Multi-camera System for Road Traffic Analysis

Juan Carlos Tocino Diaz
Quentin Houben
Jacek Czyz
Traffic authorities require reliable *traffic data* for maintenance, planning and management of roads and highways.

**Context**

Safety

Traffic flow optimisation
Context

Research Project co-funded by Brussels Region and Macq Electronique
Partner: ULB
Research started in November 2007
Outline

Objectives
System general description
Camera auto-calibration
Mono algorithm
Stereo algorithm
Conclusion
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 general description

Cameras on bridge
Video analysis
System outputs a list of high-level events
(e.g. vehicle detected <class> <time> <lane> <speed>
Camera auto-calibration

Aim: compute automatically road plane to image homography using lane marks and vehicles
Lane marks detection (lines parallel to road direction)
Vehicle lines (lines perpendicular to road direction)
Together these lines define a quadrangle used for homography computation
Camera auto-calibration: Pattern finding

Compute “background image”
Camera auto-calibration: Pattern finding

Thresholding

(a) Background

(b) Detected lane marks
Camera auto-calibration: Pattern finding

Parallel lines detection

(a) Background  (b) Detected lane marks  (c) Parallel lines
Camera auto-calibration: Pattern finding

Line fusion and filtering based on periodicity criteria (on thresholded and original images)

(a) Background
(b) Detected lane marks
(c) Parallel lines
(d) Parallel lines filtered
Camera auto-calibration: Pattern finding

Perpendicular lines detection (using two or more line segments)

(a) Background  (b) Detected lane marks  (c) Parallel lines

(d) Parallel lines filtered  (e) Perpendicular lines
Camera auto-calibration: Pattern finding

Calibration pattern:

(a) Background
(b) Detected lane marks
(c) Parallel lines
(d) Parallel lines filtered
(e) Perpendicular lines
(f) Calibration pattern
Camera auto-calibration: Pattern finding

Calibration pattern

(a) Background
(b) Detected lane marks
(c) Parallel lines
(d) Parallel lines filtered
(e) Perpendicular lines
(f) Calibration pattern
Camera auto-calibration: Pattern finding

Calibration pattern

(a) Background
(b) Detected lane marks
(c) Parallel lines
(d) Parallel lines filtered
(e) Perpendicular lines
(f) Calibration pattern
Camera auto-calibration: Pattern finding

Two lanes?
Camera auto-calibration: Pattern finding

Two lanes

Perpendicular lines are obtained from road traffic – with the assumption that cars are traveling along road axis
Camera auto-calibration: Homography

Using the four points defined by the calibration pattern, compute road plane to image homography.

Gives the relationship between image coordinates and world coordinates.
Mono algorithm

Features detection (Harris corners)
Sparse LK optical flow
3D cloud estimation from motion
Clustering into vehicle objects
Results
Mono algorithm

Features detection (Harris corners)
Mono algorithm

Sparse LK optical flow
Mono algorithm

3D cloud estimation from motion

The higher a point is above the ground, the more its distance from the camera is over-estimated.
Mono algorithm

3D cloud estimation from motion
The more a point above the ground is far away from the camera, the more its distance from the camera is over-estimated
Mono algorithm

3D cloud estimation from motion
Mono algorithm

Clustering into vehicle objects
Mono algorithm

Results

86 km/h
295x234x309 cm
Mono algorithm

Results
Stereo algorithm

Left and right images registration
Features detection (Harris features and edge based features)
Features matching using local normalized correlation or score based on edge characteristics
3D points backprojection
3D points clustering in boxes containing vehicles
Tracking
Features detection

Images are rectified
Vehicle texture:
  Reflective
  Uniform

Features detection: vehicles are characterized by corners and straight lines parallel to the road axis

Harris corners detection on each image
Features based on edge detection
Features matching

Harris features matched by normalized correlation
Edge features matched by edge comparison (contrast, profile, left and right pixel intensity)
Error detection

Spurious matches are filtered with different methods

Example:

Good match

Error detected
3D points processing

For each match: 3D points back-projection
3D points with h>0 are clustered using Minimum Spanning Tree
Tree is constructed, edge with length > thr are removed
In each clustered group, extrema 3D points are filtered. Each 3D points group define a bounding box around a vehicle.
Vehicles tracking is performed with 2D optical flow. Each Harris feature of the box is localized in the next frame and form a predicted box. The resulting predicted box is associated with the closest detected box. A detected box without associated predicted box is considered as a new vehicle.
Results
Overall results fusion

System outputs a list of high-level events (e.g. vehicle detected <time> <class> <lane> <speed>)

- video stream
- mono calibration
- stereo calibration

fusion module
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.