimp's position, making the hunt harder or easier.

Social incentive (sexual motivation) As stated before, chimps leave their hunting tasks after securing meet and consequent social inspiration (sex and preparation) within the final organize. As a result, they endeavor to accumulate meet randomly. This section explains the chaotic maps that were utilized to increase the performance of ChOA. The chaotic model updates the position of chimps during the optimization process and has a 50% chance. Equation (10) expresses the mathematical model.

$$x_{chimp}(t+1) = \begin{cases} x_{Prey}(t) - a.d & if\ \mu < 0.5 \\ Choatic\_value & if\ \mu \geq 0.5 \end{cases} \tag{10}$$

Where μ is an arbitrary number in [0, 1].

In a nutshell, the look in ChOA starts with the creation of an irregular populace of chimps (candidate Arrangements) and this optimization fine-tunes the controller parameters in the panel controller.

6. Results and Discussion

Fig 3 shows the Solar Analemma, which represents the variation of intensity of light fall at a specific time (10:00AM 45 degree latitude).

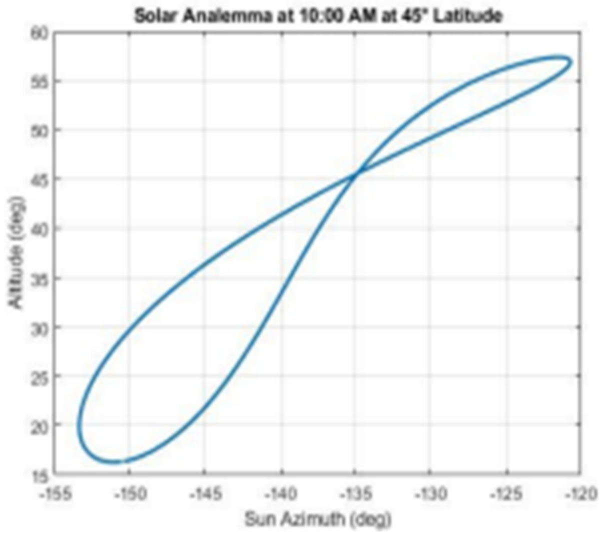

Figure 3. Solar Analemma

Fig 4 shows the total path moved by the Sun over the globe at a particular time.

Fig 5. Will give the exact performance curve of the controller optimization and tracking efficiency in due course of movement of the panel. The analysis gives an advanced Solar tracking system with computational optimization 7 the accurate value of solar tracking and optimized tuning value.

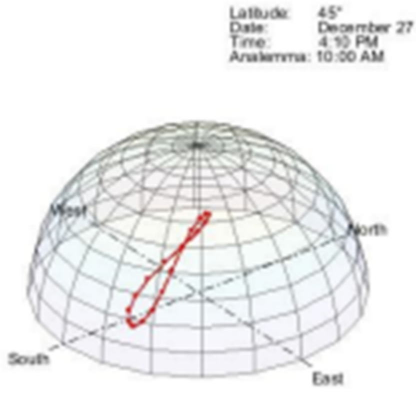

Figure 4. Solar Analemma at specified time

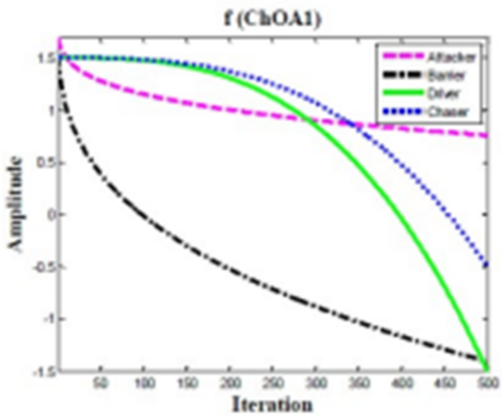

Figure 5. Implementation of Chimp algorithm and output efficiency

An advanced Solar tracking system with computational optimization 7 the accurate value of solar tracking and optimized tuning value. The chaser value of the graph will always be a little bit lag while considering the driver one. So during optimization, it brings to an optimized point. This point will give a better result even for the attacking value (overshoot in PID) of the controller.

7. Conclusion and future Scope

In this paper, the most effective algorithm for tracker alignment and movement was adopted. The result gives the exact analysis of optimization. In the future, to acquire the improved concept of Oppositional Optimization, a new mix of algorithms such as Random forest and genetic algorithms must be implemented.

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