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Development Status and Trend of Flame Detection based on Deep Learning

Yixu Wang

School of computer Science, Yangtze University, Jingzhou 434023, China

Abstract

In daily life, fire is also the most frequent and common threat event. However, the fire is relatively easy to extinguish in the initial stage. Therefore, it is necessary to identify the fire and give an alarm by using the algorithm based on deep learning. Compared with the traditional point sensor, the accuracy of flame recognition based on a deep learning algorithm may decrease, but the speed and anti-interference ability can be greatly improved. This paper mainly analyzes the development status of flame detection algorithms based on deep learning, as well as the widely used methods at present, and finally, summarize the remaining problems. The future development trend is predicted.

Keywords

Deep Learning; Artificial Intelligence; Flame Detection.

1. Introduction

With the progress and development of society and the continuous improvement of people's living standards, the environment of our daily life has become more and more complicated, which leads to the gradual increase of hidden dangers of fire. In life, fire is a serious disaster, which poses a great threat to people's lives and property. At the same time, fire is the most frequent and common threat event in daily life. The fire is relatively easy to extinguish at the initial stage, so it is necessary to identify the fire and give an alarm by using the algorithm based on deep learning. The traditional fire detection system is based on a point sensor, which is based on the sampling of temperature, light, and smoke particles to identify the fire. In this case, indoor fire detection has high accuracy, but there is a big problem with the speed. It usually takes several minutes from the occurrence of the fire to the completion of the detection, and there will be a lot of interference in the outdoor environment, resulting in false positives and false negatives, resulting in poor identification results. Time is one of the main factors to reduce fire losses. Therefore, it is necessary to reduce the detection time of flame and increase the chances of extinguishing the fire to reduce the losses. At present, the flame detection algorithm based on deep learning has been widely concerned by academia and industry. Compared with the traditional method, it greatly improves the detection speed, and has the following advantages: (1) The cost is low, no special equipment is needed, and it only depends on the monitoring camera. (2) the detection range is wide, so long as the monitoring range of the camera can be detected, and (3) the detection time is short, the flame can be detected in the early stage, and an alarm can be given before it spreads. (4) There is no need to confirm the fire scene, and the false alarm can be identified through the scene image. (5) The details of the flame can be obtained, and more flame information, such as time, place, size, etc., can be obtained by improving the algorithm.Development of flame detection.

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2. Development of Flame Detection

2.1 Traditional Flame Detection

In the traditional flame detection methods, most of the sensors are combined with sensors. The main sensors used are infrared detectors, ultraviolet sensors and visual sensors. These sensors have good accuracy in specific environments, but the detection effect in outdoor and complex environments is not ideal. The detection range depends on its installation position and the surrounding environment of the sensor. These sensors are described below.

2.1.1 Infrared Sensor

The infrared (IR) flame sensor detects and analyzes infrared spectral bands to find some predefined patterns emitted by hot gas. These patterns are sensed or detected by using a thermal imager or a thermal imager. Near-infrared radiation is detected by CCD or charge-coupled device. Water vapor will seriously affect the infrared radiation sensor because water will absorb most of the received infrared radiation. Therefore, infrared sensors cannot provide accurate results in the outdoor environment.

2.1.2 Ultraviolet Sensor

The ultraviolet (UV) sensor can detect the ultraviolet radiation emitted when the emitted flame occurs. The UV flame sensor can detect fire and explosion within 3-4 milliseconds. It is prone to false alarms caused by radiation from other ultraviolet sources (such as lightning, radiation, arc welding, and sunlight). Ultraviolet detectors can usually work better at wavelengths shorter than 300nm to reduce the influence of natural background radiation.

2.1.3 Visual Sensor

The Visualization sensor is mainly used to provide the output image of a radiation pattern that can be understood by human beings. These types of sensors are usually disturbed by smoke and fog. Visible sensors are usually used in combination with UV sensors or IR sensors to collect information, improve detection output and sense false alarms.

2.2 Current Status of Flame Detection

With the recent progress and development of deep learning, the flame detection system based on deep learning begins to develop rapidly. At first, it was only flame image detection based on multilayer perceptron, which was used to realize single-class flame image detection and recognition. Later, due to the proposal and application of the convolutional neural network CNN, a large number of CNN flame detection methods based on the convolutional neural network appeared. Through a large number of flame image training, the network can accurately recognize images containing flames. For example, the image fire detection method based on VGG16 can quickly and effectively detect fire information in different scenes. Target detection is an important research direction of computer vision. Its purpose is to accurately identify the category and position of a specific target object in a given image. In recent years, thanks to the feature learning and transfer learning ability of deep convolution neural networks, significant progress has been made in feature extraction, image expression, classification, and recognition of target detection algorithms. Given the characteristics of target detection, there is a lot of flame detection work using target detection technology. A new image fire detection algorithm based on advanced CNN models of target detection such as fast-RCNN, SSD, and YOLOv3. At the same time, it is found that the accuracy of the fire detection algorithm based on the neural network of target detection is higher than other deep learning algorithms proposed before. Among these algorithms, SSD has the highest detection accuracy, fast-RCNN has the fastest detection speed, and the YOLOv3 algorithm has good accuracy and detection speed. However, there are many improved flame target detection algorithms to solve the problem of detection accuracy degradation caused by small targets, multiple targets, and fuzzy edges in the fire. YOLO series is a widely used algorithm in target detection in recent years. Thanks to its excellent network structure and detection speed, it is widely used in various problems in industry and academia.

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3. Prospect of Flame Detection

3.1 Faster Object Detection

With the upgrading of random hardware devices and the updating of algorithms, more and faster target detection algorithms have appeared, such as YOLOV4, YOLOV5, and YOLOX. Compared with the original Yolov3 network, Yolov4 based on Darknet has a certain improvement in speed and accuracy. However, the application of Yolov4 in flame detection only shows some rudiments. The appearance of Yolov5 is accompanied by a lot of controversies. Compared with Yolov4, there is not much improvement in inaccuracy, and there are no related papers. However, Yolov5 is very fast and can be applied in a wide range of fields, but it is not widely used in flame target detection. YoloX, contrary to Yolov5, comes from the algorithm developed by Defiance Technology. Its accuracy is higher than that of other algorithms, but it has no great advantage in detection speed, so it is widely praised in an environment that requires high accuracy. Nowadays, the target detection algorithm is much more mature than before. Using the flame prediction system based on target detection will make the success rate of flame detection higher. Therefore, the use of target detection will be one of the development trends in flame detection systems.

3.2 Attention Mechanism

The attention mechanism in neural networks is to allocate computing resources to more important tasks when computing power is limited. In neural network learning, generally speaking, the more parameters of the model, the stronger the expressive ability of the model and the larger the amount of information stored in the model, but this will lead to the problem of information overload. Then, by introducing the attention mechanism, focusing on the information that is more critical to the current task among many input information, reducing the attention to other information, and even filtering out irrelevant information, the problem of information overload can be solved, and the efficiency and accuracy of task processing can be improved. Adding an attention mechanism to the flame detection system is helpful to solve the problem of poor persistence in multi-scale and improve the accuracy of the algorithm in detecting small target flames.

3.3 Semantic Segmentation

Semantic segmentation is a deep learning algorithm that associates labels or categories with each pixel of a picture. It is used to identify the set of pixels that make up a distinguishable category. If semantic segmentation is used in the flame persistence system, more flame details can be obtained, and the accuracy of detection can also be greatly improved. At the same time, because semantic segmentation is based on pixels, it can bring more development directions for flame detection, such as accurately locating the fire source in automatic fire extinguishing, reducing fire extinguishing consumption, and damage to other objects. However, due to the characteristics of pixel points, it is necessary to label the pixels of each image before training, which requires a lot of work. At present, semantic segmentation is not mature compared with target detection, but it will have a broader application prospect in the future with more advanced technology and equipment.

3.4 Natural Language Processing

Natural Language Processing (NLP) uses AI to process and analyze text or voice data in order to understand and explain content, classify content or gain insights from content. In recent years, there have been many attempts to apply NLP to target detection, and good results have been achieved. The most typical example is the Detr which applies a transformer to target detection. Combined with the core idea of End-to-End, Detr shows good accuracy and speed on the classic COCO target detection data set. DETR is different from many other detection methods. In the detection process, the final result is output by combining the objects. In inflame detection, the separation of flame and environment is also an important part. In the future, DETR will occupy a certain position in flame detection.

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4. Conclusion

At present, the flame detection system needs to rely on the target detection technology, and at the same time, it needs to combine many existing advanced technologies and make special optimization for the problems. In the future, with the update of technology and the development of hardware equipment, the flame detection system will have a broader prospect, and these technologies will promote the development of flame detection algorithms more quickly.

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