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Application of Deep Learning in Forest Fire Smoke Identification Monitoring System

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Abstract: *In order to realize the goal of "early, small and small" of forest fire and eliminate fire in the bud, a forest fire smoke identification and monitoring system based on deep learning is designed. Through real-time image processing and deep learning target recognition, the fast forest fire and smoke identification within the monitoring range is realized, and the information can be conveyed to the fire prevention headquarters in the first time after the fire occurs, so as to conduct rapid emergency response.*

Keywords: *Deep learning; Forest fire detection; Smoke detection; Monitoring system*

1. Introduction

In recent years, forest fires occur frequently in China, which causes great harm to the ecological environment and poses a great threat to human property and personal safety.In the face of the severe forest fire prevention situation, how to effectively prevent and predict the forest fire has become an urgent problem to be solved.In particular, because forest fires have rapid convection transmission and a long combustion period, the early detection of forest fires is considered to be the most effective means to reduce forest fire losses[1].

Smoke is an obvious sign of the early stages of fire, so it can quickly and accurately identify forest fire smoke is the core of forest fire prevention.Deep learning model has achieved great success in the field of target detection. It is an innovative measure and inevitable trend to use forest fire and smoke identification in the field of forest fire prevention[2]. This paper selects YOLO V5 algorithm to improve the effect of forest fire and smoke recognition, constructs and trains the forest fire smoke data set, and applies the trained network model to the forest fire and smoke recognition and monitoring system, which has certain practical value.

2. YOLO model

2.1. Introduction of the principle of the YOLO algorithm

Target detection method based on convolutional neural network can be divided into two-stage target detection and single-stage object detection according to the detection speed[3]. Two-stage target detection usually does suggestion box overhaul and background removal, then suggestion box classification and bounding box regression; single-stage target detection integrates these two processes and adopts the "anchor + classification refinement" implementation framework, such as YOLO series[4]. Both two-and single-stage algorithms look for equilibrium at fast and quasi-two points.YOLO series algorithms are favored and constantly used by various industries because they are both fast and accurate.

2.2. Network structure of the YOLO algorithm

YOLO belongs to a single-stage object detection algorithm[5], It can be directly in the position of the output detection box and the category of the detection box, mainly divided into four parts: input, Back bone, Neck and output, which is an end-to-end neural network.First, an input image is divided into a grid, and then a neural network prediction is made for each grid. Each resulting result contains a prediction information matrix of five predicted values and a kind of conditional probability parameter $S*S$ $(x, y, w, h, confidence)$ [6]. The five parameters are calculated as follows:

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$$x = \frac{x_c}{x_i} S - x_{col}, y = \frac{y_c}{y_i} S - y_{col}$$
$$w = \frac{w_b}{w_i}, h = \frac{h_b}{h_i} \tag{1}$$
$$confidence = P(Object) * IOU_{prediction}^{truth}$$

The C parameter represents which kind of the predicted object belongs to, and its mathematical expression is as follows:

$$\mathrm{C} = P(Class_i \mid Object) \tag{2}$$

YOLO V5 provides 4 types of network structures[7], Divided into YOLO V5s, YOLO V5m, YOLO V5l, and YOLO V5x by size.

3. Forest fire detection model training

3.1. Creation of the dataset

The dataset used in this paper comes from the Internet and real mobile phone shooting, with various situations such as night and day.In order to increase the generalization of the data set, the collected samples were transformed to rotation transformation, symmetry transformation, contrast change, noise transformation, and 634 data sample maps were obtained.Design the target detection in 2 categories: fire and smoke, and mark the target to be detected with the position and category on each sample image using the open source software Labelimg.The processing of the dataset is mainly divided into two steps.The first step is to convert the xml file corresponding icon into a txt file that meets the YOLO V5 format requirements, where the data format in the txt file is obj-class, x_center, y_center, width, height, corresponding to the class name number, the width, height of the annotation center box, and the width and height of the annotation box relative to the picture.The second step is to divide the data set composed of 634 preprocessed pictures into the training set, test set and validation set according to the following formula, including the number of training sets, the number of validation sets and the number of test sets: N_{train} N_{valid} N_{test}

$$\frac{(N_{train} + N_{valid})}{N_{train} + N_{valid} + N_{test}} = 0.9$$
$$\frac{N_{train}}{N_{train} + N_{valid}} = 0.9 \tag{3}$$

Store the txt file required to convert the training set, test set, and validation set into a YOLO V5 format in train.txt、test.The txt and valid.txt centre.So far, the preliminary preparation work of dataset collection, preprocessing and dataset classification was completed.

3.2. Model training

The YOLO V5l network structure was selected for training, and set the number of pictures sent to the grid learning as 10, and the training end point was 300 steps, using train.The py performs the model training, during the training process, through convolution, pooling, backpropagation and other steps, and finally generates the weight file best.pt。The total duration of the training was 10.545 hours.

4. System implementation

4.1. Composition and functions of the forest fire identification and monitoring system

The trained network model is applied to the forest fire and smoke identification and monitoring system to realize the real-time monitoring of the forest fire and smoke within the target site range.The system integrates the Beidou module and various sensors, and uses the raspberry party sensors for data acquisition and processing. The overall structure framework is shown in the figure below:

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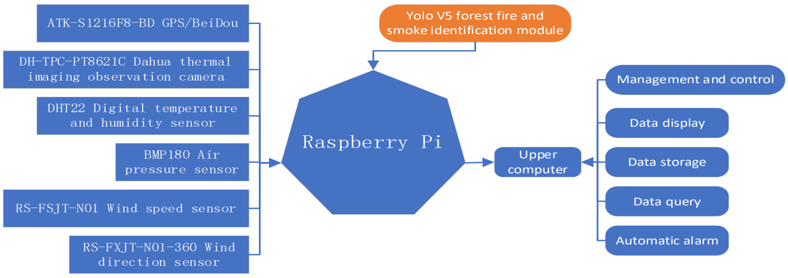

Figure 1: Structure diagram of forest fire and smoke monitoring system

Use wifi / 5G to transmit the data to the upper-computer monitoring software.The upper computer computer has the following functions:

(1) Management and control: the management module mainly conducts communication and database management, and the control module automatically controls the rotation of the camera cradle head with instructions sent by the upper computer.

(2) Data display: based on the cloud platform supporting software and visual GUI interface, display the image information, location information, temperature and humidity information, wind speed and wind direction information collected by the camera within the target location of the monitoring range in real time and make the curve drawing;

(3) Data storage: deposit each sensor data in the database for future query and analysis;

(4) Data query: it can realize the combination query of sensor historical data in different dimensions such as time and sensor type;

(5) Status display and automatic alarm of each monitoring point: when the data of each monitoring point is within the normal threshold range, and the image recognition module does not detect forest fire and smoke, the status is displayed as green.If each monitoring point identifies the situation of forest fire in the target site, the status is red light flashing and audiacoustic and optical alarm, the system will automatically alarm in the first time.

4.2. Composition and process of forest fire identification subsystem

The process of forest fire identification video surveillance system is shown in the figure below:

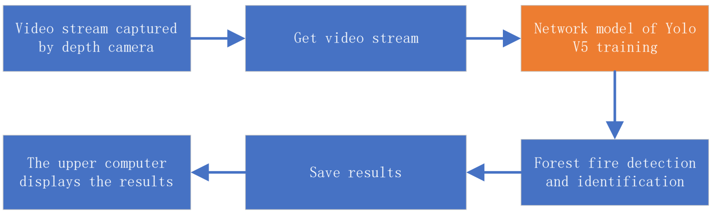

Figure 2: Process of forest fire recognition video surveillance system

The specific identification results are shown in the following figure below:

(a) *(b)*

Figure 3: (a) Original image (b) A processed and labeled image

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As shown in Fig. 3 (a) is the original image to be detected, and Fig. 3 (b) is the output image after YOLO V5 network processing and marking. It can be seen that the forest fire recognition video surveillance system has a good detection effect on forest fire and smoke, and has a high robustness.

5. Conclusion

The prediction of forest fire is related to the protection of forest resources and the safety of people's lives and property. It is important to establish an accurate and scientific forest fire monitoring and early warning system. However, it is a new trend to use deep learning methods for visual target detection, and its model is developing towards both fast and accurate.This paper, YOLO V5 method is used to develop forest fire and smoke data set and apply the trained network model to forest fire and smoke recognition monitoring system.It can be seen from the identification results that the forest fire identification video surveillance system has a good detection effect on the forest fire and smoke.In the future research, based on the existing equipment and related experimental results, will further improve the system use stability and identification accuracy, reduce the false alarm rate, so that the system can be applied to more emergency rescue fields.

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