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A Dynamic Framework of Solar Based Electric Vehicle Charging Station with Artificial Neural Network and Genetic Algorithm Techniques

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Abstract

Electric vehicles (EVs) are one of the best replacements of conventional vehicles due to environmental friendly nature. The poor State of Charge (SOC in %) control and large settling time & peak overshoot of speed are the few research gap which need to be address due to continuous degradation of battery. The paper demonstrates the conceptual design and implementation of a solar-powered electric vehicle that uses soft computing methods for smart control. The implementation of a dynamic solar-powered electric vehicle charging stations combining smart control & soft computation methods requires careful, optimal design, charging the economy, & regular upkeep. Nonetheless, it can offer an environmentally friendly, long-term EV charging option and perhaps reduce continuing operational costs. Because electric vehicles emit no pollutants, this work also assists global efforts to reduce emissions of greenhouse gases and combat climate change. In this paper, electric vehicle charging has been assessed at various voltage levels. Subsequently, an electric vehicle is controlled by DC motor. In addition to state of charging of electric vehicle which is measured in terms of state of charging, the speed of electric vehicle is analyzed. In order to attain the smooth operation of speed and SOC, an objective function has been developed. Further, the objective function has been controlled by using artificial neural network and genetic algorithm. It is observed that SOC (%) shows better and smoother performance with GA in comparison to ANN and existing methods. In addition to this, settling time and peak overshoot of the speed has been improved a lot with GA (2.5 sec, 2%) and ANN (3.1 sec, 2.7%).

Keywords- Artificial neural network, Genetic algorithm, Smart charging, State of charge control, Solar-based Electric vehicle, Vehicle dynamics.

List of Nomenclature

EV	Electric vehicle
EVC	Electric vehicle charger
SOC	State of charge
ANN	Artificial neural network
GA	Genetic algorithm
SPVCS	Solar photovoltaic vehicle charging station
P_c	Crossover probability
P_m	Crossover mutation
α	Converging factor
f	Fitness function
V	Voltage
ω	Speed
i_a	Armature current
r_a	Armature resistance

1. Introduction

The deterioration of natural resources, the consequences of global warming, and the unending consumption of fossil resources are some of the most significant environmental issues of our day (Martins et al., 2019). Both the transportation industry and the traditional electricity generation sectors provide considerable support for these difficulties (Alanazi, 2023). The idea of digitalizing sustainable transport with manufacturing based on energy from renewable sources is expected to provide a workable solution to these problems. Electric vehicles are growing in popularity due to the need for a clean, environmentally friendly mode of transportation as well as advancements in battery technology. In this way, a number of scientists have lately made contributions to the mechanical advancem. and successful implementation of the solar-powered EV charging station (Singh et al., 2021). An approach for handling energy for a smart grid environment that integrates a device to store energy with an xEV-based charging base is suggested as an ideal synchronized solar PV-battery revitalizing architecture for improving the framework's unshakable quality (Amir et al., 2023c; Luo et al., 2018). Numerous procedures related to the solar EV charging systems are being investigated thus far. Developing a vehicle system to manage the intricacies of fluctuating electricity prices through the use distributed era, including solar (Amir et al., 2023a; Luo et al., 2018).The use of dynamic EV-PV charging techniques has also been covered in a number of other publications. Sahoo et al. (2017) have concentrated on demonstrating a solar PV-based electric vehicle charging technology that is appropriate for DC faster chargings in order to limit the significant charging effects utilizing a vehicle-to-grid layout.

By creating an equip. model for PV-based charging construction, the proposed approach has largely been validated, and an ideal EMS structure to support the proposed charging approach has been established (Amir et al., 2022). Research has shown that modules for EVs with an environmentally friendly power source can reduce costs and discharges (Qi et al., 2019). In order to manage various charge plans and control concerns, an adaptive framework has been used to show logical/coherent regulated ways (Qi et al., 2019).

Additionally, these studies use limited and recognized EV data rather than comprehensive and authentic instructional selections, and they discuss conceptual rather than actual studies. Furthermore, despite focusing on the infrastructure for electric vehicle charging and its dynamics as cited by Khan et al. (2019) and Truntič et al. (2018), the practical techniq. of a charging cycle regulate technique has not been fully solidified and implemented by multiple study projects, with the exception of a few innovative control methods and approaches.

It is yet unknown what is causing the thermal runaway issue with lithium-ion batteries. Because of this bottleneck, lithium-ion battery energy density has increased, preventing a prolonged period of technological stagnation. The variety of cell chemistries complicates the analysis of this issue. The effort that Tsinghua University and its partners made to create a database for thermal analysis is reported in this study. Similar data from both differential scanning calorimetry & accelerating rate calorimetry for several cell types are included in the database. Based on the shared characteristics of the database's cells, three distinct temperatures are summed up. The thermal runaway mechanisms are learned in our quest to understand the mechanics underlying the typical temperature events. The creation processes, evolution structure, experimental methodologies, detection techniques, and mitigation methods of ISC in LIBs are all thoroughly reviewed in this research. Based on the common safety incidents of LIBs, ISC that are mainly due to common reasons are thoroughly examined. Subsequently, the foundation for ISC's evolution and behavior is greatly expanded. The ISC experimental methodologies are methodically divided into two categories: traditional and unique. The benefits and cons of each category are thoroughly described. Additionally, a thorough analysis is conducted on ISC detection techniques, encompassing both offline and online techniques. Lastly, a glimpse into the ISC mitigation research perspective is given in (Zhang et al., 2021a).

The gearbox is a significant cause of wind turbine failure. The gearbox bearings are the primary source of most gearbox breakdowns. Early detection of potential gearbox bearing wear and tear may be utilized for efficient predictive maintenance, which lowers maintenance costs overall. The self-evolving maintenance scheduling architecture for wind turbine management and maintenance is presented in this research. Additionally, a condition monitoring strategy that utilizes artificial neural networks (ANNs) and data from data collecting systems and supervision control systems is suggested. The gearbox bearings of two MW onshore wind turbines in the south of Sweden are subjected to the ANN-based condition tracking technique (Bangalore and Tjernberg, 2015). The different approaches to designing the ANN are shown in the manuscript. Because of lithium-ion (Li-ion) batteries' extended lifespan, exceptionally high power density, and advantageous environmental properties, their use has grown dramatically in recent years. Nevertheless, a number of internal and external malfunctions may arise while the battery is operating, resulting in poor performance and perhaps dangerous outcomes like thermal runaway, fires, or explosions. As a result, fault diagnosis plays a crucial role in the battery management system (BMS). It is in charge of early fault detection and control measures to reduce the impacts of problems, ensuring the battery system operates safely and dependably. A thorough analysis of numerous defect diagnostic algorithms, both model-based & non-model-based, is given in this study (Tran and Fowler, 2020).

This paper suggests a monitoring and warning system for recharging problems based on battery models. To simulate the power battery's recharging reaction, real-time adjustments can be made to variables including temperatures, voltage, and battery state of state. Through online estimations of the power battery model's SOC and batteries electrom. force, this enables the modeling of power batteries with different types, needs, and factors. CAN bus equipment for monitoring is used to acquire and evaluate data related to charger recharging, power usage, and battery refilling throughout the charging procedure (Zhang et al., 2021b). The charging response data produced by the type of battery is compared with its charging state data, as well as the charger's recharging state data is contrasted using the battery's recharging demand informat. to determine whether the charging procedure is normal. When it is determined that a charge fault took place, an alert is sent out. Over ten different fault kinds, including malfunctions in the BMS system, can be detected with this method. The viability of the charge fault tracking technique suggested in this research is confirmed by contrast and realising of real chargings accident information and information from power battery models. Despite the effects of SOC and temperatures, tests were conducted in this paper to estimate the impact of SOH on Thevenin ECM variables. The findings showed that while the polarizing capacitance decreased, the ohmic resistance and polarization resistance increased as the SOH decreased. To illustrate how SOH, SOC, and temperature affect the ECM parameters, a simulation model was also put out. Subsequently, the model underwent empirical validation, producing positive outcomes and demonstrating a notable increase in Thevenin model accuracy. This model's excellent precision and low complication make it simple to include in practical BMS systems (Tran et al., 2021). The summarize of literature review is shown in **Table.1.**

Table 1. Reserch gap of the literature review.

References	Method	Research gap
Khaligh and D'Antonio (2019)	High-power on-board chargers	SOC improvement requitred
Amir et al. (2023a)	Coordination-based intelligent energy administration system	Emphasizing on peak load
Lin et al. (2021)	IPT v/s CPT Wirless EV charging	Focus on dynamic wireless charging station
Khalid and Peng (2020)	Online Power Quality assessment	Power quality improvement required
Zhang et al. (2021a)	Short circuit and experimental mechanism	System work for lithion ion batteries

The results demonstrate considerable optical losses throughout the nation, with coupon placed in the horizontal direction showing the greatest percentage of loss (88%), with the coupons for Abuja, North Central exhibiting the largest loss. The SEM/EDX results showed minerals that could have an impact on light transmission, and pollutant data verified the size of the particles.

The novelty and original of the manuscript include as following:

- Improvement of the SOC (%) and performance variables like settling time and peak overshoot of speed with GA in comparison to ANN.
- The contribution and implementation of the genetic algorithm have improved the various performance parameters of speed and smooth control of SOC (%).

The performance parameters like poor SOC (%), more time to reach final state and more overshoot are the motivation of the research and its improvement with ANN and GA are the scope of the study. In order to bridge the research gap with the latest methods is the main contribution of the research.

The infrastructure architecture for EV charging is shown in Section 2, along with the anticipated average price of charging an EV. Infrastructure installation. Additional subcategories include operational controller for EV chargers and charging standards. The functioning of SPVCS is described in Section 3. EV sales forecasting in Indian power industry scenarios was the final step. The objective function is mathematically modeled in Section 4, the findings are analyzed in Section 5, and the conclusion is presented in Section 6.

2. Development of the EV Charging Infrastructures

The advantages of peak sun periods are thoroughly considered when constructing the solar-based recharging location, taking into account the climatic data provided by NREL for the chosen location. For instance, the time frame during which the midway sun-based power equal 1 kWh/m² is referred to as peak sun hours. For modeling purposes, an average number of hours of sunlight may be assumed. In the parking area, the structure has a separate kW solar-powered dynamic vehicle recharging lot that serves as a distribution system. It includes a range of solar-power chargers from various manufacturers. These chargers take up space and have a daily EV charging capabilityThe building is located in a residence or workplace. Standard test parameters, such as an ambient temperature between 25 and 55°C, solar radiations equivalent, and corresponding irradiation, are used to evaluate a PV module's electrical properties. For every kW of solar-powered PV in an Indian market, the cost of setup, substitution, and upkeep (O&M) expenses are estimated to be INR 600K, INR 300K, and INR 20K year, correspondingly (Amir and Haque, 2021b; Muttaqi et al., 2019).

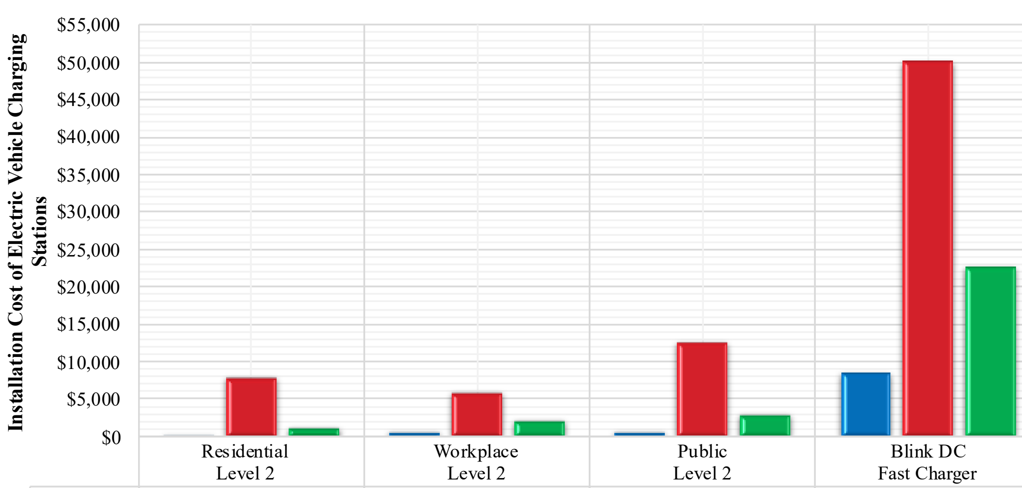

Figure 1. Forecast average cost of EV charging infrastructure installation.

Figure 1 shows the prospective charging infrastructure status together with an exploded chart of the typical installation cost. Both traditional utility grid electricity & solar-produced PV power are typically used to power this charging station, which is used to recharge cars that are sheltered under the shed (Khalid et al., 2022). As a result, the charging station gives cars the option of powering up using solar energy or traditional power during the day and regular grid electricity at night (Amir et al., 2023c; Mouli et al., 2019). The configuration of the PV system centers on the main issues that affect the price of a PV system, such as the converter unit, battery charge controller, solar-based generating unit, & controlling drives mechanism. (Shrivastava et al., 2019).

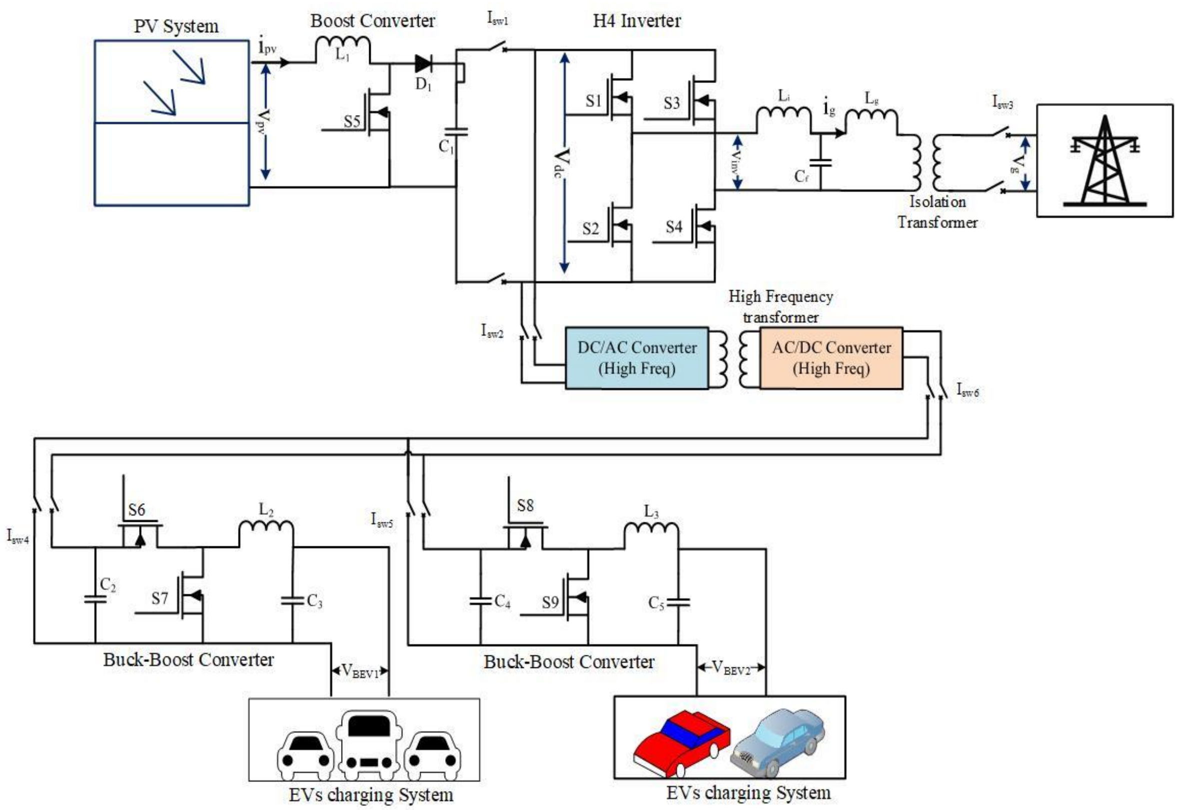

Figure 2. Optimal framework of SPVCS.

The solar photovoltaic system, a portion of the solar power converter (DC-AC) system, and the flow of electricity via buck/boost topology are among the parameters that make up the SPVCS framework, which is depicted in **Figure 2** (Amir and Haque, 2021b). While the H4 inverter converts DC power produced by the PV panels, the energy flow via the electric distribution grid through the solar-linked inverter manages the production of electricity of the air conditioner (Khaligh and D'Antonio, 2019). In order to reduce variations and irregularities in solar power generation, the DC controller for charging & batteries storage system are also combined. Surplus generated electricity can’t be fed back to the grid because the station is an independent solar hybrid device that doesn't need a grid link to function. The power grid can handle greater demand, but excess energy can't be recycled back into the system. (Lin et al., 2021).

2.1 Charging Standard

EVs' overall charging System complies with accepted and well-established standards. With the ability to accommodate a peak output power of wanted kW for substitute current, immediate recharge abilities up to a system power restriction, and potential growth possibilities up to peak kW rating, this charger seamlessly blends single-stage imposing with 3-stage recharging. The basic functions of a charging station for electric vehicles, including shipping, relationship, and control of the charging process, are depicted in a schematic. The vital connection between the vehicle and the renewable energy source or infrastructure for charging is the Electric Vehicle Supply Equipment. It functions as a cutting-edge connector that safely and effectively interfaces with the car to enable charging.

2.2 Operating Controller for EV Charger

The design of the charge controller and related operating protocols. Using light-emitting diode indicators, which could be seen with a distance, EV users can quickly ascertain the condition of the Electric Vehicle Supply Equipment (EVSE). According to the associated charging state, these colored signaling indicators successfully communicate the following financial circumstances. When an AC power source is present and the charge cable is attached to the car, it means that charging has not yet begun. This is known as operational charger status. Progressing charging: charging begins by electrical contact as soon as the cable is connected. (Khan et al., 2018; Lin et al., 2021) Problem or Warning state. Users are informed of potential issues or cautions related to the charging procedure through this stage.

3. Operation of SPVCS

The several renewable-based PV infrastructures and their components that can be used for electric vehicle (EV) charging at parking lots are illustrated in this section. A solar matrix-integrated power system with a hybrid operating mode is part of the intended EV charging station. It basically consists of a collection of parts intended to transform solar energy into electrical power. Common instances of these components are solar panels, a distribution network, energy storage, converter systems, a car's electric battery, and the load systems. The parts that follow are part of the SPVCS operations and will be discussed individually in the upcoming sections: Battery Distribution, Conversion Design, ESS as EV Charge Load, and Solar PV-based Producing Systems.

3.1 Solar PV-based Generating System

The features of the PV panels, the event solar irradiance on the the panels, and the actual temperature rise of the photovoltaic components are some of the factors that affect the result of the production of solar energy (Amir et al., 2023b; Husain et al., 2024; Malik et al., 2023; Shariff et al., 2020; Tomar et al., 2021). Let's look at a solar PV generation setup with 20 panels divided into two series portions with 10 equal characters, each certified at 300Wp. An array system with a temperature of ≥ 25°C and different levels of solar-based irradiance between 100 and 1000 W/m² will be used to assess the performance and features of this panel clusters.Changes in solar PV generation are revealed by monthly statistics on mean global horizontal radiation, which is derived from the NREL database. The data shows that, after a similar pattern from April to June, solar power generation peaks in May. On the other hand, power generation falls in the rainy months of July and September, and it reaches its lowest level during the hazy or winter season.

3.2 ESS as EV Charging Load

Facilities for electric vehicles (EVs) is right now scarce in a typical Indian setting. Designed to carry up to 46 travelers, these Level 2 The driving range for public battery electric vehicles is approximately 120 kilometers. When utilized as an Energy Storage System, a Lithium-Ion (LI) battery pack has a standard capacity of 111.3 kWh. The vehicle have a top speed of 100-120 km/h and an energy consumption of about

0.1 kWh/km. The significant discrepancy between the starting and intended battery storage charge levels determines how much power is supplied to the EV. Equation (1) provides the following formula for calculating the energy needed (E_req) for a certain kind of battery-based EV:

$$E_{req} = \Delta SoC \cdot C_{bat.BEV} \tag{1}$$

Here, C_(bat.BEV) indicates the battery charge evaluation for the specific BEV (SoC = 20-80% in the typical scenario), while E stands for the overall energy. The electrical proper. of a particular cell, as indicated in Equation (1) energy needed about changing patterns, can be used to simulate the charge profiles of the Li-battery pack. The length of time needed for a one vehicle to fully charge and the maximum no. of vehicles that may be charged simultaneously each day are revealed by analyzing departure data for large-scale EVs. The batteries used in electric vehicles (EVs), solar power production capacity, and available charging options are all largely governed by this analysis. Level-1/2/3 and ultra-fast chargers are the four types of charging stations that are frequently utilized. Workers in managerial roles in India, especially in small and medium-sized enterprises, frequently put in up to 10–11 hours a day, six days per week. A five-day, eight- to nine-hour workweek may be required for government jobs, major Indian firms, and multinational corporations (MNCs). Based on these findings, it is possible to use solar energy specifically for PEV recharging in parking lots without requiring large Energy Storage Systems (ESS) because cars are usually parked for a large amount of the day. Thus, our study supports the idea of deploying PV panels for office recharging during the day by demonstrating the frequency of charging station utilization.

3.3 Battery Storage and Converter Design

One important component of off-grid solar PV systems is battery storage. Because solar-generated power varies, these systems need a specific amount of capacity. A photovoltaic power plant directly feeds the demand while sunshine is present, storing any excess energy in an electric bank. The consumer's load requirement can then be satisfied by utilizing the battery storage system during the night or when there is not enough daylight. An energy storage device for a solar-powered recharging system is made out of a separate batteries bank, usually made of lead acid. 150 Ah (12x4) V =48 V, or 7.2 kWh, is the typical nominal rating. The equation for SOC computat. is termed as:

$$SoC(t) = (1 - Q) \cdot SoC(t - 1) + P_{cd}\,\Delta(t) \cdot e_{cd}\,E \tag{2}$$

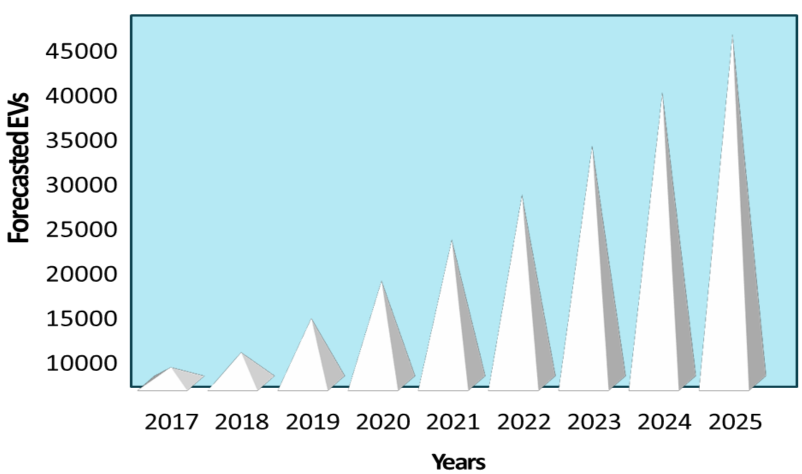

Figure 3. Forecasted EVs sell in Indian power market scenarios.

Thus, the expansion of massive EVs in Indian power market situations is depicted in **Figure 3**. The suggested research concludes with EV market projections for different charging standards, technologies, and advancements in charging flow. These tendencies will increase, but greater subsidies ought to be needed. In order to mitigate the negative effects of massive EV fleets, additional flexible infrastructure for charging is required, as this trend has tripled in the past few years.

4. Mathematical Modeling of Objective Function

The standard expression of SOC at any instant ‘t’ is given in Equation (2).

Charging and discharging of electric vehicle which is measured in terms of SOC lies within the minimum and maximum limit in the certain form of the constraint which is mentioned in Equation (3).

$$SOC^{min}(t) < SOC(t) < SOC^{max}(t) \tag{3}$$

Let the voltage of a battery is ‘V’ is used to drive the DC motor with its speed ‘ω’, i_a, r_a are the armature current and resistance and its voltage expression is mentioned in Equation (4).

$$V = K\omega + i_a r_a \tag{4}$$

This current is same as mentioned in Equation (2).

Now considering the constraint and voltage equations used in Equations (3) and (4). An objective function has been framed which is shown in Equation (5)

$$f(SOC(t),\omega) = k_1(SOC^{min}(t) - SOC(t)) + k_2(SOC(t) - SOC^{max}(t)) + k_3\left(\int \frac{V-K\omega}{r_a}dt\right) \tag{5}$$

4.1 Objective Function Controlling with ANN

Equation (5) can be realized in the form of ANN which is shown in Equation (6).

$$Y = W_1X_1 + W_2X_2 + W_3X_3 \tag{6}$$

where as

$W_1 = k_1$

$W_2 = k_2$

$W_3 = k_3$

$X_1 = SOC^{min}(t) - SOC(t)$

$X_2 = SOC(t) - SOC^{max}(t)$

$X_3 = \int \frac{V-K\omega}{r_a}dt$

Now use back propagation delay, before that error is mentioned in Equation (7) and activation function of output is sigmoid function

$$e = \frac{(Y-Y_{ref})^2}{2} \tag{7}$$

Now the weight will be updated as shown in Equation (8)

$$W_{new} = W_{old} - \eta \frac{\partial e}{\partial W_{old}} \tag{8}$$

The old and new value of weights is given in **Table 2** and structure of ANN is shown in **Figure 4**.

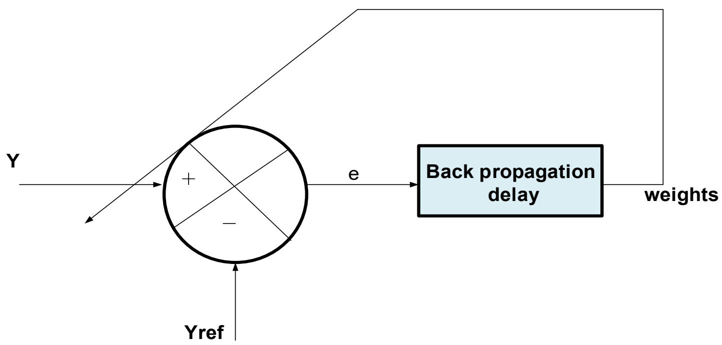

Figure 4. ANN architecture.

Table 2. Old and new values of weights.

Weights	Old value	New value
W_1	24.6	31.2
W_2	28.6	35.6

4.2 Objective Function Controlling with Genetic Algorithm

Now the objective function used in Equation (5) will be controlled with a genetic algorithm by training the k_1, k_2, k_3 as variables.

The process of implementation of genetic algorithm begins with three steps: reproduction, crossover, and mutation. The following desirable parameters are required for the implementation of genetic algorithm:
Size of population: 6
string length: 4
Probabability of the crossover, P_c=0.8
Probabability of the mutation, P_m=0.085
The objective functions which is considering three variables only (k_1, k_2, k_3). These three variables will be determined by Equation (8).

$$f^r = f^{min} + \frac{f^{max} - f^{min}}{2^l - 1} y^r \tag{9}$$

where, ‘r’ is iteration, y^r is the length of the binary string.

Equation (9) will be extended further to attain its new value which is shown in Equation (10).

$$(f^r)_{new} = \frac{1}{(1 + \frac{\alpha' \varepsilon^r}{f^r})} \tag{10}$$

Convergence factor = $f^r - (f^r)_{new}$.

The flowchart illustrating the process of the genetic algorithm is shown in **Figure 5**.

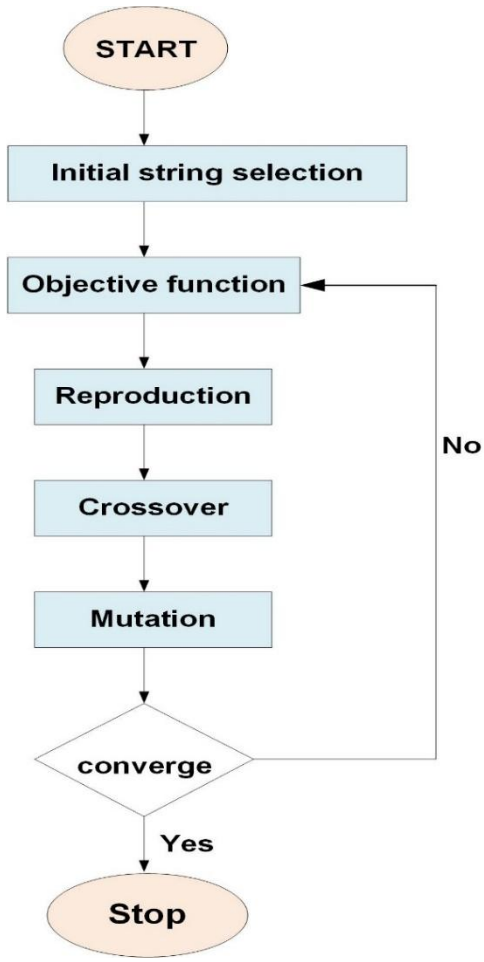

Figure 5. Flowchart explaining the genetic algorithm.

5. Result Analysis of the Proposed Model

The important characteristics like fitness function characteristics using genetic algorithm, Current best individual variations using genetic algorithm, Average distance variation with generation using genetic algorithm, variation of expectation with the raw score using genetic algorithm, Best, worst and mean square variation with generation using genetic algorithm, No. of individual variation with score using genetic algorithm, fitness of each variations with iteration using genetic algorithm, Number of children variations with individual using genetic algorithm, stopping criteria variations with its criteria met using genetic algorithm are mentioned above, which are shown in **Figures 6** to **14**. The **Figure 6** shows the fitness function and its mathematical expression given in Equation (5). The fitness function converges to 7.5 which shows its desired optimal value.

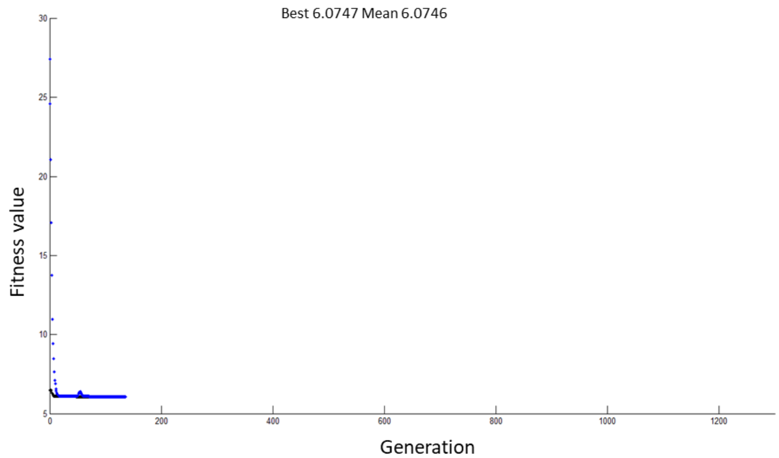

Figure 6. Fitness function characteristics using genetic algorithm.

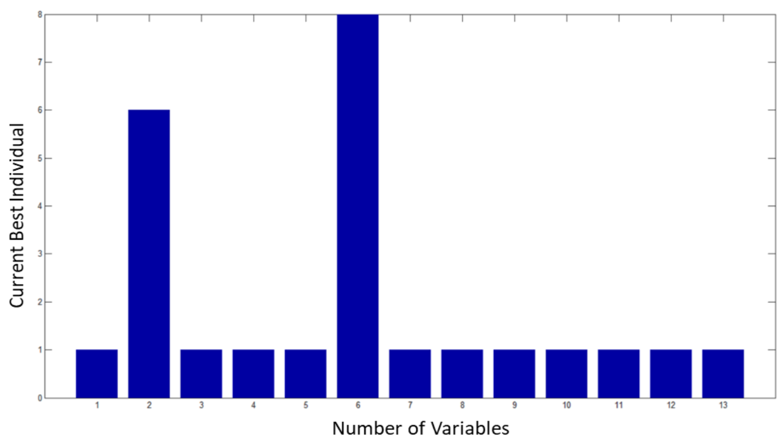

Figure 7. Current best individual variations using genetic algorithm.

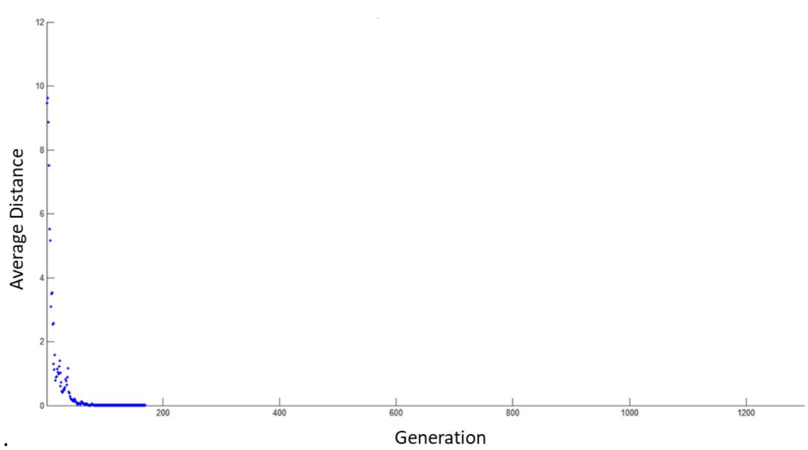

Figure 8. Average distance variation with generation using genetic algorithm.

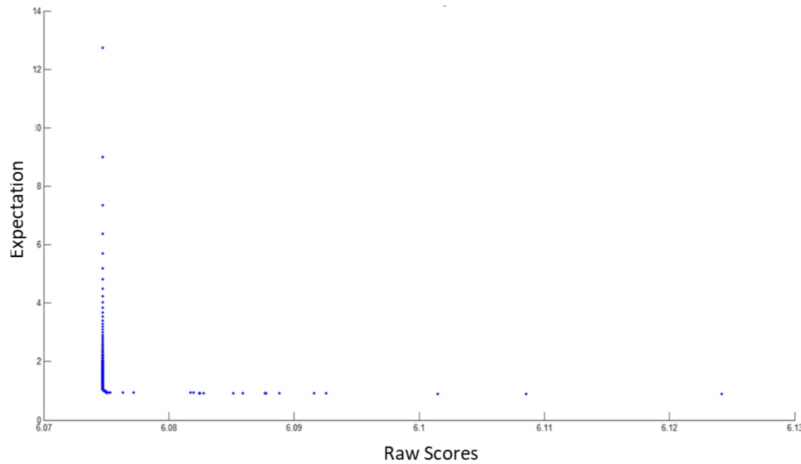

Figure 9. Variation of expectation with raw score using genetic algorithm.

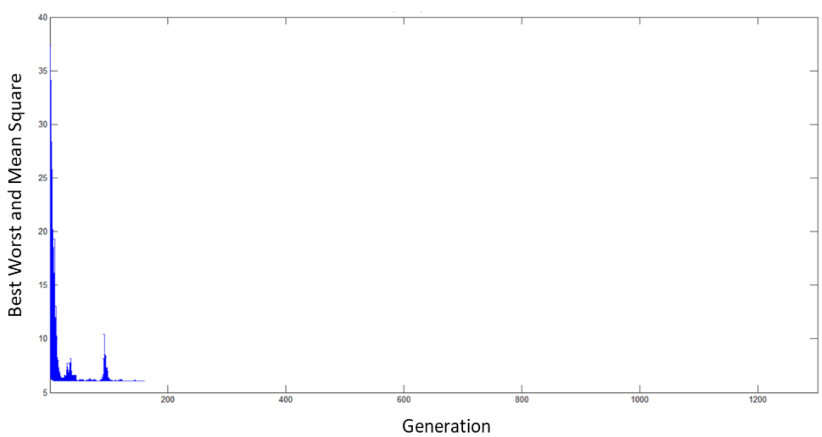

Figure 10. Best, worst and mean square variation with generation using genetic algorithm.

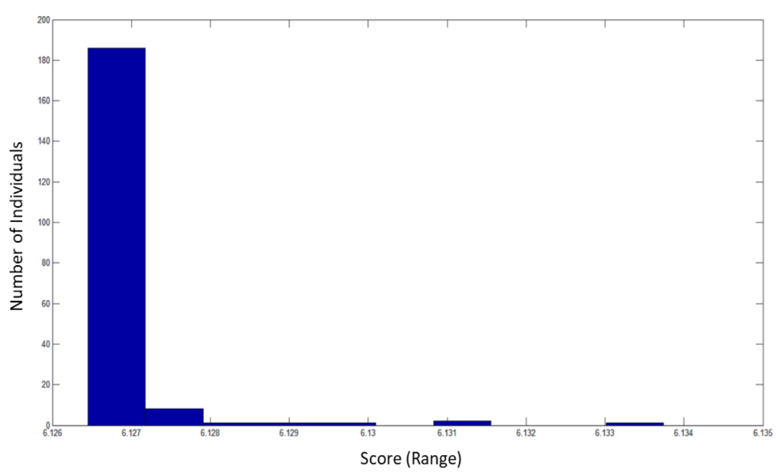

Figure 11. Number of individual variation with score using genetic algorithm.

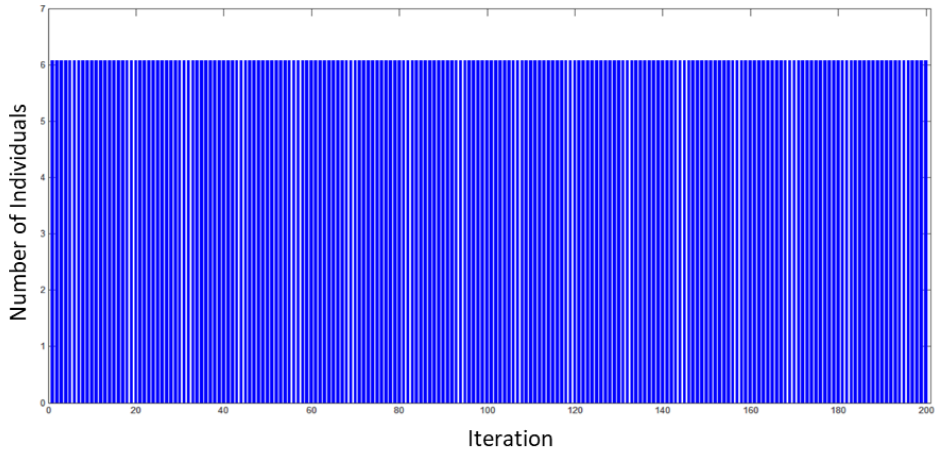

Figure 12. Fitness of each individual variations with iteration using genetic algorithm.

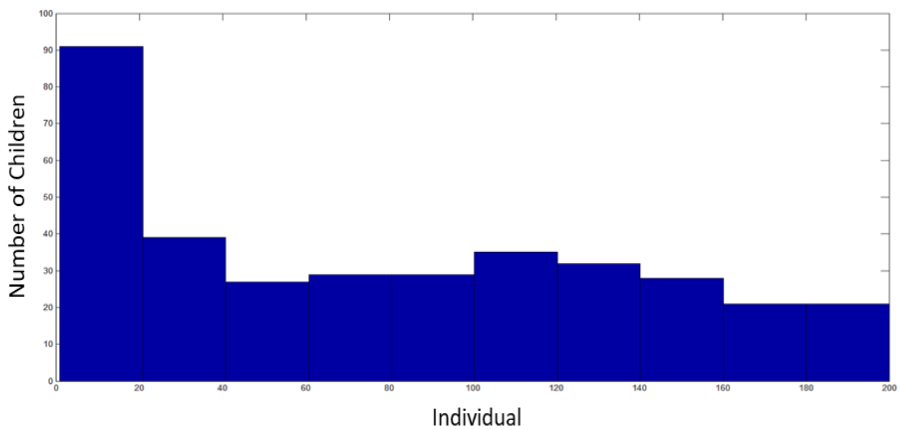

Figure 13. Number of children variations with individual using genetic algorithm.

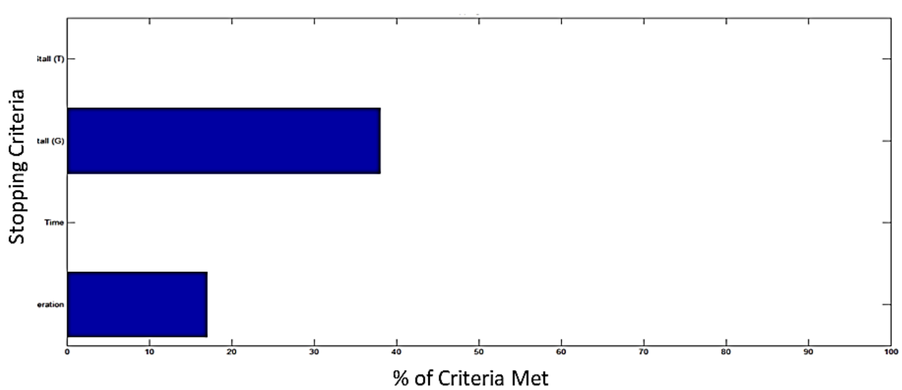

Figure 14. Stopping criteria variations with its criteria met using genetic algorithm.

The important characteristics of ANN are shown from **Figures 15** to **18** like mean square error variation, gradient variation, output base variations.

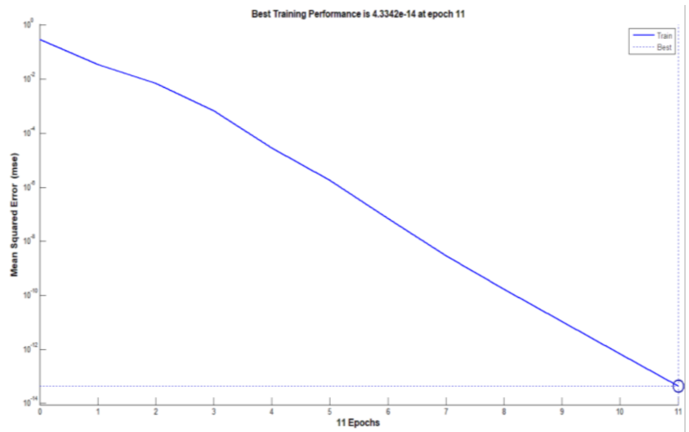

Figure 15. Mean square error characteristics variation using ANN.

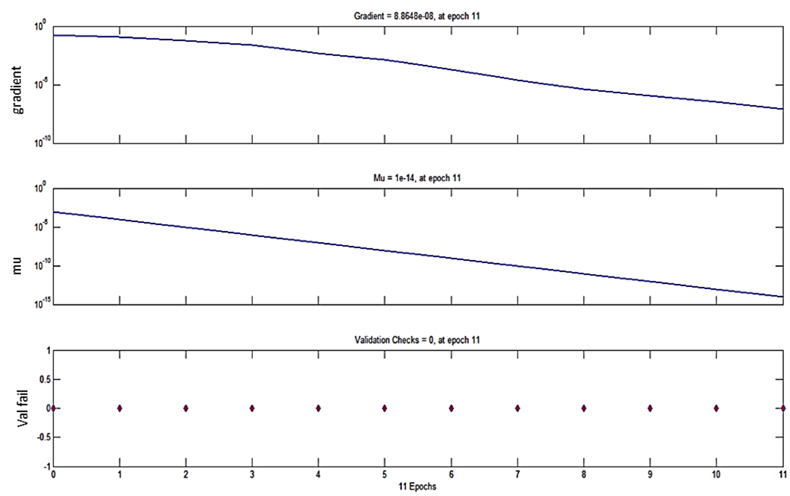

Figure 16. Gradient based characteristics variation using ANN.

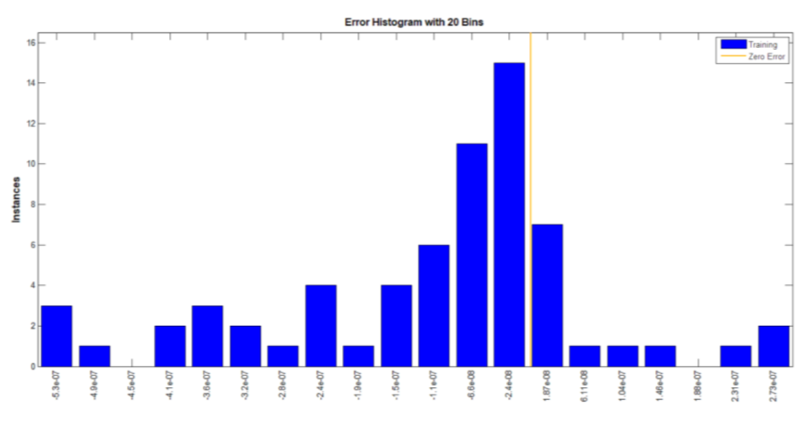

Figure 17. Different instances variation with error using ANN.

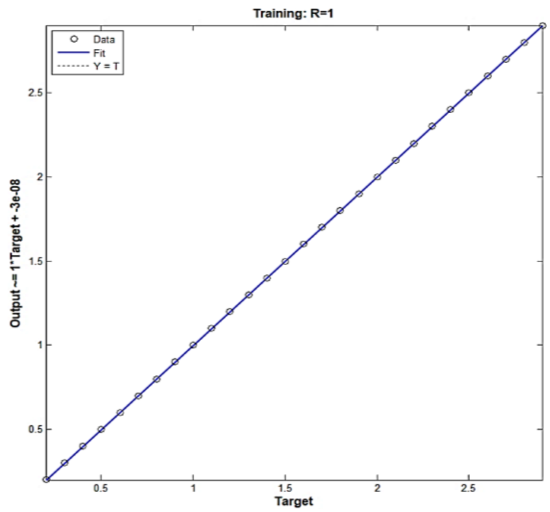

Figure 18. Output variation with target using ANN.

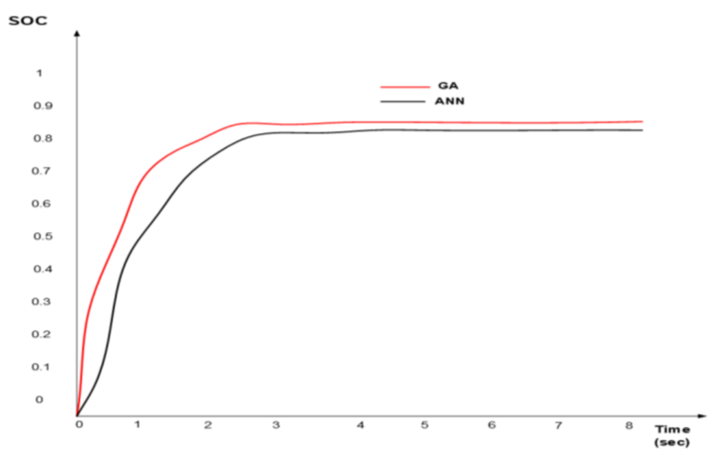

Figure 19. SOC (%) of the electric vehicle using GA and ANN at 150V.

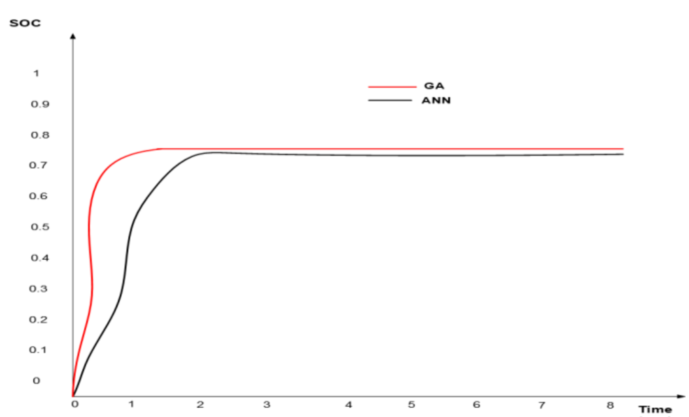

Figure 20. SOC (%) of the electric vehicle using GA and ANN at 100V.

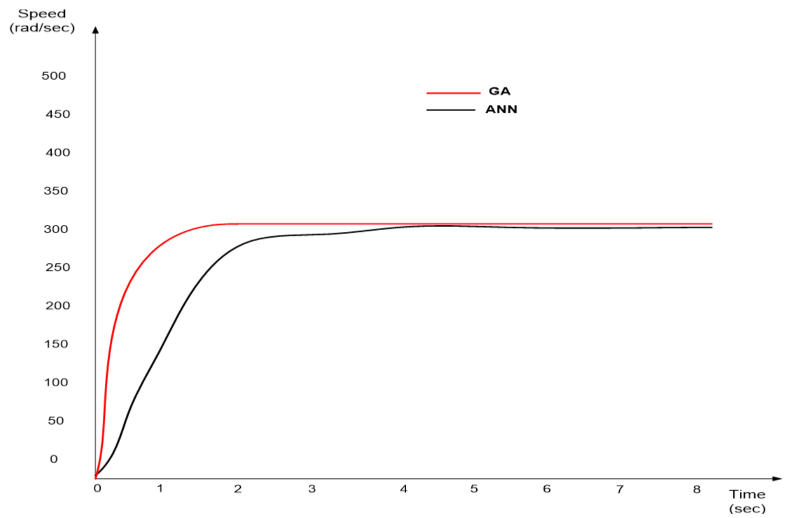

Figure 21. Speed of the electric vehicle using GA and ANN at 100V.

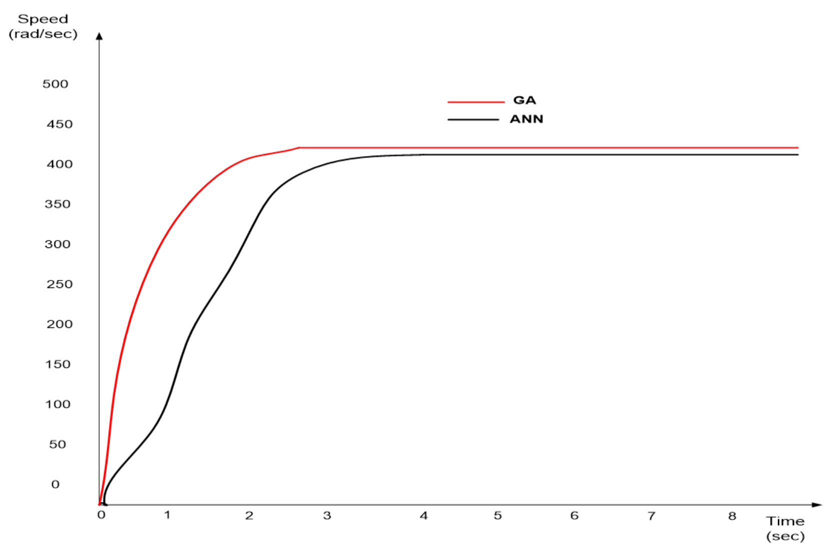

Figure 22. Speed of the electric vehicle using GA and ANN at 150V.

The speed traits with GA, ANN, and current techniques at voltages of 150V and 100V are displayed in **Figures 21** and **22**, while the SOC (%) features of batteries for electric vehicles with GA, ANN, and existing techniques (Sahoo et al., 2017) are displayed in **Figures 19** and **20**.

Table 3. SOC (%) of battery at different voltage levels using GA and ANN.

Various voltage level	GA	ANN	Sahoo et al. (2017)
100 V	0.7	0.68	0.72
150 V	0.85	0.80	0.85
200 V	0.89	0.87	0.92
250 V	0.93	0.91	0.96

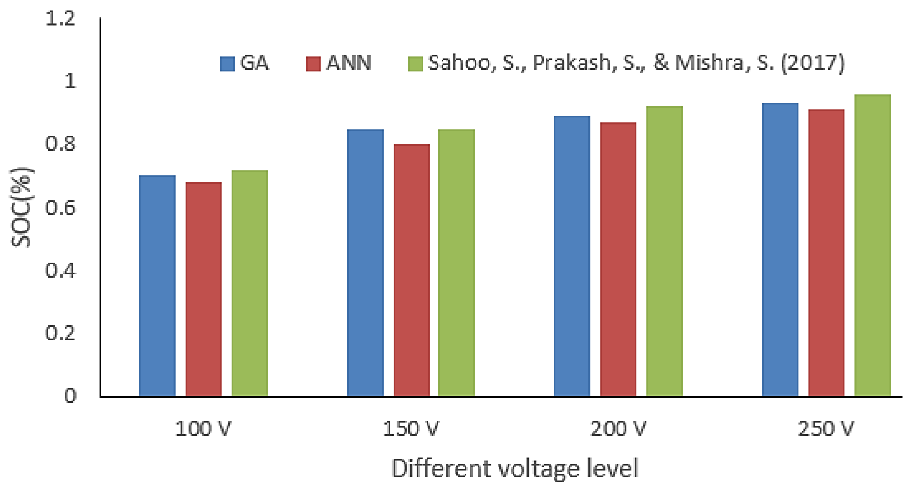

Figure 23. Graphical comparison of SOC (%) at different voltage level using GA and ANN.

Table 4. Settling time (sec) of speed at different voltage level using GA and ANN.

Settling time (sec)	GA	ANN	Sahoo et al. (2017)
100 V	2	2.5	2.9
150 V	2.5	3.5	3.9
200 V	2.8	3.2	3.6
250 V	3.1	3.9	4.8

Table 5. Peak overshoot (%) of speed at different voltage level using GA and ANN.

Peak overshoot (%)	GA	ANN	Sahoo et al. (2017)
100 V	2.7	3.1	3.8
150 V	2.8	2.9	3.5
200 V	3.1	3.4	4.1
250 V	3.5	3.8	4.3

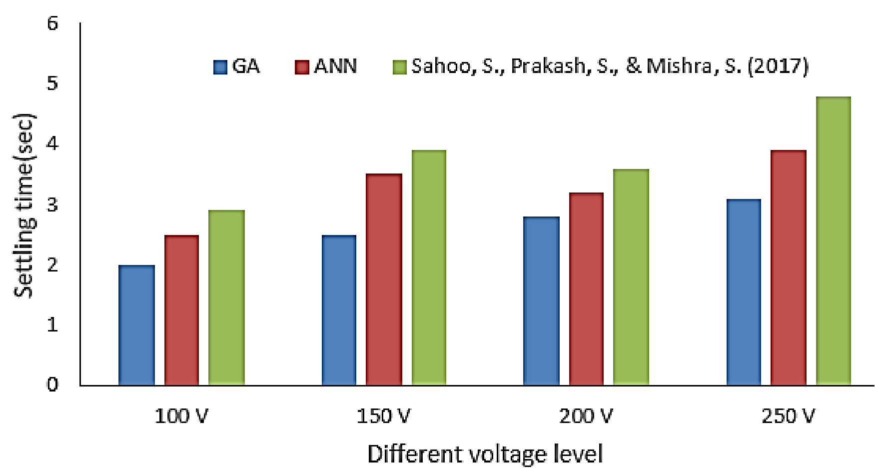

Figure 24. Graphical comparison of Settling time of speed at different voltage level using GA and ANN.

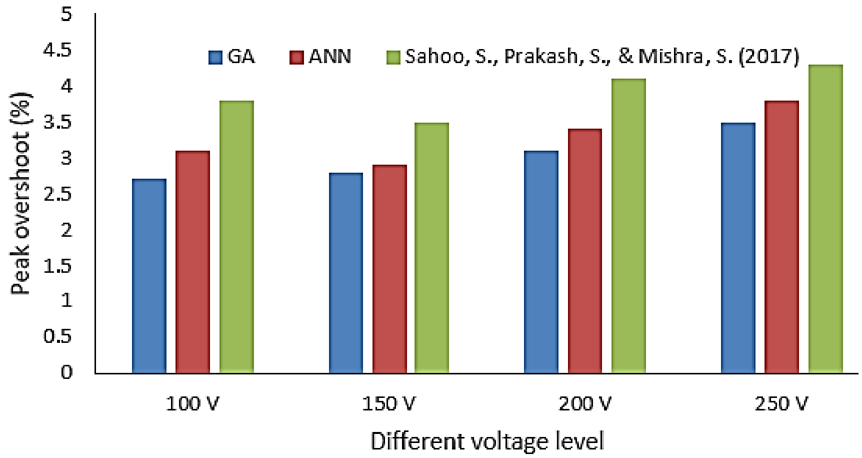

Figure 25. Graphical comparison of peak overshoot (%) of speed at different voltage levels using GA and ANN.

Table 3 displays the SOC (%) of the battery of an electric vehicle at various levels of voltage utilizing GA, ANN, and current techniques (Sahoo et al., 2017), and **Figure 23** provides a graphical contrast between the results. **Tables 4** and **5** display the settling time (in seconds) and peak overshoot (in percentage) of the speed at various levels utilizing GA, ANN, and current techniques; **Figures 24** and **25** provide a graphical comparison of these results. At various voltage levels, it has been found that GA significantly improves SOC (%) when compared to ANN. Similarly, at various voltage levels, GA is observed to have a lower peak overshoot (%) & settling time (sec) of the speed than ANN and current techniques.

6. Conclusions

An electric vehicle (EV) is one of the best substitutes for traditional cars. The structure for the for the development and execution of a smart controlling system for powered by sunlight electric vehicles utilizing soft computing methods are covered in this paper. These methods necessitate careful optimum planning, recharging economy, and ongoing upkeep in order to develop an innovative solar-powered electric vehicle charging station utilizing intelligent control & soft computing approaches. On the other hand, it may reduce continuous operating costs and offer an environmentally friendly, long-term EV charging option. This paper evaluates the charging of electric vehicles at different voltage levels. Consequently, a DC motor controls an electric vehicle. The speed of an electric vehicle is examined in conjunction with its state of charge, which is expressed in terms of state of charge (SOC). A goal function has been devised to achieve the smooth operation of both speed and SOC. Furthermore, genetic algorithms and ANN have been used to govern the objective function (GA). When compared to ANN, and existing method, SOC (%) performs more smoothly and effectively with GA. Additionally, the use of GA and ANN has greatly improved the settling time and peak overshoot of the speed.

Conflict of Interest

The authors confirm that there is no conflict of interest to declare for this publication.

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AI Disclosure

The author(s) declare that no assistance is taken from generative AI to write this article.

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