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A Target Tracking Algorithm Based on Energy Distribution

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Target tracking based on image sequence is an important research topic in computer vision, image processing and pattern recognition. In this paper, a target tracking algorithm based on energy distribution is proposed, when the physicals and the images are in short distance, which makes imaging area is larger. The experiments of tracking hand show that the algorithm achieves accurate positioning. As well, the robustness is analyzed.

1. Introduction

Digital images are widely used in a variety of applications in the field of medical diagnostics, automatic control, target tracking. Process image processing mainly through machine-to-image obtained was "understanding", and then respond accordingly. The process is as shown in Figure 1.1.

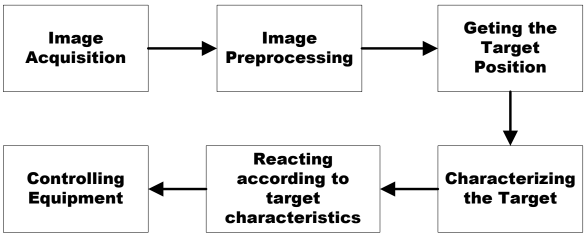

Figure 1.1: Image processing

Target tracking based on image sequence is an important research topic in computer vision, image processing and pattern recognition. Target tracking based on the image sequence is carried out by analyzing the image sequence captured by sensor, and detecting the moving target or the area of user's interest in the image, then estimated the position of target area in subsequent frames. This research has greatly important theoretical significance, because it can provide target trajectory, and provides a reliable source of data for motion analysis and scenario analysis of moving objects in the scene, it also helps for the moving target detection and recognition. Since the goal is inherently uncertain (there is not any prior knowledge of the target type) and the context is complex, the majority detection and tracking algorithms apply to only a certain situation. Universal target detection and tracking algorithm does not exist. When the target is far away, and so small imaging area, usually sampling filter tracking method is adopted; conversely in short distance, when the imaging area is larger, tracking technology known as "surface targets" is used, traditional method of which is the template matching. This paper studies the latter.

2. Hand tracking experiment

2.1 Image acquisition

In this paper, hand tracking experiment is used to introduce the step of tracking and verification tracking results. Image is captured by monocular camera in the natural environment. Figure 2.1 is a pre-acquisition target image.

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Figure 2.1: Pre-acquisition target image

2.2 Binary image processing

Color image obtained in 2.1 is binary processed using a color model, and then binary images are collected. In this process, establishing color model is a key in obtaining content-rich binary image, which is acquired through histogram analysis of respectively R, G, and B component to the pre-acquired image (see Figure 2.1) before hand tracking.

2.2.1 Color model established

The most common color system is RGB mode. In addition, there are HIS, YC_bC_r YUV and other models. Since the test was completed using a monocular camera in the natural environment, the hand's color is different with the background. After comprehensive consideration, we choose RGB color model. Before tracking the target, we need to know the approximate information about the target, such as color information, target sizes, shape of the target and so on. As color information plays a very important role in the whole process of tracking, color model, target's ranging in R, G and B color components, needs to be established before tracking.

After we got target image in a specified area, the histograms in R, G and B component, from which color model established, are calculated. From the histograms in R, G and B color components we can see that there are two peak regions in histogram, the first peak area of which is the color component range of the hand to be searched. Why we determine the first peak is as follow: There are two parts in the origin image, hand and background, which is so different in color, background is similar with white, which make it's component next to 255. At the same while, the target, compared to the background, the number of points of it has fewer pixels.

By traversing the corresponding RGB histograms, we can get the hand's corresponding color threshold range, from which, we can calculate the number of hand's pixel, which represents the size of the hand. This size is used as a reference value for the target size in the subsequent calculation.

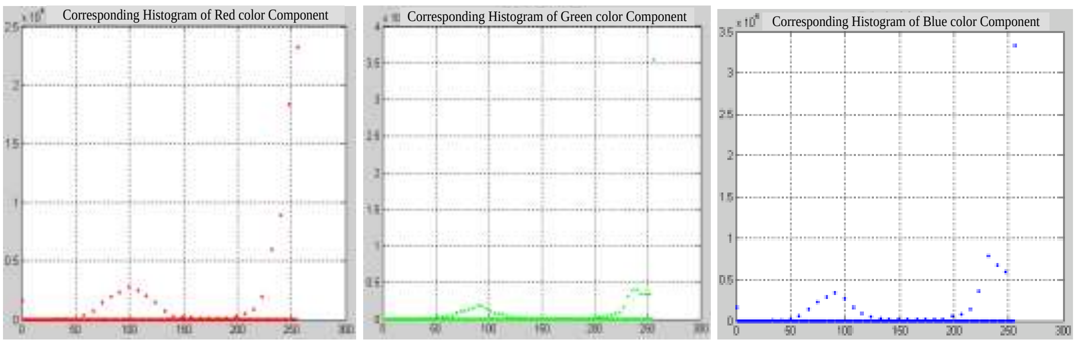


Figure 2.2: Corresponding histogram of red(left) ,green (middle) and blue (right) color component

2.2.2 Binary image acquisition

When the color model on the target established, the next task is to calculate binary image of a frame color image. We determine if the pixel is black or white through calculating the pixel's number according the color components being in line with color model. This algorithm is simple, but obvious shortcomings exist.

Error when calculating and noise make two aspects of deviation appear in the actual image acquisition and calculation process, which is described as follow:

(1) Corresponding color components of a pixel in hand area is shown as a pixel in background area. The result of this is that a dark spots appears in a binary image of a hand and even the hand region is divided into a plurality of sub-blocks.
(2) Corresponding color components of a pixel in background area is shown as a pixel in hand region. It affects more than one bright spot appeared in the binary image, so to follow-up work are adversely affected. Since the error and noise is inevitable, deviation will inevitably affect the result.

3. Tracking a specific target area based energy distribution

Finding the accurate position of the target, which is called target position measurement in a complete binary image frame, is the next step. Discussed by the upper we can know, there are several possibilities about a binary image, which is as follow:
(1) The image doesn't contain any valid information.
(2) The image contains valid information.
(3) The image contains much valid information.
What is the mean of "not contain any valid information"? Whether according to the shape, or relying on our existing knowledge, we are unable to determine the presence of the target position in the whole binary image. Why the target can't be found? First of all, there is no target hand in the original image; Secondly, color threshold used in the image binary process is too small, so that the effective information is removed; Finally, If the original image is a transition frame, (refer to one of frames between two stable hand frames)which is not stable, it is possible that the relevant information is removed after filtration, resulting in a corresponding binary image not including valid information. If a binary image doesn't include valid information, it will be given up. What is the impact of this treatment on real-time tracking? In order to answer it, we should know two concepts, one of which is time required for a frame and another is screen refresh rate, memory buffer size and the size of a frame. The concept described above have the following relationship.

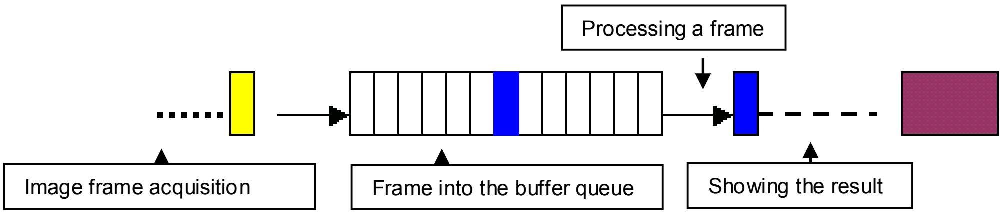


Figure 3.1: Image frame processing

If the time of an image frame acquisition is shorter than the time of processing a frame, the buffer queue will overflow, so drop frames, which show little effect on the outcome. However, if pluralities of consecutive frames are discarded, or even all frames are dropped, output display will be hopping or unchanged. In that case, re-checking the image acquisition settings and color threshold are needed, or we need to get the hands color of testers and obtaining its threshold when necessary.

3.1 Algorithm

Finding a specific target in a frame image, the method we use here is based on energy distribution, which follows several facts: firstly, the target should be distributed within a continuous region, which means that in the binary image of the hand, the palms, wrists and fingers should be more adjacent portions. That is, if the binary image contains a regional breakdown of the hand, then, palms, fingers, wrists and other parts of hand should be distributed in the adjacent sub-block, or within a sub-block. Secondly, the shape of a certain hand is relatively stable. Thus, in the corresponding binary image, energy distribution of hand adjacent regions is also relatively stable. For example, if a horizontal extending hand chosen, energy of the thumb portion is minimal, energy of middle finger portion is second, energy of the small finger is a relatively large portion, and then energy of the palm and wrist is maximal. This distribution of energy is not accidental in the above example, since it has a direct relationship with the shape of the palm, or short thumb far away from the other fingers make the region less energy. The energy distribution where the palm located is as shown in Figure 3.2 and 3.3.

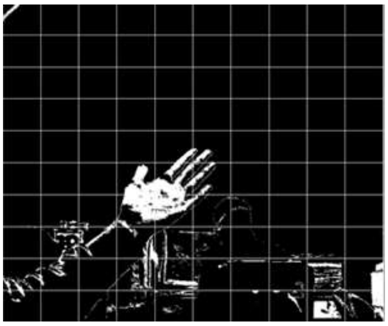
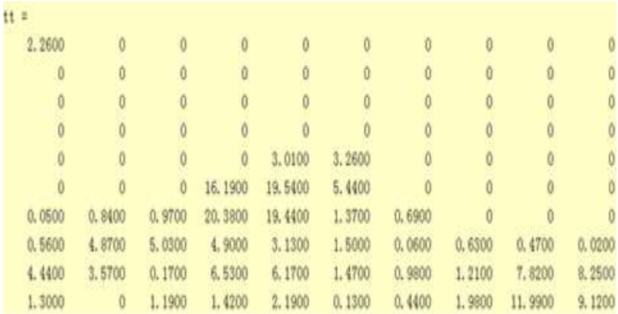


Figure 3.2: Binary image containing hand is divided diagram (left)



tt =

2.2600	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	3.0100	3.2600	0	0	0	0
0	0	0	16.1900	19.5400	5.4400	0	0	0	0
0.0500	0.8400	0.9700	20.3800	19.4400	1.3700	0.6900	0	0	0
0.5600	4.8700	5.0300	4.9000	3.1300	1.5000	0.0600	0.6300	0.4700	0.0200
4.4400	3.5700	0.1700	6.5300	6.1700	1.4700	0.9800	1.2100	7.8200	8.2500
1.3000	0	1.1900	1.4200	2.1900	0.1300	0.4400	1.9800	11.9900	9.1200

Figure 3.3: Energy distribution (unit: the number of frame) of sub-block (right)

3.2 Build Feature Vector Group

Next, we use vectors to describe the energy distribution of the hand, which is expressed by mathematical tools In the following presentation.

In a possible target area shown in Figure 3.4, whose size is assumed to be 3 × 3, we select any sub-block, such as the brown one of NO. [1,2], then place it in the center of an empty template with its adjacent sub-blocks in appropriate location. In the new template we just acquired, those empty sub-blocks, shown in white, whose energy is defined infinite, thus are called invalid sub-blocks. We calculate the energy difference vector in accordance with the following rules.

The vector contains nine components, each of which is obtained like this: we number the center sub-block and eight around it line by line. According the result of the energy of center block minus other eight blocks, we can get the components. If the value is less than 0, record 1 in corresponding position; if it is 0, write 10 in the position; if it is more than 0, the position is 1. The invalid block, whose content is 0, will not participate in the calculation.

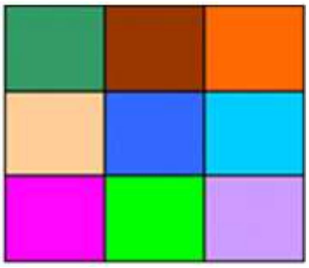


Figure 3.4: An energy region in binary image

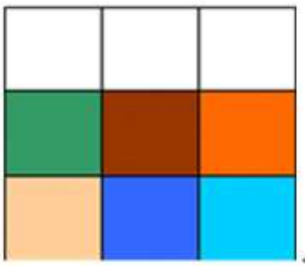


Figure 3.5: New template after revision

Calculating all sub-blocks of on the original template in the same way, we get nine vectors, which form the corresponding vector group of possible area, which is shown in Figure 3.6.

TempSigma =

0	0	0	0	10	-1	0	-1	-1
0	0	0	1	10	1	-1	-1	-1
0	0	0	-1	10	0	-1	-1	0
0	1	1	0	10	-1	0	1	-1
1	1	1	1	10	-1	1	-1	-1
1	1	0	1	10	0	1	-1	0
0	-1	-1	0	10	-1	0	0	0
1	1	-1	1	10	-1	0	0	0
1	1	0	1	10	0	0	0	0

Figure 3.6: Corresponding vectors of possible area

After the target image in Figure 2.1 is processed in the same way, we obtained standard vector group. In order to determine whether a possible area is the target area, we need to calculate the similarity of above vector and standard vector group. How to strike their similarity? The answer is computing the number of vectors in two vector group.

4. The analysis of result

After the above color modeling, binary image, feature vectors, image segmentation, and establishment of feature vector Group, let's look at the results of a static frame image as shown in Figure 4.1.
The results from Figure 4.1, we can see the position is quite accurate. Experiment's result shows that this method has high reliability in searching multiple image in natural state, and the key to accurate lookup is feature vector based on the establishment of energy distribution.

Figure 4.1: Target area search result

Before the establishment of feature vector group, the Image is divided into same size sub-blocks, whose size is related to the size of the target image, which makes increase search speed, as those obviously none-hand-shaped distribution sub-blocks are quickly dropped out in advance. Thus, this block-based algorithm's speed is significantly faster than the methods based on pixels. In the process of establishment of the feature vector group, a feature vector is standardized according to the energy distribution of block, which makes this algorithm robust.

5. Conclusions

This paper summarizes the previous study and proposes tracking algorithm based on the distribution of energy in the situation that the distance between camera and the target is short and imaging area is larger. The algorithm is applied in hand tracking experiment to verify the accuracy of the algorithm. Finally, the algorithm robustness is analyzed.

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