WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Electric Vehicle Speed Estimation using Artificial Neural Networks

Vijay Ameta[1], Dr. Vikramaditya Dave[2]

E-Mail Id: 96ametavijay@gmail.com

Department of Electrical Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

ABSTRACT:

Electric vehicle (EV) speed prediction plays a vital role in optimizing energy consumption, improving driving pattern, and improving overall vehicle performance. In this research paper proposed a new approach that uses artificial neural networks (ANNs) to predict the speed of electric vehicles. The model ANN is trained using a comprehensive dataset that includes various input parameters such as battery voltage, current, temperature, throttle position, and others. The dataset is preprocessed to handle missing values, normalize the data, and ensure data quality. The trained model ANN is evaluated using performance metrics such as mean absolute error (MAE), root mean square error (RMSE), and correlation coefficient. Experimental results demonstrate the effectiveness of the proposed approach, which achieves high prediction accuracy under various driving conditions. The developed model ANN provides valuable insights into the speed dynamics of electric vehicles and facilitates efficient energy management, route planning, and driver assistance systems. This research contributes to the advancement of EV technology and paves the way for improved performance, range estimation, and user experience in the field of electric mobility approach in accurately predicting the speed of e-vehicles under different driving conditions.

Keywords: Electric vehicles, Pure Electric Vehicles, Prediction, Artificial Neural Networks, Model, Variables, Datasets.

INTRODUCTION:

Electric vehicles (EVs) have surfaced as a significant disruptor in the automotive assiduity, offering a cleaner and further sustainable volition to conventional internal combustion machine vehicles. An electric vehicle is a transportation mode powered by one or further electric motors, drawing energy from onboard batteries or external power sources. The growing enterprises over climate change, environmental pollution, and the reduction of fossil energies have driven the rapid-fire development and relinquishment of electric vehicles worldwide. The conception of electric vehicles dates back to the early 19th century, but it's in recent times that EVs have gained substantial attention and request traction. Technological advancements, advancements in battery technology, Speed accuracy technology and government enterprise supporting clean transportation have played a pivotal part in the proliferation of electric vehicles. EVs have seen remarkable advancements in terms of range, performance, and charging structure, making them a feasible option for both particular and marketable transportation requirements. One of the crucial advantages of electric vehicles is their capability to reduce hot-house gas emigrations and ameliorate air quality. Unlike conventional vehicles that calculate on fossil energies, electric vehicles produce zero tailpipe emigrations. By transitioning to electric mobility, countries can significantly reduce their carbon footmark and combat the mischievous goods of air pollution on public health and the terrain.

Electric Vehicle Overview:

1.1 Definition and Classification of Electric Vehicles:

An Electric Vehicle (EV) refers to a vehicle that is propelled by an electric motor utilizing power from a battery and has the capacity to be recharged through an external source. It encompasses two types of vehicles: the all electric vehicle, which solely relies on an electric motor and battery for power. And the plug in hybrid electric vehicle, which is capable of being powered by both an electric motor with a battery and an internal combustion engine.

1.1.1 Battery Electric Vehicle (BEV): A Battery Electric Vehicle (BEV) is a vehicle that solely relies on a battery for power to propel itself. Unlike traditional vehicles. A BEV does not have a fossil fuel engine or generator. Instead. It operates solely on electric power stored in its battery and is driven by an electric motor. To recharge its battery. A BEV needs to be connected to an electrical power source through plugging in.

1.1.2 Plug-in Hybrid (PHEV): Hybrid Electric Vehicles use a combination of electric power and petrol or diesel power to propel the vehicle. They can be ‘plug-in’ or ‘non plug-in’. A PHEV uses an internal combustion engine (ICE) and electric motor. You can charge PHEVs from an electricity source, and access cheaper and cleaner electric power. The battery's energy is recharged by the ICE, wheel motion, or by plugging into a charge point. An additional type of PHEV, is called a Range Extender Electric Vehicle or REEV. A REEV has a small petrol powered generator to recharge the battery and allow extended range when the battery level is low. This is a more efficient way of propelling the vehicle rather than using the same fuel in a traditional engine.

1.1.3 **Hybrid (HEV):** These vehicles have both an internal combustion engine and an electric motor. The electric battery however, is only charged by the ICE, the motion of the wheels or a combination of both. There is no charging connector.

1.2 Advantages of Electric Vehicles:

Environmentally Friendly: By removing the pollutants and exhaust produced by combustion engines, electric cars provide a sustainable transportation option. By reducing the buildup of dangerous gases, electric automobiles, unlike those powered by fossil fuels, help to maintain a cleaner atmosphere.

Utilisation of Renewable Energy: Unlike conventional cars, which rely on fossil fuels with limited supplies, electric cars get their energy from renewable sources. Electric vehicles assist in reducing reliance on fossil fuel reserves and advance a more sustainable energy future by using power from renewable sources.

Less Noisy and Smoother Ride: Since electric cars don't have internal combustion engine parts that move quickly, they offer a quieter and smoother ride. As a consequence, there is less noise pollution, which benefits the residents and neighbourhoods nearby as well as those who drive.

Cost-Effective Operation: Compared to traditional fuels like petrol and diesel, which are prone to price swings, electricity is far more affordable. Additionally, the entire cost of operating electric cars may be further decreased, resulting in long-term cost savings, by using home solar power for battery charging**.**

Lower Maintenance Needs: Compared to conventional combustion engines, electric automobiles have fewer moving components, which means less wear and tear. As a result, electric vehicle maintenance requirements are often smaller, which makes repairs easier and more affordable.

Government Support and Incentives: As part of their green programmes, governments all over the world have put in place a variety of incentives, such as tax breaks and subsidies, to promote the use of electric cars. These governmental actions support the widespread usage of electric cars even further and support a healthy transportation ecology.

1.3 Challenges for Electric Vehicles:

High Initial Cost: Compared to conventional automobiles, buying an electric car has a greater initial cost. Demand for EVs is constrained by their high initial cost, which renders them unaffordable for many prospective purchasers. The pricey battery technology utilised in EVs is largely to blame for this price gap.

Limited Charging Infrastructure: In India, the infrastructure for charging electric vehicles is currently under construction and is mostly found in large cities. For EV users, especially those who live in flats or don't have designated parking places, the lack of a strong and extensive charging network is troublesome**.**

Range Anxiety: Range anxiety is the dread or worry that one may run out of battery power while driving. The adoption of EVs is significantly hampered by their short driving range. Even if EV ranges have increased, many people still believe that they may not have enough range for long-distance travel, especially in a nation with enormous expanses like India. The range of EVs might decrease as a result of the batteries' deterioration over time.

Electric Vehicles Mathematical Modeling:

An electric vehicle (EV) drive system was created using the Matlab-Simulink platform using distinct block diagrams for the motor, battery, motor controller, and proportional-integral (P-I) controller. The system was represented by the ensuing equations:

The torque produced by a DC motor (Td) is inversely proportional to the armature current (Ia).

$$T_d = K_m \cdot I_a$$

where Km represents the motor constant, which is determined by the specific winding construction of the motor.

The voltage developed in the motor, denoted as Vd, is directly proportional to the armature speed, ωd.

$$V_d = K_m \cdot \omega_d$$

The voltage at the high side of the motor, also known as the terminal voltage (Vhigh), can be expressed as follows:

$$V_{high} = I_{high} \cdot R_a + L_{high} \cdot di(t)/dt + V_d$$

where, $\mathbf{I_{high}}$ is the current at the high side (terminal current), R_a is the armature resistance value, and $\mathbf{L_{high}}$ is the inductor value at the high side.

Assuming negligible friction and inertia losses, the electrical torque developed (Td) in the motor is equal to the output mechanical torque (Tmech). Consequently, the electrical power developed is equivalent to the mechanical power generated. To maintain this balance, a simplistic motor controller is employed, ensuring that the input power matches the output power. For the purpose of analysis, the controller is considered ideal, with no losses and no time lag.

High side voltage (input), $V_{high} = K \cdot V_L$

High side current (input), $I_{high} = (1/K) \cdot I_L$

where **K** is the controller gain value, V_L is voltage at the low side (output), and I_L is the current at the low side (output).

The battery is modeled as the voltage source, E_f and internal power loss in the battery resistance, R_a

$$V_L = I_L \cdot R_a + E_f$$

The required battery's internal voltage is calculated using the current and voltage from the motor controller. The difference between the calculated EB (EB (calculated)) and the actual EB (EB (actual)) represents the battery voltage error, B_{error} to be used by the P-I controller for gain adjustment.

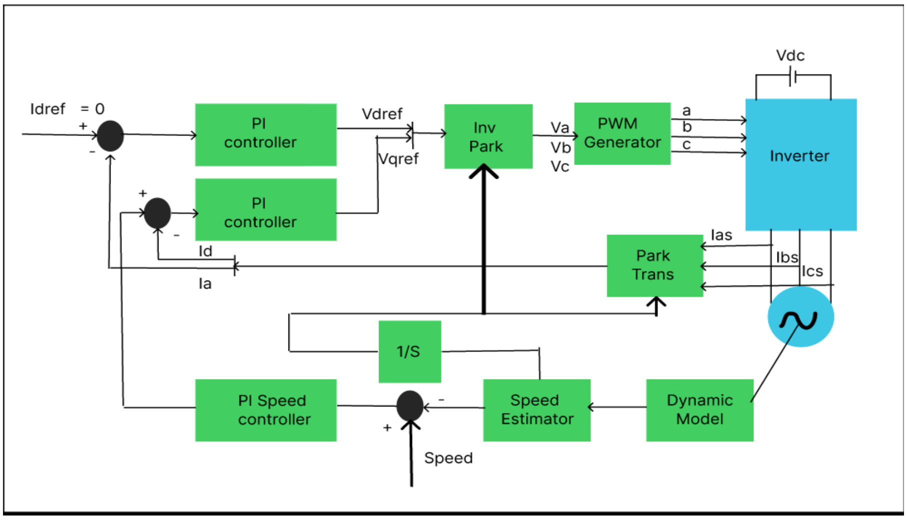
$$B_{error} = EB\ (actual) - EB\ (calculated)$$

The (P-I controller employs the values of the proportional gain, K_p and integral gain, K_i to compute the motor controller's, **K** value.

$$K = (K_p + s \cdot K_i) \cdot B_{error}$$

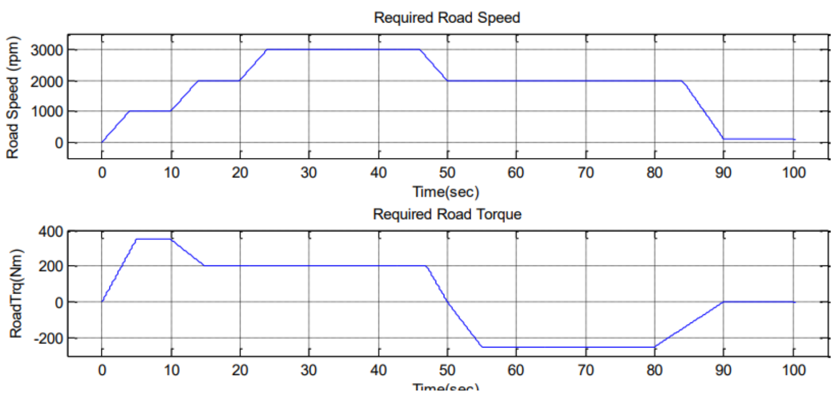
In order to reduce the costs associated with on-road testing, the road conditions were replicated in a computer simulation as part of the drive cycle modeling. For the purpose of driving tests and simulations, vehicle speed values were defined for a specific drive cycle duration of 100 seconds. The corresponding torque values were obtained by considering the interplay between the vehicle dynamics and the determined speed values.

However, since the vehicle dynamics are not included in the model, it is assumed that the torque values are known for the simulation. The speed and torque data were respectively added into the drive cycle subsystem using look-up tables.



Model of Traction Chain

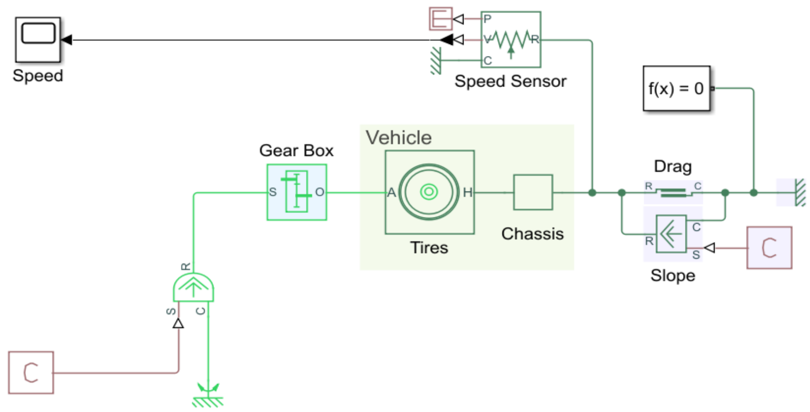
Electric Vehicle Simulation: The drive cycle subsystem incorporated speed and torque data using look-up tables. The resulting drive cycle consisted of a comprehensive set of speed and torque values, as illustrated below:



Speed and Torque Values required For Simulation

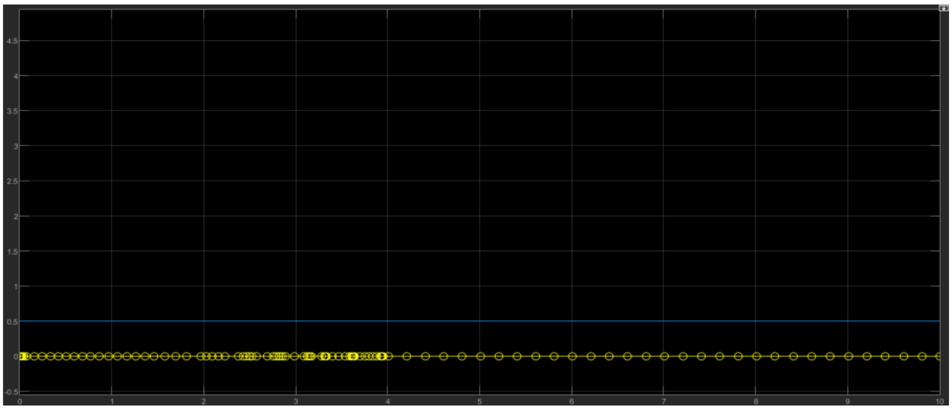
Simualtion Result:

The EV drive simulation model produced from mathematical Eqs. which are represented by each subsystem block. From the model, simulation points were selected and added to the output scopes in order to determine and illustrate the energy flow, performance and efficiency of two important elements of the EV drive train: (i) the motor, and (ii) the battery. 1. Road speed, torque and power The speed accuracy requirement during the simulation is calculated from the input road speed and road torque.

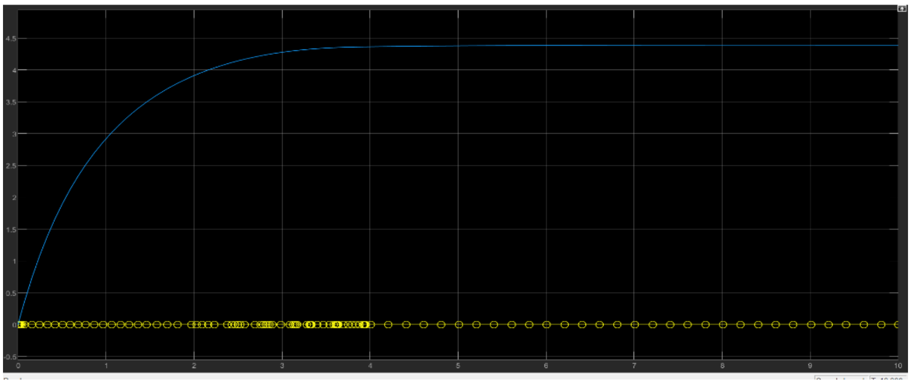


Block Diagram of Power train for EV

Input Range:- The speed and acceleration values we are considering fall within the range of 0.5 to 1. This range defines the minimum and maximum values for both speed and acceleration. By specifying these values, we can analyze and discuss various aspects related to motion, such as velocity changes, rates of acceleration, or the behavior of objects in motion.



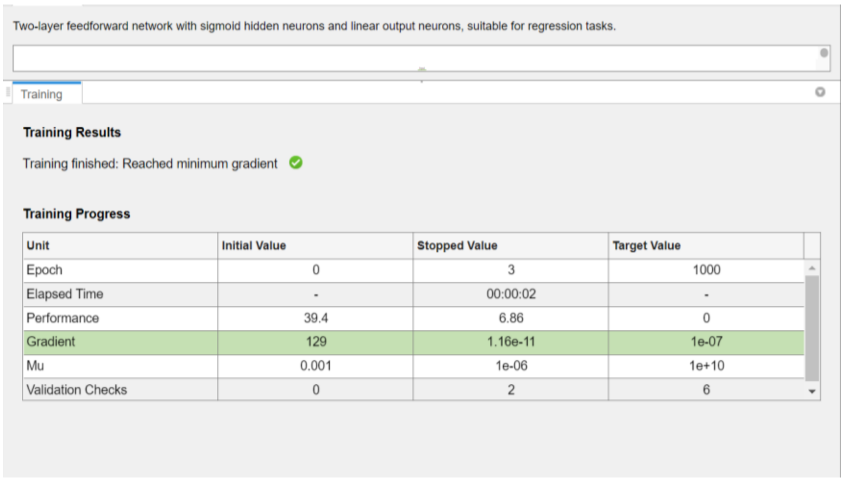
Input Road Speed



Output Average Speed

Output Speed Range:- The output we observe exhibits a pattern of steady increase in relation to acceleration. As the acceleration increases, the output value rises gradually. However, there comes a point where the output reaches a peak value and then remains constant thereafter. This behavior suggests that beyond a certain level of acceleration, the output no longer shows any significant changes and maintains a consistent value. This observation indicates a potential limit or saturation point in the relationship between acceleration and the resulting output.

Data Training Result:



Two-layer feedforward network with sigmoid hidden neurons and linear output neurons, suitable for regression tasks.

Training

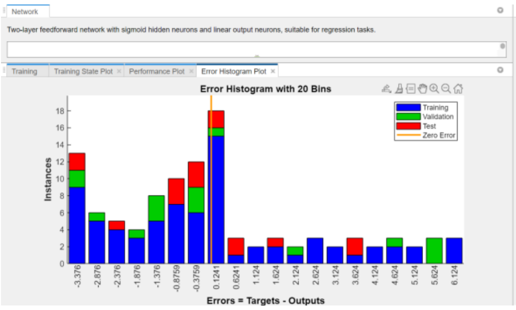
Training Results

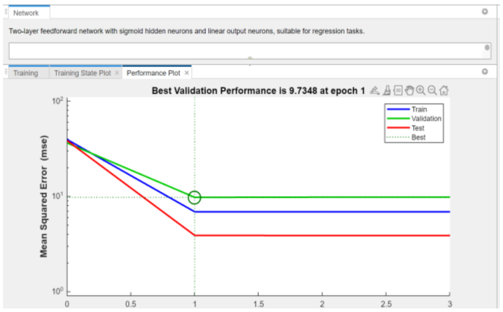
Training finished: Reached minimum gradient

Training Progress

Unit	Initial Value	Stopped Value	Target Value
Epoch	0	3	1000
Elapsed Time	-	00:00:02	-
Performance	39.4	6.86	0
Gradient	129	1.16e-11	1e-07
Mu	0.001	1e-06	1e+10
Validation Checks	0	2	6

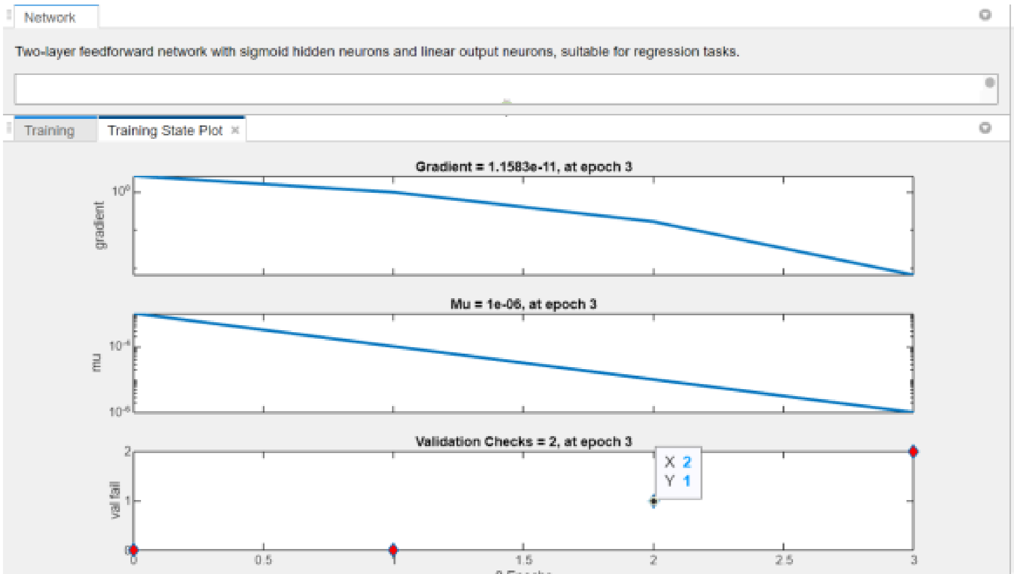
Artificial Neural Network Training Result



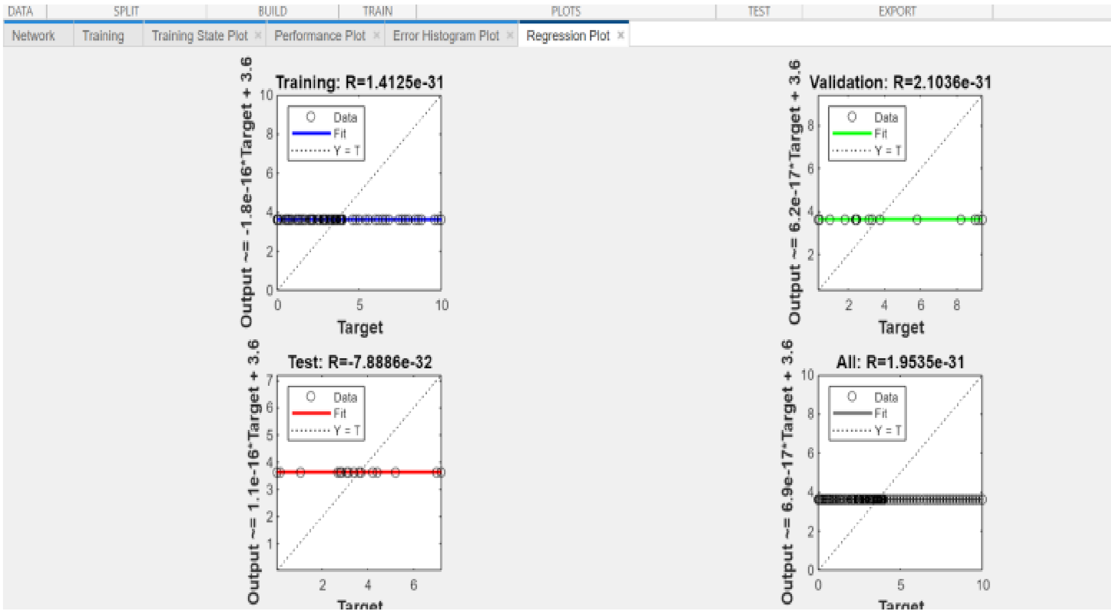


1. Error Histogram Plot

2. Mean Squared Error Plot



Training State Plot



Regression Plot

Conclusion:

The growing demand for pure electric vehicles has underscored the necessity for an effective predictive model to aid in the manufacturing process of diverse electric vehicle types. To address this need, a Direct Artificial Neural Network approach was employed, yielding highly accurate predictions for nine common parameters in pure electric cars. The model's performance was evaluated through rigorous analysis of unit and overall model errors.

By utilizing the combined electric charge consumption as the basis for modeling, the input speed of 0.5 resulted in an average output speed of 4.35. The model formation process involved thorough training and testing, leading to the determination of key metrics such as the training gradient, training mean squared error, validation checks, and root mean square error, which were measured at 1.158, 6.8614, 2, and 0.467, respectively.

To enhance the model's reliability and robustness, alternative datasets were also employed for evaluation, further validating its effectiveness. The developed model holds significant potential for manufacturers and engineers, providing them with the ability to simulate future designs by inputting specific parameters. This empowers them to make well-informed decisions and optimize their designs based on the predicted outcomes provided by the model.

Overall, the implementation of this predictive model presents a valuable tool for the electric vehicle industry, offering a means to improve design processes and drive advancements in the field. The model's high degree of accuracy and its ability to predict various parameters make it a promising asset for manufacturers and engineers seeking to meet the increasing demand for pure electric vehicles while ensuring optimal performance and efficiency.

References:

[1] Schaltz, S. Soylu (Ed.), 2011. Electric Vehicles - Modelling and Simulations In: INTECH ,Janeza Trdine Rijeka, Croatia 2011, pp. 1-24.

[2] Trigg T, Telleen P, Boyd R, Cuenot F, D'Ambrosio D, Gaghen R. 2013. Global EV outlook: understanding the electric vehicle landscape. In: International Energy Agency. 2013, pp. 1-40.

[3] T.A.T. Mohd, M.K. Hassan and WMK. A. Aziz 2015. Mathematical Modeling And Simulation of an Electric Vehicle. In: Journal of Mechanical Engineering and Sciences (JMES) in June 2015, pp. 1312-1321.

[4] Guinee, R.A. & Lyden, C.; 2017. Accurate Modelling And Simulation Of A DC Brushless Motor Drive System For High Performance Industrial Applications, IEEE ISCAS'99 - IEEE International Symposium on Circuits and Systems, May/June 2017, Orlando, Florida

[5] E. Hashemi, M. Pirani, A. Khajepour, B. Fidan, A. Kasaiezadeh, and S. Chen, "Opinion dynamics-based vehicle velocity estimation and diagnosis," IEEE Trans. Intell. Transp. Syst., vol. 19, no. 7, pp. 2142–2148, Jul. 2018.

[6] McDonald D. 2019. Electric Vehicle Drive Simulation with MATLAB/Simulink. Proceedings of the 2019 North-Central Section Conference.

[7] Ding, X., Wang, Z., Zhang, L., & Wang, C. (2020). Longitudinal Vehicle Speed Estimation for Four-Wheel-Independently-Actuated Electric Vehicles Based on Multi-sensor Fusion. IEEE Transactions on Vehicular Technology, pp.1–10.

[8] K.Fujii, H.Fujimoto 2020 Slip Ratio estimation and control without detection of vehicle speed for electric vehicle, Proc. IEE of Japan, Technical Meeting Record, IIC-06-01, pp. l-6

[9] Ilyès Miri, Abbas Fotouhi, Nathan Ewin 2021. Electric vehicle energy consumption modelling and estimation – A case study. International journal of energy research .12july, 2021 pp. 1-23

[10] Hong J., Park, S. and Chang, N. 2022. Accurate remaining range estimation for Electric vehicles. Paper presented at: Proceedings of the Asia and South Pacific Design Automation Conference, ASP-DAC. IEEE, 25 January 2022, pp. 781-786.

[11] Pan C, Dai W, Chen L, Chen L, Wang L 2022. Driving range estimation for electric vehicles based on driving condition identification and forecast.\ AIP Adv. 2022. pp. 1-11

[12] Ashokkumar, R., Suresh, M., Sharmila, B., Panchal, H., Gokul, C., Udhayanatchi, K.V., Sadasivuni, K.K., Israr, M. 2022. A Novel Method for Arduino Based Electric Vehicle Emulator. Int. J. Ambient Energy, pp. 4299–4304.

[13] Martyushev, N.V., Malozyomov, B.V., Sorokova, S.N., Efremenkov, E.A., Qi, M. 2023. Mathematical Modeling of the State of the Battery of Cargo Electric Vehicles. Mathematics, pp. 7-11

[14] Malozyomov, B.V.; Martyushev, N.V.; Sorokova, S.N.; Efremenkov, E.A.; Qi, M. Mathematical Modeling of Mechanical Forces and Power Balance in Electromechanical Energy Converter. Mathematics, pp. 2384-2394.