

Algorithm of Ship Tracking based on the the filtering theory of Video Sequences

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Abstract: In order to realize real-time monitor of ship traffic situation to improve shipping safety and efficiency, reduce the burden on the driver and supervisor, this paper presents the Algorithm of ship tracking based on the the filtering theory of video sequences. The algorithm applies particle filter and mean shift algorithm to the technology of automatic ship tracking, at the same time it introduced the advantages and disadvantages between the Mean shift algorithm and particle filter algorithm by comparison. Experimental results show that the accuracy of particle filter tracking algorithm is lower than the mean shift algorithm, but it has better real-time. And also found that with the increase of the particles' number, the tracking accuracy is improved, but the running time becomes longer and the real-time gets worse.

Introduction

In the process of exploration that humans continue to move forward, with the development of the science and technology the traffic is continuously maturing. Although there is a well-developed transportation system, a large number of vehicles in use has frequently arose the accidents. In recent years, maritime industries have also arose that many ships collided, ship and bridge crash and many more. So there is an urgent need for advanced systems technology to count the message of surface motion of the ship and description of the shipping trajectory. It has a remarkable significance that applies the computer vision technology to the identification and tracking of ships to prevent the collision, manage the ship scheduling and better handle of traffic management^[1].

Therefore, it is still the direction of current research that we are able to develop a precise, fast and stable video moving target tracking algorithm to cope with the complex changes of the environment^[2]. To resolve some constraints of the target of the video tracking, it must involve the field of computer vision algorithms, filtering theory and many other related core technologies. Therefore, the issue based on the analysis and comparison of the relevant key technology of the tracking target, try to make more effective tracking solution. In-depth study of this topic not only has a high value, but also on the visual understanding of the mechanism, as well as to promote the development of machine learning and artificial intelligence has important theoretical significance^[3].

Description of Mean Shift algorithm

1) The initial frame of the target model

The probability of the u-th feature value can be present by formula(1):

$$\hat{q} = C \sum_{i=1}^n k\left(\left\|\frac{x_0 - x_i}{h}\right\|\right) d[b(x_i - u)] \quad (1)$$

2) The current frame model

According to the initial frame model, the probability of the search window's u-th feature value in the current frame can be expressed as:

$$\hat{p}(y_0) = C_h \sum_{i=1}^n k\left(\left\|\frac{y_0 - x_i}{h}\right\|\right) d[b(x_i - u)] \quad (2)$$

3) The similarity function

The initial frame object's model and the current model can be used the same similarity function description, which is defined as formula (3):

$$\hat{r}(y) = r(\hat{r}(y), \hat{q}) = \sum_{n=1}^m \sqrt{\hat{p}_u(y) \hat{q}_u} \quad (3)$$

4) Mean Shift vector

The similarity function can be described as follows:

$$r(\hat{r}(y), \hat{q}) = \frac{1}{2} \sum_{u=1}^m \sqrt{\hat{p}_u(y) \hat{q}_u} + \frac{C_h}{2} \sum_{i=1}^{n_h} w_i k\left(\left\|\frac{y - x_i}{h}\right\|\right)^2 \quad (4)$$

In the feature section, when the similarity function $\hat{r}(y)$ is a maximum, you can get the desired Mean Shift vector:

$$m_{h,G}(y) = y_1 - y_0 = \left[\frac{\sum_{i=1}^{n_h} x_i w_i g\left(\left\|\frac{\hat{y} - x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n_h} w_i g\left(\left\|\frac{\hat{y}_0 - x_i}{h}\right\|^2\right)} \right] - y_0 \quad (5)$$

Description of Particle filtering algorithmic

1) Initialization

Based on the distribution of $p(x_0)$, randomly sampling in the vicinity of x_0 we can get a series of particles $x_0^i, i = 1, 2, \dots, N$.

2) SIS

The importance of the distribution of $q(x_k | x_{0:k-1}, z_{1:k})$ usually can be simplified as $p(x_k | x_{k-1})$,

so we can get N particles $x_k^i \propto p(x_k | x_{k-1})$ by the sample.

3) Calculate the weight

Calculate the weight $w_k^{(i)}$ of each particle, and normalize $w_k^{(i)} = w_k^{(i)} / \sum_{i=1}^N w_k^{(i)}$.

4) Posteriori probability estimation

Outputs a set of weighted of particles $\{(x_k^i, w_k^i), i=1,2,...,N\}$, according to a average weight of the particles or the maximum of posteriori probability, get estimates of the current time k .

5) Particle resampling

According to the weight of particle to resampling particles that power heavy particles differentiate into a plurality of particles, remove the small particle weight, get new N particles.

6) State transition

When $k+1$ time comes, recording observations, repeat 2-6.

Experimental results and analysis of ship tracking based on Mean Shift algorithm and Particle filter algorithm

The Mean Shift algorithm firstly initialize the target of the tracking, hand-selected by mouse mode as shown in Figure 4.1. The tracking results are shown in Figure 4.2 to Figure 4.4.

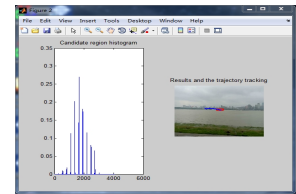
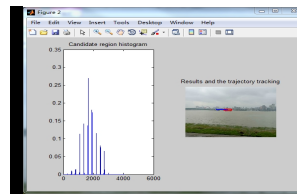
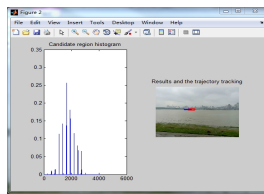


Figure 4.1 Select images

Figure 4.2 Section 50

Figure 4.3 Section 100

It can be seen from the Figure 4.2 to 4.4 that it is a more accurate tracking, at Figure 4.2 Section 50 the two ships staggered and the tracking frame of the video has slightly offset at Figure 4.3 Section 100, but after a little time the track frame becomes accurate; the final tracking results shown in Figure 4.4. Observation of the tracking movement is basically same to trajectory.

The Particle filter algorithm firstly initialize the target of the tracking, hand-selected by mouse mode as shown in Figure 4.5. The tracking results are shown in Figure 4.6 to Figure 4.8.

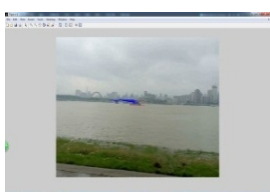
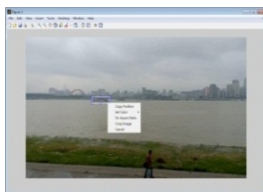


Figure 4.5 Section 20

Figure 4.6 Section 70

Figure 4.7 Section 100

Figure 4.8 Section result

It can be seen from the Figure 4.5 to 4.8 that during tracking, the tracking box often shift, especially when the two ships staggered the shift is more obvious, but the tracking target will fall after a few frames. Although the track was chaotic, there is a vacillating situation and the effect is not good enough, the direction is correct.

System Analysis

Through calculating the distance of the center of the track and the center of the actual motion to compare and calculate the error of the two algorithms. The center point of actual movement using the manual method to choose, program, elect nine frame, determine the center of the coordinates; then

using polynomial fitting method, fit six times, finally fit the actual trajectory;then calculate the error of two traces and trajectory,with an average error and variance of per frame to measure.The comparison of tracking error shown in Table 5.1.

Table 5.1 Comparison of tracking error

Tracking algorithm	Error	gap
Particle Filter	3.7212	5.7782
Mean shift method	2.3213	

Table 5.2 Comparison of running time

Tracking algorithm	Run Time (s)
Particle Filter	48.151951
Mean shift method	115.003216

Table 5.1 shows that in the process of tracking,the jitter of two algorithms both are more serious,but the overall trend is correct,the average error of the mean shift method is less than the particle filter method,a difference is no more than 6 pixels.

Two algorithms for the analysis of real-time, using the commands tic and toc, the total run time of the program and the results are shown in Table 5.2.

Table 5.2 shows that the run time of particle filter algorithm is much less than the mean shift algorithm, it has better real-time.

Analyze the effect of particle number,the number of particles is respectively set to 100,200,500,1000,2000, observe the effect of the number of particles on the running time and the tracking error shown in Table 5.3.

Table 5.3 Effect of the number of particles on the running time and the tracking error

The number of particles	Per frame error (pixels)	The number of particles	Run Time (s)
100	3.9718	100	35.889891
200	3.7212	200	48.151951
500	3.0853	500	63.085486
1000	2.7546	1000	121.126432
2000	2.3691	2000	196.054916

Table 5.3 shows that with the number of particles increases,the amount of calculation increased, the program's running time becomes longer, the real-time get worse;on the visual look the effect of tracking get better,but the change of actual error is not obvious,it is due to the number of polynomial fitting, and also relates on the selected target and the initial template.

Conclusion

Research for ship tracking can help predict the situation of the ship and help the driver prepare well to avoid collision in advance,so the ship's automatic detection and tracking technology has a high practical significance and emergency.This paper studies the principle of Mean Shift theory and particle filtering,designed tracking algorithm based on particle filter tracking algorithm and mean shift algorithm.By comparing the tracking results of the two algorithms, including tracking error and real-time, find that the tracking error of particle filter algorithm is larger than the mean shift algorithm, but it has better real-time.At the same time through studying the influence of the number of particles' effect on the particle filter,confirm that with the number of particles increases that the amount of calculation increases, the program's running time becomes longer,the real-time get worse, but the tracking performance get better.

Acknowledgements

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References

- [1] Jun Liu.:Infrared motion detection and tracking of ships for ship collision avoidance warning[J].Optical Engineering(2010), In Chinese.
- [2]Hongxia Chu:Tracking key technology of the particle filter and based on mean shift. Harbin Engineering University(2011), In Chinese.
- [3]Peiliang Wu , Lingfu Kong, Fengda Zhao, and Xianshan Li:Particle Filter Tracking Based on Color and SIFT Features.IEEE(2008).
- [4]Chenghe Zhu:Water sports Ship identification tracking technology based on image sequences:[D]. Nanchang: Jiangxi University(2012), In Chinese.
- [5]Kun Wang:Based on video motion of the ship recognition and tracking technology research [D]. Xiamen: University of Xiamen(2009), In Chinese.
- [6]Regazzoni,Cavallaro and Porildi:Video Tracking in Complex Scenes for Surveillance Applications[J].EURASIP Journal on Image and Video Processing(2008),p.89.