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Improvement of Ev Performance using Artificial Neural Network Controller

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Abstract:

The Electrical Vehicle (EV) emerges as the new era solution for the pollution that is caused by conventional vehicles and battery shortage issue in electrical vehicles. This technology has got higher demands in the recent years. Due to increase in demand and manufacturers competitiveness, there is need of better control and management system for EV for efficient and optimal control. Controller design plays a vital role in this regard as all the control actions are dependent upon it. Therefore, in this research, intelligent controller is designed that is based on Artificial Neural Network technique. Which shows better and effective results for controlling speed of HEV, making environment ecofriendly and eliminating all battery shortage issues.

Keywords: *Artificial Neural Network, Control, Hybrid Electrical Vehicle, Management, Speed Controller.*

I. INTRODUCTION

Challenges in energy saving are astronomical, and there is a spiraling increase in the cost across the world. A major source of the greenhouse effect is due to the increasing number of vehicles which results in environmental pollution [1]. Electric Vehicles (EV) have lesser harmful emissions and are capable of dealing with pollution problems in an efficient way. EVs use one or more electric motors for propulsion. Technological progress in engineering arena with specific reference to EVs has immensely contributed in making the sustainable society and better quality of human life. Internal Combustion Engine (ICE) is a greatest contributor to urban air pollution and also second highest contributor to global warming with approximately 21% emission of greenhouse gasses and the depletion of fossil fuels and their increasing prices, have significantly amplified interest in EV controller [2].

II. RESEARCH MOTIVATION

Many researchers have been working on the modelling and controlling of an EV. Due to their sustainability and cheaper running cost, EV are likely to be the way of the future. Developments throughout the 20th century have resulted in simpler and more efficient electric vehicle [3]. EVs have cutting edge compared to other technology that they only consume energy, but at the same time store and transport electricity and can reduce the emissions that contribute to climate change. The fuel to Electric Vehicles is extremely cheap as compared to traditional ICE engine vehicles. It also produces less heat and air pollution. In addition, EVs are economical and eco-friendly. This very feature of EVs makes them an incredible alternative for fuel vehicles.

In recent some years, Greenhouse gas problem increases day by day and also the gasoline fuel rate increases nearly about 90 Rs/li. In daily life routine, public transportation is very important but the fuel rate, some people avoid using bikes or cars. So, many automobile manufacturer and new companies put their effort to convert the conventional vehicle into electric vehicle that provide reliable solution. A vehicle is propelled with electric motors and draw power from onboard electric source is an electric vehicle. It is more durable and mechanically simpler than gasoline vehicle. It gives more fuel efficiency than gasoline because it does not produce emission like Internal combustion engine. However, automobile industry is not completely moving towards pure electric cars because there is inherent problem of existing batteries technology. For storing the electric energy, most common storage device used in Electric vehicle is battery. It can store large amount of energy in a small volume and weight. The recent report shows that there were more vehicle running on a gasoline product in past few years but now the report has been changed with increasing the usage of Hybrid and Electric vehicle. Presently people are more inclined towards the Hybrid vehicle but the future will be totally based on electrification.

III. MOTORS COMMONLY USED IN EV's

Different types of motor exhibit different characteristics, which makes it important to evaluate motors on some basic parameters for choosing a particular type of motor for an electric vehicle. Electric motors used in electric vehicle should have important attributes like simple design, high specific power, low maintenance cost, and good control. Motors that are widely used by electric vehicle manufacturers are DC brushed motors, DC brushless motors, Induction (Asynchronous) motor, Synchronous motor, Switched Reluctance motor.

IV. COMPONENT

DC Brushed Motor:

In DC brushed motor, brushes along with commutators provide a nexus between external supply circuit and armature of the motor. Brushes can be made up of carbon, copper, carbon graphite, metal graphite and are mostly rectangular in shape [2]. Wearing of commutators due to continuous cutting with brushes is one of the main drawbacks of DC brushed motors. Also, friction between brushes and commutators, limits the maximum motor speed.

Batteries:

EVs utilize the batteries to power the propulsion. These are designed in such a way that they can provide power over a sustained period. Three varieties of batteries namely lead acid, lithium ion, and nickel-metal hydride can be used in EVs. The different researches reveal that EV has higher efficiency compared to its counterparts as cost of fuel in ICE is substantially higher than the equivalent cost of electricity in EVs.

Controller:

Batteries delivers the power to the controller, which in turn distributes to the motor [7]. The potentiometers provide the signal that tells the controller how much amount of power it has to deliver. It delivers a controlled amount of power to the motor which can be either zero when the car is stationary, or it can be full when the driver operates the accelerator pedal or any power level in between. The controller is employed to regulate the torque generated by the motors by modifying the energy flow. If and only if both the potentiometer signals are equal, the controller operates.

V. INTRODUCTION TO ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) is a computational tool with flexible and self-adaptive nature to control complex and nonlinear properties of a system. ANN is inspired by biological neural network from human brain and mimics the function performed by it. Neural Network is based upon neuron and it is approximated that human brain contains about 150 billion neurons inter-connected together to build up the network making it complex and structured. In ANN, one neuron is connected to the other with different weights and information which is then distributed for learning during training. Artificial Neural Network have ability to learn from its experience and makes decisions accordingly when faced to similar environment.

Artificial Neural Network are multitasking and have ability to perform more than one function on same duration. ANN is widely used in control applications which include processes like nonlinearity removal, optimization and identification with different parameters in complicated operations. In this paper feedforward neural network controllers are proposed. In feedforward neural network, neurons are arranged in layers and each layer is connected to the next layer allowing information to transfer in forward direction only. Information comes at input layer and it is transferred at hidden layers until it reaches at the output layer.

VI. SIMULATION MODEL

The simulation model used in this paper has been taken from literature which shows the block diagram of a possible cascade control scheme for an HEV driven by a dc motor. Figure 1 shows the bock diagram of the simulation model that is taken from [11] along with its numerical values. The model has been thoroughly analyzed and investigated by Nise [25]. Preitl and Bauer[11] used two conventional PI controllers and simulated in MATLAB SIMULINK for controlling speed and current of a hybrid electrical vehicle but those controllers were linear controllers therefore we are replacing those controllers with neural network based controllers. The model is shown in Figure 1 which is a cascade control scheme for the HEV driven by a dc motor. Gc1 and Gc2 are the speed controller and torque controller respectively. The input and output of the model are reference speed and actual speed of the vehicle respectively. In this paper, a feedforward neural network is developed to replace the speed controller i.e. Gc1. Because of nonlinear nature of neural network controllers, it is expected that better performance can be achieved. The feedforward neural networks are trained by using the supervised learning strategy. The weights are calculated by using the error backpropagation learning algorithm. The developed neural network is a three layer network: input, hidden and output layer, as shown in Figure 2.

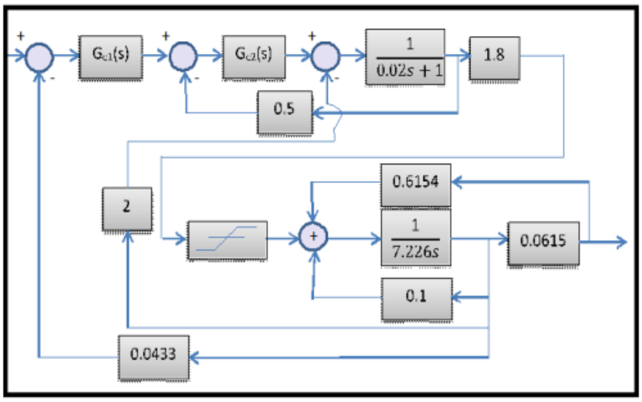

Fig..1. Cascade Control Scheme.

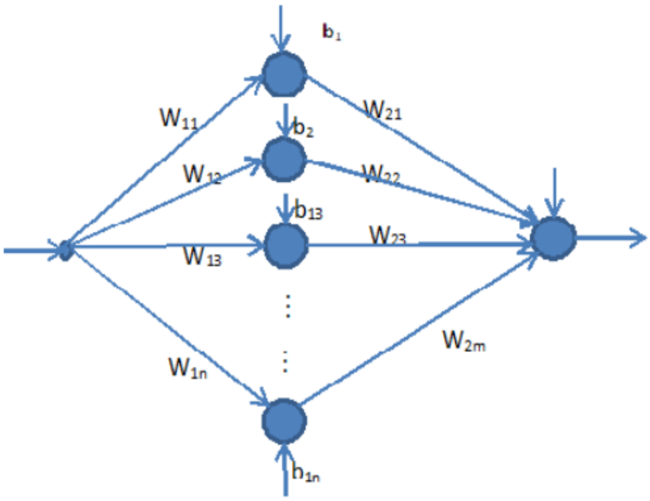

Fig.2. Proposed Neural Network Controller.

Transient stability

An electrical power system is a nonlinear, high order system which is subjected to both predictable and unpredictable disturbances. These disturbances can also be classified as internal (random load) and external (lightning strikes, wind).

Transient stability problems are those related to large-scale disturbances which cause the lose of synchronization in a portion of the system, and in extreme cases, instabilities of the system.

Stability of power systems deals with the character of the electromechanical oscillations of synchronous generators created by disturbances in the power system conditions.

Electromechanical oscillations represent exchange of energy among generator rotors (via the interconnection network) which is caused by the instantaneous unbalance between generation and consumption of electric power.

This imbalance is inherent to an AC power system and varies from low levels during normal changes of system operating conditions, to relatively large levels in the case of major disturbances such as faults. In both cases, the system stability depends on its capability to efficiently preserve synchronous operation of all its parts and damp out electromechanical oscillations between them.

When the disturbance is small, the system is confined to a small region around an equilibrium point. Linear models are used and the stability properties of this equilibrium point are studied. If the disturbance is large, the subsequent oscillatory transient will be of significant magnitude. And now the stability of the system is determined following the trajectories related to the attraction region of the equilibrium point.

In this case both nonlinear model and theory are used.

Existing approaches to assess transient stability:

1. Numerical integration

2. The second method of Lyapunov

3. Probabilistic Methods

4. Pattern recognition

5. Neural Networks

1. Numerical methods

The system dynamics are described by a set of first order differential equations. These are solved during the fault and post-fault period by numerical integration algorithms such as Runge-Kutta and its variations. Real-time operation constraints make it difficult to apply this method to power systems.

2. Second Method of Lyapunov

The main idea is to evaluate the Lyapunov function at the instant of the last switching in the system. If the value is smaller than a reference value then the post-fault transient process is stable.

3. Probability method

Probability of stability is defined as the probability that the system remains stable should the considered disturbance occur. Security is measured in terms of the probability of a transition from normal state to the emergency or "in extremis" state measured relative to a threshold.

4. Pattern Recognition (PR)

The transient stability studies using PR have focused on the selection of the initial system description, feature extraction and on the design of classifiers.

VII. RESULT AND SIMULATION

ANN is an efficient information processing system. Connection link connects each neuron with the other neuron and weights are associated with each connection link. It can perform multiple parallel operations simultaneously. The size and complexity is based on the chosen application and the network designer.

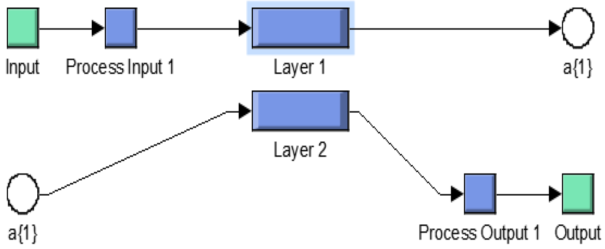

Fig.3.ANN layers.

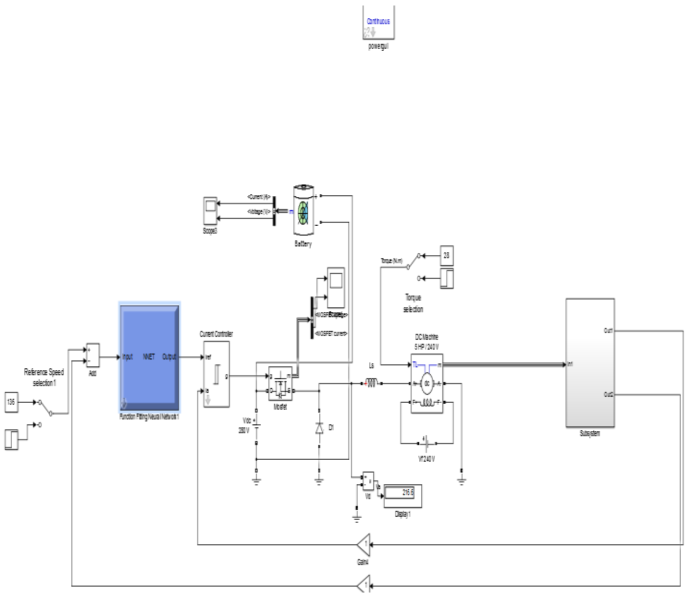

Fig.4. System modelling.

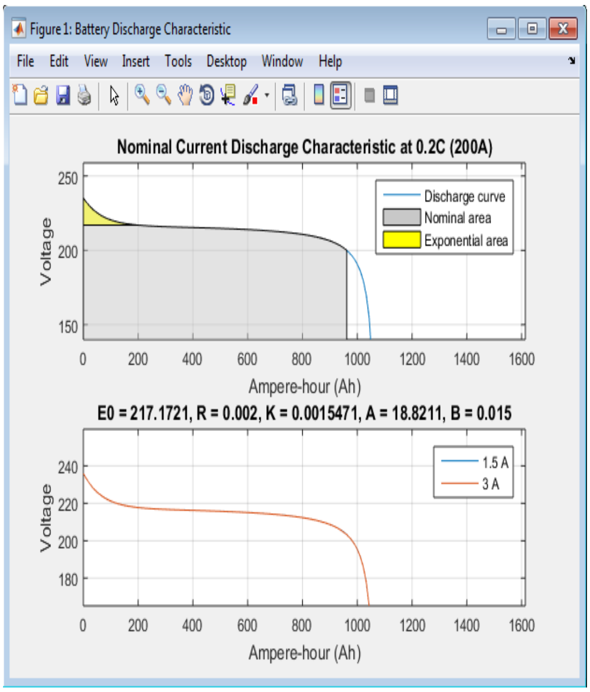

Fig.5. Charging and discharging Curve.

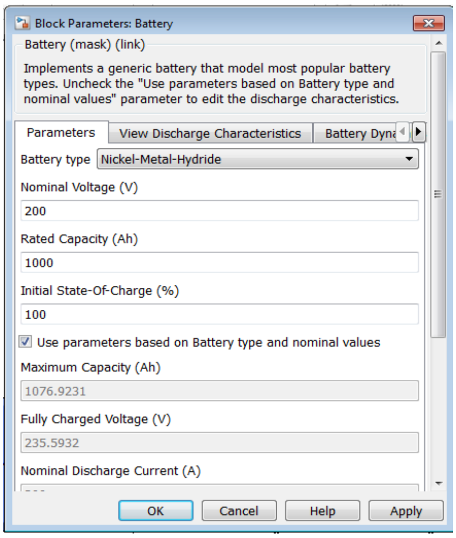

Fig.6. Battery Parameters.

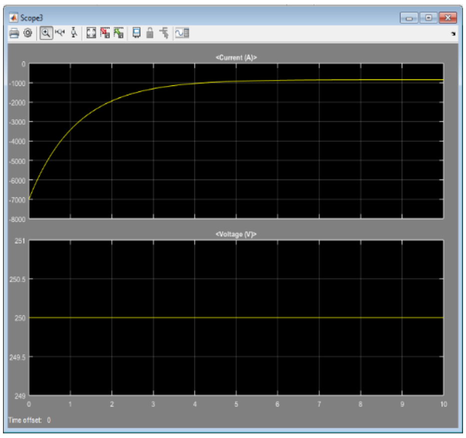

Fig.7. Battery across Voltage and Current.

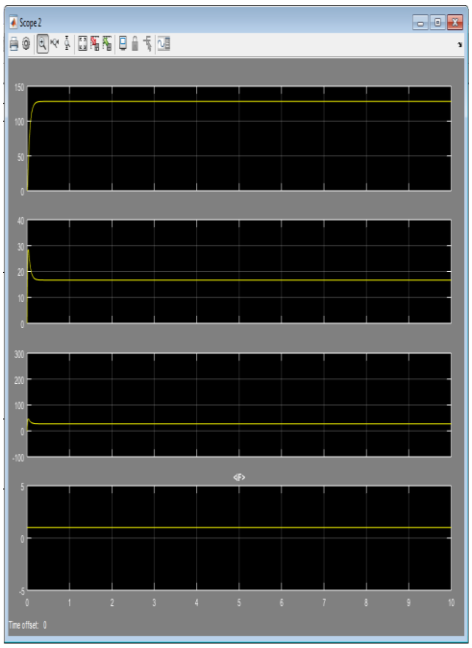

Fig.8 EV Motor Control Parameters.

VIII. CONCLUSION

This paper, proposes a neural network as a speed controller for a hybrid electrical vehicle. A mathematical model has been taken from the literature and a conventional PI controller has been used to generate data for training. Simulation results show that the proposed neural network based speed controller shows better transient behavior in terms of the overshoot. As its response is better than the PI controller, therefore it gives optimal and efficient speed control and management of hybrid electrical vehicle, making environment clean and reducing pollution from the city with efficient controller design. Moreover this is preliminary work. Further investigations are underway to develop a neural network based cascade control system with speed and current control schemes for optimal management and control of HEV.

Further Research

First, there is a need for more research on the interpretability and interoperability of hybrid deep learning models. While these models have shown promising results in improving prediction accuracy, their complex architectures can make it difficult to understand how they make predictions. Future research should focus on developing techniques to interpret and explain the output of these models to enhance their transparency and trustworthiness. Second, there is a need for more research on the robustness and generalizability of hybrid deep learning models.

These models can be sensitive to variations in the input data, such as changes in the driving behavior or the charging infrastructure. Future research should focus on developing techniques to enhance the robustness and generalizability of these models to improve their performance in real-world scenarios. Third, there is a need for more research on the scalability and efficiency of hybrid deep learning models. These models can be computationally expensive and require large amounts of data for training. Future research should focus on developing techniques to reduce the computational complexity and data requirements of these models to make them more practical and efficient for real-world applications. Finally, there is a need for more research on the integration of hybrid deep learning models with other optimization and control techniques. These models can provide accurate predictions of the EV charging state, but their output needs to be translated into actionable decisions for optimizing the charging operations. Future research should focus on developing techniques to integrate these models with optimization and control algorithms to improve the efficiency and effectiveness of the charging operations.

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