

# Research on the Application of Deep Learning in Fire Warning of New Energy Vehicles

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## Abstract

With the enhancement of environmental awareness in countries around the world, new energy vehicles, as a new type of green transportation mode, are receiving increasing attention. However, the safety issues of new energy vehicles, especially fire safety, have drawn extensive attention from all sectors of society. Compared with traditional fuel vehicles, the power systems and energy storage systems of new energy vehicles are more complex. In particular, battery packs are highly prone to causing fires under conditions such as high temperatures, overcharging, and short circuits. Once a fire breaks out, it not only causes severe damage to the vehicle itself, but also threatens the lives of passengers and seriously endangers the surrounding environment and public safety. Therefore, how to effectively prevent and warn of fires in new energy vehicles is an important issue to ensure their safe operation.

## Keywords

**Deep Learning; Fire Prevention and Early Warning for New Energy Vehicles; Application Strategies.**

## 1. Introduction

The fire early warning system is of great significance for ensuring the safe operation of new energy vehicles. Traditional fire early warning systems mainly rely on sensors to detect physical quantities such as temperature and smoke. Although they can provide safety guarantees to a certain extent, they have problems such as response delay and high false alarm rate. In recent years, fire early warning methods based on deep learning have been widely applied. By constructing deep learning models, multi-dimensional information during vehicle operation, such as battery status, ambient temperature, current and voltage, can be analyzed in real time. This method can automatically learn potential patterns and abnormal patterns from the data, achieving early warning of fire risks. Therefore, conducting research on fire early warning methods for new energy vehicles based on deep learning not only ensures the safe operation of new energy vehicles but also holds significant importance for promoting the construction of intelligent transportation in China.

## 2. Current Research Status at Home and Abroad

In recent years, with the rapid development of new energy vehicles, the number of fire accidents involving them has been increasing day by day, which has become a hot issue of global concern. New energy vehicle fire accidents not only cause huge economic losses to the vehicles themselves, but also seriously threaten the lives and safety of drivers. Compared with traditional fuel vehicles, new energy vehicles are equipped with lithium-ion batteries that

rapidly release a large amount of energy during thermal runaway, triggering intense combustion reactions and leading to fires. In addition, in fires involving new energy vehicles, toxic and harmful gases such as carbon monoxide and hydrogen cyanide are released, whose toxicity is much higher than that of conventional fuel combustion, causing greater harm to the accident scene [1]. In the field of public transportation safety, the frequent occurrence of fires in new energy vehicles has also seriously disrupted the order of public transportation, especially on major traffic arteries such as cities and highways. Fires can cause traffic paralysis, affect the passage of rescue vehicles, delay rescue opportunities, and expand accident losses.

With the rapid development of deep learning technology, the fire early warning system for new energy vehicles is facing new opportunities and breakthroughs. Deep learning, as a powerful tool for big data analysis and pattern recognition, can efficiently process and analyze massive vehicle operation data, and mine the fire risk characteristics and patterns hidden in big data. Compared with traditional data analysis methods, deep learning algorithms have stronger learning and adaptive capabilities, and can automatically extract key information from multi-dimensional and complex data to build more accurate fire early warning models [3]. If deep learning algorithms are used to conduct long-term analysis on the long-term operation data of batteries, it is possible to predict the health status of batteries and the risk of thermal runaway, providing a more reliable basis for fire early warning. The fire early warning method based on deep learning, through intelligent optimization methods, can achieve intelligent optimization of the fire early warning system. It can dynamically adjust the early warning strategy and threshold according to different vehicle usage scenarios and environmental conditions, thereby improving the accuracy and reliability of the early warning.

### **3. Analysis of the Causes of Fires in New Energy Vehicles**

New energy vehicle fire accidents are often the result of the combined effect of multiple factors. Conducting an in-depth analysis of the causes of their fires is a prerequisite for formulating effective fire prevention and control strategies. Technically speaking, lithium-ion batteries, which are the core components of new energy vehicles, are an important cause of fires. After long-term use, lithium-ion batteries may experience internal short circuits due to reasons such as battery aging, overcharging, overdischarging, and mechanical damage, which in turn can lead to thermal runaway and cause fires. In addition, the electrical systems of new energy vehicles are rather complex, with issues such as aging circuits, short circuits, and electromagnetic interference, which can easily lead to fires [4]. In terms of external environmental factors, new energy vehicles may be affected by high temperatures, high humidity, mechanical collisions and other external environmental factors during operation, which can easily lead to battery thermal runaway and cause fire accidents. In addition, there are a large number of safety hazards during the use and maintenance process, such as non-standard charging operations and unreasonable modifications, which may lead to the failure of the car's safety protection mechanism and cause fire accidents.

## **4. Research on the Specific Application of Deep Learning Models in Fire Prevention and Early Warning**

### **4.1. Early Warning of Battery Thermal Runaway**

To address the issue of early warning for battery thermal runaway, a multi-dimensional data collection and analysis system can be established to precisely monitor and warn of the risk of battery thermal runaway. Considering the characteristics of battery thermal runaway, a complete data collection network needs to be constructed for analysis. New multi-functional sensors are mainly deployed on the surface of individual battery cells, at electrode connection

points, and inside the modules. High-precision temperature sensors are distributed on the surface of individual cells to monitor real-time changes in battery surface temperature. Current and voltage sensors are used to monitor changes in voltage and current during charging and discharging. Gas sensors are installed inside the battery modules to detect the composition and concentration of flammable gases produced during thermal runaway. Meanwhile, data such as cycle life and charge-discharge rate during battery operation are collected to provide reliable data basis for subsequent characteristic analysis.

After data collection, systematic preprocessing is carried out. Methods such as median filtering and Gaussian filtering are used to denoise temperature, current, and voltage signals, eliminating outliers caused by sensor errors and electromagnetic interference. Standardization methods are adopted to map data of different scales, enhancing comparability. Principal Component Analysis (PCA) is utilized to reduce the dimensionality of gas component data and extract gas component features, reducing data redundancy. In feature engineering, the rate of change, gradient, and other derived characteristics of the data are analyzed, and hidden information in the data is further explored to construct multi-dimensional feature vectors including basic parameters, derived characteristics, and gas components.

For the abnormal detection of battery surface temperature based on convolutional neural networks, a standardized image acquisition and processing procedure needs to be established. Infrared thermal imagers are configured with fixed frame rates and resolutions to ensure the stability and consistency of image data. Preprocessing methods such as gray-scale transformation, non-local mean denoising, and Canny edge enhancement are applied to the collected infrared images. The algorithm divides the cell surface into regular detection grids, each corresponding to an input unit in the CNN model. Sliding window technology is used to segment the image at fixed steps, and after normalization, it is input into the convolutional neural network. The model uses multiple convolutional layers to extract temperature distribution features from the image, and pooling layers to reduce the dimensionality of the data, with the probability of temperature anomaly output in the fully connected layer. When the anomaly probability of a certain area exceeds the set threshold, the abnormal area is located based on the grid coordinates, triggering the warning mechanism and outputting the anomaly level information.

#### **4.2. Vehicle Electrical System Fault Diagnosis**

By means of multi-source data fusion and intelligent analysis, effective detection and early warning of electrical short circuits, overloads and other faults are carried out. A multi-source data acquisition and fusion framework is constructed to design an electrical short circuit overload detection algorithm. The system adopts high-precision current and voltage sensors to collect real-time current and voltage of each circuit, in order to meet the requirements of collecting fault characteristics [6]. At the same time, the driving status of the vehicle is collected, including information such as vehicle speed, engine speed, and gear position. Time synchronization processing method is adopted for the collected multi-source data to ensure the consistency of various types of data in the time dimension. In terms of feature extraction, key parameters are extracted from the vehicle operating status data to form a unified feature vector. This method utilizes sliding window technology to partition the various feature vectors of the power system and divide them into samples of a certain length, each representing the state of the power system at a certain moment.

Meanwhile, a detection model based on deep learning is established by combining multi-layer perceptron (MLP) and convolutional neural network (CNN). Before inputting data, normalize the sample data to meet the requirements of the model input. This model automatically extracts characteristic modes under short-term overload conditions from sample data of normal operation and fault conditions. In practical applications, new sampling data is collected in real-

time, preprocessed and feature extracted, and input into the model. This model adopts forward transmission method to output the probability of the current power system under normal, short circuit, overload and other conditions. When the system experiences short circuits, overloads, or other situations, the system will activate the fault alarm mechanism. Based on the topology information of the on-board electrical system, locate the specific lines or components that have malfunctioned, and use the on-board fault diagnosis system to warn the driver. At the same time, display the location and type information of the fault on the display screen, providing accurate maintenance guidance for maintenance personnel.

Applying speech recognition technology to early warning of electronic component failures requires the establishment of a complete acoustic data acquisition and analysis process. Reasonably configure the high-sensitivity microphone array around the electrical components of the vehicle to ensure that the sound signals generated by the electronic components during operation can be fully collected. This method eliminates background noise through wavelet denoising algorithm, extracts effective frequency components using bandpass filter, and achieves the transformation from continuous signal to discrete signal through inter frame transformation. This method preprocesses speech signals to obtain feature vectors such as Mel frequency cepstral coefficients, and combines time-domain and frequency-domain information to establish feature matrices. On this basis, establish speech classification models based on deep learning, such as convolutional neural networks (CNN), recurrent neural networks (RNN), etc. In practical applications, the sound signals of electrical components are collected in real-time, preprocessed and feature extracted, and input into the model. This model calculates the probability values of current electrical components under normal working conditions and different types of faults. When the probability of a certain type of fault occurring exceeds the alarm threshold, an alarm signal is given and the type of faulty component is given.

#### **4.3. Environmental Perception and Fire Prevention Technology for New Energy Vehicles**

For new energy vehicles, environmental awareness and fire prevention are important aspects to ensure their safe operation. The power system and energy storage equipment of new energy vehicles (such as lithium-ion batteries) are susceptible to external environmental factors during operation, which increases the risk of fire. Therefore, based on deep learning and environmental perception technology, real-time monitoring of the operating environment of new energy vehicles and predicting their potential fire risks is the key to improving the safety and reliability of new energy vehicles.

It is necessary to establish a complete vehicle environment monitoring and analysis system for the fire risk characteristics of new energy vehicles. By installing multiple sensors in the car, real-time meteorological parameters such as air temperature, humidity, and pressure in the car environment can be obtained, as well as status information such as temperature, voltage, and current of the car battery. At the same time, in order to ensure the accuracy and timeliness of data, it is necessary to dynamically adjust the vehicle's operating status and external environment. For example, in environments with high temperature and humidity, the risk of fire in battery systems will greatly increase. Therefore, it is necessary to increase monitoring frequency to detect possible abnormal conditions in a timely manner. Install environmental sensor networks in key parts of the car, such as battery packs and high-voltage power supply systems, to collect information on temperature, humidity, and combustible material distribution inside the car. By collecting data on vehicle structure layout, route distribution, driving behavior, etc., combined with multi-source environmental data, research spatiotemporal matching methods to ensure data consistency in time and space. Taking typical urban road traffic as the research object, targeting the characteristics of urban road traffic environment, with road traffic as the background, roads as the research area, and urban road

traffic as the main research object, in the feature design stage, key parameters such as battery temperature change, humidity change rate, and voltage fluctuation are extracted, and the correlation between various environmental factors is calculated. A multi-dimensional feature set of meteorology environment vehicle status is constructed, and a correlation model between vehicle environmental factors and fire risk is constructed.

When predicting fire hazards in new energy vehicles based on recurrent neural networks (RNNs), it is necessary to perform time-series data processing. On this basis, a vehicle workspace partitioning method based on genetic algorithm is proposed. A new spatiotemporal sequence model is proposed by collecting environmental characteristic data of each unit at different time steps to form spatiotemporal sequence samples. The model utilizes a cyclic structure to learn the variation patterns and spatial correlations of temporal data. Introduce attention mechanism, focusing on key environmental factors such as battery temperature change rate and humidity change rate, to improve prediction accuracy. By utilizing Geographic Information System (GIS) technology, the predicted results are visualized to generate a heatmap of potential fire risks. According to the threshold of fire hazard, it is divided into three levels: low, medium, and high, and warning information is issued to drivers or safety departments. At the same time, by continuously collecting new environmental data, establishing a dynamic update mechanism, and updating prediction results in real time, continuous monitoring and accurate warning of fire hazard areas can be achieved.

## 5. Conclusion

Rotary kiln is also used in the production of saloon with production capacity by burning specific clay soil that possesses adequate quantity of silica, alumina, and iron oxides. The external diameter of the kiln is.

The main purpose of a rotary kiln hydrolyser is to convert olive pits into char fated to the production of activated char. The capacity of plant is about of wet olive pit, distribution of pyrolysis products as function of the process temperature.

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