A New Method to Detect Moving Targets

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Abstract. In the moving target detection, there are a lot of methods. But the effects of those algorithms are limited, especially in complex environment. This paper puts forward a new method to detect moving targets, which uses virtual binocular disparity. It is called virtual because the environment uses one camera but the theory is about two cameras. Virtual binocular disparity algorithm regards moving targets as static targets under two cameras. It uses two neighboring images, the current frame image and the next frame image. The algorithm looks the two images as two static images under two cameras, then uses stereo match theory to calculate the disparity of the neighboring images. Because the background of the two images is the same, the disparity of their background is about zero. And the disparity of moving targets is positive or negative. The sign of disparity means the direction of targets moving. So we can use the sign of disparity to distinguish the targets moving in different directions. The direction detected out will be helpful for subsequent work, for example, targets tracking and counting etc. This algorithm fully uses the continuity property of moving targets, so it can have good effect. In the end of the paper, experiments are used to prove the algorithm.

Introduction

Moving target detection is to detect the object which moves in the background. It is widely used in safety monitoring and traffic monitoring and so on. Target detection in complicated conditions is difficulty point and hotspot of many scholars, because it is not only complex, but also its processing affects subsequent work [1]. Currently, moving target detection mainly has three methods. They are frame subtracting, optical flow method [2], and background subtracting [3]. Frame subtracting realizing detecting the change of scene through comparing the neighboring two or three frame images, and its adaptability in dynamic environment is very strong, but the precise of detection is not satisfying. Optical flow method can be used in the situation, in which the camera is moving, but its anti-noise property is not very good, and its calculating complexity is very high. Background subtracting is adapted to the condition in which the camera is static, and the key point is background modeling. The performance is related to the complexity of monitoring scene and the demand of system. Gaussian mixture model [4] aiming at the noising and complex background, can process slow variation of illumination. Its original modeling is slow and has huge computing quantity and demands large quantity memory. Elgammal etc put forward to this view in which Gaussian model is not necessary, and estimates the probability of density of background directly [5]. This method is simpler, but the memory demanding and calculating complexity is higher. Aiming at the problems of low velocity of modeling and large quantity of memory and calculating, Apewokin puts forward multi-mode means algorithm. Although it overcomes the shortcomings above and can be used in embedded system, it cannot adapt to complex background. [6][7]

This paper puts forward a new method to detect moving target based on virtual binocular disparity. Original images are formed under one camera, but this method uses binocular theory to detect target, and it has some features that other methods do not have.
**Principle of Virtual Binocular Disparity**

**Virtual Binocular Algorithm**

The camera is always fixed to monitoring moving target. It is shown in Figure 1. The target moves from position A in current frame to position B in the next frame, and the background is relatively static but complex. The classical kind of this condition is passengers flow statistics in public transportation. Because of the complexity of background, the moving target is difficulty to detect.

It can be seen from Figure 1 that if focus on the moving target we can imagine that two cameras are installed as shown in Figure 2, and the target is static. So current frame is taken by camera A, and the next frame is taken by camera B. Because the background in the two frame is the same, if the disparity is calculated, the disparity of background is zero, and the disparity of moving target is the length of moving. We can select a threshold in disparity image to pick up the moving target. The two cameras are imagined, so it is called Virtual Binocular.

![Figure 1. One camera monitoring moving target.](image1)

![Figure 2. Virtual Binocular.](image2)

![Figure 3. Moving target from different direction.](image3)

This method can detect the direction of moving target, so it can detect moving target from different direction very easily. It is shown in Figure 3. Target 1 moves to position 1’, and target 2 to position 2’. The disparity of target 1 is positive, but the disparity of target 2 is negative. It can be distinguished the direction by the signs of disparity very easily.
There are some other conditions. For example, sometimes two moving targets move in one direction, and in this condition two targets move in different velocity. Thus, the disparity of the two objects is different too, so they can be distinguished by threshold.

In order to get disparity, stereo matching should be used in the current frame and the next frame. It becomes the key point of virtual binocular disparity algorithm.

**Stereo Matching**

In virtual binocular disparity, it should calculate, or at least attempt to calculate, a disparity for each point. The determination of the disparity can be regarded as a template matching problem. Given a rectangular window of size \((2n+1)\times(2n+1)\) around the current point in the first image, we must find the most similar window in the second image. The gray value matching methods typically are the fastest methods for stereo matching. The simplest similarity measures are the SAD (sum of absolute gray value differences) and SSD (sum of squared gray value differences). For the stereo matching problem, they are given as following.

Here, in the equations parameters \(r, c\) are the coordinate of image. \(d\) is the disparity in this position. \(g_1, g_2\) is the gray value of two images.

\[
sad(r,c,d) = \frac{1}{2n+1} \sum_{j=-n}^{n} \sum_{i=-n}^{n} |g_1(r+i,c+j) - g_2(r+i,c+j+d)|
\]

\[
ssd(r,c,d) = \frac{1}{(2n+1)^2} \sum_{j=-n}^{n} \sum_{i=-n}^{n} (g_1(r+i,c+j) - g_2(r+i,c+j+d))^2
\]

The two similarity measures have the disadvantage that they are not robust against illumination changes, which frequently happen in stereo matching because of the different viewing angles along the optical rays. Consequently, in some applications it may be necessary to use the normalized cross-correlation (NCC). For the stereo matching problem, it is given by:

\[
ncc(r,c,d) = \frac{1}{(2n+1)^2} \sum_{j=-n}^{n} \sum_{i=-n}^{n} \frac{g_1(r+i,c+j) - m_1(r+i,c+j)}{s_1(r+i,c+j)^2} \times \frac{g_2(r+i,c+j+d) - m_2(r+i,c+j+d)}{s_2(r+i,c+j+d)^2}
\]

Here, \(m_j\) and \(s_j\) \((j = 1,2)\) denote the mean and standard deviation of the window in the first and second images. The advantage of the normalized cross-correlation is that it is invariant against linear illumination changes.

After we have computed the similarity measure for the disparity search space for a point to be matched, we might be tempted to simply use the disparity with the minimum (SAD and SSD) or maximum (NCC) similarity measure as the match for the current point. However, this typically will lead to many false matches, since some windows may not have a good match in the second image. In particular, this happens if the current point is occluded because of perspective effects in the second image. Therefore, it is necessary to threshold the similarity measure, i.e., to accept matches only if their similarity measure is below (SAD and SSD) or above (NCC) a threshold. Obviously, if we perform this threshold, some points will not have a disparity, and consequently the disparity will not be completely density.

Normally, the two images to be matched are left-right images. But in some environment, moving target moves up-down in images. In order to calculate disparity conveniently, the images should be rotated 90 degree. Then the theory above can be used to calculate disparity without changes.

**Moving Targets Extraction**

After disparity has gotten, we should extract the target in disparity image. As described above, some points will not have a disparity. We should use some method to overcome this feature. Here, we mainly use several steps to extract target as follows.

Firstly, select a threshold which is positive to binarize the disparity image, in order to extract the target of one direction.

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Secondly, region morphology operations are used to filter noise. Here, mainly use open operation. It can filter out small regions, which always belong to noise.

Thirdly, use curves to envelope the regions. We can regard the envelopment as the moving target.

Fourthly, select a threshold which is negative to binarize the disparity image to extract the target of other direction.

**Targets Moving in One Direction**

In this section, we will use practical work to describe the algorithm of virtual binocular disparity. The images used here are sampled in actual environment.

Figure 4 is two images showing target moving in one direction. The two images are neighbor. Because the target moves up-down, we should rotate them 90 degree in anticlockwise order, or rotate 270 degree in clockwise order. Then Figure 5 will be gotten, and the person going up-down changes to right-left. After rotate the images, we can use the stereo match theory above to get left-right disparity.

![Figure 4. Original two neighboring images.](image1)

![Figure 5. Rotated images.](image2)

Then, calculate the disparity of the two images using the stereo matching theory, and disparity image as figure 6 is gotten. It can be seen easily that the disparity of moving target is negative and the disparity of static background is about zero. In disparity image, some negative threshold is used to binarize it, then figure 7 will be gotten.

![Figure 6. Disparity image.](image3)

![Figure 7. Threshold the disparity image.](image4)

![Figure 8. Holes are full-filled.](image5)

![Figure 9. Filter out noise.](image6)

Then, calculate the disparity of the two images using the stereo matching theory, and disparity
image as figure 6 is gotten. It can be seen easily that the disparity of moving target is negative and the disparity of static background is about zero. In disparity image, some negative threshold is used to binarize it, then figure 7 will be gotten.

As is described above, some points have not disparity value, which will lead to holes in threshold image. So we should full-fill the holes, and figure 8 can be gotten. It can be seen that there are a lot of noise in figure 8, so region morphology operation open operation should be used to process it. Subsequently, figure 9 can be gotten. From figure 9, it can be seen that the white region is just the moving target. That is to say, the moving target is detected out by the virtual binocular disparity.

From the experiment above, it can be seen that the virtual binocular disparity algorithm can detect moving target easily, especially they move in different directions. This algorithm is superior to other methods detecting moving targets, for example, frame subtracting and background subtracting cannot distinguish the direction of moving target.

**Summary**

To detect moving targets, we use virtual binocular disparity theory to detect targets in one camera environment. It can not only detect moving targets, but also detect the direction of them. It brings more convenience to subsequent work. The performance of the theory is proved by actual environment.

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