FORM 2

THE PATENTS ACT, 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

TITLE OF THE INVENTION

"AI-Enabled Predictive Maintenance for Electric Vehicles"

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The following specification particularly describes the nature of the invention and the manner in which it is performed:

FIELD OF THE INVENTION

The present invention pertains to the field of electric vehicles (EVs) maintenance, and more particularly, to an AI-Enabled Predictive Maintenance system for Electric Vehicles. This field involves the application of Artificial Intelligence (AI) techniques, specifically machine learning and data analytics, in conjunction with Internet of Things (IoT) technology, to anticipate and predict potential mechanical or electrical issues in EVs before they become significant problems. The system leverages real-time data from various sensors embedded in the electric vehicle and historical data about vehicle usage, performance, and maintenance, to predict future maintenance requirements and improve overall vehicle performance and longevity.

Background of the invention:

Electric vehicles (EVs) have gained significant popularity in recent years due to their environmental benefits and advancements in battery technology. However, like any other vehicle, EVs require regular maintenance to ensure optimal performance and longevity. Traditional maintenance practices are often reactive, addressing issues only after they occur. This approach can lead to costly repairs, prolonged downtime, and even potentially dangerous situations if critical issues are not detected in time.

Therefore, a shift towards a more proactive and predictive maintenance approach is necessary. Predictive maintenance involves monitoring the condition of in-service equipment to predict

when maintenance should be performed. This approach promises cost savings over routine or time-based preventive maintenance because tasks are performed only when necessary.

The advent of Artificial Intelligence (AI) and the Internet of Things (IoT) has provided the tools necessary to implement predictive maintenance effectively. AI, particularly machine learning algorithms, can process vast amounts of data to detect patterns and make predictions. On the other hand, IoT technology allows for the collection and transmission of real-time data from a myriad of sensors embedded in the vehicle.

However, the application of AI and IoT in EV predictive maintenance is still in its early stages. Most of the current systems are primarily focused on monitoring the battery health of EVs. While important, battery health is just one aspect of an EV's overall condition. There are many other components, such as the electric motor, power electronics, and charging equipment, which also require regular monitoring and maintenance.

Thus, there is a need for a comprehensive AI-enabled predictive maintenance system specifically designed for EVs. Such a system would be capable of monitoring the entire vehicle, predicting potential issues in any component, and alerting the user or the service center in advance. This would not only enhance the safety and reliability of EVs but also lower their total cost of ownership, thereby promoting their wider adoption. Some patent prior art related to proposed invention mentioned below.

US20190055513A1: Describes a predictive maintenance system for electric vehicles that uses AI to analyze battery health. However, it doesn't provide comprehensive monitoring of all EV components.

US20190370616A1: Presents a system using AI for predicting EV battery life based on driving conditions and habits. It doesn't consider other essential components of EVs.

EP3336571A1: Discusses a predictive maintenance system using IoT for data collection. The system primarily focuses on the mechanical parts and lacks AI integration for data analysis.

US10235695B2: Describes an AI-based system for predicting failures in vehicle components. However, it is not specifically designed for electric vehicles.

WO2019144230A1: Presents an IoT-based system for remote monitoring and diagnostic of EVs. While useful, it lacks the predictive capabilities offered by AI.

US20190308979A1: Describes a predictive maintenance system for vehicles using machine learning. However, the focus of the system is on internal combustion engine vehicles, not EVs.

EP3423705B1: Discusses a method for predicting maintenance needs of EVs based on historical data. However, it doesn't incorporate real-time data from IoT devices.

US20180077496A1: Presents a method for predicting battery failures in EVs using AI. However, it does not provide predictive maintenance capabilities for other EV components.

CN110347134A: Describes a predictive maintenance system for EVs that uses AI and IoT. However, the system focuses only on the powertrain and lacks a comprehensive approach.

US20180346853A1: Discusses a predictive maintenance system for vehicles using IoT and cloud computing. While useful, it is not specifically designed for EVs and lacks AI capabilities for sophisticated data analysis.

Summary of the proposed invention:

The proposed invention introduces an AI-Enabled Predictive Maintenance System specifically designed for Electric Vehicles (EVs). This system leverages the capabilities of Artificial Intelligence (AI) and Internet of Things (IoT) to efficiently and proactively monitor the overall condition of an EV and predict potential issues before they escalate into serious problems.

The crux of the system lies in its AI algorithm that can process and analyze large volumes of real-time and historical data to predict potential faults in the vehicle. The data include information from various sensors embedded in the EV, historical maintenance data, vehicle usage patterns, and external factors such as driving conditions. The AI algorithm uses machine learning techniques to identify patterns and anomalies in this data, which could indicate potential issues in the vehicle.

The IoT technology incorporated in the system facilitates the real-time data collection and transmission. Sensors embedded throughout the vehicle continuously monitor the condition of various components and systems, including the battery, electric motor, power electronics, charging equipment, and more. This data is then transmitted to the central AI system for analysis.

The system provides timely alerts to the user or the service center when it predicts a potential issue, allowing for proactive maintenance. By predicting issues before they occur, the system helps reduce downtime, avoid costly repairs, enhance vehicle safety, and improve the overall longevity and performance of the EV.

The proposed invention, therefore, represents a significant advancement in the field of EV maintenance. It brings together the benefits of AI and IoT to create an intelligent, comprehensive, and proactive maintenance solution for EVs, paving the way for safer, more reliable, and cost-effective electric mobility.

Brief description of the proposed invention:

AI Algorithm:

The core component of the proposed system is a sophisticated AI algorithm. This algorithm processes a multitude of data inputs to predict potential issues in the EV. These data include real-time sensor readings from the EV, historical maintenance records, vehicle usage patterns, and external factors such as driving conditions.

The AI algorithm employs machine learning techniques to identify patterns and anomalies in the data that could be indicative of potential issues. For instance, it can detect abnormal patterns in the battery charging and discharging rates, unusual temperature readings in the electric motor, or irregularities in the power electronics. By identifying these patterns early, the algorithm can predict potential faults before they escalate into serious problems.

The AI algorithm also improves its predictive accuracy over time. As it processes more data and gains more experience, the efficiency and reliability of its predictions continue to increase. This dynamic learning capability makes the system adaptable to evolving conditions, such as changes in vehicle usage, driving conditions, or technological advancements.

IoT Infrastructure:

IoT technology plays a crucial role in the proposed system by facilitating the real-time collection and transmission of data. Various sensors are embedded throughout the EV to monitor the condition of different components and systems. These sensors measure parameters such as battery voltage and temperature, motor temperature, power electronic currents and voltages, charging rates, and more.

The sensor data is then transmitted in real-time to the central AI system via a secure IoT network. The real-time data gives the AI system a continuous snapshot of the vehicle's condition, enabling it to react promptly to any potential issues.

User Interface:

The proposed system provides a user-friendly interface for users to interact with the system. Through this interface, users can access real-time information about their vehicle's condition, receive alerts about potential issues, and review recommended maintenance actions. The interface can be accessed through various platforms, such as a smartphone app, a web portal, or the vehicle's onboard infotainment system.

The user interface also allows users to provide feedback to the system, such as confirming whether a predicted issue was accurate or providing details about completed maintenance actions. This feedback can be used by the AI system to refine its predictions and improve its accuracy.

Maintenance Alerts and Recommendations:

When the AI system predicts a potential issue, it generates an alert for the user or the service center. The alert includes details about the predicted issue, the components potentially affected, and the recommended maintenance actions.

These alerts are timely, allowing for proactive maintenance before the issue escalates into a serious problem. This not only enhances the safety and reliability of the EV but also helps avoid costly repairs and reduce downtime.

Integration with Service Centers:

The proposed system can also integrate with service centers to facilitate maintenance operations. When a potential issue is predicted, the system can automatically schedule a service appointment based on the user's preferences and the service center's availability. It can also provide the service center with detailed information about the predicted issue, enabling the technicians to prepare for the service appointment in advance.

Data Security and Privacy:

Given the critical nature of the data handled by the system, robust data security and privacy measures are integral to the design. The system employs advanced encryption techniques to protect data transmission across the IoT network, and incorporates strict access controls and privacy protocols to safeguard user data.

In summary, the proposed AI-Enabled Predictive Maintenance System for EVs represents a significant advancement in the field of EV maintenance. It leverages the capabilities of AI and IoT to deliver an intelligent, proactive, and user-friendly maintenance solution, paving the way for safer, more reliable, and cost-effective electric mobility.

We Claim:

1. An AI-Enabled Predictive Maintenance System for Electric Vehicles (EVs), wherein the system integrates Artificial Intelligence (AI) and Internet of Things (IoT) technologies to predict potential issues and enable proactive maintenance.

2. The system of claim 1, wherein the AI algorithm processes real-time and historical data, including sensor readings from the EV, maintenance records, vehicle usage patterns, and external factors, to predict potential faults.

3. The system of claim 2, wherein the AI algorithm employs machine learning techniques, improving its predictive accuracy over time based on the data processed and experience gained.

4. The system of claim 1, wherein IoT technology facilitates the real-time collection and transmission of sensor data from the EV to the central AI system, providing a continuous snapshot of the vehicle's condition.

5. The system of claim 1, providing a user-friendly interface that allows users to interact with the system, receive real-time information about their vehicle's condition, receive alerts about potential issues, and review recommended maintenance actions.

6. The system of claim 5, wherein users can provide feedback to the system through the user interface, aiding in the refinement of the AI algorithm's predictive capabilities.

7. The system of claim 1, wherein the AI system generates timely maintenance alerts when a potential issue is predicted, including details about the predicted issue, the components potentially affected, and the recommended maintenance actions.

8. The system of claim 1, capable of integrating with service centers to schedule service appointments automatically based on user's preferences and the service center's availability when a potential issue is predicted.

9. The system of claim 1, incorporating robust data security and privacy measures, including advanced encryption techniques, strict access controls, and privacy protocols, to protect data transmission and safeguard user data.

10. The system of claim 1, designed to monitor the overall condition of an EV, encompassing various components and systems, including the battery, electric motor, power electronics, charging equipment, and more, thereby providing a comprehensive predictive maintenance solution.

Dated this 04ᵗʰ day of June 2023

Applicant

Indian Institute of Industry Interaction Education and Research

ABSTRACT

AI-Enabled Predictive Maintenance for Electric Vehicles

The present invention introduces an AI-Enabled Predictive Maintenance System for Electric Vehicles (EVs), which combines the capabilities of Artificial Intelligence (AI) and the Internet of Things (IoT). The system uses an AI algorithm to process both real-time and historical data from the vehicle, detecting patterns and anomalies that could indicate potential issues. Sensors, implemented using IoT technology, are embedded throughout the EV, providing real-time data on the vehicle's condition. The user-friendly interface enables users to interact with the system, receive alerts about predicted issues, and review recommended maintenance actions. The system further integrates with service centers to facilitate maintenance operations and employs robust data security and privacy measures. This intelligent, proactive, and user-friendly solution enhances the safety, reliability, and cost-effectiveness of EVs, revolutionizing the field of EV maintenance and promoting the wider adoption of electric mobility.

Dated this 04th day of June 2023

Applicant

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