Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):1948-1954

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Automatic counting of anchor rods based on target tracking

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ABSTRACT

In order to solve the problem of manual counting in the process of driving anchor rods into ground, an automatic counting method based on target tracking is proposed. First, an improved template matching method is proposed to track anchor drilling machine. Then, target information can be recorded and a target path diagram is generated. Finally, median filter is used to process tracking results and peaks in the path diagram are counted as the number of anchor rods. It's demonstrated that the improved template matching method enables to accelerate matching process while keeping pleasure tracking accuracy and counting precision. In addition, a software system adopted this method has been put into practice.

Key words: target tracking; template matching; automatic counting

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INTRODUCTION

Anchor rod is a kind of stress bars that one end is connected to engineering building and the other end is in rock and soil layer [1]. Pre-stress anchor rods can effectively bear the structure load and prevent deformation of structure, so as to maintain the stability of roadways' structure. Nowadays, most of coal roadways are supported by mining anchor rods. For safety in production, different roadways, however, have different requirements for the number of anchor bolts in one position to support the structure, so it's necessary to count the number of anchor rods in the process of driving them into ground.

Traditional bolts count is counting the anchor rods manually. It is considered as a rather laborious and time consuming process [2], so it is necessary to design an automatic counting method for anchor rods. With the development of computer image processing technology, automatic counting method based on image processing is used widely. Osama Masoud and Nikolaos P. in [3] proposed a method for tracking and counting pedestrians. Paper [2] implemented colony counting using the fast radial transform algorithm and image processing technology. Design and application on an automatic counting for steel bars is proposed in paper[4].

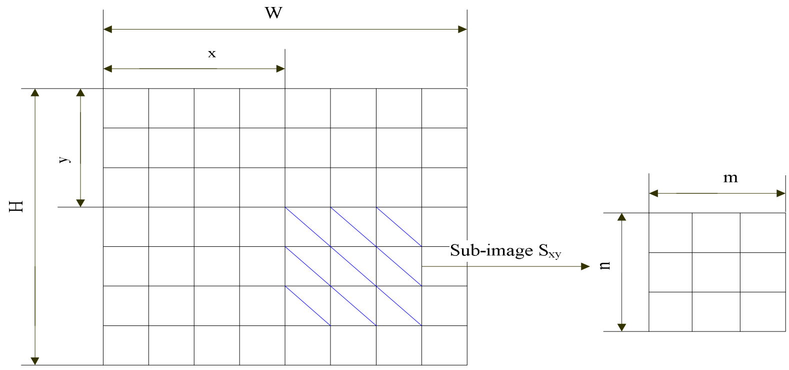
This paper proposes an anchor rods counting method based on target tracking. Target tracking involves automatically locating moving objects across successive frames in image sequences [5]. Among all the target tracking methods, we are focusing on the template matching method which gains an increasing attention for its simple calculation, convenient template selection and easy to implement [6]. The template matching method, in common way, slides a window with a similar size to the template to all possible positions of the image, and then finds out patches that look like the template based on a similarity measure [7].

Due to down-hole video's poor quality, uneven light distribution and complex background, traditional template matching method could not satisfy the requirement of down-hole target tracking. This paper proposes an improved template matching algorithm to track down-hole targets. In the tracking process, adaptive step length and prediction are adopted as the search strategy and template update mechanism is used, so as to reduce the amount of calculation and enhance accuracy and stability of tracking. After tracking, median filter is used to deal with the tracking results and peaks in the target path diagram are counted to obtain anchor drilling machine's movement time.

TRADITIONAL TEMPLATE MATCHING ALGORITHM AND RELATED WORKS

Template matching is a technique for finding the location of a reference image or an object inside a scene image. The conventional method of template matching uses cross correlation algorithms[8]. It is the process of searching a sub-image in an image which is most similar with a known small image called target template. Template matching diagram is shown in figure 1.

Traditional template matching algorithm carries out global search on the whole image. It possesses high tracking accuracy. With the number of images increasing, however, its tracking process will become slower so that it is difficult to conform to the requirement of real-time [9]. To reduce computational time, researches on template matching method mainly concentrate on different applications and a variety of improvements. Paper [10] changed similarity measure function, and a fast correlation matching criteria is established. Chen. in [11] proposes a matching method based on gray statistics, and enhances the matching speed greatly. The template matching method is applied to high-speed target tracking and a cross template is designed to improve matching speed in paper [12]. A matching algorithm based on correlation and template updating is used in target tracking in [13]. The speed of the template matching method is associated with matching similarity measure functions and search strategies other than factors of images themselves, this paper is mainly to improve the search strategy.



(a) An image S to be searched **(b) Template image T**

Fig.1: Template matching diagram

IMPROVED TEMPLATE MATCHING ALGORITHM

In order to speed up the matching process, this paper proposes an adaptive search strategy to determine initial search point by using prediction method, adjust search step and search direction. First, Kalman filter is used to predict initial search point. Then, search area and search step are adjusted to speed up the search. Finally, template update mechanism is adopted to ensure that the template information is real-time for tracking. As for similarity measure function, the well known normalized cross correlation (NCC) is adopted.

Selection of initial search point

Target information changes in different frames, but the movement and deformation between two consecutive frames are small. Based on such assumption, target information of previous frame can be used to provide a reasonable initial search point location for next frame.

Kalman filter is employed to predict initial search point locations of each frame image. The target information in the first two frames is obtained through human-computer interaction and is used to initialize Kalman filter, then Kalman filter coefficient is adjusted in the process of tracking. The content about Kalman filter can be found in paper [14]. According to the target information of current frame, the location of initial search point in next frame can be predicted to prepare for further locating.

In addition, the target may disappear in the field of view due to temporary shelters, so it’s necessary to make predictions of target location to ensure continuous tracking.

Adjustment of search area and step length

Because video’s sampling time is very short (e.g.29 frames per second), target locations in adjacent frames change in a certain range. Under this premise, we can narrow the scope of search area around initial point locally, without having to search target in the whole image. In addition, step length can be adjusted adaptively. If the matching degree is higher, decrease step length to find a better match point, otherwise, increase it to ensure faster search. Both adjustment of search area and step length can contribute to reduce calculation.

Setting moving orientation

In down-hole monitoring videos, the process that a target moves in a certain track repetitively is always monitored. Target information can be used to fitting trajectories so that the search direction can be set. Search direction combined with the above search step length adjustment will help to speed up the search process.

Particular way is: original search is along x and y directions at the same time. After obtain enough target location information, the target trajectory can be fitted in least squares sense. If trajectory changes small between adjacent frames, we can search targets along the movement direction that is fitted, otherwise along x and y directions.

Updating template

In this paper, the template image is updated based on the similarity degree between matched area and template. When the current goal's similarity with the template is greater than similarity threshold Th1, using current goal and template to update the template for next frame, otherwise, the template is not updated. Template updating strategy is the following:

(1) When the similarity between the real-time target and template is greater than the threshold, tracking is normal, and the information of target is well for updating. Template updating formula is shown as the formula below.

$$M_t = (1-\alpha) M_{t-1} + \alpha O_t \quad (1)$$

Where, M_t is the updated template; $M_{t-1}$is the template before updating; O_t is the sub image of current frame which is better matched to the template M_{t-1}; α is the weighting coefficient determined according to the similarity degree of change.

(2) If the similarity is lower than the threshold, it may happen that current tracking target is in a shade, so its information can't be used to update the template.

This adjustment method of the template can overcome the influence of rheology and mutation in tracking process and guarantee continuous tracking.

Similarity calculation

The similarity calculation method adopted in this paper is normalized cross correlation (NCC), as shown in formula (2),Where f(x+i,y+j) is the gray value of the point (x+i,y+j) in frame images and T(i,j) is the gray value of the point (i,j) in template image. It can be used to compute similarity of the sub-image and the template image shown in figure 1.

$$R(x,y) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} f(x+i,y+j)T(i,j)}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n} f^2(x+i,y+j)\sum_{i=1}^{m}\sum_{j=1}^{n} T^2(i,j)}} \quad (2)$$

Algorithm description

(1) Initialize parameters: F0, S0, T0 and select the initial area of a target manually.F0(m×n) is search area size, S0 is step length, and T0 is the lower limit of similarity.

(2) Searching in F0：F0 is centered by object predition location;

```
 T1=0;
 for(int i=0;i< m;i++)
 {
   for(int j=0;j< n;j++)
   {
if(R(i,j)>T1)
{
        T1= R(i,j);
}
```

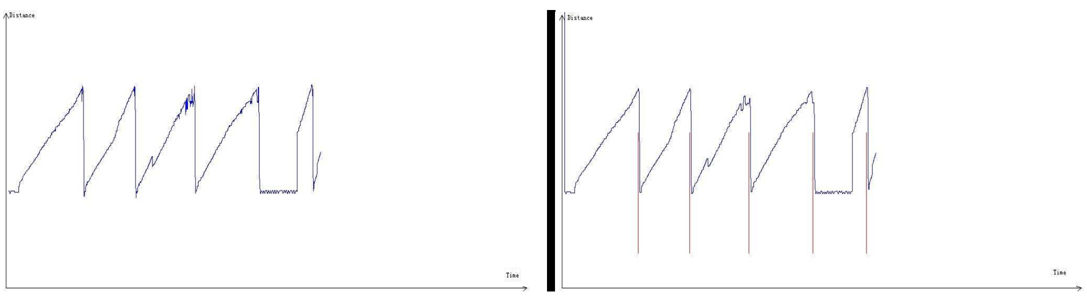
```
    }
  }
if(T1> T0)
{
     S0= S0/2;
     Search again in F0;
     Find the object location;
}
else
{
   While(T1< T0&&the size of F0 less than the size of a frame)

   {
      Increase F0 ,the max value of F0 is as the same as the frame;
      Search again in F0;
   }
   if(T1>T0)
   {
      Object location is found ;
   }
   else
   {
      Object is missing;
      Object location is the prediction value;
   }
}
```

(3) Fit trajectories ,update the template and search object in next frame;

AUTOMATIC COUNTING

This part can be divided into two sections: data preprocessing and counting. Median filter is adopted to smooth the target location information. The smooth effect can be seen in the comparison of the two pictures in figure 2. After data preprocessing, we adopt first derivative to find peaks, where the value of first derivative changes greatly.

The proposed method in chapter 3 is used into a down-hole video to track the anchor rod drilling machine. The target location is recorded and used to draw target path diagram. The horizontal axis shows time and longitudinal axis shows the distance to original point. The path diagram is shown in figure 2(a). We use filter to preprocess tracking result so as to obtain the number of peaks as counting result, seeing in figure 2(b). Red lines in figure 2(b) sign the peaks and the number of red lines is the counting result.



(a) Target path diagram **(b) Counting result**

Fig.2: Tracking and counting result of a video

RESULTS AND DISCUSSION

Images in Down-hole videos are usually gray images. Uneven illumination distribution, unclear images, complex background and much field disturbance, all of these bring difficulty to target tracking. This paper improves the traditional template matching method for fast tracking drilling machine of anchor rods. In addition, for targets' repetitive motion on the trajectory, the tracking results can be used for statistical target movement, so as to reduce the related staff work which needs artificial statistical target motion frequency.

To verify the validity of the algorithm, two groups of underground videos are selected in this paper. Both groups of videos are about a target repeatedly moving on one trajectory, the proposed approach can be used for target tracking and statistics.

The evaluation of experimental results is divided into two parts: image tracking speed and tracking accuracy. Tracking speed consists of the time required for each frame and the mean deal time, and video tracking accuracy is the proportion of automatic counting results and actual values.

Figure 3 in this paper shows the tracking result adopted the proposed method. Black rectangle used to tag matching target, and figure (a), (c), (b), (d) are respectively 0, 900, 1400, 4400 frames tracking matching figures. Table 1 and table 2 show the statistics results of tracking speed and tracking accuracy.

(a) Tracking image of 0 frame **(b) Tracking image of 900 frame**

(c) Tracking image of 1440 frame **(d) Tracking image of 4400 frame**

Fig.3: Tracking results of underground anchor video 1

Table 1:Image tracking time table of video1

Tracking method	Frame 0 (at.s)	Frame 900 (at.s)	Frame 1400 (at.s)	Frame 4400 (at.s)
Improved method	0.063	0.031	0.078	1.016
Traditional method	0.078	0.878	0.194	1.414

Table 2: Algorithm performance evaluation of video 1

Tracking method	Average time of processing frames(at.s)	Accuracy of tracking (at.%)	Accuracy of count (at.%)
Improved method	0.2392	95.40	96.07
Traditional method	0.7685	94.49	95.62

Figure 4 in this paper shows the tracking result adopted the proposed method. Black rectangle used to tag matching target, and figure (a), (c), (b), (d) are respectively 120, 1680, 5370, 12440 frames tracking matching figures. Table 3 and table 4 show the statistics results of tracking speed and tracking accuracy.

(a) Tracking image of 120 frame **(b) Tracking image of 1680 frame**

(c) Tracking image of 5370 frame **(d) Tracking image of 12440 frame**

Fig.4: Tracking results of underground anchor video 2

Table 3 Image tracking time table of video2

Tracking method	Frame 120 (at.s)	Frame 1680 (at.s)	Frame 5370 (at.s)	Frame 12440 (at.s)
Improved method	0.016	0.094	1.047	0.035
Traditional method	0.059	0.578	0.943	1.052

Table 4 Algorithm performance evaluation of video 2

Tracking method	Average time of processing frames(at.s)	Accuracy of tracking (at.%)	Accuracy of count (at.%)
Improved method	0.1526	89.53	90.46
Traditional method	0.6344	90.09	90.93

The experimental results show that under the condition of outside interference, such as light changes, the proposed method could effectively accomplish target tracking and automatic counting. This method is simple and it can speed up tracking significantly, complete target tracking under small amount of shade and ensure the accuracy of automatic counting.

CONCLUSION

The improved template matching algorithm is a method for fast target tracking. Prediction of initial search point, adjustment of search area, updating of the step and templates assure that the speed of the target tracking is accelerated and tracking accuracy can be guaranteed. The simulation results show that this algorithm greatly improve the tracking speed under the premise of tracking accuracy guaranteed and automatic counting based on target tracking can be effectively applied to anchor rod supervisory videos. This counting method relies on the target tracking results closely, so modifying the template in size and angle to complete better tracking in image sequences is a problem worth further study.

Acknowledgements
The authors wish to thank the National Natural Science Foundation of China for contract U1261114, the foundation of education department of Shaanxi province of China for contract 12JK0929, the research foundation of Research and Development Plan of Shaanxi province of China for contract 2012JM8029, under which the present work was possible.

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