

MULTI-DIMENSIONAL FIRE DETECTION METHOD FOR LOCOMOTIVE

Technical Field

The present invention relates to the technical field of safety of rail transit equipment, and more particularly to a multi-dimensional fire detection method for a locomotive.

Background Art

At present, relatively mature fire detection technologies and related products already exist both domestically and internationally, such as temperature detectors, smoke detectors, and flame detectors. These detection devices detect fires respectively by utilizing temperature of fire flames, smoke concentration, and optical characteristics, and determine fire occurrence based on a single detected parameter through a simple threshold algorithm. However, it has been found in practical applications that fire prevention and control systems are prone to problems such as high false alarm rates, long detection times, and detection failures, which in turn cannot effectively achieve prevention and control of vehicle fires, thereby posing hidden dangers to the safe operation of vehicles. Moreover, traditional temperature detection, smoke detection, and flame detection technologies have obvious shortcomings. Such detection devices are affected by the

complex application scenarios of rail transit, such as installation sites, spatial height, humidity, dust, air flow rate, oil and gas, and light, making it difficult or even impossible to effectively detect fires.

Summary of Invention

The present invention provides a multi-dimensional fire detection method for a locomotive so as to overcome the above technical problems.

To achieve the above object, the technical solution of the present invention is a multi-dimensional fire detection method for a locomotive.

The method includes:

S1: in a reference application scenario, collecting in real time a fire characteristic data of a detection area by a detection unit of a system, the fire characteristic data including first fire characteristic data and second fire characteristic data, the first fire characteristic data including a CO gas concentration C_t , a temperature T_t , and a smoke concentration, the second fire characteristic data including a light signal,

S2: performing preprocessing on the first fire characteristic data by a control unit of the system to obtain an average value of the first fire characteristic data in an initial operating state of the reference application

scenario using an average value acquisition method based on the fire characteristic data in the initial operating state,

S3: obtaining an average value of the fire characteristic data in the initial operating state of an actual application scenario by the average value acquisition method based on the fire characteristic data in the initial operating state to obtain an effective first fire characteristic data of the actual application scenario, meanwhile, obtaining a weighting coefficient of the first fire characteristic data of the actual application scenario based on an average value $Aver$ of the fire characteristic data in the initial operating state of the reference application scenario,

S4: performing preprocessing on the second fire characteristic data by the control unit of the system to obtain an effective second fire characteristic data,

S5: performing normalization processing on the effective first fire characteristic data and the effective second fire characteristic data of the actual application scenario to obtain a normalized effective first fire characteristic data and a normalized effective second fire characteristic data, and

S6: obtaining a system fire alarm output determination parameter W based on the weighting coefficient of the first fire characteristic data of the actual application scenario,

the normalized effective first fire characteristic data, and the normalized effective second fire characteristic data to provide a basis for locomotive staff to determine whether a fire alarm has occurred.

Further, in S3, a method for obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario includes:

S31: obtaining a change ratio of the average value of the first fire characteristic data:

$$Esm = Aver_am / Aver_a1$$

$$Etm = Aver_tm / Aver_t1$$

$$Ecm = Aver_cm / Aver_c1$$

wherein Esm is a change ratio of an average value of the smoke concentration, Etm is a change ratio of an average value of the temperature Tt, Ecm is a change ratio of an average value of the CO gas concentration, Aver_am is an average value of the smoke concentration in the initial operating state of the actual application scenario, Aver_tm is an average value of the temperature Tt in the initial operating state of the actual application scenario, Aver_cm is an average value of the CO gas concentration in the initial operating state of the actual application scenario, Aver_a1 is an average value of the smoke concentration in the initial operating state of the reference application scenario, Aver_t1 is an average value of the temperature Tt

in the initial operating state of the reference application scenario, and $Aver_{c1}$ is an average value of the CO gas concentration in the initial operating state of the reference application scenario, and

S32: obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario based on the change ratio of the average value of the first fire characteristic data:

$$A_m = A * E_{sm}$$

$$T_m = T * E_{tm}$$

$$C_m = C * E_{cm}$$

wherein A_m is a weighting coefficient of the smoke concentration of the actual application scenario, T_m is a weighting coefficient of the temperature T_t of the actual application scenario, C_m is a weighting coefficient of the CO gas concentration of the actual application scenario, A is a weighting coefficient of the smoke concentration of the reference application scenario, T is a weighting coefficient of the temperature T_t of the reference application scenario, and C is a weighting coefficient of the CO gas concentration of the reference application scenario.

Further, in S2, the average value acquisition method of the first fire characteristic data includes:

S21: obtaining the first fire characteristic data of the system at a current moment and the first fire

characteristic data of the system at a previous moment within a system startup time threshold t after power-on of the system to obtain an absolute value of a difference between the first fire characteristic data of the system at the current moment and the first fire characteristic data of the system at the previous moment:

$$wDiff = |nDet_Data - nTemp_Buffer|$$

wherein $nDet_Data$ is the first fire characteristic data at the current moment received by the system, and $nTemp_Buffer$ is the first fire characteristic data recorded at the previous moment,

S22: recording the first fire characteristic data of the system at the current moment when $wDiff$ is smaller than a preset maximum difference $DIFF_VALUE_MAX$, and

S23: obtaining the average value $Aver$ of the first fire characteristic data in the initial operating state within the system startup time threshold t based on the first fire characteristic data at the current moment, which has been recorded.

Further, in S3, a method for obtaining the effective first fire characteristic data of the actual application scenario is as follows:

after a system startup time threshold t following power-on of the system, when the average value of the fire characteristic data in the initial operating state of the

actual application scenario is not greater than a detection threshold $mThreshold$ set by the detection unit of the system, the first fire characteristic data obtained by the detection unit of the system after the system startup time threshold t is the effective first fire characteristic data.

Further, in S4, a method for preprocessing the second fire characteristic data includes:

S41: within a second startup time threshold following power-on of the system, executing S42 when a flame detection device does not obtain a light signal, otherwise, determining that the flame detection device is faulty,

S42: after the second startup time threshold following power-on of the system, controlling the flame detection device to power off and reset by the control unit of the system when the flame detection device obtains a light signal and issues a first fire alarm, and

S43: when, after the flame detection device powers off and resets, the flame detection device obtains a light signal for a second time and issues a second fire alarm, as well as a duration of obtaining the light signal for the second time is greater than a fire alarm signal duration threshold, regarding a light signal Ft , which is the light signal obtained for the second time, as the effective second fire characteristic data.

Further, in S6, the system fire alarm output

determination parameter W is obtained as follows:

$$W = A_m * a_1 + T_m * t_{em1} + C_m * c_1 + F * f_1$$

wherein F is a weighting coefficient of a light signal F_t of the reference application scenario, a_1 is a normalized effective smoke concentration data, t_{em1} is a normalized effective temperature data, c_1 is a normalized effective CO gas concentration data, f_1 is a normalized effective light signal data, A_m is a weighting coefficient of the smoke concentration of the actual application scenario, T_m is a weighting coefficient of the temperature T_t of the actual application scenario, and C_m is a weighting coefficient of the CO gas concentration of the actual application scenario.

Advantageous Effects of Invention: the present invention discloses a multi-dimensional fire detection method for a locomotive, in which fire characteristic data in a reference application scenario is obtained and preprocessed to obtain the average values of the fire characteristic data in the initial operating states of the reference application scenario and the actual application scenario. The effective first fire characteristic data of the actual application scenario and the weighting coefficient of the first fire characteristic data of the actual application scenario are thereby obtained, while the effective second fire characteristic data is also obtained. Finally, the system fire alarm output determination

parameter W is obtained to provide a basis for locomotive staff to determine whether a fire alarm has occurred. By reasonably arranging fire detectors according to different application scenarios of rail transit and performing comprehensive fusion of multi-source information obtained by various sensors, the method effectively solves the problems of high false alarm rates and detection failures caused by external environmental interferences in traditional detectors, improves the timeliness and accuracy of fire recognition, and provides a strong guarantee for the safe and stable operation of vehicles.

Brief Description of Drawings

In order to illustrate the examples of the present invention or the technical solutions in the prior art more clearly, the following briefly introduces the accompanying drawings that need to be used in the description of the examples or the prior art. Obviously, the accompanying drawings in the following description are some examples of the present invention, and for a person skilled in the art, other drawings can also be obtained from these accompanying drawings without creative effort.

Fig. 1 is a flow chart of a fire detection method of the present invention.

Fig. 2 is a schematic diagram of an application

scenario of a fire detection system and detector selection in an example of the present invention.

Fig. 3 is a schematic diagram of a preprocessing flow of a fire characteristic data in the example of the present invention.

Fig. 4 is a flow chart of the fire detection method in the example of the present invention.

Description of Embodiments

In order to make the purposes, technical solutions and advantages of the examples of the present invention clearer, the technical solutions in the examples of the present invention will be clearly and completely described below with reference to the accompanying drawings in the examples of the present invention. Obviously, the examples to be described are some, but not all, examples of the present invention. Based on the examples of the present invention, all other examples obtained by a person skilled in the art without creative efforts are within the protection scope of the present invention.

In the present example, a multi-dimensional fire detection method for a locomotive is provided, as illustrated in Fig. 1, including the following steps.

In the example of the present invention, detector selection is first performed according to the application

scenario of the fire detection system. Specifically, the application scenario includes detection areas such as a locomotive electrical compartment, a diesel engine compartment, an electrical cabinet, and a battery cabinet. Different types of detectors are selected according to different detection areas. The detectors mainly include smoke detectors, temperature and flame detectors, characteristic gas detectors, and aspirating detectors. For the electrical compartment, photoelectric smoke detectors and temperature detectors are selected, for the diesel engine compartment, photoelectric smoke detectors, temperature detectors, and flame detectors are selected, for the electrical cabinet, aspirating detectors (combined detection of smoke and CO gas) are selected, and for the battery cabinet, temperature detectors and CO characteristic gas detectors are selected. See Fig. 2.

S1: in a reference application scenario, collecting in real time a fire characteristic data of a detection area by a detection unit of a system, the fire characteristic data including first fire characteristic data and second fire characteristic data, the first fire characteristic data including a CO gas concentration C_t , a temperature T_t , and a smoke concentration, the second fire characteristic data including a light signal F_t . Specifically, the reference application scenario may be a test scenario before the

detection unit of the system is shipped from the factory, or may be another scenario. Its function is to serve as a standard for calculating the weighting coefficients of the CO gas concentration data, smoke concentration data, and temperature when environmental changes occur.

Specifically, as illustrated in Fig. 3, the detectors transmit the detected fire characteristic parameters, such as smoke, temperature, CO characteristic gas concentration, and flame light signal, to a controller, and the controller performs data preprocessing on different types of fire characteristic parameters. Communication between the controller and the detectors is performed through a two-wire bus, RS485, and CAN communication. For the characteristic parameters of smoke, temperature, and characteristic gas concentration, the system mainly performs dynamic data storage and filtering processing, and after the system has operated for a period of time t , the average value of the dynamically stored characteristic parameters is calculated, and the calculation result of the average value is used to determine whether the detectors are operating normally. For the characteristic parameters of light signal, in order to prevent the flame detector from generating false fire alarms due to light signals, the system performs data preprocessing based on the alarm output time and the number of alarm outputs of the detectors.

S2: performing preprocessing on the first fire characteristic data by a control unit of the system to obtain an average value Aver of the first fire characteristic data in an initial operating state of the reference application scenario using an average value acquisition method based on the fire characteristic data in the initial operating state.

Preferably, a method for obtaining the average value of the first fire characteristic data in the initial operating state includes the following steps: S21: obtaining the first fire characteristic data of the system at a current moment and the first fire characteristic data of the system at a previous moment within a system startup time threshold t after power-on of the system to obtain an absolute value of a difference between the first fire characteristic data of the system at the current moment and the first fire characteristic data of the system at the previous moment:

$$wDiff = |nDet_Data - nTemp_Buffer|$$

wherein nDet_Data is the first fire characteristic data at the current moment received by the system, and nTemp_Buffer is the first fire characteristic data recorded at the previous moment.

S22: recording the first fire characteristic data of the system at the current moment when wDiff is smaller than a preset maximum difference DIFF_VALUE_MAX.

S23: based on the recorded first fire characteristic

data at the current moment, obtaining the average value Aver of the first fire characteristic data in the initial operating state within the system startup time threshold t, wherein the method for obtaining the average value Aver of the first fire characteristic data in the initial operating state within the system startup time threshold t is a conventional method of calculating an average value in the art, and therefore is not described in detail herein.

S3: obtaining an average value of the fire characteristic data in the initial operating state of an actual application scenario by the average value acquisition method based on the fire characteristic data in the initial operating state to obtain an effective first fire characteristic data of the actual application scenario, meanwhile, obtaining a weighting coefficient of the first fire characteristic data of the actual application scenario based on an average value Aver of the fire characteristic data in the initial operating state of the reference application scenario.

Preferably, a method for obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario includes:

S31: obtaining a change ratio of the average value of the first fire characteristic data:

$$Esm = Aver_am / Aver_a1$$

$$E_{tm} = A_{ver_tm} / A_{ver_t1}$$

$$E_{cm} = A_{ver_cm} / A_{ver_c1}$$

wherein E_{sm} is a change ratio of an average value of the smoke concentration, E_{tm} is a change ratio of an average value of the temperature T_t , E_{cm} is a change ratio of an average value of the CO gas concentration, A_{ver_am} is an average value of the smoke concentration in the initial operating state of the actual application scenario, A_{ver_tm} is an average value of the temperature T_t in the initial operating state of the actual application scenario, A_{ver_cm} is an average value of the CO gas concentration in the initial operating state of the actual application scenario, A_{ver_a1} is an average value of the smoke concentration in the initial operating state of the reference application scenario, A_{ver_t1} is an average value of the temperature T_t in the initial operating state of the reference application scenario, and A_{ver_c1} is an average value of the CO gas concentration in the initial operating state of the reference application scenario, and

S32: obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario based on the change ratio of the average value of the first fire characteristic data:

$$A_m = A * E_{sm}$$

$$T_m = T * E_{tm}$$

$$C_m = C * E_{cm}$$

wherein A_m is a weighting coefficient of the smoke concentration of the actual application scenario, T_m is a weighting coefficient of the temperature T_t of the actual application scenario, C_m is a weighting coefficient of the CO gas concentration of the actual application scenario, A is a weighting coefficient of the smoke concentration of the reference application scenario, T is a weighting coefficient of the temperature T_t of the reference application scenario, and C is a weighting coefficient of the CO gas concentration of the reference application scenario.

Preferably, a method for obtaining the effective first fire characteristic data of the actual application scenario is as follows.

After a system startup time threshold t following power-on of the system, when the average value of the fire characteristic data in the initial operating state of the actual application scenario is not greater than a detection threshold $mThreshold$ set by the detection unit of the system, the first fire characteristic data collected by the detection unit of the system after the system startup time threshold t is regarded as the effective first fire characteristic data, otherwise, it is determined that the sensor of the detection unit of the system corresponding to the first fire characteristic data is faulty, and the detection values of

the faulty sensor are no longer used as a basis for fire alarm determination.

In the present example, when an absolute value $wDiff$ of the difference between the first fire characteristic data at the current moment and the first fire characteristic data at the previous moment is greater than a preset maximum difference $DIFF_VALUE_MAX$, the first fire characteristic data at the current moment is regarded as an interference signal.

Specifically, within the system startup time threshold t after power-on of the system, the detection data of the first fire characteristic data is not subjected to a fire alarm algorithm determination, but only the first fire characteristic data is preprocessed. First, the control unit allocates a data buffer space for storing various characteristic parameters. The space size for a certain characteristic parameter is set as N , which can store m pieces of data in real time, and the data is stored in a queue manner. Furthermore, during the process of real-time data reception, filtering processing is performed on the first fire characteristic data. $nDet_Data$ is defined as the characteristic parameter of the detector received at a certain moment, and $nTemp_Buffer$ is defined as the characteristic parameter recorded at the previous moment. $wDiff = |nDet_Data - nTemp_Buffer|$ is defined as the absolute

value of the difference between the two, and it is determined whether $wDiff$ is greater than the preset maximum difference $DIFF_VALUE_MAX$, wherein $DIFF_VALUE_MAX$ is set according to the application scenario. When $wDiff$ is greater than the preset maximum difference $DIFF_VALUE_MAX$, the characteristic parameter $nDet_Data$ of the detector at the current moment is regarded as an interference signal and is not stored, otherwise, the characteristic parameter $nDet_Data$ of the detector at the current moment is regarded as normal data, and $nDet_Data$ is stored, and meanwhile, $nTemp_Buffer$ is updated with $nDet_Data$ for use in the filtering processing at the next moment. The system startup time threshold t after power-on of the system is manually set, and t values of detectors from different manufacturers may differ.

Furthermore, after the system startup time threshold t following power-on of the system, the average values $Aver$ of various first fire characteristic data in the initial operating state are calculated. When the average value $Aver$ of a certain first fire characteristic data is greater than the threshold $mThreshold$ set under the normal operating state (the $mThreshold$ is set according to the application scenario), it is determined that the sensor for collecting the corresponding first fire characteristic data is faulty, and the characteristic parameter of the faulty sensor is no longer used as a basis for fire alarm determination.

S4: performing preprocessing on the second fire characteristic data by the control unit of the system to obtain an effective second fire characteristic data.

Preferably, a method for preprocessing the second fire characteristic data is as follows.

Specifically, the detection unit of the system collects in real time the characteristic parameter of the light signal Ft. The light signal Ft received by the system is a dry contact signal, namely a switching signal of 0 or 1. When the detector detects a flame, it outputs a signal 1, which is a fire alarm signal, and when no flame is detected, it outputs a signal 0. In order to prevent the flame detector from generating false fire alarms, a data processing method for the flame detector includes:

S41: within a second startup time threshold following power-on of the system, executing S42 when a flame detection device does not obtain a light signal, otherwise, determining that the flame detection device is faulty,

S42: after the second startup time threshold following power-on of the system, controlling the flame detection device to power off and reset by the control unit of the system when the flame detection device obtains a light signal and issues a first fire alarm, and

S43: when, after the flame detection device powers off and resets, the flame detection device obtains a light

signal for a second time and issues a second fire alarm, as well as a duration of obtaining the light signal for the second time is greater than a fire alarm signal duration threshold, regarding a light signal F_t , which is the light signal obtained for the second time, as the effective second fire characteristic data.

Specifically, in the present example, when the system determines that the flame detector has issued a fire alarm within a second startup time threshold of 10 seconds after the system is powered on for the first time, the system determines that the flame detector is faulty, and the light signal characteristic parameter of the detector is no longer used as a basis for fire alarm determination. After 10 seconds, the flame detector begins to operate normally. When the flame detector acquires a light signal and issues a first fire alarm, the control unit performs a power-off reset operation on the flame detector. When, after reset, the detector acquires a light signal for the second time and issues a second fire alarm, and the duration of acquiring the second light signal is greater than a fire alarm signal duration threshold, that is, the fire alarm signal of the flame detector lasts for more than 5 seconds, the control unit of the system determines that the flame detector has issued a fire alarm. The light signal F_t output by the flame detector is regarded as the effective second fire

characteristic data.

S5: performing normalization processing on the effective first fire characteristic data and the effective second fire characteristic data of the actual application scenario to obtain a normalized effective first fire characteristic data and a normalized effective second fire characteristic data.

Specifically, the preprocessed fire characteristic data C_t , T_t , S_t , and F_t are subjected to normalization processing so as to be mapped into a range of 0 to 1. The method of normalization processing is a conventional technique in the art and is therefore not described in detail herein.

S6: obtaining a system fire alarm output determination parameter W based on the weighting coefficient of the first fire characteristic data of the actual application scenario, the normalized effective first fire characteristic data, and the normalized effective second fire characteristic data to provide a basis for locomotive staff to determine whether a fire alarm has occurred.

Preferably, the system fire alarm output determination parameter W is obtained as follows:

$$W = A_m * a_1 + T_m * t_{em1} + C_m * c_1 + F * f_1$$

wherein F is a weighting coefficient of a light signal F_t of the reference application scenario, a_1 is a normalized

effective smoke concentration data, $tem1$ is a normalized effective temperature data, $c1$ is a normalized effective CO gas concentration data, and $f1$ is a normalized effective light signal data.

Specifically, the system is networked with the central control unit of the locomotive for communication, and the communication method adopts Ethernet or CAN communication. The system is able to acquire in real time the locomotive operating conditions, time, altitude, geographical location, and other status information. By obtaining the status information of the locomotive under different operating environments, the system is able to dynamically adjust the characteristic weighting coefficients A_m , T_m , and C_m . The adjustment method is as follows: when an environmental factor such as the operating condition of the locomotive changes, the average values of various fire characteristic parameters in the initial operating state of the actual application scenario are recalculated according to the method of acquiring the average value $Aver$ of the fire characteristic data in the initial operating state of the reference application scenario. These average values are respectively the average value $Aver_am$ of the smoke concentration in the initial operating state of the actual application scenario, the average value $Aver_tm$ of the temperature T_t in the initial operating state of the actual application scenario,

and the average value Aver_{cm} of the CO gas concentration in the initial operating state of the actual application scenario.

Specifically, in the traditional fire alarm determination method, the system adopts a weighted algorithm to determine whether a fire has occurred. According to different application scenarios, different weighting coefficients are assigned to the multi-sensor parameters. The coefficients mainly include a weighting coefficient A of the smoke concentration in the reference application scenario, a weighting coefficient T of the temperature T_t in the reference application scenario, a weighting coefficient C of the CO gas concentration in the reference application scenario, and a weighting coefficient F of the light signal F_t in the reference application scenario. The system fire alarm output determination parameter is W, expressed as: $W = A * s_1 + T * tem_1 + C * c_1 + F * f_1$, wherein the weighting coefficients of the respective parameters in the reference application scenario are determined according to the reference application scenario and the surrounding environmental factors, based on the experience of staff. Finally, the W value is used to determine whether the system has issued an alarm. The system fire alarm threshold is set as W_t, and when $W > W_t$, it is determined that the system has a fire alarm, otherwise no fire alarm has occurred, as

illustrated in Fig. 4.

In the example of the present invention, before the environmental factors change, the average values of the smoke concentration, temperature T_t , and CO gas concentration in the initial operating state of the reference application scenario are respectively $Aver_a1$, $Aver_t1$, and $Aver_c1$. The change ratios of the average values of the respective first fire characteristic data are calculated, and due to the differences in application environments, the weighting coefficients of the respective characteristic data are adjusted. The adjusted characteristic weighting coefficients are $A_m = A * E_{sm}$, $T_m = T * E_{tm}$, and $C_m = C * E_{cm}$. The system fire alarm output is weighted as follows: $W = A_m * a1 + T_m * tem1 + C_m * c1 + F * f1$. The dynamically adjusted weighting coefficients based on the reference application scenario enable the fire alarm output determination parameter W to have more practical guiding significance.

Specifically, in the present example, detector selection is performed according to the actual application scenario, and the system performs data preprocessing and data fusion on the detected fire characteristic data. The system can acquire in real time the locomotive operating conditions, and the controller, based on the status information of the locomotive under different operating environments, is able to dynamically adjust the

characteristic weighting coefficients of the algorithm. The system collects fire characteristic data in real time and calculates the fire alarm output determination parameter W based on the characteristic weighting coefficients. When the system determines that a fire has occurred, the fire control unit issues an audible and visual alarm and uploads the fire alarm signal to a TCMS system (train control and monitoring system of the locomotive). The solenoid valve on the cylinder is then actuated to release a fire extinguishing agent to suppress the fire.

Advantageous Effects of Invention: the present invention discloses a multi-dimensional fire detection method for a locomotive, in which fire characteristic data in a reference application scenario is obtained and preprocessed to obtain the average values of the fire characteristic data in the initial operating states of the reference application scenario and the actual application scenario. The effective first fire characteristic data of the actual application scenario and the weighting coefficient of the first fire characteristic data of the actual application scenario are thereby obtained, while the effective second fire characteristic data is also obtained. Finally, the system fire alarm output determination parameter W is obtained to provide a basis for locomotive staff to determine whether a fire alarm has occurred. By

reasonably arranging fire detectors according to different application scenarios of rail transit and performing comprehensive fusion of multi-source information obtained by various sensors, the method effectively solves the problems of high false alarm rates and detection failures caused by external environmental interferences in traditional detectors, improves the timeliness and accuracy of fire recognition, and provides a strong guarantee for the safe and stable operation of vehicles.

In the present example, different types of sensors are arranged according to the environment and requirements of the detection site, so as to fully utilize the advantages of each sensor, complement each other, and implement multi-information fusion detection with information sharing. By performing filtering and preprocessing on the detection data, interference signals and fault signals are eliminated, making the detection data more authentic and reliable. Taking into account the influence of different scenarios and environmental factors, multi-dimensional synchronous detection is implemented to fuse different types of fire characteristic parameters. Meanwhile, the system is networked with the central control unit of the locomotive to obtain locomotive status information, thereby dynamically adjusting the characteristic weighting coefficients. As a result, the fire alarm algorithm becomes more intelligent,

effectively reducing the system false alarm rate and achieving accurate fire recognition.

Finally, it should be noted that the above examples are only used to illustrate the technical solutions of the present invention, but not to limit them. Although the present invention has been described in detail with reference to the foregoing examples, a person skilled in the art should understand that the technical solutions described in the foregoing examples can still be modified, or some or all of the technical features thereof can be equivalently substituted. However, these modifications or substitutions do not make the essence of the corresponding technical solutions deviate from the scope of the technical solutions of the examples of the present invention.

CLAIMS

1. A multi-dimensional fire detection method for a locomotive, the method comprising:

S1: in a reference application scenario, collecting in real time a fire characteristic data of a detection area by a detection unit of a system, the fire characteristic data including first fire characteristic data and second fire characteristic data, the first fire characteristic data including a CO gas concentration C_t , a temperature T_t , and a smoke concentration, the second fire characteristic data including a light signal;

S2: performing preprocessing on the first fire characteristic data by a control unit of the system to obtain an average value of the first fire characteristic data in an initial operating state of the reference application scenario using an average value acquisition method based on the fire characteristic data in the initial operating state;

S3: obtaining an average value of the fire characteristic data in the initial operating state of an actual application scenario by the average value acquisition method based on the fire characteristic data in the initial operating state to obtain an effective first fire characteristic data of the actual application scenario, meanwhile, obtaining a weighting coefficient of the first fire characteristic data of the actual application scenario

based on an average value Aver of the fire characteristic data in the initial operating state of the reference application scenario;

S4: performing preprocessing on the second fire characteristic data by the control unit of the system to obtain an effective second fire characteristic data;

S5: performing normalization processing on the effective first fire characteristic data and the effective second fire characteristic data of the actual application scenario to obtain a normalized effective first fire characteristic data and a normalized effective second fire characteristic data; and

S6: obtaining a system fire alarm output determination parameter W based on the weighting coefficient of the first fire characteristic data of the actual application scenario, the normalized effective first fire characteristic data, and the normalized effective second fire characteristic data to provide a basis for locomotive staff to determine whether a fire alarm has occurred.

2. The method according to claim 1, wherein, in S3, a method for obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario includes:

S31: obtaining a change ratio of the average value of the first fire characteristic data:

$$E_{sm} = A_{ver_am} / A_{ver_a1}$$

$$E_{tm} = A_{ver_tm} / A_{ver_t1}$$

$$E_{cm} = A_{ver_cm} / A_{ver_c1}$$

wherein E_{sm} is a change ratio of an average value of the smoke concentration, E_{tm} is a change ratio of an average value of the temperature T_t , E_{cm} is a change ratio of an average value of the CO gas concentration, A_{ver_am} is an average value of the smoke concentration in the initial operating state of the actual application scenario, A_{ver_tm} is an average value of the temperature T_t in the initial operating state of the actual application scenario, A_{ver_cm} is an average value of the CO gas concentration in the initial operating state of the actual application scenario, A_{ver_a1} is an average value of the smoke concentration in the initial operating state of the reference application scenario, A_{ver_t1} is an average value of the temperature T_t in the initial operating state of the reference application scenario, and A_{ver_c1} is an average value of the CO gas concentration in the initial operating state of the reference application scenario, and

S32: obtaining the weighting coefficient of the first fire characteristic data of the actual application scenario based on the change ratio of the average value of the first fire characteristic data:

$$A_m = A * E_{sm}$$

$$T_m = T * E_{tm}$$

$$C_m = C * E_{cm}$$

wherein A_m is a weighting coefficient of the smoke concentration of the actual application scenario, T_m is a weighting coefficient of the temperature T_t of the actual application scenario, C_m is a weighting coefficient of the CO gas concentration of the actual application scenario, A is a weighting coefficient of the smoke concentration of the reference application scenario, T is a weighting coefficient of the temperature T_t of the reference application scenario, and C is a weighting coefficient of the CO gas concentration of the reference application scenario.

3. The method according to claim 1, wherein, in S2, the average value acquisition method of the first fire characteristic data includes:

S21: obtaining the first fire characteristic data of the system at a current moment and the first fire characteristic data of the system at a previous moment within a system startup time threshold t after power-on of the system to obtain an absolute value of a difference between the first fire characteristic data of the system at the current moment and the first fire characteristic data of the system at the previous moment:

$$wDiff = |nDet_Data - nTemp_Buffer|$$

wherein $nDet_Data$ is the first fire characteristic

data at the current moment received by the system, and nTemp_Buffer is the first fire characteristic data recorded at the previous moment,

S22: recording the first fire characteristic data of the system at the current moment when wDiff is smaller than a preset maximum difference DIFF_VALUE_MAX, and

S23: obtaining the average value Aver of the first fire characteristic data in the initial operating state within the system startup time threshold t based on the first fire characteristic data at the current moment, which has been recorded.

4. The method according to claim 1, wherein, in S3, a method for obtaining the effective first fire characteristic data of the actual application scenario is as follows:

after a system startup time threshold t following power-on of the system, when the average value of the fire characteristic data in the initial operating state of the actual application scenario is not greater than a detection threshold mThreshold set by the detection unit of the system, the first fire characteristic data obtained by the detection unit of the system after the system startup time threshold t is the effective first fire characteristic data.

5. The method according to claim 1, wherein, in S4, a method for preprocessing the second fire characteristic data includes:

S41: within a second startup time threshold following power-on of the system, executing S42 when a flame detection device does not obtain a light signal, otherwise, determining that the flame detection device is faulty,

S42: after the second startup time threshold following power-on of the system, controlling the flame detection device to power off and reset by the control unit of the system when the flame detection device obtains a light signal and issues a first fire alarm, and

S43: when, after the flame detection device powers off and resets, the flame detection device obtains a light signal for a second time and issues a second fire alarm, as well as a duration of obtaining the light signal for the second time is greater than a fire alarm signal duration threshold, regarding a light signal F_t , which is the light signal obtained for the second time, as the effective second fire characteristic data.

6. The method according to claim 1, wherein, in S6, the system fire alarm output determination parameter W is obtained as follows:

$$W = A_m * a_1 + T_m * t_{em1} + C_m * c_1 + F * f_1$$

wherein F is a weighting coefficient of a light signal F_t of the reference application scenario, a_1 is a normalized effective smoke concentration data, t_{em1} is a normalized effective temperature data, c_1 is a normalized effective CO

gas concentration data, f_l is a normalized effective light signal data, A_m is a weighting coefficient of the smoke concentration of the actual application scenario, T_m is a weighting coefficient of the temperature T_t of the actual application scenario, and C_m is a weighting coefficient of the CO gas concentration of the actual application scenario.