A multi-camera system for video-based road traffic analysis

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Context

- Traffic authorities require reliable **traffic data** for maintenance, planning and management of roads and highways
- safety
- traffic flow optimisation
**Context**

- Research Project co-funded by Brussels Region and Macq Electronique
- Partner: ULB
- Research started in November 2007
- Some preliminary results will be presented
Outline of the talk

- Objective
- System general description
- Implemented modules
- Preliminary results
Objectives

- Camera-based System that collects traffic data, e.g.
  - vehicle flow – lane occupancy
  - vehicle classes (truck, car, car + trailer, ...)
  - vehicle velocities

- System able to interpret the traffic scene
  - detect dangerous behaviour, lane violations
  - detect congestions
System description

- Cameras on bridge
- Analysis of video
- System outputs a list of high-level events (e.g. vehicle detected <time> <class> <lane> <speed>
System description

Video stream

2D analysis
- Calibration

Stereo analysis
- Stereo calibration

Fusion Module
• Single video stream modules
  – 2D image analysis (vehicle detection and tracking)
  – camera calibration: road plane to image homography

• Stereo module
  – rectification, feature matching and clustering, 3D backprojection
  – camera calibration: fundamental matrix

• Fusion module
  – fusion 2D and 3D info to describe the dynamic scene as a list of 3D objects with position history
  – metric fusion (speed and length) and class fusion (fusion class labels of image regions)
• Single video stream modules
  – 2D image analysis (vehicle detection and tracking)
  – camera calibration: road plane to image homography

• Stereo module
  – rectification, feature matching and clustering, 3D backprojection
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• Fusion module
  – fusion 2D and 3D info to describe the dynamic scene as a list of 3D objects with position history
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2D calibration

• Aim: compute automatically road plane to image homography using road lines and vehicles
  – road line detection (lines parallel to road direction)
  – vehicle lines (perpendicular to road direction)
  – Together these lines define a quadrangle used for computing the homography
2D calibration : Road line detection

- compute “background image”
2D calibration: Road line detection

- thresholding
2D calibration: Road line detection

- line detection (blob principal axes)
2D calibration: Road line detection

- line fusion and filtering based on periodicity criteria (on thresholded and original images)
2D calibration : Road line detection

- perpendicular line detection
  - using 2 or more line segments
  - using vehicle perpendicular lines (video)
2D calibration : Homography

- Using the 4 points defined by the quadrangle corners, compute homography $H$
- Allows to measure length and velocity of vehicles
2D image analysis modules

- Viola-Jones object detector trained to detect vehicles fronts
- Thousands of training images have been collected
• image is scanned with a rectangle
• Classifier is applied each sub-image included in the rectangle
2D image analysis module

- Tracking: sparse LK optical flow to determine position of vehicle in next frame
- Video (2D image analysis analysis alone)
**Stereo module**

- F matrix obtained manually
- Image pair rectification
- Feature detection (harris corners)
- Corner matching using phase correlation
- 3D points backprojection and filtering of spurious matches
- 3D points clustering in boxes containing vehicles
- Tracking
**Stereo module**

- Image pair rectification
  - easier matching => correspondence on an horizontal line
- Stable feature detection on both images: harris corners
Stereo module

- After corner matching using phase correlation and 3D points backprojection
- 3D points with h>0 are clustered using Minimum Spanning Tree
- Tree is constructed, edges with length > thr are removed
2D analysis for textureless objects

- Problem with harris corners matching: long vehicles without any details
2D analysis for textureless objects

- Detection of high object
- Search of long plain surface in left and right images
2D analysis for textureless objects

- Search of 4 vertices
  - Segmentation: Seed growing
  - Contour is used to extract line segment
- Must be robust enough against segmentation errors
  - Conditions on line segments help to filter out irregularities
2D analysis for textureless objects

- The 4 vertices in each image are matched
- Result: red rectangle
- Video
Conclusion and Future Work

- We are developing a video-based system for traffic analysis
- High level description of the scene is obtained by modules using either 2D or 3D info
- Currently we investigate ways to perform fusion of the two modules
  - definition of rules to conciliate “opinions” of the modules