Software Module for Object Detection in Video Sequences

Analysis of image sequences

Background modeling

Motion detection

Outdoor monitoring

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Field of application

Image-based analysis systems for real-time monitoring and analysis purposes generally require the automatic identification of events of interest in different situations.

Figs. 1 and 2: Traffic scene with different illumination conditions at different times of day

Important fields of application include security and monitoring systems, the collection of information for subsequent offline evaluation, the acquisition of data for control purposes, etc. Concrete examples of application include motion detection in rooms and on properties of special security significance, the determination of object and event statistics both in industrial and scientific realms, and the detection of vehicles and pedestrian in traffic scenarios, with the objective of intelligent control of traffic signals.

Development trends

The development of observation and monitoring systems in recent years has been fundamentally characterized by innovations in and refinement of camera and video technology, as well as low hardware costs resulting from economies of scale in producing large numbers of units. Especially the significant reduction in costs results in the fact that visual observation via video is playing an increasingly important role in modern economies.

In terms of analyzing video sequences, the trend is moving away from manual analysis. Analysis by an observer requires a significant commitment of human resources; moreover, it is subjective and thus prone to error. In recent years, the constantly increasing computing power in the low-cost PC sector has made automatic, cost-effective analysis of series of images possible. This means that even sophisticated and complex tasks can be realized in real time.

Automatic object detection

Automatic analysis of video sequences is especially difficult in outdoor scenes. The recording conditions are extremely varied and unpredictable.

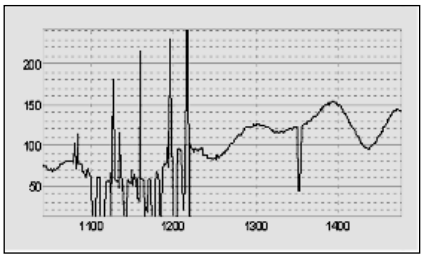
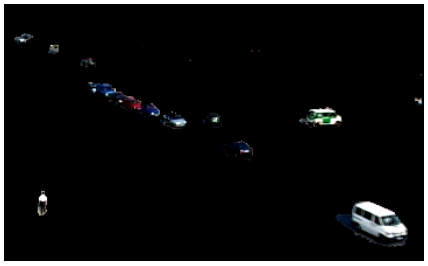


Fig. 3: Intensity over time of an image pixel in the roadway area of a traffic scene, size of the image series: 500 images (5 images/s), intensity spikes: vehicles passing by

Sudden global changes in scene illumination are especially critical here, as is to a certain extent scene content (transition from sun/clouds, rain, snow, etc.). The intensity and speed of weather-related changes are not usually predictable.
An additional problem in automatic analysis of outdoor scenes is false detections, caused by movement of trees, bushes, grass, water, electrical lines, etc. in the wind.



Figs. 4 and 5: Multiple Gauss procedure; source image and detection result

Background modeling

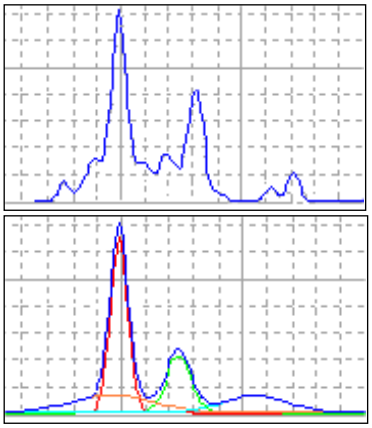
The software module is capable of a range of different detection procedures. The basis of all procedures is a static modeling of the image background. The quality of segmentation thus does not depend on the appearance and variety of objects to be detected, as is the case in object model-based procedures. The respective background model is constantly updated based on the current video data and the detection results. The actual motion or object detection occurs by comparing the current video image with the current background model. The initialization of the background model takes place manually, based on an object-free single image, or automatically, as part of a short local training phase.

Procedures for object detection

The software library provides the following procedure options:
difference accumulator, Kalman estimator, single Gauss, multiple Gauss.
The procedures vary with respect to modeling quality and running time.
In the difference image accumulator, differences in subsequent images are interpreted as objects. Kalman estimators and single Gauss procedures reproduce the statistics of each individual pixel in a normal distribution. Deviations from the current distribution function as object indicators.
The first three procedures operate very quickly, but are unsuitable for the complex demands of outdoor scenes. Simple fluctuations in lighting are tolerated or adapted to by all three procedures.

Multiple Gauss procedure

The multiple Gauss procedure was developed within the framework of a traffic flow analysis project. In contrast to the simple segmentation approaches, this is the only method capable of operating under the difficult conditions of outdoor scenes. A particular problem in the realm of vehicle detection is the discrepancy between rapid global changes in the background brightness and the standstill periods of vehicles at traffic signals. In the case of illumination fluctuations near resting objects, a special update procedure helps avoid false detections upon renewed motion.



Figs. 6 and 7: Histogram over time and multiple Gauss approximation of a single pixel

Changes in the image background are adapted to through an adjustable time constant. Due to the modeling of the background with several overlapping Gauss distributions, different background states are stored. This makes it possible for instance to log periodic changes in background image areas.

Figs. 8 and 9: Initial image and results of object detection with the multiple Gauss procedure, during strong rainfall

Motion detection in video sequences through background modeling	
Library module: Dynamic Link Library (Dll) Operating system: all Windows PC versions Running time (AMD Athlon™ 2700 XP, image size 256x256): - simple procedures: < real-time video - multiple Gauss procedure: 0.07 s	Detection procedures: - Difference accumulator - Kalman estimator - Single Gauss - Multiple Gauss