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Study on the Background Extraction of Traffic Video in Smart City

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Abstract

In traffic video, background differencing is frequently applied for detecting moving vehicles. Therefore, background extraction is a key technology in traffic flow video detection system. In this paper, the way of modeling for background with single Gaussian model is introduced, and a simple experimental system for the background extraction in traffic video is designed and realized. Furthermore, defects of Gaussian model in practical application are improved.

Keywords: *traffic video; background modeling; single Gaussian model*

1. Introduction

With the rapid development of economic society and rising living standard, video surveillance is widely applied in daily life. At the first beginning, video surveillance was only applied in some key departments like banks, public security bureaus, *etc*. while at present, video surveillance has already been quite common, especially in the traffic road system, it seems that the monitoring spreads all over the crossroads of each street. However, at first, when more and more monitoring information is achieved, it is difficult for the monitoring personnel to process the monitoring video information at a certain moment. Secondly, the monitoring personal shall monitor the video information constantly, which may have a great impact on their health. Thirdly, long-term employment of these monitoring members may bring in a huge cost. Therefore, aiming at the existing problems of video monitoring, the intelligent video surveillance is put forward, and it mainly consists of two parts: front part and rear part. The main function of the front part is imaging, while the rear part is computing. The intelligent video surveillance mainly extracts sensitive information in each scene, for instance, it may predict existing danger according to the judgment of vehicle violation, the motion trail and speed of vehicles in complicated traffic environment. Later, it will send prompt message for the monitoring personnel according to the specific conditions, and it may alarm for some individual cases, which will get the video monitoring personnel to process specific problems timely. With the constant soaring of video monitoring data, the intelligent video surveillance takes place of most manual work, posing a huge positive influence on the timeliness and effectiveness of the video monitoring system. Besides, it also saves substantial human power, and in long-term sense, it reduces the economic cost.

When the intelligent video surveillance is applied in traffic, it turns to be intelligent transportation system, in which the extraction of moving target from traffic video sequence is one of the most critical steps. Furthermore, background extraction is also the foundation of motion detection, and the difference between the current image and background image will be applied for expressing the moving targets. With this method, it can achieve plenty of traffic information. Such system usually detects the moving vehicles with background differencing.

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Consequently, background extraction is also one of the most crucial technologies in the traffic flow video detection system.

At first, modeling of background shall be carried out for background extraction. The key steps of background modeling are to detect the moving targets by aiming at the current background frames. Binary classification can be employed for solving this problem, namely each pixel dot is divided as the background pixel dot or the foreground pixel dot, and then it will be processed for obtaining the required results.

Generally, the scene with no moving targets is captured in background image acquisition, but it cannot realize the self-adaption, and it can only be applied for the short-time monitoring. Furthermore, it cannot be applied in the background modeling of intelligent monitoring system. Many scholars of this field attempt to construct background model satisfying the conditions with a lot of information. For instance, the top-layer extraction result is taken as the feedback result of background estimation for judging if these pixel dots are in the background part or moving foreground, thus to solve the binary classification problem.

In the research field of digital image processing, the target segmentation and extraction of digital image is a significant research hotspot, for it has attracted extensive attention from the researchers in the pattern recognition, computer vision, digital image processing, etc. and it has a wide application range. With the intensive study on the target segmentation and extraction of digital image, it will certainly drive the long-term development of pattern recognition, computer vision, digital image processing, *etc*.

Target segmentation and extraction is a significant research branch in the field of computer vision and digital image processing. Substantial data image processing method can be applied for target segmentation and extraction, and it is also widely applied in the pattern recognition. Therefore, it has attracted the attention of various researchers. In the traffic video detection, the quality of speed of generating background image turn to be significant factors influencing the performance of detection system. If the quality is quite unsatisfactory, it may result in the substantial noise in the differencing of background and current input image, which may impact the detection of foreground target. If the speed of background generating is too slow, it may not be able to realize the real-time requirements, which may result in the failure of practical application. Consequently, for the entire traffic video detection system, a background generating algorithm with favorable quality and speed is quite crucial.

2. Research Status

Background model is established through the analysis of video frame in the background generating and updating algorithm, thus to generate the real-time background. The common background generating algorithms consist of background modeling based on statistics, background modeling based on Gaussian model, and background model based on Kalman filtering.

For the background modeling algorithm based on statistics, the background image is mainly generated according to the mean value of pixels in video sequence. It is simple in calculation, but it may be interrupted by the foreground moving target easily. Consequently, it is only applied for cases with few moving targets, and the background is visible for most of the time.

The background modeling algorithm based on Kalman filtering is favorable for the tracing of moving targets, and it is a linear dynamic system recursive technique in Gaussian noise. The distinct edition of background estimation mainly lies in the different tracing state space. The simplest state variable is the grey level of pixel, but the calculated amount is substantial, and it cannot be applied in the real-time system.

Background model based on the Gaussian distribution can adapt to the illumination changes well, and it has perfect robustness for stopping or slow targets. Therefore, the modeling of video background with Gaussian distribution is introduced and analyzed in this paper.

In practice, it is quite difficult to extract a completely ‘pure’ background image. Owing to the influence of external factors, such as the light ray, atmosphere, and so on, the background

will also change accordingly. For the moving target detection problem of the video camera, a well-known solution is the optical flow, which mainly work out the optical flow field of image sequence with partial differential equation, thus to predict the motion state of the video camera. As for the fixed video camera, optical flow method can also be applied. However, it is quite complicated, and it is really difficult to conduct real-time calculation. Since the background variation is quite slow when the video camera is fixed, Gaussian background model is employed in this paper.

In this paper, background extraction is carried out by aiming at the traffic video with fixed video camera. Since single Gaussian model has good timeliness and robustness when compared to other background extraction method, and it is also applicable for the fixed video camera, single Gaussian model is selected as the research object, for analyzing the principles and process of single Gaussian model in the background modeling of traffic video. A simple experimental system is accomplished, realizing such functions as the achieving of background, storing of foreground and background. Furthermore, the disadvantages of applying Gaussian model in traffic video are analyzed, and some improving methods are proposed.

3. Experiment Design Principles

3.1. Theoretical Basis of Single Gaussian Model

Gaussian distribution, also called normal distribution, is the most common probability distribution model, which is frequently applied in digital image processing, computer vision and pattern recognition for depicting some random quantity variations, such as the feature distribution, noise, pixel grey level, etc. In addition, Gaussian distribution is also applied for the localization processing, such as smoothing filtering, Gabor transformation, etc. On one hand, normal distribution reflects a general statistical law related to the variable quantity in nature, and on the other hand, normal distribution has good mathematical properties, for instance, it has the same functional form in the time domain and frequency domain. Besides, it has continuous derivative of each order, making it convenient for research and analysis. The background modeling algorithm based on Gaussian distribution mainly judge if the pixel is background dot or not through the background distribution model, thus to distinguish the foreground and background dot. And finally, the foreground dots obtained will form the segmented object. As for the algorithm implementation, it mainly inspects the matching of each pixel to the Gaussian distribution in the background model, for instance, when the pixel value is in 1s of the Gaussian model, it is considered that it is in accordance with the distribution, and it is the background model. If it does not match any Gaussian distribution in the background model, it is considered as the foreground dot. Background model is established through training, and it is updated constantly during the modeling process. Only slight human interference is needed, and the rest can be realized automatically.

3.2. Principles and Process of Establishing Gaussian Model

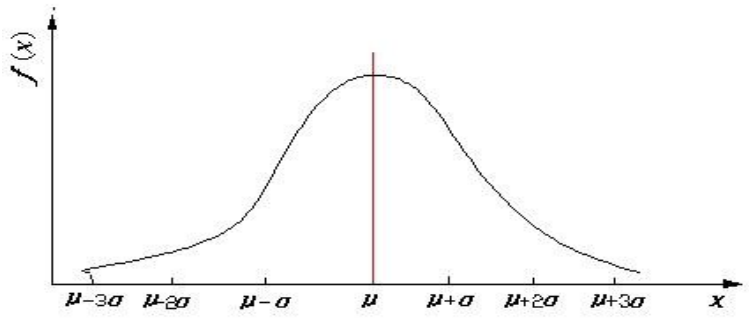
Single Gaussian model is a processing method of image processing background extraction, applicable for invariable background. Other methods, such as mixed Gaussian model, are the expansions of single Gaussian model. Single Gaussian model is the most convenient, and with parameter iteration method, there is no need for modeling every time.

According to the single-distribution Gaussian background model, for s background image, the distribution of specific pixel luminance satisfies Gaussian distribution. Namely, for the background image, B (x, y) satisfies:

IB(x,y) ~ N(u,d)

Namely, it satisfied the equation $$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

The graph is shown as follows



Normal distribution curve

Thus, the color distribution of the image can be expressed by single Gaussian model, and the Gaussian model is η(x,μt,Σt), in which Xt stands for the color limit of each pixel dot, and t stands for the time.

It can be concluded that when η(x,μt,Σt)≤Tp (probability threshold), the dot will be judged as foreground dot, or it is the background dot.

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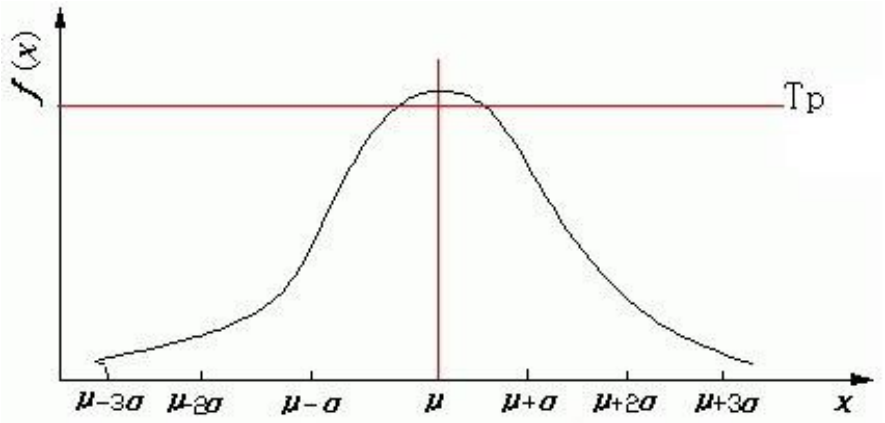


Normal distribution curve

In a length of video, especially when the video camera is fixed, the background generally stays invariable. That is to say, for some pixel dot, the color of the background is near a mean value, and there won't be great variations. If in a certain moment, the color value is above the straight line Tp, it can be considered that it is the color value is background. Once there are great changes in the color, namely below the straight line Tp, it means that the current color value is the color of foreground. Thus, foreground and background can be distinguished.

Consequently, each pixel attribute of the background model consists of two parameters, namely the average value u and variance Σ.

Meanwhile, with the passage of time, there may be slow changes in the background image. As a result, the parameter of each pixel dot shall be updated constantly.

$u(t+1,x,y) = a*u(t,x,y) + (1-a)*I(x,y)$

$\Sigma t+1 =(1-\alpha)*\Sigma t+\alpha*dt*dt$

Here, a is the updating parameter, standing for the speed of background changed, dt is the difference between the current pixel color and average color value.

4. Overall Design Scheme and Programming Environment

4.1 Experimental Environment

In this paper, the program compiled is finished with OpenCv. OpenCv (Open Source Computer Vision Library), namely the open source computer vision library, is a set of function base developed by Intel Company based on the image processing of C/C++ language and computer vision. It consists of a series of C function and slight C++ categories, realizing many general algorithms of image processing and computer vision. OpenCv has the following advantages:

Open C/C++ source code

Optimized code developed on the basis of the order set of Intel processor

Unified structure and function definition

Powerful image and matrix operational capability

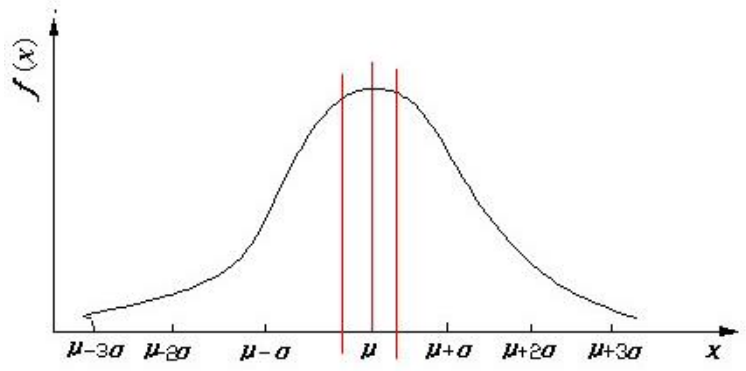
Convenient and flexible user interface.

Since OpenCv is only a class library, it requires the support of programming platform. The programming software of this project or this paper is Visual C++2005, and the edition of OpenCv is 2.0. As a result, OpenCv can be applied for providing powerful image processing function, and Visual C++ 2005 can also be applied for making a visual interface.

4.2 Experiment Implementation Process

Video consists of many frame images, and the background extraction shall analyze each pixel of each frame image. If Gaussian distribution equation is applied for analysis, the calculation will be quite substantial. Therefore, in the actual programing application, the Gaussian distribution is transformed, and the original form is:

$f(x)=\frac{1}{\sqrt{2\pi}\sigma}e^{\frac{(x-\mu)^2}{2\sigma^2}}$ ≥Tp, both sides will multiply by $\sqrt{2\pi}\sigma$, and then logarithm will be taken for both sides for multiplying by 2σ2. Later, the sign is transferred. Finally, extraction of square root is conducted for both sides, and the following inequality can be obtained: $|x-u|$ ≤T. Here, T is a new threshold, as shown in the following figure.



Normal distribution curve

In this figure, if the color value of the pixel dot is distributed in the red lines, it will be the background, or it is the foreground. With such equation transformation, a lot of calculation amount will be reduced.

4.3. Implementation Plan

In order to realize the background modeling, it should achieve the video source at first. There are two sources: one is the real-time acquisition from the video camera, and the other is to open the existing video files. After the video files are achieved, modeling of background in video can be conducted.

With the above steps, background model can be set for the current video. It may take some time to establish the background modeling for the video flow, for the program requires constant updating for background model. Initially, all the pixel of the first frame picture is deemed as the background, and then with the changes of frames, Gaussian model will update the background according to the updating equation. When certain frames are updated, the Gaussian model will keep the pixel value of which the difference from the current pixel does not exceed the threshold. And then the pixel value will be kept in the matrix, and the expectation matrix obtained is the background.

5. Application of Single Gaussian Model in Traffic Video

5.1. Experimental Computational Results

In this project, a length of traffic video with fixed video camera is taken as the experimental material, and in the following part, it is the experimental effect of background modeling.

Figure 5-1. Original Picture

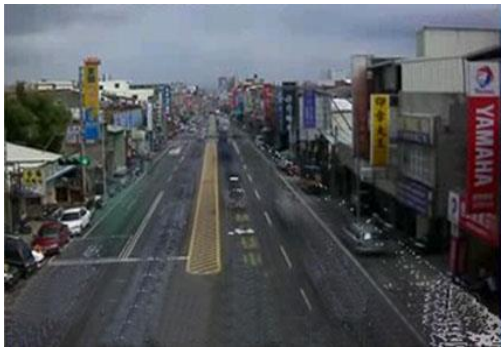


Figure 5-2. Background Picture

Figure 5-3. Foreground Picture

5.2. Experimental Result Analysis

With the above experimental result, it can be observed that the timeliness of single Gaussian model is perfect for the background modeling, but the background image achieved

is not quite ideal, and there are still traces of moving cars in the background image. Therefore, in the next step, the trace shall be removed.

6. Improvement of single Gaussian Model

Through analyzing the experimental result, it is concluded that background modeling with single Gaussian model only may not achieve ideal background. As for the removal of traces, with further study and consideration, some improved thoughts about single Gaussian model are shown as follows.

It has been discovered through the experiment and previous achievements that the background shall be updated constantly, so that it can satisfy the changes of scene. During the updating process, the experiment shall guarantee the criterion of first-in and first-out, namely, the newly added sample model shall be abandoned at first. For any newly added pixel point, the following updating strategy shall be selected: judge if it is the background dot, and if it is, it should be added into the background model, or it will not be processed. No matter it is the background dot or not, it shall be added into the background model. The above mentioned strategies have both advantages and disadvantages. The first one may increase the precision of background detection, for it does not add the foreground dot into the background model. However, the accuracy of judging the pixel dot will influence the final processing result, while the second strategy does not require judgment, but it add some pixel dots that do not belong to the background mode, which may result in the declining experiment accuracy.

In this paper, the updating strategy is selective updating, and the equation is $|x - u| \leq T$, namely the pixel dots whose difference between the selection and expectation is smaller than the threshold will be selected as the background dots, and then with the equation: $u(t+1,x,y) = a*u(t,x,y) + (1-a)*I(x,y)$, $\Sigma t+1 = (1-\alpha)*\Sigma t+\alpha*dt*dt$, the new expectation and variance will be updated. With this equation, it can be seen that since the current frame pixel takes up a certain weight in updating the expectation, when the vehicles moves slowly, the background updating may be influenced by the slowly moving vehicles, as shown in the following figure.

Figure 6-1. Original Picture

Figure 6-2. Background Picture

In this frame picture, the red circle notes that the white car drives slowly, and the trace left is quite obvious.

7. Conclusion and Expectation

In this paper, the basic principles of single Gaussian model, and the implementation of single Gaussian model in programming are studied. The defects of single Gaussian model is

application have been discovered by observing the experimental result, and some improving measures have been put forward. The real implementation of improved single Gaussian model in programs, and the further improvement of single Gaussian model will be the direction of further study and perfection of the paper.

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