Optimal Power Management in battery/ SCAP of Electric Vehicles using Artificial Intelligence techniques

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Abstract-Energy management is a critical technology in Electric Vehicle (EV) for maximizing efficiency, and fuel economy, as well as reducing pollutant emissions.The Energy storage systems (ESS) is the prime factor that accounts for the Electric Vehicle (EV) performance and reliability. However, the conventional ESS is heavy, costly and bulky in nature and so the EV characteristics like mileage are limited. The improvement of thermal battery behaviour is the only energy source which reduces the cost and thus optimizes the performance of EVs. The Fuel cell (FC) is also a good alternative source with higher efficiency and zero emissions but, it has a sluggish dynamic responsiveness, lengthy startup time, brittle output characteristics, and expensive cost. FCs has a major advantage of incorporating ESS, which have the ability to cover the fast power variations. A major problem when using more battery cells is that a huge peak power or quick charging/discharging can harm one or more cells. Hybrid Energy storage systems (HESS) consisting of supercapacitors and battery are used in EVs where the supercapacitors serve as a supplementary energy resource for satisfying the instant high power demands. Several control strategies have been suggested to coordinate the power flow between the supercapacitors and the energy sources.

Keywords Battery Energy management HESS SCAP Deep Convolutional Neural Network

INTRODUCTION

To avoid low efficiency operation, a DC-DC converter is included which optimize the HESS power flow by minimizing the HESS power loss and enhances the battery life time by minimizing the battery current magnitude and variations. To maximize the energy management for electric vehicles, HESS like battery and super capacitors (SCAP) are used which has two objectives, such as (i) determining the SCAP reference by considering real-time dynamics of load and (ii) optimizing the power flow by reducing the magnitude variation of battery power and power loss. A sophisticated model of the DC-DC converter is taken into account in this HESS power management issue, which includes both conduction and switching losses. Also, the optimization issue is numerically tackled for varied drive cycles utilizing controllers of the converters. Therefore, to train and predict the control parameters of HESS for better energy management in EVs, recent Artificial intelligence strategies (Machine learning/Deep learning) along with hybrid meta-heuristic algorithms is used. Hence, this study will focus on the use of machine learning and deep learning models to predict the control parameters with the assistance of optimization strategies to enhance the performance of the module in effective energy management, as this technique has proved to be a very promising one in the EV applications.

1. Energy Management System (EMS) of HESS for EVSThe energy management scheme (EMS) of HESS for EVs utilizing proposed hybrid procedure is proposed. To maximize the energy management for EVs HESS is utilized. The combination of two or more power sources with an electric traction motor is the EV (Kou- chachvili et al. 2018). Primary ESS is the battery which embraces smooth loads, while secondary ESS is the super capacitor (SCAP) which covers the frequent transient loads. Through the regenerative braking, both the battery and SCAP recuperate the vehicle mechanical energy. So also, for smooth and frequent charging, the battery and SCAP are dependable. Subsequently, huge decreases in the cost and

optimizing the execution of EVs can be accomplished. Besides, it is essential to oversee appropriately the vitality got from and into the system to maximize the advantages of the HESS in the EVs. Assessing the HESS performance is one of the significant criteria in EV is its driving cycle considered. Here, on the efficiency of the DC/DC controlled SCAP into EV, in the significant impact of the driving cycle was consolidated. The strain of batteries is decreased so the battery peak current is adjusted adequately. The SCAP permits greater energy extraction from the batteries. In the EV, different parts are plotted. They are HESS (battery and SCAP), charge port, DC-to-DC converter, electric genera- tor, electric traction motor, exhaust system, fuel tank, internal combustion engine, power electronic controller, thermal system, traction battery pack and transmission.

In the battery pack, the charge port enables the vehicle to connect with an outer power supply. DC/DC converter converts the power into higher- to lower-voltage DC power. The auxiliary battery is the main function of the converter to run the vehicle accessories and recharge. While braking electric generator creates electricity from rotating wheels which moves the energy to the battery pack of the traction. The electric traction motor drives the vehicle's wheels utilizing power from the traction battery pack. Through the tailpipe, the system channels debilitate gases from the engine out. To add fuel to the tank, the fuel filler is utilized. Gasoline is stored by the fuel tank until the EV required by the engine. Combustion engine is worked because of the injection of fuel to the combustion chamber.

Hybrid Technique For EMS In EVS

Among load demand, the battery and SCAP energy management problem of HESS is to split effectively. HESS consists of two sections: one section is used for computing the voltage of SCAP reference and another section is used for optimizing the flow of power through HESS. At first, by considering real-time dynamics of load the SCAP reference voltage is computed the motor characteristics, such as driving conditions, the dynamics of the vehicle and regenerative braking systems. Secondly, reduce the magnitude variation of the battery power and the loss of power simultaneously. using the Deep CNN model predicts the optimal parameters of HESS. Furthermore, the proposed technique optimizes the voltage of SCAP, magnitude of battery current, variations of battery current and battery power

Voltage control loop of battery

The constant current–constant voltage (CCCV) charging is the simple methodology to charge the battery. Here, the battery capacity can be indicated as *q*bat.

When the battery voltage reference *v*bat;ref is far from the actual battery voltage *v*bat then the battery current is constant.

The battery current is decreased when the voltage of battery is near and equivalent to battery voltage reference.

Description of proposed system

Nowadays, the Hybrid Energy Storage Systems (HESS) is gaining popularity as a result of their superior system efficiency and battery life time when compared to solitary energy sources. The SCAP and battery energy management issue of HESS is effectively split along load demand. Due to the system's complexity, it's very hard to establish an optimized energy management control method. To train and evaluate the optimal parameters of HESS, a Deep CNN model is proposed in this work. Deep CNN may be used to approximate complicated systems successfully. Deep CNN is trained using the training data and is known for its fast convergence and resilience.

In the proposed work, the parameters, such as will be optimally tuned using the Deep CNN model. To validate the Deep CNN performance, the relationship among the predicted and the actual outputs is considered. To produce the optimal control signals using the Deep CNN model, the weights of the Deep CNN model will be optimally tuned using the proposed MI-HBA algorithm. This assists in enhancing the performance of the Deep CNN model in optimal power management. The model is shown in Fig 1

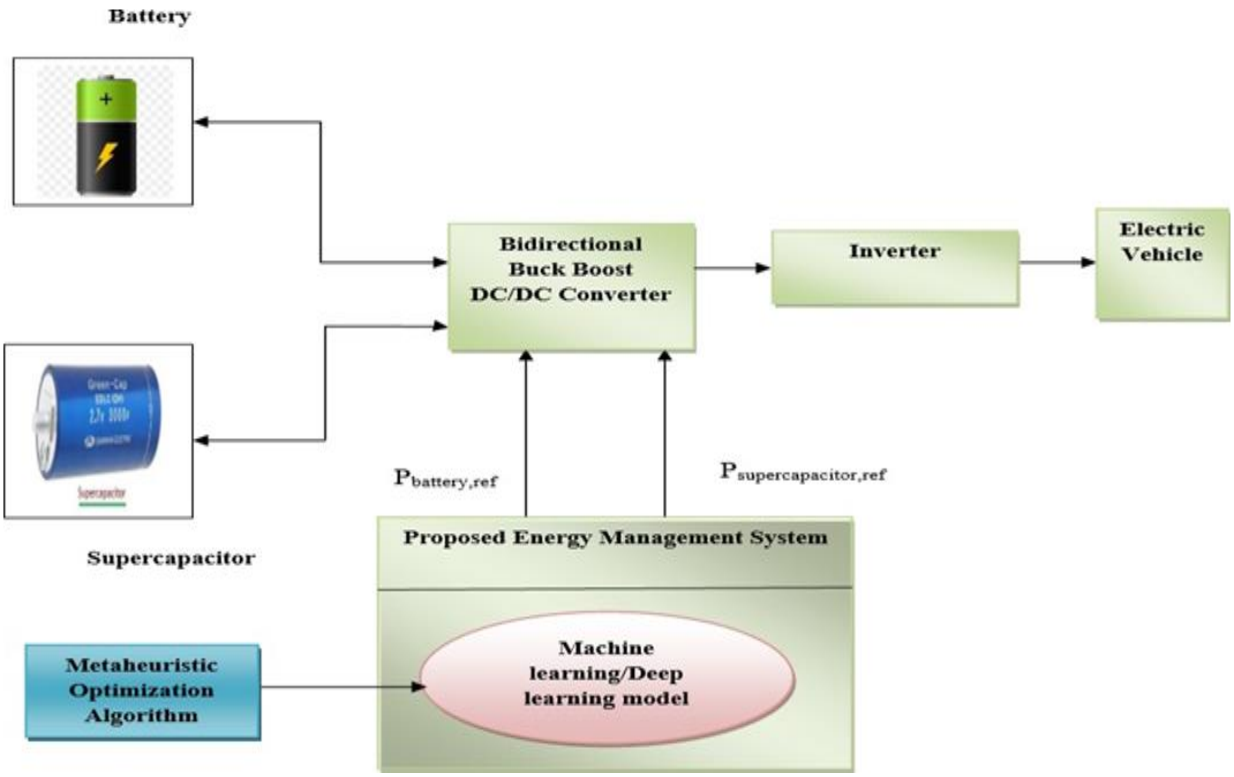

Fig 1: Overall Structure of proposed model

Deep Convolutional Neural Network Model

D-CNN based approach for power/energy estimation of EV is being developed for the first time. To train and evaluate the optimal parameters of HESS, a Deep CNN model is proposed in this work Deep CNN may be used to approximate complicated systems successfully. Deep CNN is trained using the training data and is known for its fast convergence and resilience. In the proposed work, the parameters, such as Kp ,Ki ,Kd , λ and μ of the FOPID controller will be optimally tuned using the Deep CNN model. To validate the Deep CNN performance, the relationship among the predicted and the actual outputs is considered. To produce the optimal control signals using the Deep CNN model, the weights of the Deep CNN model will be optimally tuned using the proposed MI-HBA algorithm.

One of the challenges was the requirement of internal vehicle data from the manufacturers for calibration of simulation models, which is vary hard to obtain as the manufacturer do not share the data in public domain. The proposed methodology requires only three parameters namely, vehicle speed, road elevation and tractive effort. Also, the required input parameters can be easily obtained or calculated, for instance, vehicle speed and road elevation can be easily obtained using Global Positioning System (GPS) and Geographic Information System (GIS), the proposed deep learning based solution pro- vide real-time energy consumption as output and can be used to provide real-time guidance to the driver about remaining energy in the battery and hence, remaining driving range of the vehicle.

Also, the deep learning architectures can learn more complex patterns than shallow networks, as existing ANN based models have only one hidden layer. Recent advances in computing power and fast learning algorithms have made training deep learning architectures feasible. Due to this, deep learning architectures have gained a lot of interest in the automotive sector also and have been successfully applied in numerous problems like image classification, object detection, traffic flow prediction etc. Also, the nonlinearity and complexity induced by the combination of all the influencing parameters make the problem of energy consumption estimation more suitable for a deep learning approach, in contrast to other regression techniques. This motivates the authors to focus on the deep learning based models to solve the problem of estimation of energy consumption of EV. The current work, by providing experimental results, proves that a deep learning architecture is suitable for the problem at hand. The Structure of Deep CNN model is shown in Fig 2.

The following are the main contributions of this work:

i)A D-CNN based methodology has been developed which requires only three external parameters, namely, Road Grade, Tractive Effort and Vehicle Speed and can accurately estimate the energy consumption.

ii) The proposed model can be easily trained for other vehicles either using the real world driving data which is subject to availability or using the simulated data from the simulated model, as done in the current case.

iii) The effect of different input features descriptors on models performance has also been stud- ied by training the D-CNN models with three different feature descriptors namely, Gramian Angular Field (GAF), Cosvariance and Eigen Vectors.

i) The effect of different number of hidden layers has been explored by training the models with different number of layers.

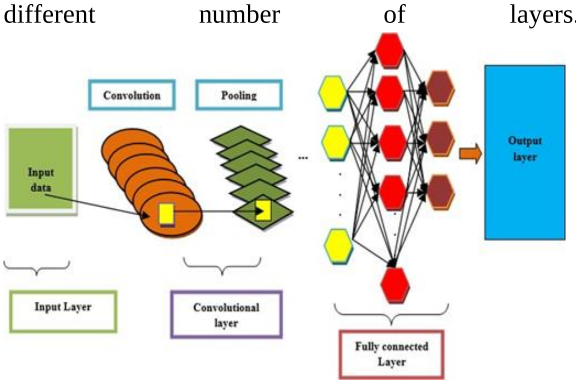

Fig 2: Structure of Deep CNN model

1.1 MI-HBA Algorithm

The novel meta-heuristic algorithm known as Memory integrated Honey badger Algorithm (MI-HBA) which helps to improve the performance of the Deep CNN model in selecting the optimal parameters, such as and of the FOPID controller. The characteristic features derived from two standard optimization strategies, such as Crow search Algorithm (CSA) and Honey Badger Algorithm (HBA) are merged to develop a novel mathematical model. The weights of Deep CNN are optimally tuned through the novel mathematical model with the objective of minimizing the errors and maximizing the prediction accuracy of the parameters, such as Kp ,Ki ,Kd , ƛ and μ of the FOPID controller

3.2.1 Crow Search Algorithm

Crow Search Algorithm (CSA) is a recent algorithm developed by Alireza Askarzadeh in 2016, Since CSA has been widely used and applied to different optimization problem such as chemical engineering, medical, power energy, feature selection, and image processing. which simulates the crow behavior in storing their food and retrieving it when they need it. Crow is an intelligent bird that can remember faces and warn its species in danger. One of the most evidence of their cleverness is hiding food and remember its location. Moreover, the exploration and exploitation of CSA. Overall, the pseudocode of CSA can be modeled. Fig 3 is the flowchart of CSA, and its main phases can be shown as follows:

- Initializing crows swarm in d-dimensional randomly.
- A fitness function is used to evaluate each crow, and its value is put as an initial memory value.

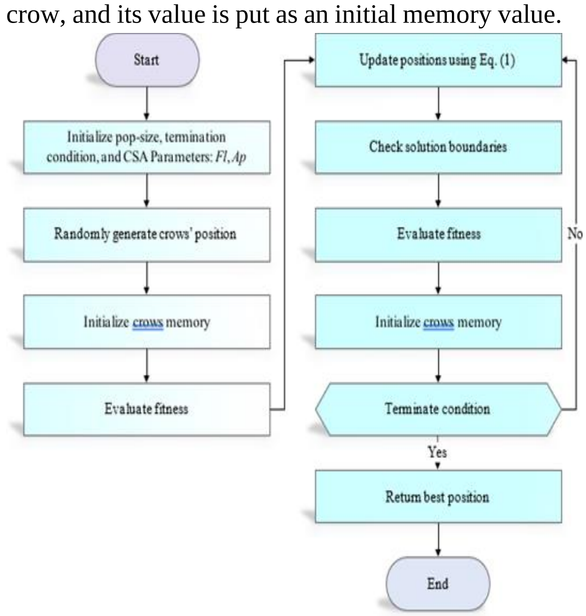

Fig 3 The Flowchart Of CSA

3.2.1 Honey badger optimization algorithm

This paper presents a load frequency control using meta-heuristic method to find the gains of PID controllers. In this study, a novel meta-heuristic method, Honey Badger Algorithm is proposed to find the optimal K p , K i and K d parameters of PID controller. The proposed algorithm is tested on two-area power system. However, electric vehicle battery, which is one of the electrical energy storage devices, has been added to the two-area power system. The settling time of the frequency has been investigated as a result of the load disturbance. Finally, a comparison was made between the traditional methods, Genetic Algorithm and Ziegler-Nichols method, and Honey Badger Algorithm. Upon comparison of the results, it is revealed that the proposed algorithm shows fast-damping steady-state deviations frequency with presence of step load disturbance.

CONCLUSION

Thus optimizes the performances of EVs by Introducing the Deep Convolutional Neural Network (Deep CNN) which is used to train and predict the controller parameters associated with the HESS. Proposes a novel meta-heuristic algorithm known as Memory integrated Honey badger Algorithm (MI-HBA) which improve the performance of the Deep CNN model in selecting the optimal parameters, such as parameters is obtained.

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