Fast Method of Moving Object Tracking

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Introduction

The article describes a series of tests of different computer vision techniques used to track a moving object in a scene taken by a digital camera (e.g. DV camcorder). The performance provided by standard techniques was found unsuitable either because of high computational demands (or complexity respectively) or for poor movement tracking ability. A novel approach was developed with focus on high performance in moving object tracking and low computational demands so that the method can be easily implemented into low power systems (microcontrollers, etc.).

Motivation

The research was motivated by a need of a set of computer vision techniques for an autonomous mobile system navigation. The basic idea behind the navigation and autonomous control of a mobile system is that the moving objects are considered important as they could cause a collision in a short-time horizon. On the other hand the still objects (merged to the scene background) present no collision danger within short time periods. The mobile system is navigating through the space by an analysis of the scene – the global trajectory planning is usually not time critical. However, considering other moving objects in the space, the autonomous system must be able to detect a collision threat and plan a dodging manoeuvre in the shortest time possible.

Tested Standard Methods and Their Performance

During an extensive testing phase, 3 computer vision methods (nowadays considered standard) were tested within the framework of the moving object tracking task. All of them were used to perform an image segmentation: (i) Hough transform, (ii) SUSAN feature detector, and (iii) Skeletonisation.

Hough transform proved expectedly outstanding ability to find an analytically described object (in fact a geometrical shape). Its sensitivity to image noise is very low and an ability to cope incomplete data is also high above average. These desirable features are balanced by high computational demands of the method. Although the testing was performed on a powerful dual-core Pentium machine, and the algorithm was written in C++ using speed optimisation, it was not suitable for a real-time application, as the analysed frame rate was 3 fps.

The ***SUSAN*** (Smallest Univalue Segment Assimilating Nucleus) feature detector is quite a novel approach presented some eight years ago by Smith [1]. It has a very low computational load and is easy to implement (so that it is suitable for small, low-consumption embedded systems, microcontrollers, and other poor performance hardware). On the other hand this method was not able to overcome substantial amount of image noise and thus produced a lot of false features that have no connection with the actually tracked moving object.

Skeletonisation proved good performance when working on a noisy images and incomplete data. The computation load was significantly lower compared to the Hough transform. However, the segmentation ability dropped congruently – especially small still objects of the same or similar geometrical shapes caused confusion. Moveover such a method needs further processing of the resulting data to segment the scene so that the moving object can be localised.

The Method: Segmentation via Temporal Difference

As the previously mentioned methods did not fully satisfy the conditions, an alternative approach was developed and tested: The image is not segmented in order to locate objects but *to locate a movement*. The scene images are transformed using the following FIR spatiotemporal filter:

$$y(i, j, t) = \psi(i, j, a)\ |x(i, j, t) - x(i, j, t - \varphi(a))|,$$

where x is an input image function, y is an output image function, ψ is a non-linear smoothing function, and φ is a temporal shift function. Both ψ and φ are dependent on a smoothing parameter a. The ψ function is also dependent on spatial coordinates i and j what enables to prefere a region where the tracked object was localised in past (presuming the object is moving at certain speed that can't change arbitrarily fast due to object inertia).

After the filtering, standard thersholding and labelling procedures are applied to localize movement traces. These are analysed using vector field analysis techniques.

Application

The developed method can be used in various technical applications: (i) navigation of an autonomous mobile system (e.g. AI driven car, aircraft, etc.) as a part of a collision-avoiding subsystem; (ii) security appliances like e.g. aiming a security camera around the observed area to monitor mischief activities; (iii) robotics, where it can be used as a part of a robot navigation system (e.g. robotic football).

Results

A simple and effective method of moving object tracking was developed. The method is easy to implement, has very low computational power demands and is thus very suitable for low power computer systems (e.g. 8052- or ARM-based microcontrollers). The method is reliable and stable in tasks where the tracked object moves at speeds sufficiently higher than the speed of change of the monitored scene. The most substantial disadvantage of the presented method is a complete inability to indicate an unexpected disappearance of the tracked object.

References

[1] S. Smith: *The SUSAN Edge Detector in Detail*, the article is freely available from Internet at URL http://www.fmrib.ox.ac.uk/~steve/susan/node6.html.

[2] P. Weinfurt: *Detekce a analýza pohybu objektu ve scéně (Detection and analysis of object movement in a scene)*, M.Sc. Thesis, University of West Bohemia, Plzeň, 2006.