A smoke detection algorithm of energy difference between frames based on adaptive LOG operator on the infrared video processing

Yuanyuan Liu per 1st *Author*
Nanchang Institution of engineering
NanChang, China
Lyy1981552@163.com

GuangMing Liu per 2 st Author
Nanchang Institution of engineering
NanChang, China

Abstract：**It is conductive to discover the fire or smoke leakage in the monitor region that detecting the smoke area clearly. Firstly, an adaptive LOG algorithm of smoke detection based on energy difference is proposed by the paper. After detecting the enhancement smoke area by energy difference between frames , dynamic accumulation, filtering and extracting smoke leakage position will be performed. The experiment shows, the method proposed by the paper can detect smoke in infrared video perfectly, and avoid the influence that the thermal infrared imager can't detect the leaking location of smoke sensitively because of the radiation of high-temperature field surrounding by.**

Keywords：*Smoke detection Adaptive algorithm of LOG Energy difference between frames Dynamic accumulation*

I. FOREWORE

Smoke detection method in high-temperature field based on infrared image sensor is a research hotspot in recent years. With the rapid development of infrared industry, it has been widely applied for military, fire protection, body temperature measure, gas leaks, power monitoring and so on. Many domestic and foreign researchers are applying themselves to researching smoke detection on image processing, such as the domestic method is that using average filter algorithm extracts backgrounds areas, then detecting the spread region of smoke by using frame difference algorithm ; Nobuyuki and others from Japan proposed smoke detection technology based on fractal coding , which makes use of smoke regional self-similar, fractal coding regions characteristic to detecting smoke. Because of weak feature of smoke, there are primary problems which is losing the high-frequency weight of image, reducing in object's details of edge, and enhancing noise easily. Wavelet analysis has been widely used in this field , but the algorithms are so complex on infrared image processing that it should produce the local extremum easily in the wavelet images.

Therefore, this paper aims at gas leakage detection in infrared video, proposes an enhancement smoke detection method based on adaptive LOG operator. At first , we extract background that can be reserved high frequency weight adaptively , then , get smoke erupting region based on energy difference between frames. The algorithm the paper proposes aims at the features that thermal infrared imager have a greater impact on the radiation of high temperature field, reduces the false detection rate of extracting smoke leakage area. Engineering experiments show , the algorithm proposed by the paper can detect erupted smoke in the industrial equipment effectively and real-timely. It is an important action to the field of gas detection, fire alarming initially, smart monitor and so on

II. ADAPATIVE LOG OPERATOR

Based on the LOG arithmetic edge detection model by Marr and Hildreth, Marr and Ullman put forward a moving detector. The detector calculates time differential coefficient of Gaussian and Laplacian. On this condition, the paper analyzes the moving characteristic of dim targets, brings forward a moving detection arithmetic function model that has the direction characteristic of across-zero. It enhances the dim moving direction of smoke.

Thereof, ∇ is the symbol of Laplacian, and $G_D(x,y)$ is named by broad two-dimension Gaussian function.

$$G_D(x,y)=\frac{1}{2\pi\delta^2}\exp\left[-\left(x^2/2\delta_x{}^2+y^2/2\delta_y{}^2\right)\right] \quad (1)$$

Pulled twiddle factors in the broad two-dimension Gaussian function:

$$x=(x-x_0)\cos\theta-(y-y_0)\sin\theta \quad (2)$$

$$y=(x-x_0)\sin\theta+(y-y_0)\sin\theta \quad (3)$$

We can get an adaptive anisotropy function of motion detection:

$$\nabla^2 G_D(x,y)=K\left(2-\left((x\cos\alpha-y\sin\alpha)^2/\delta_x{}^2+(y\cos\alpha+x\sin\alpha)^2/\delta_y{}^2\right)\right) \quad (4)$$
$$\exp\left[-\left((x\cos\alpha-y\sin\alpha)^2/2\delta_x{}^2+(y\cos\alpha+x\sin\alpha)^2/2\delta_y{}^2\right)\right]$$

σ_x,σ_y are two scale parameters in the detective function, α is the angle of the long axes of detective function and X axes, which shows the direction of the function.

When there is smoke erupting in the detection area, we can consider it as dim moving targets. As the follow figure, it is to detect the two-dimension moving targets between frames by the detective model in the ideal case. The x-label stands for the angle of the direction of smoke erupting and detection function's long axis, the y-label stands for moving energy difference that can describes the shift direction of smoke area,

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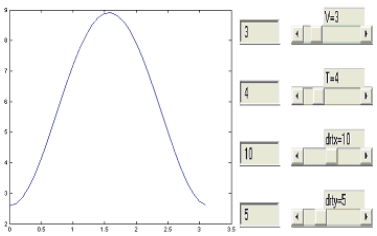

Figure 1. The curve of moving energy difference between frames and angle α

So, we use the value of energy difference when $\alpha = \frac{\pi}{2}$ to express the moving edge of smoke, in which it can enhance the high frequency weigh of targets and keeps down the position edge details of smoke leakage.

III. ITHM AND IMPLEMENT FLOW

At present, the smoke detection algorithm is divided into two parts, which are smoke enhancement and background extracted . In this paper, a smoke detection algorithm of energy difference between frames based on adaptive LOG operator is also based on this idea, which introduces motion detection operator and the adaptive enhancement factor. The following graph shows the flowchart of our algorithm propose by the paper.

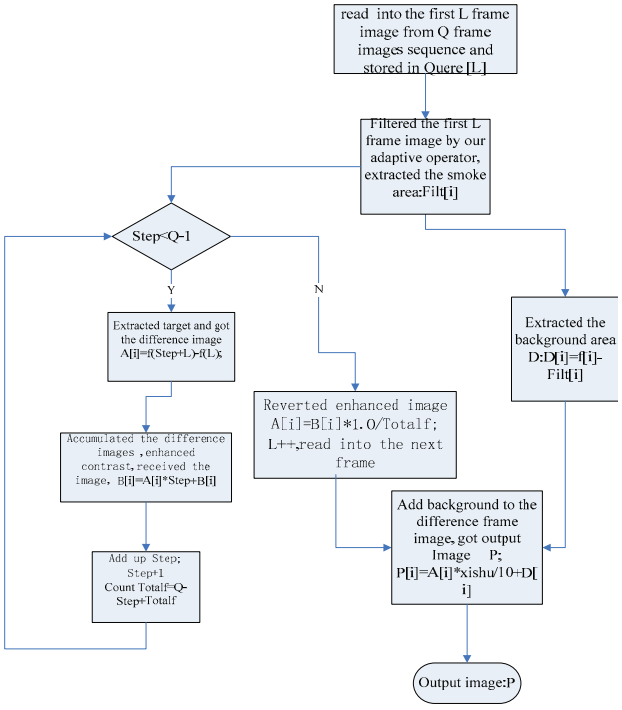

Figure 2 The algorithm flowchart of the adaptive smoke detection method

A. Smoke Detection

It is a difficult problem and hotspot to estimate the moving direction of smoke and enhance its feature in the real-time video prosscessing. Supposed that the AD-value array when the first K frame in the video is $f_k(x,y)$, put it convolute to the adaptive LOG operator, we extract the smoke target :

$$I_k(x,y) = f_k(x,y) \otimes \nabla^2 G_D(x,y) \quad (5)$$

Because features that are received by $I_k(x,y)$ are weak, they have a greater impact on high frequency noise. In consideration of the smoke feature of gradual enhancement when leakages, we use the adaptive LOG operator to detect the smoke target, then enhance multi-features of the target area .

B. Smoke Enhancement

The AD-array of extracted smoke target in the current frame is defined as $I_k(x,y)$, $I_{k+i}(x,y)$ is the smoke area in the first K+I frame, $i = 1,2,3,4,5,6$. The backer the sequence goes, the more smoke leakages. And the area features begin to be enhanced and accumulated. For this feature, the paper proposed the mathod based on adaptive energy difference between frames to accumulate smoke areas:

$$T(x,y) = \sum_{i=0}^{3} \left[I_{k+6-i}(x,y) - I_{k+i}(x,y) \right] * FRAME\_STEP \quad (6)$$

inside, $STEP\_FRAME$ is enhancement factor..The bigger $STEP\_FRAME$ is fetched, the more powerful the features of smoke are , at the same time, the stronger high frequency noise is. So $STEP\_FRAME$=3、4、5、6 should increase adaptively in this way when i increases by the time of difference between frames. As the following formula:

$$STEP\_FRAME = 3、4、5、6 \quad (7)$$

C. Background Update

The research shows that smoke keeps out other items in a way partly, this phenomena is named as vague background in the airspace domain, and high frequency weight attenuation in the frequency domain. The characteristic becomes a basis of smoke detection.

The paper proposes the improved LOG operator, adoptes the energy value that can select direction to extract background area. When smoke appears in the image, energy value will begin to reduce . However , energy value will increase, when the profile of background appears. So we defines the current AD array of background area as:

$$D_k(x,y) = f_k(x,y) - I_k(x,y) \quad (8)$$

$f_k(x,y)$ is the first K frame image in the sequence, $I_k(x,y)$ is the first K frame image

$D_k(x,y)$ is the background that is extracted by the adaptive operator.

IV. EXPERIMENT RESULT AND ANALYSISs

Because of a lack of standard images library of diction smoke, the paper uses the real-time video about the gas (sulfur hexafluoride) leakage to experiment . The size of infrared image that we gathered is 320×240, and the soft platform of experiment is VC6.0++ .

At first, the leakage area of sulfur hexafluoride in the video is weaker to watch by our eyes, so the detection algorithm is a key. The following are the detected results that we uses the method proposed by the paper and average algorithm each other to detect the video whose palettes are red and grey . We selected the first fifty frame image of detected results to compare, and simulated and achieved its histogram of detection rate in the soft platform of MATLAB.

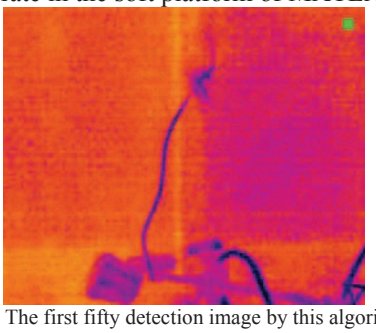

Figure 3 The first fifty detection image by this algorithm

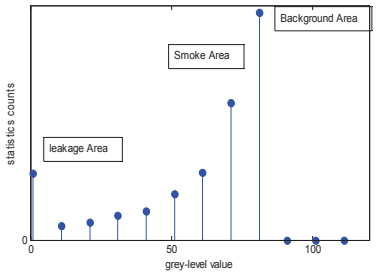

Figure4 The histogram of detected image by this algorithm

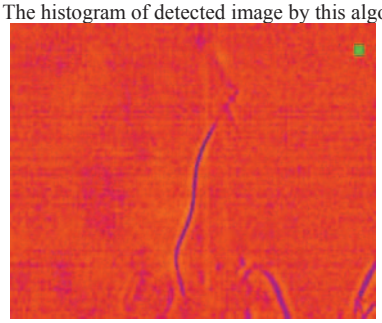

Figure5 The first fifty detection image by average algorithm

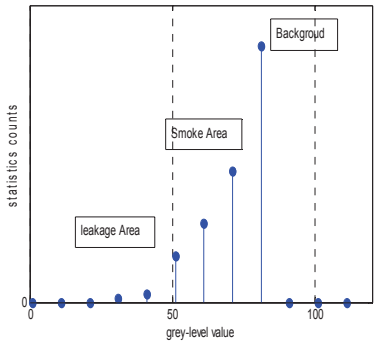

Figure6 The histogram of detected area by average-value algorithm

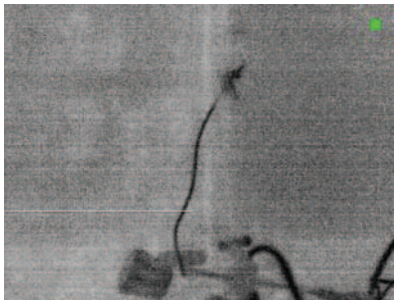

Figure 7 The detection result to grey image by our algorithm

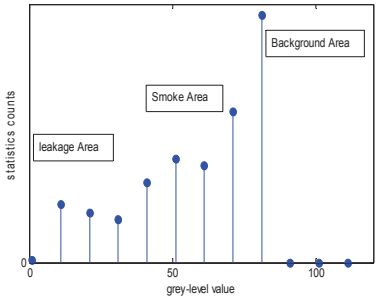

Figure8 The histogram of detected area by our algorithm in grey palette

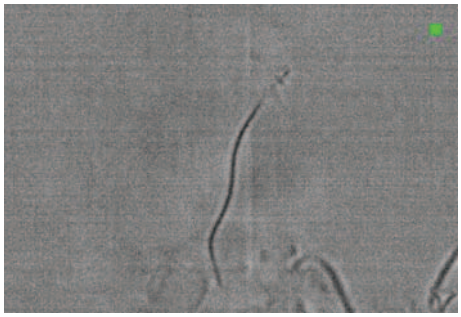

Figure 9 The detection result to grey image by Average algorithm

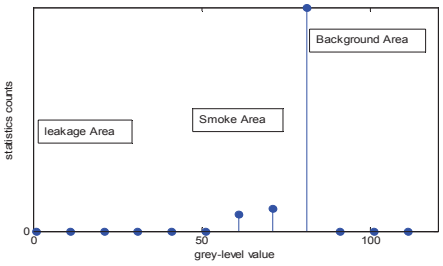

Figure10 The histogram of detected area by average-value lgorithm in grey palette

As the results , the algorithm proposed by the paper have a greater advantage in detecting leakage of sulfur hexafluoride that was gathered by thermal infrared imager. Not only can it detect the clear area of smoke erupting, but also can it keep down the high frequency weight of background detail.

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