CarFUSION: Combining Part Detection and Point Tracking for Dynamic 3D Reconstruction of Vehicles

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Dataset: http://www.cs.cmu.edu/~ILIM/projects/IM/CarFusion/

Motivation & Goal

Goal: Fast and accurate 4D sensing of vehicles from multiple cameras.

Application:
1. Traffic behavior understanding
2. Autonomous driving
3. Pollution analysis

System Pipeline

Insight

Structured point: accurate matching but imprecise tracking
Unstructured point: precise tracking but inaccurate matching

Evaluation of 2D Structured Points

1. The distances between the structured points and unstructured points are constant over time for rigid deformation
2. No cross-view matching of the unstructured points are needed

Challenge

Noisy and incomplete keypoint detection (structured point) prohibits accurate multiview car association and reconstruction by ray triangulation.

Formulation

\[ E_c = \sum_{t} e_{reprojection} + e_{symmetry} + e_{length} \]

Time alignment: Motion coherency

\[ e_{symmetry} = \sum_{t} \sum_{i \neq j} \left| \frac{\|R_i(t)f - T_j(t)f - U_jc - S_i0}{\|R_i0 - U_jc\|} \right|^2 \]

Rigidity Link: Length preservation

\[ e_{length} = \min \sum_{t} \sum_{i \neq j} \left| \frac{\|R_i(t)f - T_j(t)f - U_jc - S_i0\|}{\|R_i0 - U_jc\|} \right|^2 \]

Reprojection of structured points

Input videos

Structured point detection & 3D scene reconstruction

Evaluation of 2D Structured Points

Output

Pretrained

Unstructured point tracking

Structured point bootstrapping

Bootstrapped

Ground truth

3D scene reconstruction & camera calibration

Time alignment

cRANSAC

rRANSAC: Whole car multiview association

4D Reconstruction

Fifth Ave. & Craig St.: reconstruction of 32/45 cars from 9 cameras @60fps for 3 minutes

Butler St. & 40th St.: reconstruction of 29/33 cars from 12 cameras @60fps for 3 minutes

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City of the Future