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Design study of fire risk early warning robot

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Abstract: As an important means of fire prevention, fire risk detection and early warning can timely alarm in the early stage of fire spread, strive for the golden time for fire extinguishing personnel, and have the value of reducing the loss of life and property caused by fire. Nowadays, the fire risk detection and early warning technology has developed to the stage of fire risk warning robot. With the flexibility and intelligence of the early warning robot, the accuracy of fire warning will be further improved, and the probability of false alarm and false alarm in the fire warning detection will be reduced, so as to promote the improvement of fire safety management level.

Fire as a common disaster in modern society, the natural environment and human life and property safety has a serious threat, through the development of intelligent early warning robot with good fire risk monitoring performance, intelligent warning robot in the early fire accurately extract the corresponding disaster characteristics, and accurately find out the ignition location, which can before the fire spread to emergency treatment, effectively reduce the risk of fire. And compared with the traditional fire detection method, the fire risk early warning robot can effectively solve the problem of monitoring dead Angle, and the design of its multi-sensor has significant utility for reducing the probability of fire over report, so it has considerable research and application value.

1. Fire risk early-warning mechanism

1.1 Fire spread rule

The spread of fire rule can according to the controllable situation of the fire and its main characteristics is divided into four stages: at the beginning of the fire, the ignition location temperature is higher than the surrounding environment, mainly for inadequate smoldering fire, in the fire CO concentration will rise sharply, the fire changes at this stage has obvious uncertainty, smoldering fire will not necessarily continue to expand for fire cause serious fire disasters, at the same time, after the fire warning robot detected the disaster risk, only with a small amount of fire extinguishing medium can achieve extinguishing effect, to block the spread of fire.

In the fire development stage, combustion has already formed at this time, and the temperature at the ignition point is obviously significantly, close to the maximum combustion temperature. At this time, the CO gas release value is the highest, accompanied by a large amount of smoke. In traditional fire detection, it is a common fire detection principle to capture the smoke characteristics of fire, and smoke alarm has been widely used in many public places.

Then is the development stage of comprehensive fire, the flame begins to appear, the flame temperature is very high, which is a dangerous stage of fire. Life and property safety has a great threat, when the fire occurs to this stage, the fire loss is inevitable. So it is necessary to pass the corresponding fire spread, and complete the fire control work as soon as possible to control the disaster loss.

Finally, the fire is the fire weakening stage, where the fuel has been basically exhausted, the temperature of the fire position begins to drop, the CO concentration and smoke concentration show signs of decline, until the fuel is completely exhausted, the parameter will return to normal.

1.2 Fire detection and early warning mechanism

In the current development and design of fire detection and early warning equipment, the logic of the early warning mechanism is to extract the fire development characteristics and use the corresponding environmental information detection sensor to capture the abnormal environmental parameters of fire, so as to build the fire alarm response system. By designing the corresponding algorithm, the sensor feedback to the fire trend, environmental data to do more intelligent fire warning and report, for fire, smoke, and high temperature, these different levels of fire characteristics, can borrow by CO sensor, smoke sensor, flame detector, temperature sensor and other environmental information detection equipment for comprehensive monitoring of fire, and build the corresponding detection mechanism for fire warning and alarm monitoring, so as to control the fire in the early easy to put out the fire.

1.3 Common fire detection technology and its defects

Current commonly used fire detection technologies are mainly divided into sensor-based or video-based fire detection technologies. Among them, the sensor mainly has photosensitive type, smoke sensing type, gas type and temperature sensing type. By detecting the physical or chemical changes generated in the combustion process of combustible materials to feedback the fire warning, it mainly has the following three defects: ① vulnerable to environmental influence. Existing fire detectors are vulnerable to the installation environment. When the humidity in the air is too high, the dust content is too large or the air flow rate is too fast, it is easy to lead to the leakage and miscalculation of fire, and cannot play the proper role of fire warning. Therefore, the application value of such fire detectors is low in large open places.② Fire feedback is single. Using sensor for fire detection can timely report the fire situation, but the report content is limited to whether the fire occurs, unable to the fire location, combustible types and fire specific spread situation information to report, so through the sensor for fire warning staff to come to the scene, may lead to fire time missed.③ The detection range is limited. The detection scope covered by the sensor-centered fire detection technology is limited. At the same time, due to the easy environmental influence, the detection scope will be further reduced, resulting in the generation of detection dead corners between the detectors, resulting in the increase of the detection misreporting rate.

Compared with the fire detection technology with sensor as the core, the fire detection technology with video as the core has increased the accuracy of detection, and can capture the clue of fire by extracting the picture features, so it has high accuracy and efficiency. However, the fire detection technology with video as the core has a high dependence on the algorithm model, and the feature calculation and probabilistic analysis ability of the algorithm will have a direct impact on the accuracy of the fire detection technology. Therefore, using the fire detection technology with video as the core needs to select the appropriate and efficient algorithm model carefully.

2. Research status of fire risk early warning robot

Due to the small detection range, high false alarm leakage rate and insufficient flexibility of traditional fire risk detection technology, it is necessary to adopt advanced information technology and robot research in traditional fire detection methods, so that the design of application range and detection accuracy has significant advantages of fire risk early warning robots. First of all, the fire risk early warning robot can carry out good fire early warning and forest fire, warehouse fire, hospital fire and other sites, compared with the traditional fire risk detection technology, the fire risk early warning robot can be more intelligent and flexible fire inspection activities, so that the fire can be accurately detected in the early fire and early warning stage. The fire risk warning robot can also find the fire point through automatic detection, further improve the rescue speed of fire extinguishing personnel, and make it possible to extinguish the fire in the early stage of flame spread, which is of great significance for improving the level of fire safety management [1].

3. Hardware design of the fire risk early warning robot

3.1 Chassis design

At present, there are four kinds of widely used robot mobile platform structures: leg structure, crawler structure, wheel structure and composite structure. Among them, the leg structure has strong obstacle crossing ability, but the movement efficiency and weight bearing ability are low. Meanwhile, due to the high degree of freedom of the structure, its control system is more complex, which is prone to problems such as poor attitude stability. The track mobile platform also has a strong obstacle ability. Due to its compact structure, large contact area with the ground, it can adapt to various complex ground conditions and has good load-bearing performance. The disadvantage is that the work efficiency is low, while the movement consumes a lot of energy, and the machine structure is easy to wear. The structure design of wheeled mobile platform is relatively simple, more flexible, at the same time, the load capacity is strong, the moving efficiency is high, the disadvantage is that the off-road ability is poor; The composite mobile platform is a combination of the above three mobile structural platforms. The main envelope wheel-rail composite, wheel-leg composite, wheel-leg composite, track-leg composite, and track-wheel-leg composite. The composite mobile platform can choose the appropriate walking structural platform according to the actual site, which can effectively improve the robot's adaptability to the environment and walking level, but the structure is too complex. So it's hard to control the problem.

For the above four types of chassis design, need according to the actual design requirements to select the appropriate mobile platform structure, such as for factories, warehouse is given priority to with flat road site design fire risk warning robot shall select the wheeled structure of mobile platform, if the construction site of such traffic more complex places design fire risk warning robot, should select excellent cross-country ability of crawler mobile platform [2].

3.2 Hardware equipment

In the design of fire risk warning robot, it mainly includes three modules, namely environmental monitoring module, mobile control module and control endpoint module. In order to ensure the normal operation of each module, appropriate hardware equipment is needed, including the environmental monitoring module includes camera and various environmental monitoring sensors to ensure that it can capture and feedback various fire characteristics; the mobile control module includes main control board, motor, power supply, motor drive board, data transmission system, etc. The control endpoint is the module that the robot needs to take action after the data feedback. In the design of the fire danger warning robot, the main function of the control endpoint module is to send warning information to the background immediately after the fire is found, and directly alarm when an open fire occurs, so as to control the spread intensity of the fire.

4. Software design of fire risk warning robot

4.1 Detection mechanism

When selecting the fire detection mechanism of fire risk warning robot, there are three main design pathways: ① single sensing alarm mechanism. Because the fire early to put out action to minimize the disaster, so in the design of fire risk warning robot can focus its detection features in the fire of the smoke, or by detecting the CO concentration in the air perception the fire stage, using the corresponding algorithm analysis fire judgment results.② Integrated sensing and alarm mechanism. Comprehensive sensing alarm mechanism for forest fire, urban fire due to the scope is difficult to find at the beginning of the fire disaster signs of fire type has a prominent effect, through the smoke, temperature, light, flame sensor installation to early warning robot, improve the signs of disaster capture accuracy, at the same time can further judge the development of the fire, provide certain guidance for subsequent rescue operations.③ Camera and alarm mechanism. The camera alarm mechanism is the fire detection mechanism with video as the core. In the inspection process, the robot can capture the fire signs in the scene visually with the help of the camera, and give timely warning, with a high accuracy rate[3].

4.2 Algorithm selection

4.2.1 Fuzzy clustering algorithm

For the fire risk early warning robot composed of a single sensor, the fuzzy clustering algorithm can meet the corresponding calculation and judgment requirements. In the process of operation, the fuzzy clustering distance between the target data to obtain the membership of the target and class center, so as to achieve the classification [4] of the fuzzy target. In the fire risk warning, the fuzzy clustering algorithm can be used to process and calculate the environmental information feedback by the sensor, compare it with the fire environmental information, and determine whether it is a true fire, so as to complete the corresponding fire warning work.

4.2.2 Fusion algorithm

For the fire risk warning robot with multiple sensor information sources, the fusion algorithm of fire analysis and calculation can be used to fuse various fire information through the characteristics of fire stage to the basic probability function, and the D-S evidence model can be used to determine the fire probability. At the same time, the intelligent nature of the fire can be realized, so as to output more comprehensive and rich disaster data analysis. By establishing a D-S evidence fusion model for fire warning, the fire probability of environmental data can be accurately described and corresponding membership functions established. In actual operation, the algorithm can extract various fire data, effectively avoid the uncertainty of a single fire signal, and thus improve the accuracy of fire warning, as shown in Figure 1.

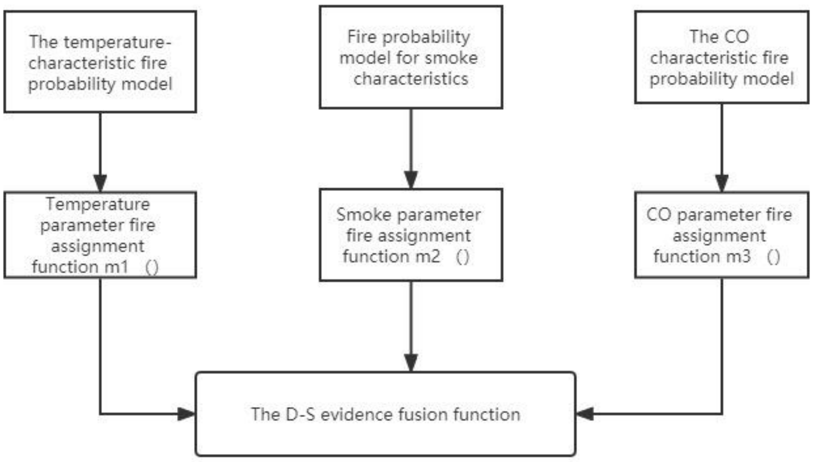

Figure 1: Fire warning D-S evidence fusion algorithm process

4.2.3 Convolutional neural network

In terms of image recognition, due to the further development of artificial intelligence technology, deep learning algorithms for image feature recognition have significant advantages over other algorithms. Therefore, in the design of fire risk detection robots, robots can use convolutional neural networks to receive video information analysis, extract fire features, and make more accurate disaster judgments. At the same time, the convolutional neural network has the characteristics of weight sharing, so the number of parameters in the process of image training is small, which can effectively save the storage space, and also has certain advantages in extracting image information. In the operation process of the convolutional layer neural network, the convolution, activation layer, pooling layer and the full connection layer will be gradually superimposed, so that the simple features in the original image information can be gradually superimposed to the level of complex features, and the network can be output in the way of classification or regression.

5. Design of fire risk early warning robot monitoring system

5.1 Main interface design

In the design of the fire risk early warning robot, in addition to ensuring the detection efficiency and accuracy of the robot, it is also necessary to design the corresponding monitoring system, so that the corresponding fire monitoring staff can control the early warning robot. In the monitoring system, it is necessary to build the corresponding human-computer interaction interface to ensure that the monitoring personnel can send the work instructions to the early warning robot accurately and timely to improve its fire warning effect. Among its main interface should include environmental information, motion control and image view three parts, to ensure that the monitoring and machine can achieve good information interaction, at the same time help to monitor the specific operation of the machine timely perception, which can quickly find the machine fault, ensure the early warning robot running smoothly [5].

5.2 Control instruction design

The control instructions for the fire risk early warning robot are mainly path planning and communication instructions. In the path planning, the monitoring personnel need to select the patrol starting point and target point of the warning robot, and then plan through the corresponding path algorithm and GPS terrain information, so that the warning robot can complete the inspection of the corresponding target site in the shortest time. At the same time, it is also necessary to use GPS to detect the geographical location of the early warning robot, so as to have a more intuitive understanding of the operation of the early warning robot. When it stays in the same coordinate for a long time, it can indicate that the robot has a failure. In terms of the design of communication instructions, the monitoring personnel should be given the authority to collect the image acquisition data of the warning robot and the sensor, and ensure that real-time communication between the two can be achieved, so as to ensure that the alarm information of the warning robot and the control instructions of the monitoring personnel can play an effective role.

6. Conclusion

To sum up, compared with the traditional fire detection technology, the fire risk early warning robot has a better performance in terms of detection range, detection accuracy and practicability. At the same time, in the design of fire risk early warning robot, it is necessary to carry out three-level planning of hardware, software and monitoring system, combined with specific fire early warning requirements and terrain characteristics, select the appropriate early warning robot design, so that it can fully meet the corresponding needs of fire risk detection, and effectively protect the safety of personnel life and property.

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