REVIEW ARTICLE

Artificial Intelligence for Smart Solar Power Irrigation– Comprehensive Review

S.Sumathi*, S.Krishnan

Department of Electrical and Electronics Engineering, Mahendra Engineering College, Mallasamudram, Namakkal- 637 503, India

ABSTRACT: The paper presents a comparative study of different performance prediction of solar photovoltaic systems that could be simply and efficiently used by artificial intelligence techniques. We have plenty of sunlight, but scarcity of water to carry out plantation farming activities. However, the availability of highly efficient and cost-effective pump controllers using solar technology is limited. This review article is based on bridging the gap between water and sunlight for smart irrigation in India. This article also focuses on the comprehensive and comparative study of the most-adopted Artificial Intelligence (AI), Fuzzy Logic (FL), Proportional-Integral-Derivative (PID) and, Genetic Algorithms (GA) based on MPPT techniques using solar-powered irrigation. Internet of Things (IoT) is used for monitoring plantation field for humidity, moisture, control pests, temperature, plant diseases, fertilizers, etc. with the purpose of making sure the quality of vegetables, fruits and so on. Smart farming has to be incorporated by employing solar-based pump sets for irrigation as electricity is not available in the farmland. For excellence in farming, AI-enabled cameras can be used to capture images of the entire farm and investigate the images in near-real-time to identify several problems and provide timely action to achieve higher yield which in turn improves the quality of farming. The proposed intelligent system is to achieve good performance with fewer fluctuations and no overshoot, if implemented.

KEYWORDS: Artificial intelligence, solar power system, irrigation, pump controller

https://doi.org/10.29294/IJASE.7.3.2021.1894-1903

INTRODUCTION

Water scarcity is turning into an alarming issue throughout the globe these days that successively has redoubled the threat of significant food crisis. Therefore, there must be an associate degree economic technique to utilize the available market resources judiciously. As agriculture is one of the biggest water consuming sectors, managing irrigation level plays a very important role-half in saving water for different purposes and utilizing economically. As we use the primitive methods in irrigation, more than 25% water is wasted. An improvised system of irrigation can save a lot of water which is presently wasted due to poor water management.

In order to minimize wastage of water and improve water management, the application of applied mathematical strategies has become important. The ever-increasing demand for energy and the constant decline in the existing sources of fossil fuels and the growing alarm concerning atmosphere pollution, pushed researchers to find new, non-conventional, renewable energy resources like solar or wind energy, for the assembly of power [1]. With the advancement in technology in the digital world the researchers developed a tendency to push our limit of thinking and attempt to coalesce the traditional brain with a man-made one. It's the method by that a personality builds an associate in the form of intelligent machine.

The uncertainty related to modeling and performance prediction of star electrical phenomenon systems may be simply and expeditiously resolved by computer science techniques. Previous literature, Support vector machine, CNN, ANN, Deep learning and Machine learning domains reinforce the machine work and help to develop additional advanced technology and tools for performance prediction and modeling of star electrical phenomenon systems. The objective of this paper is to review the process of numerous data processing techniques within the field of geophysical science and check the efficiency of the predictions created within the same. In addition, the chosen articles on the radiation prediction victimization ANN, FL, GA, and their hybrid models are summarized. The review provides for the suitability of ANN, FL, GA, and hybrid models for the correct prediction of the radiation. Figure 1shows the block diagram of the solar power irrigation system.

1. Artificial Intelligence in Agriculture

Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. With the stimulation of AI, various innovative logics and methods were developed and exposed in order to make the process of problem-solving simpler. The

**Corresponding Author: sumathis@mahendra.info*
Received: 10.12.2020 **Accepted:** 11.03.2021 **Published on**: 22.02.2021

methods are listed below.

2.1. Artificial neural networks (ANN) Based MPPT Controller for a PV System

Artificial neural networks have been incorporated in the agriculture sector due to their advantages over traditional system. The main benefit of neural networks is to predict and forecast on the basis of parallel reasoning. Instead of thoroughly programming, neural networks can be trained. Gliever and Slaughter [2] used ANN to differentiate weeds from the crops. Maier and Dandy (2000) used neural networks for forecasting water resource variables. Arif et al. [3] developed two ANN models to estimate soil moisture in Paddy fields using decidedly less meteorological data. Both of these models were then corroborated and validated by studying observed and estimated soil moisture values. The first ANN model was generated to get the estimate ET. The help of minimum, average, and maximum air temperature was taken. To develop the second model, solar radiation, precipitation, and air temperature data were gathered. Both these models resulted in the accurate and reliable estimation of soil moisture in the paddy fields with the use of the least meteorological data with less labor and less time.

Hinnell et al. [4] developed neuro drip irrigation systems where ANNs were used to predict the spatial water distribution in the subsurface. For the drip irrigation method to properly function, water distribution in the lower level of the soil is of great importance. Here, ANNs make the prediction which comes in handy for the user which in turn results in the fast decision-making process. Thus, the ANN model provides continuous patterns to the user. Abdelsalam et al [5] described Perturb and observe algorithm which is generally referred to as hill-climbing technique of tracking the maximum PowerPoint. This algorithm sometimes perturbs the panel voltage and compares the output power with the earlier value of the perturbation cycle. When power increases, the perturbation is kept in the same direction until maximum power is reached. Perturbation is inverted, when there is a decrease in power thus oscillating around the MPPT.

Shekha [6] has developed an Intelligent IoT-based Automated Irrigation system where sensor data pertaining to soil moisture and temperature captured and accordingly KNN (K- Nearest Neighbor) classification machine learning algorithm deployed for analyzing the sensor data for prediction towards irrigating the soil with water. Khaldi et al. [7] proposed a neural network-based MPPT using the variables derived through Newton- Raphson method. ANN-based MPPT for a grid-connected SPV system with an augmented-state feedback linearization controller has good sensitivity to rapidly varying atmospheric conditions than the conventional techniques.

Khaldi et al research was based on the modeling, simulation, and optimization of a pumping system by using solar and conventional energy sources in the form of standalone and hybrid systems to supply irrigating water. The simulations, performed by HOMER, provided the best system configuration based on hour-by-hour data for energy availability and demands. Ezinwanne et al [8] reported AI by employing the algorithm with an ANN. The artificial neural network is used to calculate the array voltage and current, which is then utilized by perturb and observe algorithm to predict the voltage at MPP. The performance of the algorithm greatly depends on the accuracy of predicted values of current and voltage. Also, the instantaneous operation of ANN helps in avoiding the oscillations due to perturbations. The Incremental Conductance (IC) method is based on the derivative of the conductance. INC algorithm is founded on the fact that the slope of the P-V characteristic is zero at the MPPT.

Ngan & Tan, [9] the real-time power values and ANN predicted that power values are compared and optimized by the PSO algorithm to determine the reference current for duty cycle production. A new approach was employed in traditional backpropagation training algorithms with PSO-based training algorithms for ANN. In this approach, the search space for PSO is limited and thus it conserves time and the trained ANN has a very low mean square.A genetic algorithm is a method for optimizing discontinuous, highly non-linear problems through evolutionary ideas of natural selection and genetics processes like selection, crossover, and mutation. It randomly selects individuals from the given population as parents and produces children for the next generation. The population evolves towards an optimized solution over successive generations. This technique can be employed to generate an optimized reference value to generate a control pulse for the DC-DC converter to achieve MPPT [10].

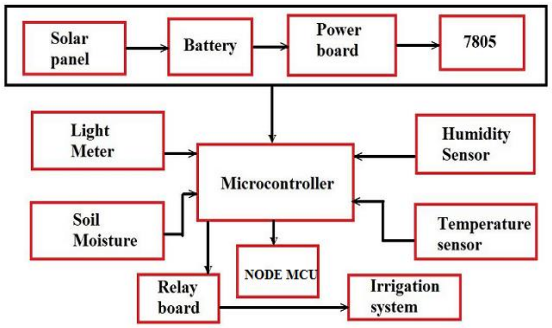

Figure 1 Block diagram of the solar power irrigation system

2.1. Fuzzy Logic Based MPPT Controller for a PV System

Fuzzy Logic (FL) deals with the ranges of various parameters rather than data points and hence, FL could predict accurate results for all data points within the range of various parameters. The accuracy of FL depends on human knowledge. Boubakeur et.al [11] reported that the PSO-based optimization is used to find the optimal scaling parametersof a fuzzy logic-based MPPT controller that maximizes the potency of an electrical phenomenon pumping system. The performance of the proposed PSO-based fuzzy controller is compared with those obtained using fuzzy logic and P&O controllers under variations of meteorological conditions. The simulation results proved to be a good robustness performance of the proposed Fuzzy based PSO controller over the other regarding the gained solar energy and the daily pumped water.

Sicat et al. [12] demonstrated fuzzy modeling of farmers' knowledge (FK) for agricultural land suitability classification using GIS. Multi-class fuzzy sets using S-membership functions were generated for soil texture, soil depth and slope because of correlation or equivalence between farmers' definitions and scientific classifications **of** such landcharacteristics. Finally, the authors described the knowledge bases and the spatial data captured into a GIS and the procedures followed for FK-based modeling of agricultural land suitability.

Carlos Robles Algarín [13] presented the design and modeling of a fuzzy controller for tracking the maximum power point of a PV System. Matlab/Simulink was used for modeling the components of a 65 W PV system: PV module, buck converter, and fuzzy controller; highlighting as a main novelty the use of a mathematical model for the PV module, which, unlike diode-based models, only needs to calculate the curve fitting parameter. The simulation results demonstrated the superiority of the fuzzy controller in terms of settling time, power loss, and oscillations at the operating point. Suresh Vendoti [14] developed a GA-based optimization method to find the optimal scaling parameters of a fuzzy logic-based MPPT controller that maximize the efficiency of a photovoltaic pumping system.

MPPT technique was developed by Ghobari et al [15] by evaluating instantaneous conductance and junction conductance. An array voltage and current were employed with a function of array junction current by employing an Adaptive Neuro-Fuzzy (ANFIS) solar cell model. Subsequently, an analytical model was introduced to approximate hardware circuitry and measurement noise with a wavelet approach depended on de-noising. MPPT technique decreased the hardware setup with the aid of one voltage sensor with higher array power efficiency at minimum response time. The efficiency of the MPPT technique was not enhanced to the desired level of irrigation.

Si et al. [16] used fuzzy management theory within the controller of the system. By implementing fuzzy management theory, a precision-based result was obtained. High accuracy fuzzy management theory interprets the variables into the outlined variables sets which contain fuzzy terminologies like 'High', 'Very high' so on. There square measure 9 sets outlined for variable set E and 2 for the variable set world organization.

Sannakki et al. [17] developed a grading leaf disease that was segregated into five parts namely Image acquisition where the researchers have captured images of Pomegranate leaves, image pre-processing where the captured image is then resized, filtered, and processed according to the required parameter.

Prakash et al. [18] reported based on fuzzy logic was developed to study the Soybeans crop. This system gathered its database from farming officers, available literature, and experts of soybean crops. Fuzzy logic was used to study the whole system and advising the farmer as an expert. The system used MATLAB as a user interface module.

MPPT control depended on a fuzzy polynomial model for improving the effectiveness of solar PV electricity production was reported by Mohanraj et al [19]. MPPT was based on polynomial fuzzy designing, polynomial Parallel Distributed Compensation (PDC), and Sum-of-Squares (SOS) disintegration. A generalization of normal Takagi-Sugeno (T-S) fuzzy representation and Linear Matrix Inequality (LMI) was utilized to minimize the tracking time with higher PV system efficiency.Time complexity was not minimized by employing the polynomial fuzzy system.

Fractional-Order Fuzzy Logic Control (FOFLC) approach for MPPT was reported by Shekhar et al. [20]Fuzzy logic was provided with superior tracking accuracy in weather variation. Then, a fractional-order factor was chosen concerning the dynamic choice of the fuzzy controller. This considered an alpha factor for developing the fuzzy domain at the minimum searching time of MPP. Subsequently, a smaller alpha factor was employed as the maximum power point for attaining the fuzzy domain to minimize the oscillations at MPP. FOFLC in a PV system was effective in dynamic actions with enhanced tracking accuracy. Optimized fractional-order was not employed for extending the performance of the FOFLC approach.

2.3. Neuro-Fuzzy Logic Based MPPT Controller for a PV System

Fuzzy logic thought emulates human reasoning and thinking methods to solve advanced non-linear

issues. Fuzzy primarily based drawback resolution or improvement systems involve 3 major methods - linguistic levels of fuzzy subsets (NG-negative, ZE-Zero, PE-Positive) that may be processed by the controller is called fuzzification. The duty cycle of the convertor, the particular output of the solar array and also the output of the ANFIS is compared, and also the error signal is given to the Proportional-Integral controller (PI). Finally, the output of the controller is that the duty cycle [21].

Singh et.al [22] presented a novel adaptive neuro-fuzzy control approach for the renewable interfacing inverter. The main objective is to achieve smooth bidirectional power flow and nonlinear unbalanced load compensation, where the conventional proportional-integral controller may fail due to the rapid change in the dynamics of the highly nonlinear system. The inverter is actively controlled to compensate the harmonics, reactive power, and the current imbalance of a three-phase four-wire (3P4W) nonlinear load with generated renewable power injection into the grid simultaneously.

Mohamed et al [23] considered a digital control method for a PV system. A neuro fuzzy-logic and dual MPPT controller was employed. The MPPT controller fuzzification, inference, and defuzzification. The method of translating the input variables into is an astronomical two-axis sun tracker implemented for identifying the sun through both azimuth and elevation angles to acquire higher solar radiation. Then, the power converter among the PV panel and load was also maintained by using MPPT.FLC-MPPT was dependent on the voltage control method of the power converter including a discrete PI controller for altering the duty cycle. The input reference voltage was adaptively disturbed until the maximum power was attained.

The ANFIS-based MPPT controller is enforced for Quasi-Z-Source electrical converter Xia et al [24] during this algorithmic program, radiation and temperature is thought about as inputs and most Voltage (Vmpp) as an output. The output voltage of the solar array is compared with the utmost output voltage of the ANFIS, and also the error signal is shipped to the PI controller. The PI controller is needed to produce the right duty cycle for the dominant two-switch flyback electrical converter. Table 1 shows the comparison of various Intelligent systems achieve good performances, less fluctuations with no overshoot if implemented properly.

Table 1. Comparison of various intelligent systems achieve good performances, less fluctuations with no overshoot if implemented properly

References	Techniques used	Description	Methods	Variable	CKT	TUNING
Steven [25]	Look Up Table	MPP of a PV system is calculated before hand for each probable environmental condition and stored in the memory device of MPPT's control optimization.	Incremental Conductance	Voltage or Current	Analog and Digital	Yes
Arif [3]	Differentiation	This soil moisture technique determines MPP of a PV system	Sampling Method	Voltage or Current	Digital	Yes
Shekhar[6]	Feedback Power with Voltage	Similar to above technique with variation related to dP/dVequating 0 at MPP in irrigation system	Sampling Method	Voltage or Current	Analog and Digital	No
Hamed Taheri [23]	Forced Short Circuit Current	Nonlinear characteristics of PV system is modeled using mathematical equations or numerical approximations for IMPP=KSCISC	Incremental Conductance	Voltage or Current	Analog and Digital	Yes

Prakash[18]	Forced Open Circuit Voltage	In this technique, roots can be calculated from the fuzzy logic	Incremental Conductance	Voltage or Current	Digital	Yes
Singh[22]	3P4W distribution network	Characteristics based on implementation of ANFIS control for renewable interfacing inverter	Incremental Conductance	Voltage	Digital	Yes
Moham[23]	One Cycle Control	Fuzzy logic control Four Switch ThreePhase Inverter Fed IM drives	Sampling Method	Current	Analog and Digital	Yes

3. Maximum power point tracking controllers for Photovoltaic systems

Brunton et al. [25] described the MPPT algorithm to enhance solar array performance. The robust unreliable irradiance circumstances were adapted and an Extremum Seeking (ES) controller employed the natural inverter ripple confirmed on a replicated solar array with a grid-tied inverter. The ES controller increased the efficiency with transient rise-time to the MPP.In addition, the impacts of capacitor size on ES control depended on ripple was also analyzed. Tracking approach was not recognized by boost converters.Kollimalla& Mishra [26]reported an adaptive perturb depended on short-circuit current and observe MPPT approach for mining the maximum power from PV panel. A current perturbation and adaptive control approach were developed. These approaches were utilized to create PV panel function at maximum power and the operating limit issues were recognized to assign an operating point closer to MPP respectively. Then, these restrictions were originated according to the alternations in the irradiance and current.

VivekNandan Lal & Sri Niwas Singh [27] discussed MPPT employing modified Particle Swarm Optimisation (PSO) for increasing performances. The grid and current control were employed for a single-stage utility-scale PV system to incorporate reactive power into the grid. Then, the single-stage method was utilized to enhance efficiency and power converter topology. Subsequently, a modified PSO approach was unified with additional control methods. The MPP also get altered with the difference in solar irradiation and temperature. MPPT was appropriate for all circumstances with minimum steady-state variations. Energy utilization was not efficiently performed for attaining better results in MPPT.

Mohamed et.,al.,[28] described a tracking controller for improving MPP operation for PV Water Pumping Systems (PVWPS). PVWPS was comprised of a PV array and controlled DC converter to provide an external magnet DC motor joined with a centrifugal pump. The tracking controller was adaptive-logic used for searching, prediction and identification with the aid of the Cuckoo Search (CS) approach. Then, control approaches were also offered for MPPT. Optimization issues were not resolved to the desired level by employing a tracking controller. Elgendy et al. [29] developed Perturb and Observe (P&O) implementation approaches depended on system strength, features performance and energy consumption for PV pumping systems. The characteristics of parameters on system performance were analyzed and the issues of every approach were recognized for diverse weather circumstances. But, stability was reduced when operated in a high perturbation rate. Renaudineau et al. [30] described a framework with one DC/DC converter for every photovoltaic generator. Then, an optimal operating point of the system was identified by considering the practical restrictions from dc/dc converters' connection, mismatching event and MPPT characteristics of the inverter for establishing the system operating point. The real-time inhibited optimization issue was addressed by the PSO approach. The efficiency of the DC/DC converter was poor in achieving MPPT.

Kok Soon Tey&SaadMekhilef [31] developed a modified incremental conductance (Inc Cond) algorithm for identifying GMPP under limited shading circumstances and load difference. The duty cycle of the DCDC converter was included to enhance the MPPT process. Then, attainment of GMPP was performed exactly under various limited shading circumstances. In addition, the reaction at the time of load difference and solar irradiation was effectively made. Consequential oscillations were not restricted by using Inc Cond algorithm.

Sridhar et al. [32] designed a shuffled frog leap algorithm (SFLA) for recognizing the global maximum power point. SFLA was capable of efficient tracking and does not require any additional arithmetic computations in hardware implementation. Subsequently, the performance of a PV system was improved even under limited shaded circumstances. Xinyu Fan et al. [33]approach for establishing voltage bands that were voltage regions of Global Maximum Power Points (GMPPs). The non-repeated irradiance case was investigated to acquire GMPPs with respect to electrical features of a series-

parallel-linked PV array.Subsequently, slope coefficients were balanced for the influence of temperature. Modeling of global maximum power point tracking approaches was also performed with the investigation of GMPPs estimated regions.

A nonlinear MPPT controller was studied by Taheri Taheri [34] on a two-diode model. MPPT technique was performed in combination with a Z-source dc-dc converter as an interface among PV system and load. A nonlinear MPPT approach and a nonlinear controller were employed for the production of the duty cycle. Then, the modelling of the MPPT controller was implemented with the consideration of nonlinearity of the PV model and power electronics converter. Subsequently, an adaptation scheme was developed as PV model parameters differ with respect to insolation, temperature and location of the operating point on PV characteristics.

Devassy and Singh [35] developed solar PV array Integrated Unified Power Quality Conditioner (PV-UPQC-S) depended on modified p-q theory. A Generalized Cascaded Delay Signal Cancellation (GCDSC) was employed for mining Fundamental Frequency Positive Sequence (FFPS) voltages employed in p-q theory to produce reference grid currents for shunt compensator. A concept of clean energy production with power quality enhancement was utilized to increase utility. In addition, the dynamic characteristics of PV-UPQC-S were studied with respect to irradiation and fluctuations in grid voltage.

Devassy and Singh [36] reported a three-phase single stage solar PV-UPQC. PV-UPQC was a combination of shunt and series linked voltage compensators with general DC-link. The shunt compensator was employed for implementing the dual operation of mining power from the PV array. Then, a moving average filter depended on an enhanced synchronous reference frame control was utilized to obtain load active current component. In addition, grid side power quality troubles were resolved by using series compensator. A voltage in-phase/out of phase with a Point of Common Coupling (PCC) voltage was incorporated by the compensator at the time of sag and swell circumstances. The power quality was increased with clean energy production. The irradiation variance remains unaddressed in PV-UPQC.

Artur MS Furtado et al., [37] discussed Maximum Power Trapezium (MPT) comprising of probable GMPPTs. GMPPT approach was developed with the aid of MPT and data about the minimum voltage difference among adjacent local peaks to attain GMPP high tracking time. A minimum sampling rate was also selected as a function of the PV inverter capacitance and higher charging/discharging current. But, shading complexity was not sufficiently consideration. Mahdi Jedari& Hamid Fathi [38] discussed PV arrays designing and Maximum Power Point Estimation (MPPE). PV array polynomial model was implemented from a single diode equivalent circuit and parameters of the polynomial model were determined through the evaluation of voltage and current around MPP. Then, Maximum Power Point Voltage (MPPV) was estimated and the PV array voltage was made permanent at MPPV. In addition, computation complexity and estimation power losses were also minimized.

Efstratios I Batzeliset al. [39] illustrates state-space characteristics of PV system dynamics driven through irradiance difference. PV dynamic model was integrated with maximum power output. Then, the Lambert function was employed to represent the PV generator's Equations. The accuracy and computational efficiency were improved and the integration of huge power systems was also addressed. But, the oscillations were not reduced.

Stand-Alone Photovoltaic Energy System (SAPES) was described byHadeed Ahmed Sher et al. [40]with an assist of hybrid MPPT to assure peak energy harvesting. Hybrid MPPT integrated Short Current Pulse (SCP) approach and P&O approach. Then, the offline parameter short circuit current was performed among offline parameter and instantaneous current. A distinct power conversion was achieved by employing flyback inverter in discontinuous conduction mode (DCM).Tracking speed and convergence was decreased in hybrid MPPT. The solar PV system was presented by Bhim Singh et al. [41]for enhancing the performances. Robust model reference adaptive system (MRAS) technique for rotor speed estimation of direct torque control (DTC) of an induction motor drive used for solar PV powered water pumping. The maximum power point tracking (MPPT) of PV array is assured by a proposed P&O algorithm, which has improved tracking time without deviation during insolation change.

Ikhlaq Hussain et al. [42] described an adaptable dual-mode single-stage solar PV with a combination of three-phase voltage-weak allocation. A Multilayer Perceptron (MLP) neural network control structure was employed in dual approaches. PV was utilized in presenting active power with Distributed Static Compensator (DSTATCOM) capability to extend the quality of energy. Then, DSTATCOM was employed during the inaccessibility of SPV production. The system was capable of repeated operation for voltage-weak distribution grid with common voltage fluctuations and flickers. In addition, the single-stage converter was applied with an INC for MPPT and MLP to obtain basic components of load currents. MLP was compacting, general and alleviate in construction. The unbalanced conditions of load were not addressed by using MLP neural network.

Sally Sajadian& Reza Ahmadi [43] discussed predictive control method to distributed MPPT

approach. This helped in extending the energy preservation performance of a cascaded power optimizer system under active weather circumstances. Then, a submodule MPPT representation predictive control loop and a supervisory MPPT loop were employed for every converter and power optimization respectively. An enhanced energy capture, robust active response and negligible oscillations were attained by employing predictive control method. The level of convergence was decreased which leads to performance inefficiency of the predictive control method.

Zheng Jun Chew &Meiling Zhu [44] intended control circuit in combination with a full wave diode bridge rectifier and a DC-DC converter. This aided in preserving energy from a Piezoelectric Energy Harvester (PEH). The control circuit was adaptive to diverse vibrations with efficient maximum power at minimum power consumption. Power consumption was not optimized to the desired level. Sergei Kolesnik et al [45]described the Maximum Power Line (MPL) control to increase tracking of MPP speed even in the presence of quick irradiation alteration. MPL was a curve capable of linking all probable MPP coordinates at a specified temperature. An irradiation-independent explicit expression was developed to enable real-time realization without any photocurrent inference.

Metry et al [46]designed an MPPT approach with the aid of Model Predictive Control (MPC). A model depended on predictive control was employed for restricting the current sensor necessitated for recognized MPPT approaches.This was performed by using exclusive monitoring, communications equipment and networks for the assessment of solar irradiation alteration. Then, an observer model was introduced for the resistive load with the aid of accessible sensors for enhancing the strength of the controller to disturbances in the load but the system consistency was not enhanced sufficiently.

Vedantham et al[47] discussed an adaptive nonlinear control approach for Grid Interfaced Photovoltaic (GPV) system. Harmonics currents rejection, reactive energy compensation was performed by acquiring peak power from the PV array.Subsequently, Strictly Positive Real (SPR) Lyapunov function was designed for estimating update laws. The switching losses were also avoided by modifying the DC link voltage. In addition, the feed-forward loop was also integrated for enhancing the performance of system response. Adaptive nonlinear control approach failed to consider the computational complexities.

Three phase grid linked solar PV was designed by Singh et al. [48] based on Fast Zero Attracting-Normalized Least Mean Fourth (FZA-NLMF). A control method was employed in resolving power quality issues and peak power was produced from PV array. Voltage Source Converter (VSC) was linked to a PV array to covert active power. Then, the system dynamic reaction was enhanced and made efficient. In addition, power quality issues were restricted and conditioning was provided by means of functioning in rationality with fragile allocation grid. The output power was not improved efficiently.

Chandani Sharmaet al [49]reported the comparative study of maximum power point tracking (MPPT) techniques. It has been analyzed with different MPPT methods following the same goal of maximizing the PV system output power by tracking the maximum power on every operating condition. In this paper maximum power point tracking techniques are reviewed on basis of simplicity, convergence speed, digital or analogical implementation, sensors required, cost, range of effectiveness, and in other aspects

PROPOSED IDEAS

The need for automation within the agriculture sector is urgently needed and there are many ways it is enforced in observe. Irrigation is that the foremost factor wherever automation is necessary for optimum water usage. Soil wet device helps to observe the wet level of the soil and starts watering the farm because the price gets below the brink level set by the farmer. The embedded system and net of Things facilitate to development of a compact system that monitors the water level of the farm while not human interaction. The proposed system based on a Single-Ended Primary Inductance Converter (SEPIC) which is driven by Particle Swarm Optimization (PSO) based Maximum Power Point Tracking (MPPT) technique to operate the solar panel. Brushless DC (BLDC) motor is used for pumping the water system.

The speed of the BLDC is controlled by using the Sinusoidal Pulse width modulation (SPWM) technique through the Voltage Source Inverter (VSI) and DC-link voltage controller. The Solar Photovoltaic (SPV) array generates the electrical power demanded by the motor -pump. This electrical power is supplied via a SEPIC and VSI to the motor pump. Ideally, at the output of the SEPIC converter, which acts as a source for the VSI, the same amount of power is transferred. In practice, due to the various losses linked with a DC link voltage controller, a slightly less amount of power is transferred to feed the VSI. Figure 2 shows the proposed idea of the solar irrigation system.

The pulse generator generates switching pulses for the SEPIC converter using the PSO-MPPT algorithm. The PSO-MPPT algorithm uses voltage and current feedback from the SPV array and achieves the optimal value of the duty cycle. It also produces a real switching pulse by contrasting the service cycle with a wave of the high-frequency carrier. The optimum production of power and thus the

performance enhancement of the SPV system is accomplished in this way. The VSI, which converts DC power from a SEPIC to AC, feeds the BLDC motor to drive a water pump coupled to its shaft. The VSI is operated in simple frequency switching by an electronic BLDC motor switch assisted by its built-in encoder. High-frequency switching losses are thus reduced, leading to increased efficiency in pumping. This proposed system improves crop yield and decreases the cost of crop production leading to increased savings for the agricultural trade. The early and accurate finding of plant diseases is used in preventing yield loss. An automatic disease diagnosis and the controlling system were proposed to identify the disease infection on plant leaves based on soil quality monitoring and fertilization. Figure 2 shows the proposed idea of solar irrigation system using artificial intelligence.

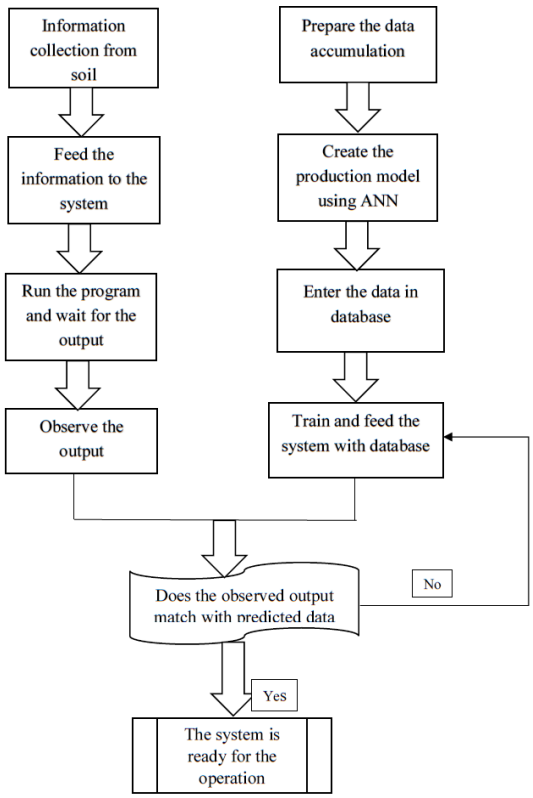

Figure 2: Proposed idea of solar irrigation system using artificial intelligence

CONCLUSION

The present article successfully reviewed the solar powered irrigation using artificial intelligence. An extensive review was done to present the suitability of various AI techniques like, ANN, FL, GA and their hybrid models for prediction of solar radiation and the performance of solar photovoltaic systems. The review is focused on the sections, first section includes summary of various studies reported on application of ANN, FL, GA and their hybrid models to predict solar radiation. Also various articles related with application of MPPT technique in PV Systems with controllers were discussed. The proposed intelligent systems are to achieve good performances, fewer fluctuations with no overshoot if implemented. The soil moisture values help in the automation of the water pump for irrigation, and the camera snapshots of the crops are sent to the cloud for storage and further processing.

Acknowledgement

The authors wish to thank AICTE-Research Promotional Scheme, Government of India for providing financial support to carry out this work.

REFERENCES

[1] Alexander Zerrahn., Wolf-Peter SchillClaudiaKemfert.,2018. On the economics of electrical storage for variable renewable energy source, European Economic Review. 5(3), 233- 238.2. Gliever C, Slaughter, D.C., 2001Crop verses weed recognition with artificial neural net-works. ASAE paper 4 (1), 1–12.

[2] Arif, C., Mizoguchi, M., Setiawan, B.I., Doi, R., 2012.Estimation of soil moisture in paddyfield using Artificial Neural Networks. International Journal of Advanced Researchin Artificial ntelligence. 1 (1), 17–21.

[3] Hinnell A.C., Lazarovitch N., Furman, A., Poulton,M., Warrick, A.W., 2010. Neuro-drip: estimationof subsurface wetting patterns for drip irrigation using neural networks. Irrigation Science,28, 535–544.

[4] Abdelsalam A., Massoud A., Ahmed S., Enjeti., P 2011. High-performance adaptive perturb and observe MPPT technique for photovoltaic-based microgrids. IEEE Trans Power Electron, 26(4):1010–1021.

[5] Shekhar, Y., Dagur, E., Mishra, S., Tom, R.J., Veeramanikandan, M., Sankaranarayanan, S., 2017.IntelligentIoT based automated irrigation system. International Journal of Applied Engineering Research, 12(18), 7306–7320.

[6] Khaldi 2014 Design of photo voltaic pumping system using water tank storage for a remote area in Algeria.Renewable Energy Congress, 5th International At: Hammamet , Tunisia.

[7] Ezinwanne, 2017. Energy Performance and Cost Comparison of MPPT Techniques for Photovoltaics and other Applications. Energy Procedia 107,297-303.

[8] Ngan &Tan. 2016. Multiple Peaks Power Tracking Using Particle Swarm Optimization with Artificial Neural Network Algorithm. Advances in Solar Photovoltaic Power Plants,5(10), 107–138.

[9] Hadji, S., Galbert,, J. P., &Krim., F., 2015. Theoretical and experimental analysis of genetic algorithms based MPPT for PV systems. Energy Procedia, 74, 772–787.

[10] Hadjaissa Boubakeur. 2016. A PSO-based Optimization of a fuzzy-based MPPT controller for a photovoltaic pumping system used for irrigation of greenhouse. Iranian Journal of Fuzzy Systems, 13(3),1-18.

[11] Sicat, R.S., Carranza. E.J.M., Nidumolu, U.B., 2005. Fuzzy modeling of farmersknowledgefor land suitability classification. Agriculture System, 83, 49–75.

[12] Carlos Robles Algarín., John TabordaGiraldo., Omar Rodríguez Álvarez., 2017.Fuzzy Logic Based MPPT Controller for a PV System. Energies, 10(12), 56-61.

[13] Suresh Vendoti, GA., 2019. Based Optimization of a Stand-alone Hybrid Renewable Energy System for Electrification in a Cluster of Villages in India,Fifth International Conference on Science Technology Engineering and Mathematics, Chennai, India.

[14] Ghobari., H.M., Mohammad, F.S., 2015. Intelligent irrigation performance: evaluation and quantifying its ability for conserving water in arid region. Applied Water Science 1,73–83.

[15] Si, Y., Liu, G., Lin, J., Lv, Q., Juan, F., 2007. Design of control system of laser leveling machine, based on fussy control theory. International Conference on Computer and Computing Technologies in Agriculture,3(1), 1121–1127.

[16] Sannakki, S.S., Rajpurohit, V.S., Nargund, V.B., Kumar, A., Yallur, P.S., 2011. Leaf disease

[17] Grading by machine vision and fuzzy logic. International Journal Computer Technology Applications, 2 (5), 1709–1716.

[18] Prakash, C., Rathor, A.S., Thakur, G.S.M., 2013. Fuzzy Based Agriculture Expert System forSoyabean.International Journal of Advanced Research in Computer Engineering & Technology, 1(8),1–13.

[19] Mohanraj, I., Ashokumar, K., Naren, J., 2016. Field monitoring and automation using IOT inagriculture domain. 6th International Conference on Advances in Computing & Communications, Cochin, 931–939.

[20] Shekhar, Y., Dagur, E., Mishra, S., 2017. Intelligent IoT based automated irrigation system. International Journal Applied Engineering Research. 12 (18), 7306–7320.

[21] Terki, A., Moussi, A., Betka, A., 2012. An improved efficiency of fuzzy logic control of PMBLDC for PV pumping system. Applied Math. Model, 36(3), 934–944.

[22] Singh, M., Chandra, A.,2013. Real-time implementation of ANFIS control for renewable interfacing inverter in 3P4W distribution network. IEEE Trans. Ind. Electron, 60(1),121-128.

[23] Mohamed, V.,Zaky, S., Mohamed, K.,Metwaly., 2017. A Performance Investigation of a Four Switch ThreePhase Inverter Fed IM drives at Low Speeds Using Fuzzy Logic & PI Controllers.IEEE Transactions on Power Electronics, 32(5),345 -352.

[24] Xia,C., Xiao,Y., Chen,W., Shi.T., 2014.Torque ripple reduction in brushless dc drives based on reference current optimization using integral variable structure control. IEEE Transactions on Industrial Electronics, 61(2),738-752.

[25] Steven L Brunton et al., 2010, Maximum Power Point Tracking for PhotovoltaicOptimization Using Ripple-Based ExtremumSeeking Control. IEEE Transactions on power electronics, 25(10), 233 -237.

[26] Sathish Kumar Kollimalla., Mahesh Kumar Mishra.,2013.Adaptive Perturb & Observe MPPT Algorithm for Photovoltaic System, IEEE Power and Energy Conference at Illinois, 3(5), 42-47.

[27] Vivek Nandan Lal.,Sri Niwas Singh., 2016. Modified particle swarm optimization-based maximum power point tracking controller for single-stage utility-scale photovoltaic system with reactive power injection capability,' IET Renewable Power Generation, 10(7), 899-907.

[28] Mohamed,A .,Enany (2017). Cuckoo search–based maximum power point tracking controller for PV water pumping system, Journal of Renewable and Sustainable Energy,9(2), 1-11.

[29] Mohammad Sarvi, Saeedeh Ahmadi &Shirzad Abdi., 2013. A PSO-Based Maximum Power Point Tracking for Photovoltaic Systems under Environmental and Partially Shaded Conditions', Progress in Photovoltaics Research and Applications, Wiley Publications, 23(2),1-14.

[30] Hugues Renaudineau., Fabrizio Donatantonio., Julien Fontchastagner., Giovanni Petrone, Giovanni Spagnuolo., JeanPhilippe Martin., Serge Pierfederici., 2015.A PSO-Based Global MPPT Technique for Distributed PV Power Generation' IEEE Transactions on Industrial Electronics, 62(2),1047-1058.

[31] Kok Soon Tey., Saad Mekhilef.,2014.Modified Incremental Conductance Algorithm for Photovoltaic System under Partial Shading Conditions and Load Variation, IEEE Transactions on Industrial Electronics, 61(10), 5384-5392.

[32] Sridhar, R., Jeevananthan, S., Dash, S.S., Pradeep Vishnuram.,2017.A new maximum power tracking in PV system during partially shaded conditions based on shuffled frog leap algorithm. Journal of Experimental & Theoretical Artificial Intelligence, 29(3), 1-14.

[33] Xinyu Fan., Fang Deng., Jie Chen.,2017.Voltage band analysis for maximum power point tracking of stand-alone PV systems. Solar Energy, Elsevier, 144, 221-231.

[34] Hamed Taheri., Shamsodin Taheri.,2017. Two-Diode Model-Based Nonlinear MPPT Controller for PV Systems. Canadian Journal of Electrical and Computer Engineering, 40(2), 74-82.

[35] Sachin Devassy., Bhim Singh.,2017. Modified p-q Theory Based Control of Solar PV Integrated UPQC-S,IEEE Transactions on Industry Applications, 53(5),5031-5040.

[36] SachinDevassy, Bhim Singh.,2015.Design and Performance Analysis of Three-Phase Solar PV Integrated UPQC. IEEE Transactions on Industry Applications, 54(1), 73-81.

[37] Artur, MS, Furtado, FabricioBradaschia, Marcelo, Cavalcanti.,LeonardoLimongi, R 2018. A Reduced Voltage Range Global Maximum Power Point Tracking Algorithm for Photovoltaic Systems under Partial Shading Conditions. IEEE Transactions on Industrial Electronics, 65(4), 3252-3262.

[38] MahdiJedari., Hamid fathi, S., 2017.A New Approach for Photovoltaic Arrays Modeling and Maximum Power Point Estimation in Real Operating Conditions. IEEE Transactions on Industrial Electronics, 64(12),9334 – 9343.

[39] Sergei Kolesnik., Moshe Sitbon., Efstratios Batzelis., Stavros Papathanassiou., TeuvoSuntio, .,AlonKuperman., 2017. Solar Irradiation Independent Expression for Photovoltaic Generator Maximum Power Line.IEEE Journal of Photovoltaics, 7(5),1416 – 1420.

[40] Hadeed Ahmed Sher., Arslan Abbas Rizvi., Khaled Addoweesh., E.,Kamal Al-Haddad 2017.A Single Stage Stand-Alone Photovoltaic Energy Systemwith High Tracking Efficiency. IEEE Transactions on Sustainable Energy, 8(2), 755 – 762.

[41] Bhim Singh., 2018.A Novel MPPT Control Technique for Solar Powered DTC of IMD with a Robust Speed and Parameters Adaptation Scheme for Water Pumping. IET Renewable Power Generation,13(2), 67-71.

[42] Ikhlaq Hussain, Rahul Kumar Agarwal., Bhim Singh., 2018 .MLP Control Algorithm for Adaptable Dual-Mode Single-Stage Solar PV System Tied to Three-Phase Voltage-Weak Distribution Grid. IEEE Transactions on Industrial Informatics, 14 (6), 2530 – 2538.

[43] Sally Sajadian., Reza Ahmadi., 2017. Distributed Maximum Power Point Tracking Using Model Predictive Control for Photovoltaic Energy Harvesting Architectures Based on Cascaded Power Optimizers. IEEE Journal of Photovoltaics, 7(3), pp. 849-857.

[44] Zheng Jun Chew.,Meiling Zhu., 2018.Adaptive Maximum Power Point Finding Using Direct *V*OC/2 Tracking Method with Microwatt Power Consumption for Energy Harvesting.IEEE Transactions on Power Electronics, 33 (9),1-9.

[45] Sergei Kolesnik. MosheSitbon., Efstratios Batzelis., Stavros Papathanassiou., TeuvoSuntio., .,Alon Kuperman., 2017. Solar Irradiation Independent Expression for Photovoltaic Generator Maximum Power Line. IEEE Journal of Photovoltaics, 7(5), 1416 – 1420.

[46] MorcosMetry., Mohammad Shadmand., B, Robert Balog, S., Haitham Abu-Rub., 2017. MPPT of Photovoltaic Systems Using Sensorless Current-Based Model Predictive Control. IEEE Transactions on Industry Applications,53(2), 1157 – 1167.

[47] Srinivas Vedantham., Shailendra Kumar., Bhim Singh.,Sukumar Mishra.,2018. A Multifunctional GPV System Using Adaptive Observer Based Harmonic Cancellation Technique. IEEE Transactions on Industrial Electronics, 65(2), 1347 – 1357

[48] Amresh Kumar Singh., Ikhlaq Hussain.,Bhim Singh., 2018.Double-Stage Three-Phase Grid-Integrated Solar PV System With Fast Zero Attracting Normalized Least Mean Fourth Based Adaptive Control. IEEE Transactions on Industrial Electronics, 65(5), 3921 – 3931

[49] Chandani Sharma., Anamika Jain., 2014. Review maximum power point tracking techniques,International Journal of Recent Research in Electrical and Electronics Engineering,5 (1), 65-72.