칼만 필터를 이용한 물체 추적 시스템

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Object Tracking System Using Kalman Filter

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요 약

물체의 움직임에 관한 추적방법은 여러 가지 문제점을 갖고 있다. 물체의 움직임에 관한 추적방법은 물제의 장면, 비 강체 물체의 구조, 물체와 물체 및 물체의 장면 폐색 및 카메라의 움직임과 모두 움직이는 물체의 패턴변화에 의해 결정되기 때문이다. 추적방법은 일반적으로 매 프레임의 위치나 물체의 형상을 필요로 하는 높은 수준의 응용프로그램이나 시스템 내에서 처리된다.

본 논문에서는 확장 칼만 필터(EKF)에 따라 물체의 활성 시각 추적 물체 잠금 시스템을 실행하고, 실행된 데이터를 바탕으로 분석하여 도입된 단일 카메라 추적 시스템 알고리즘에 2대의 카메라와 각각의 비전에 따라 물체 추적 시스템을 설명하고, 물체의 상태를 파악하여 각 카메라에서 움직임에 관한 추적이 실행된 후 개별 트랙에 최종 시스템 물체의 움직임 트랙과 결합하여 사용되는 추적시스템에 대해 연구하였다.

ABSTRACT

Object tracking, in general, is a challenging problem. Difficulties in tracking objects can arise due to abrupt object motion, changing appearance patterns of both the object and the scene, non-rigid object structures, object-to-object and object-to-scene occlusions, and camera motion. Tracking is usually performed in the context of higher-level applications that require the location or the shape of the object in every frame.

This paper describes an object tracking system based on active vision with two cameras, into algorithm of single camera tracking system an object active visual tracking and object locked system based on Extend Kalman Filter (EKF) is introduced, by analyzing data from which the next running state of the object can be figured out and after the tracking is performed at each of the cameras, the individual tracks are to be fused (combined) to obtain the final system object track.

키워드

active visual system, extended Kalman filter, multiply-cameras, object tracking

Ⅰ. Introduction

Object tracking has been widely used in reality, such as Vehicle Tracking and Recognition [1], Driver Assistant System [2], etc. Active vision [3] is a kind of technology carried out by controlling the movement of camera for object, its flexibility and adaptability to the surrounding environment have significantly improved than ordinary tracking systems.

Kalman filter [4] is a recursive prediction essentially. The smoothing effect of the Kalman filter helps to handle the situations where targets are momentarily missed detected. Prior research [5] has been done on all of the main parts of our project, however, previous results have yet to be combined in a satisfactory way by using single cameras. Therefore, we described a method for the fusion of tracks obtained from two cameras placed at two different positions [6].

Ⅱ. Kalman Filter In Action

Let's take instances on Kalman filter to help in developing a better feel for the capability of the filter. We are trying to estimate the distance *d* between two cars. The distance could be constant $d_{t+1} = d_t$, increasing or decreasing with the passage of time $d_t = d_{t-1} + v$ [7].

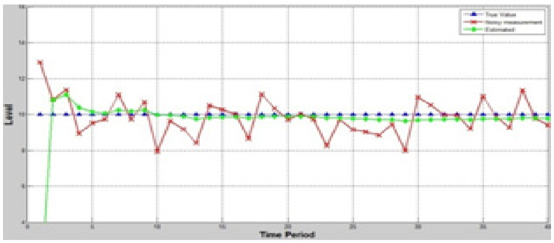

Fig. 1 Distance tracking result between two cars when the distance is a constant

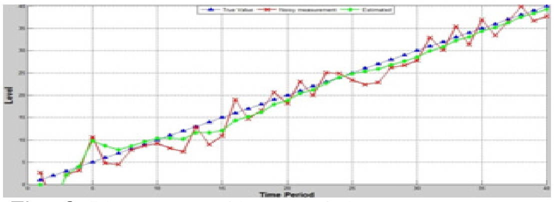

Fig. 2 Distance tracking result between two cars when the distance is increasing with a constant rate

Figure 1 shows that the Kalman filter for a constant distance tracking successfully works. After stabilization the estimated state is within 0.5 of the "true" value, even though the measurements are within 2 of the true value. In another case (Fig. 2) the filter quickly adapts to the true value. We did not tell the Kalman filter anything about the actual increasing rate of the distance, and it figured it out all by itself, even with a bad unsure initialization. The examples effectively meet the main purpose of the Kalman filter: noisy data in and hopefully less noisy data out.

Ⅲ. Tracking Algorithm

Object locked technique is that when the object being tracked is not in the center of the image in the current frame, then move the joints of the camera to make sure it relocate in the center. Combine objects Lock technology with the use of Kalman filter to predict and correct the movement of the camera, that is OLBEKF.

Take the analysis of Pan motor on behalf of the whole motion model of camera (Fig. 3). If we suppose the movement of object model is: $x_k = x_{k-1} + v\Delta T + \frac{1}{2}a\Delta T^2$, we can get the motion model of the camera as: $y_{Tilt_{k+1}} = y_{Tilt_k} + \frac{\cos^2 y_{Tilt_k}}{h}(v\Delta T + \frac{1}{2}a\Delta T^2)$.

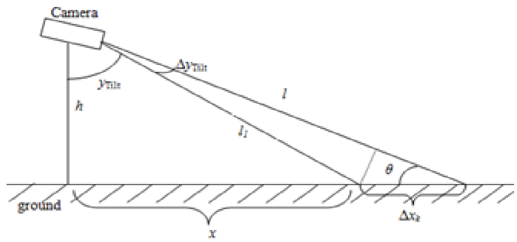

Fig. 3 Object movement affine model

We apply two extended Kalman filter for the filtering prediction of motors Pan and Tilt respectively.

Algorithm: tracker
Input: initial angles of motors Pan and Tilt
Input: each frame of image
Output: control the movement of camera smoothly
while (each frame of image)

Choose recognizer and take the center of the image to be the initial recognizing site, to get the offset (Δx , Δy) that the target object relative to the image center.

Calculate the offsets of the two motors: $\Delta x_{Pan} = \tan^{-1}\frac{\Delta x}{d}$, $\Delta y_{Tilt} = \tan^{-1}\frac{\Delta y}{d}$.

Update the corresponding Kalman filter with Δx_{Pan} and Δy_{Tilt} of the current frame:

(a) x_{Pan}=kalman_pan.update(Pan+Δx_{Pan});
(b) y_{Tilt}=kalman_tilt.update(Tilt+Δy_{Tilt}).

(4) Predict the location of the camera for the next frame with Kalman filter:

(a) xPan=kalman_pan.Predict(Pan);
(b) yTilt=kalman_tilt.Predict(Tilt).

(5) Set a new position of camera using motors Pan and Tilt.

end while

The state vector of the Kalman filter are shown as: $x_k = [s\,v\,a]^T$, where: *s* is the angle, *v* is angular velocity and *a* is angular acceleration.

If the output of recognizer in the current image is failure, it indicates that the loss of the current tracking, and the system should be reset. During the system reset process, the identification of object tracking will become a neutral position, which will bring errors to the whole tracking system. In this paper we used two cameras to track the object and subsequently fused the tracks obtained from the trackers associated with each of the cameras to obtain a final track.

We suppose that each camera and its associated tracker can be treated as the constituents of a sensor node. When the fusion algorithm comes to know that the object is out of the field of view of a camera, it stops using the information obtained from the corresponding sensor node since it will be erroneous and the updating filter system of the camera should be reset.

The processing architectures for track fusion algorithm is described as Sensor-to-system track fusion: It is, whenever a set of sensor tracks are received, the position estimates of the target tracks are extrapolated to the time of sensor tracks and fused with the newly received sensor tracks. This process is repeated when another set of sensor tracks is received (Fig. 4) [6].

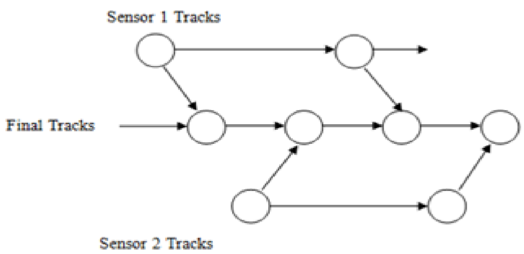

Fig. 4 Sensor to System track fusion

The advantage of this fusion algorithm is that it is robust to common process noise. The method used to integrate the complementary information passed by the two sensors.

Ⅳ. Conclusion

The OLBEKF technology for single camera has following advantages:

(1) The image quality is improved. The angular velocity of camera and the movement of objects are granted to be equal, and image blurs are also reduced in a most effective way.

(2)Robustness of the algorithm is good. The object is always in the center of the image, which with the maximum possible to reduce situations of tracking loss.

(3)High algorithm efficiency. Based on the strong antinoise capability of extended Kalman filter, results of the recognizer are always had $\begin{cases}\Delta x=0\\ \Delta y=0\end{cases}$, which greatly accelerates the recognition speed of recognizer.

The fusion algorithm used for fusing tracks of multiple cameras can enhance the tracking performance as compared to the single camera tracking. Therefore, with the combination of OLBEKF technique and multiple-cameras fusion algorithm the object tracking system introduced in this paper can be guaranteed to be much stable and accurate. Future work includes how to take advantage of single camera tracking multiple objects, and how to take advantage of multiple camera joint to track multiple objects, they are important methods to improve performance of the tracking system.

References

[1] MIURA J, KANDA T, SHIRAI Y. An active vision system for real-time traffic sign recognition [C] // Proc IEEE on Intelligent Transportation System. Dearborn, MI, USA, 2000: 52-57.

[2] FRANKE U, GORZIG S, LINDNER F, et al. Autonomous driving goes downtown [J]. IEEE Intelligent System & Their Applications,1998, 13(6): 40-48.

[3] PAN Feng, WANG Xuanyin, WANG Quanqiang. Moving object tracking research based on active vision [C] // Proc 5th World Congress on Intelligent Control & Automation, 2004, 5: 3846-3849.

[4] Greg Welch and Gary Bishop, “An Introduction to the Kalman Filter”, Design 7, no. 1 (2001): 1-16.

[5] LIU Xiaohui, CHEN Xiaoping. Tracking technique for active vision based on extended Kalman filter. Computer Aided Engineering, Feb. 2007.

[6] M.K. Bhuyan, Brian C. Lovell, Abbas Bigdeli. Tracking with Multiple Cameras for Video Surveillance. Digital Image Computing Techniques and Applications, 9th Biennial Conference of the Australian Pattern Recognition Society on, pages 592-599, Dec. 2007.

[7] Subject MI63: Kalman Filter Tank Filling. Avaliable: http://www.cs.cornell.edu/Courses/cs4758/2012sp/materials/MI63slides.pdf.