

Paidimalla Naga Raju¹,
 Raghu Kalyana²,
 D. N. V. S. Vijaya Lakshmi³,
 V. Rambabu⁴

Wireless Power Transfer for EV Charging using AI-A Review



Abstract: - The automation sector's emphasis on battery-operated vehicles has intensified owing to the surge in electric vehicle (EV) production, propelled by ecological considerations and fluctuating fuel costs. This alteration has heightened the need for electric vehicle charging stations, particularly in densely populated areas where establishing such infrastructure may be hindered by financial and spatial constraints. This study presents a viable and cost-effective solution to these challenges: a wireless power-based EV charging system. This system, tailored for parking lots, public spaces, and urban environments, utilizes artificial intelligence (AI) to optimize charging efficiency. Central to the system is the wireless transceiver, allowing seamless AI integration and wireless power transfer for reliable and efficient charging. The proposed wireless power-driven EV charging technique provides a more direct solution to the increasing need for EV infrastructure, particularly in urban areas. It not only fulfills consumer demands but also promotes a sustainable and environmentally responsible transportation ecosystem via the integration of wireless technology and artificial intelligence.

Index Terms— Artificial Intelligence, Electric Vehicles, Wireless Power Transfer, AI, EV.

INTRODUCTION

In the modern digital world, using digital resources is essential for delivering immediate answers to problems without compromising physical assets. The surge in digitization has led to a heightened need for accurate physical attributes of tangible things and the swift monitoring of environmental changes to address urgent concerns. Addressing issues related to electric vehicle (EV) charging is a primary problem in this context. Dr. Milan Rosina, Principal Analyst for Power Electronics and Batteries at Yole Development, underscores the need for enhanced voltage, power, and energy transfer in electric vehicle charging systems. In contrast to wireless chargers for smartphones, achieving precise vehicle alignment over a charger and regulating the distance between the charger (transmitter) and the car's receiver pose significant hurdles.

The substantial expenses related to the installation of charging stations, especially in densely populated areas, provide a considerable obstacle to the widespread adoption of electric cars. The establishment of charging infrastructure is often hindered by budgetary limitations, which obstruct the expansion of electric vehicle use. To monitor various physical parameters throughout the charging process, the use of Wireless Sensor Networks (WSN) is essential. Nonetheless, current Wireless Sensor Networks lack the flexibility to efficiently manage changes in observed parameters.

To address these problems, it is essential to design an Adaptive and Intelligent System (AIS) that offers a dependable and cost-effective infrastructure for electric car charging. A robust sensor network is crucial to this project. Employing wireless charging technology is a viable strategy, especially in densely populated areas such as parking lots of retail malls, theaters, hotels, and parks.

Wireless charging has several benefits in bustling areas. This study advocates for the deployment of an Adaptive and Intelligent Wireless Sensor Network (AI-WSN) system for electric charging stations, specifically designed for parking lots and densely populated locations. Through This system guarantees the use of magnetic resonance technology. extended and more efficient charging durations compared to wired methods while maintaining the reliability of connected charging systems. This system is a practical option for charging electric cars in densely populated metropolitan areas due to its cost-effectiveness and simple design.

LITERATURE REVIEW

S. Manikandan, this study presents an IoT-based battery management system (BMS) for electric vehicles (EVs), including wireless charging to improve user comfort. The system employs real-time monitoring, sensor data, and cloud connection to enhance battery health and prolong its longevity. The document addresses the design, hardware, software, and performance assessment of the system. [1]

^{1,2,3,4}International School Of Technology And Sciences For Women

Y. Wang This study presents a dynamic wireless charging system for electric cars (EVs) that compensates for driving power in real time while the vehicle is in motion. It analyzes the impact of vehicle speed on power consumption and the modification of system settings under essential compensation conditions. A power control approach is presented, modifying either the transmission voltage or the vehicle's equivalent load resistance.

R. S. Vijayashanthi This article discusses the issues of pollution, fuel shortages, and the elevated expenses associated with electric cars (EVs) by suggesting an IoT-driven charging station framework that utilizes cloud-based transaction data and QR code payment systems. M. A. Al-Hitmi This article introduces a Dual Active Bridge (DAB) rapid charging system for several Electric Vehicles (EVs) with diverse power ratings, using a shared DC connection voltage. This study by V. K. Chaudhari introduces a solar-powered dynamic charging system for electric cars (EVs) via mutual induction, aimed at being environmentally sustainable and economically viable. Infrared sensors identify the electric vehicles in the charging lane and initiate the power supply to the coils. The method diminishes battery costs, facilitates wireless charging, and promotes cleaner, renewable energy alternatives for the expanding electric vehicle industry.

R. J. Bharathi This paper examines the increasing use of Electric Vehicles (EVs) driven by escalating fuel prices and the need for sustainable development, while also addressing the deficiency in charging infrastructure. It analyzes many wireless power transfer techniques, including inductive coupling, for the charging of electric vehicles. A simulation and experimental implementation were performed, attaining 90% efficiency across various alignment and distance conditions.

J. M. Kharade In electric cars, electrical energy is stored in batteries. The duration needed to charge the electric vehicle is extended. The electric vehicle charging stations are crucial in this context. At now, individuals are uninformed about the number of charging stations available during the route. Consequently, locating a charging station and determining slot availability will consume additional time, whereas the system will display the availability of charging slots at each station along our route.

This work by F. Ramoliya offers an AI-based electric vehicle (EV) charging allocation system that optimizes the selection of charging stations (CS) based on the EVs' state of charge (SoC), cost, and distance. A neural network model forecasts the state of charge for optimal scheduling, and various charging station selection scenarios are prioritized. The system is assessed using performance measures, with the Adam optimizer yielding the optimal results for State of Charge prediction and scheduling efficacy.

This article by A. Raza examines options for electric vehicle (EV) charging systems using hybrid sources, plug-in hybrids, and all-electric cars, emphasizing the integration of IoT and AI for performance monitoring.

METHODOLOGY

Artificial Intelligence (AI) is transforming the automotive sector, particularly in relation to Electric Vehicles (EVs). Artificial intelligence offers electric vehicles several benefits, such as enhanced efficiency, advanced safety features, and improved performance.

Predictive Maintenance: In the domain of electric vehicles (EVs), artificial intelligence (AI) is crucial, particularly for predictive maintenance. Progressive electric mobility companies are using predictive maintenance methods instead of traditional preventive maintenance. Through the use of AI/ML and data analytics, these technologies provide a new benchmark for the industry in electric vehicle lifecycle management. This innovative approach reduces costs while concurrently improving the accessibility and feasibility of electric vehicle adoption. Artificial Intelligence (AI) enables drivers to modify their driving behaviors, hence prolonging the vehicle's lifespan via the study of user behavior data.

Enhanced Efficiency: AI significantly contributes to the optimization of electric vehicles (EVs). Its duties including accurately predicting remaining charge and conducting health assessments to enhance battery performance. AI algorithms are essential for optimizing power usage by dynamically adjusting the vehicle's speed, acceleration, and deceleration to enhance its range.

Safety Features: AI enhances electric vehicles by enabling Advanced Driver Assistance Systems (ADAS). These systems use artificial intelligence (AI) to detect and mitigate potential traffic hazards, including bicycles, pedestrians, and other vehicles.

Artificial Intelligence can identify potential collisions and notify the user by analyzing data from several sensors, temporal factors, and cost systems. In advanced systems, artificial intelligence (AI) may assume control of the overcharging vehicle to alert users of overheating and prioritize safety.

Enhanced User Experience: Furthermore, AI enhances the electric vehicle user experience by personalizing the charging setup to accommodate wired or wireless preferences and adjusting the time depending on certain characteristics. Users get immediate guidance and assistance, including suggestions for optimal billing practices and alerts about new tools or methodologies. This customized and instructional method substantially enhances the entire electric vehicle user experience.

Enhanced efficacy

The efficiency of electric vehicles (EVs) may be significantly enhanced with the use of artificial intelligence (AI). Artificial intelligence may enhance the charging process by forecasting the vehicle's idle periods and scheduling the charging to take place during off-peak hours when power availability is abundant. AI can estimate when the battery needs replacement and suggest the optimal timing based on the vehicle's use. Enhanced fleet management: AI has become a pivotal element in transforming fleet management for electric vehicles (EVs). Fleet managers may now use AI-driven solutions to oversee and improve the operation of their electric vehicle fleets. Utilizing AI, fleet managers may oversee fuel economy, anticipate repair needs, and examine geographical data about traffic patterns and vehicle movements. Moreover, AI enables fleet managers to do data-driven analytics to optimize routes, so minimizing downtime and yielding substantial cost savings while enhancing operational efficiency. AI's improved capabilities usher fleet management for EVs into a new era marked by proactive decision-making and efficient operations, eventually promoting sustainability and profitability in the transportation industry. The strategic enhancement of vehicle use is facilitated by the employment of AI-generated data insights, particularly concerning battery health and daily range. This improvement ensures a more efficient and effective operation. For instance, when a fleet vehicle is used less often than normal, this information is employed to automatically assign it to a suitable task, hence enhancing overall fleet management efficiency.

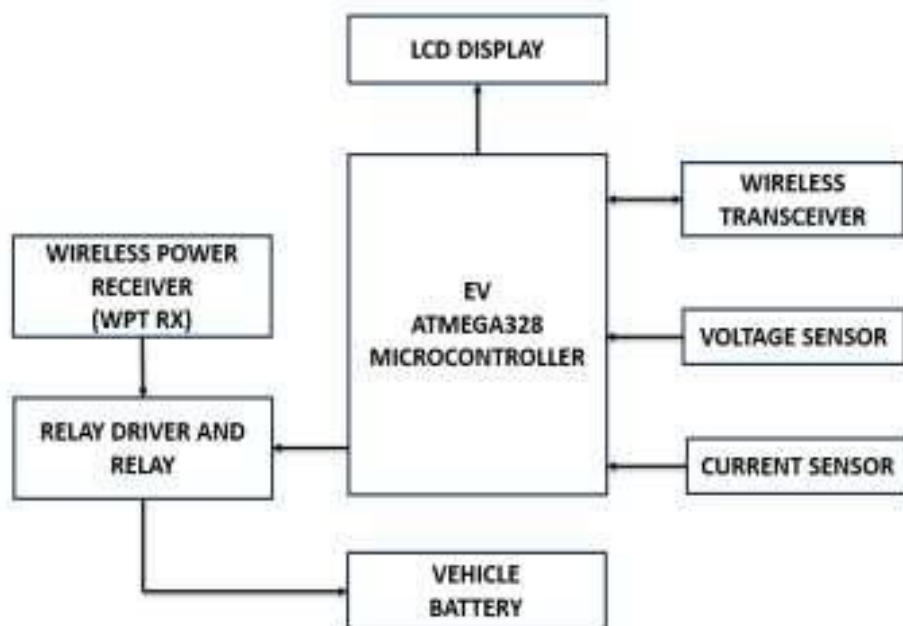


Figure 1 Block Diagram EV node Rx

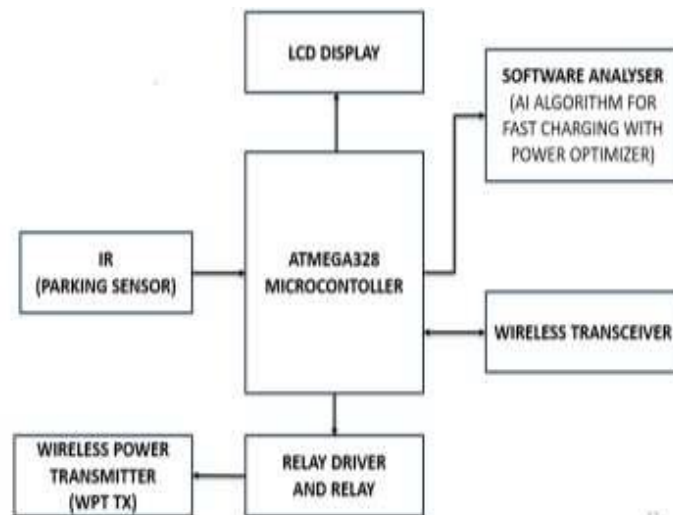


Figure 2 Block Diagram Tx

The suggested system has two components that integrate circuitry for electric cars, parking spots, and charging stations in a novel manner. A microcontroller is included into these devices to initiate and manage control signals. Infrared and voltage sensors are integrated inside the wireless gadget.

The infrared sensor in the parking area identifies the position of an electric vehicle as it enters a parking slot. The wireless sensor network of the charging device seeks permission to start charging once it is correctly positioned. The PC's AI software evaluates the system's intelligence, power, and charge duration for rapid and efficient charging. The Wireless Power Transfer (WPT) transmitter initiates power transmission to the electric vehicle upon approval from the wireless electric vehicle unit. The vehicle unit's receiver part guarantees fast-charging capabilities by using magnetic resonance technology to collect wirelessly sent power.

A voltage sensor continuously monitors the battery level of the electric automobile. A signal indicating the conclusion of power transfer is sent from the vehicle's wireless transmitter to the charging unit's wireless receiver section upon the vehicle reaching full charge.

The overall efficiency of the electric vehicle charging process is enhanced by the seamless integration of sophisticated control and wireless technology.

IMPLEMENTATION

At present, power stations using wireless power transfer (WPT) are not widely accessible. Consequently, wired charging stations are essential, perhaps necessitating several connections. Nevertheless, dependence only on wired connections may provide dependability challenges, particularly in light of the heightened demand for charging electric vehicles.

Furthermore, AI systems are not involved in this situation.

Require several connections and cables. Must be managed manually by an operator. The continual insertion and removal of cables may deteriorate the charging port, possibly resulting in damage. This may need altering the charging port.

Wireless charging for electric cars offers convenience and simplicity for EV owners. The use of wireless power transfer (WPT) technology obviates the need for physical connections throughout the charging process. Charging may be automated by toggling relays between the WPT transmitter (Tx) and receiver (Rx). Integrating artificial intelligence (AI) into the system augments its capabilities, enabling automatic ON/OFF activities. AI enhances astute decision-making by determining optimal charging times and modulating power levels based on vehicle requirements. This automation optimizes the charging process for electric vehicle owners, hence improving overall efficiency and convenience.

Benefits: The incorporation of AI accelerates the system. Prolonged battery longevity and intuitive usability. Estimations of estimated charging durations become attainable. Queue congestion for recharging, similar to that at gas filling stations, may be prevented.

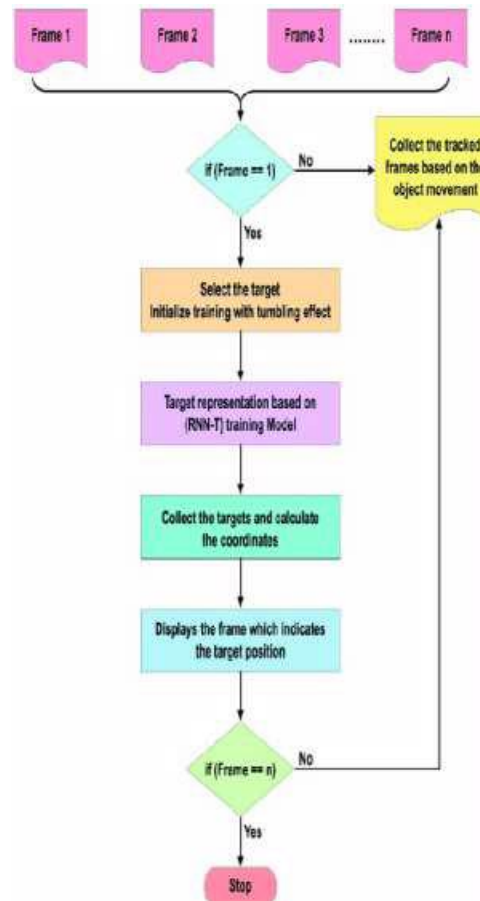


Figure 2 RNN Algorithm Flowchart for EV

CONCLUSION

Recurrent Neural Networks (RNNs) are a distinct category of neural networks characterized by their unique design, whereby the result of one phase affects the input of the subsequent step. In contrast to conventional neural networks that regard inputs and outputs as distinct entities, RNNs were explicitly designed to tackle situations necessitating the preservation of historical knowledge, such as forecasting the subsequent word in a phrase. To fulfill this memory need, RNNs include a Hidden Layer, which is essential to their design. In RNNs, the "memory" component retains pertinent information throughout calculations by uniformly performing the same operation across all inputs or hidden layers, with identical parameters for each input. This method reduces the complexity of the parameter set in comparison to other neural networks. RNNs simplify the challenges of escalating parameters and retrieving prior outputs by transmitting each output as input to the next hidden layer while preserving consistent weights and biases across all levels. This process converts isolated activations into linked ones, creating a coherent and efficient structure. RNNs consolidate the input, hidden, and output layers into a unified recurrent layer, maintaining uniformity in weights and biases across all hidden layers. This intentional design decision improves the network's capacity to record sequential dependencies and efficiently manage memory-dependent operations.

REFERENCES

- [1] Santosh Soni and Manish Shrivastav SN Applied Sciences 2019 SN Applied Sciences (2019) 1:1052.
- [2] Qing Zhang, Wenzheng Xu, Weifa Liang, Jian Peng, Tang Liu and Tian Wang Wireless Networks Springer (2018) 10:1007.
- [3] Shiva Prakash and Vikas Saroj Springer Wireless Networks 2019 Springer (2019) 10:1007. Muhammad adil, Jehad ali, Qui thanh Hoai ta, Muhammad attique and Tae-sun chung Digital

- [4] Object Identifier 2020 IEEE (2020) 10.1109. Tu W, Xu X, Ye T, Cheng Z A study on wireless charging for prolonging the lifetime of wireless sensor networks *Sensors* 17(7):1560
- [5] R. Senthil Kumar, K Mohana Sundaram and K. S. Tamilselvan Hybrid Reference Current Generation Theory
- [6] for Solar Fed UPFC System *Energies* March 2021 vol. 14 no. 6 pp.1527.
- [7] K.R. Sugavanam, R. Senthil Kumar, S. Sri Krishna Kumar, S. Karthikumar and V Tamilmullai Design of FLC for OVRReduction of Negative Output KY Converter
- [8] *International Journal of Applied Engineering Research (IJAER)* 2014 Vol:9(24) pp:23689- 23699
- [9] D. Patil, M. K. McDonough, J. M. Miller, B. Fahimi, and P.T.Balsara, "Wireless Power Transfer for Vehicular Applications: Overview and Challenges," *IEEE Transactions on Transportation Electrification*, vol. 4, no. 1, pp. 3-37, 2018.
- [10] G. A. Covic, J. T. Boys, M. L. Kissin, and H. G. Lu, "A three-phase inductive power transfer system for roadway-powered vehicles," *IEEE Transactions on Industrial Electronics*, vol. 54, no. 6, pp. 3370- 3378, 2007.
- [11] M. Ehsani, Y. Gao, and A. Emadi, *Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design*. CRC press, 2009.
- [12] A. Emadi, M. Ehsani, and J. M. Miller, *Vehicular electric power systems: land, sea, air, and space vehicles*. CRC press, 2003.
- [13] A.Abdolkhani and A. P. Hu, "A Contactless Slipring System Based on Axially Travelling Magnetic Field," *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. PP, pp. 1-1, 2014.
- [14] G.Jung, B. Song, S. Shin, S. Lee, J. Shin, Y. Kim, C. Lee, and S. Jung, "Wireless charging system for on-line electric bus(oleb) with seriesconnected road- embedded segment," in *Environment and Electrical Engineering (EEEIC)*, 2013 12th International Conference on, 2013.
- [15] M.Badawy, N. Arafat, S.Anwar, A. Ahmed, Y. Sozer, and P. Yi,"Design and implementation of a 75 kw mobile charging system for electric vehicles," in *Energy Conversion Congress and Exposition (ECCE)*, 2013 IEEE,2013. Green AW, Boys JT. 1994. 10 kHz inductively coupled power transfer: Concept and control. *Proceedings of the IEE International Conference on Power Electronics and Variable-Speed Drives*, October 26–28, London. Seung-Hwan L, Lorenz RD (2011) A design methodology for multi-kW, large air-gap, MHz frequency, wireless power transfer systems. Paper presented at the IEEE energy conversion congress and exposition (ECCE), 2011.
- [16] L. A. Maglaras, J. Jiang, F. V. Topalis, and A. L. Maglaras, "Mobile energy disseminators increase electrical vehicles range in smart city," in *Hybrid and Electric Vehicle Conference, IET*, November 2014.
- [17] S.Lukic and Z. Pantic, "Cutting the cord: Static and dynamic inductive wireless charging of electric vehicles," in *Electrification Magazine, IEEE* 2013, vol. 1, no. 1. pp. 57-64.
- [18] [12] D.Patil, M. K. McDonough, J. M. Miller, B. Fahimi, and P. T. Balsara, "Wireless Power Transfer for Vehicular Applications: Overview and Challenges," *IEEE Transactions on Transportation Electrification*, vol. 4, no. 1, pp. 3-37, 2018.
- [19] A. Kamineni, G. A. Covic, and J. T. Boys, "Interoperable EV detection for dynamic wireless charging with existing hardware and free resonance," in *Emerging Technologies: Wireless Power Transfer (WoW)*, 2016 IEEE PELS Workshop on, 2016, pp. 169-173: IEEE.
- [20] Y. Wang, H. Wang, T. Liang, X. Zhang, D. Xu, and L. Cai, "Analysis and design of an LCC/S compensated resonant converter for inductively coupled power transfer," in *Transportation Electrification Asia-Pacific (ITEC Asia-Pacific)*, 2017 IEEE Conference and Exp, 2017, pp. 1-5: IEEE.