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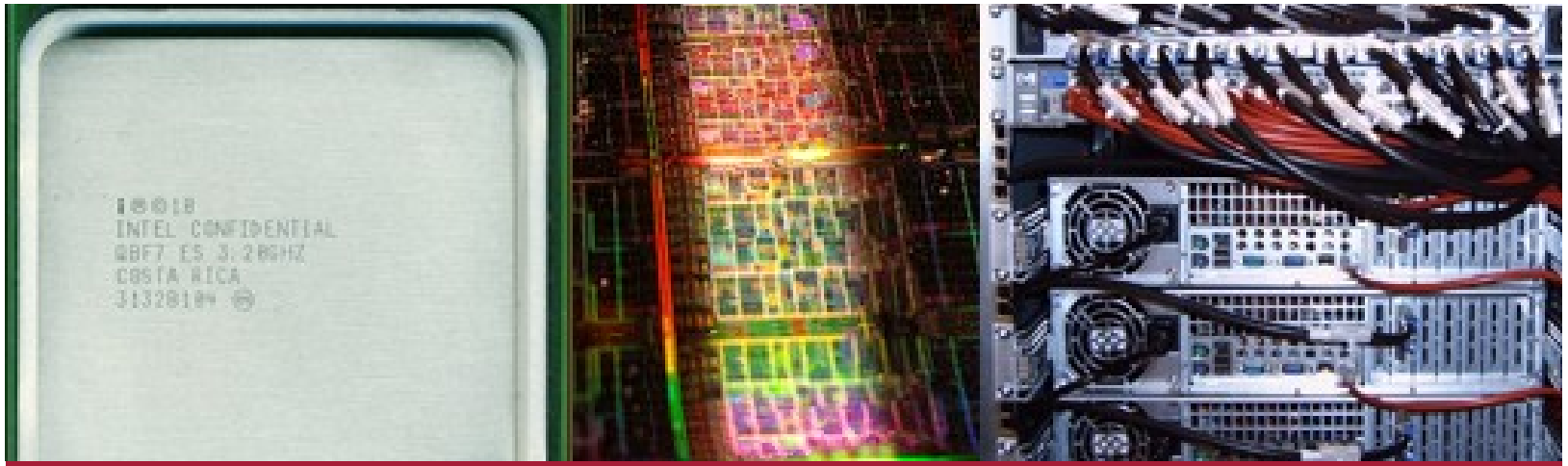
MATHEMATISCH-
NATURWISSENSCHAFTLICHE FAKULTÄT

Eingebettete Systeme



Evaluating optical flow vectors through collision points of object trajectories in varying computer-generated snow intensities for autonomous vehicles

25/6/2018, Vikas Agrawal, Marcel Frueh, Oliver Bringmann and Wolfgang Rosenstiel

Topics

- Motivation
- Optical Flow
  - Sparse Optical Flow
  - Dense Optical Flow
- Evaluation
  - Setup
  - Evaluation Methods
    - Pixel Robustness
    - Vector Robustness
  - Our Results
- Conclusion and Goals

Motivation

- Success of ADAS relies on sensor data
- Sensors improved significantly
  - Reduction of Noise
  - Better Resolution

Topics

- Motivation
- **Optical Flow**
  - Sparse Optical Flow
  - Dense Optical Flow
- Experiments and Evaluation
  - Setup
  - Evaluation Background
    - Pixel Robustness
    - Vector Robustness
    - Data Processing Methods
  - Our Results
- Conclusion and Goals

Optical Flow

- Pixel flow in a (consecutive) image sequence
- Calculation of the movement of a pixel between image pairs through:
  - Sparse Optical Flow Method
  - Dense Optical Flow Method

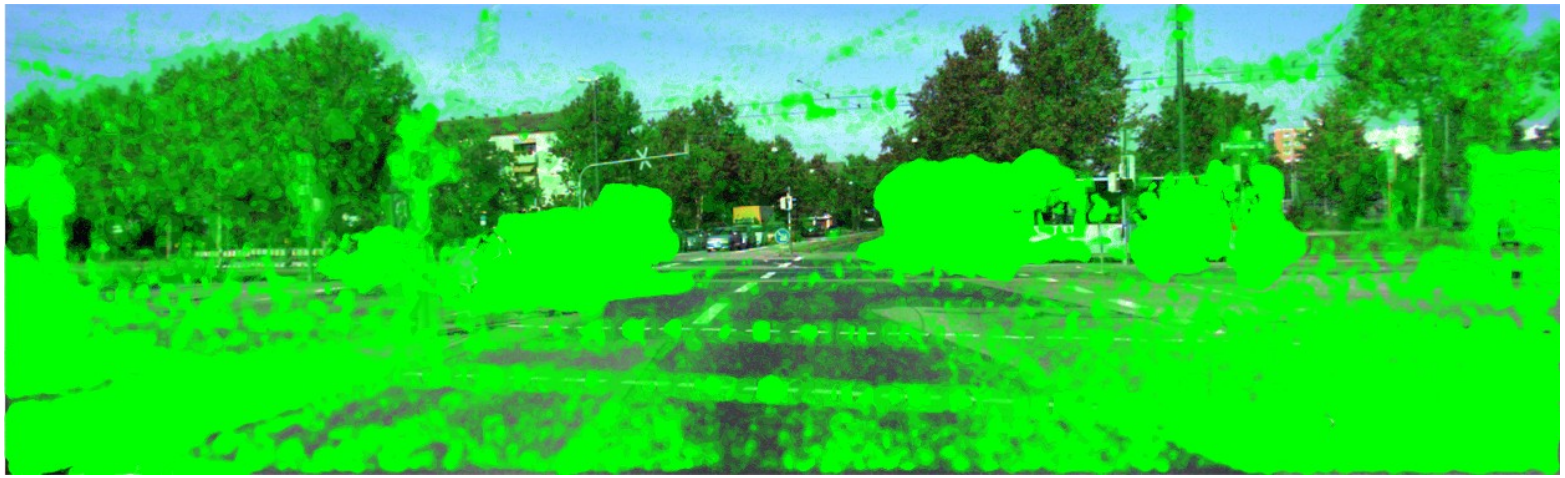
First Frame

Second Frame

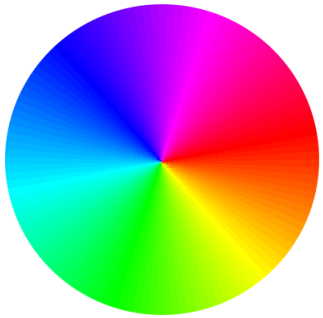
Kitti Vision Benchmark Suite

Sparse Optical Flow

Dense Optical Flow



Dense Optical Flow



Throwback: Motivation

- Success of ADAS relies on sensor data
- Sensors improved significantly
  - Reduction of Noise
  - Stronger Resolution
- Importance of highly accurate underlying algorithms
  - Non perfect environmental conditions
  - Occlusion

How can we evaluate the above algorithms in computer generated noise

https://openclipart.org/detail/190312/seated-man-thinks

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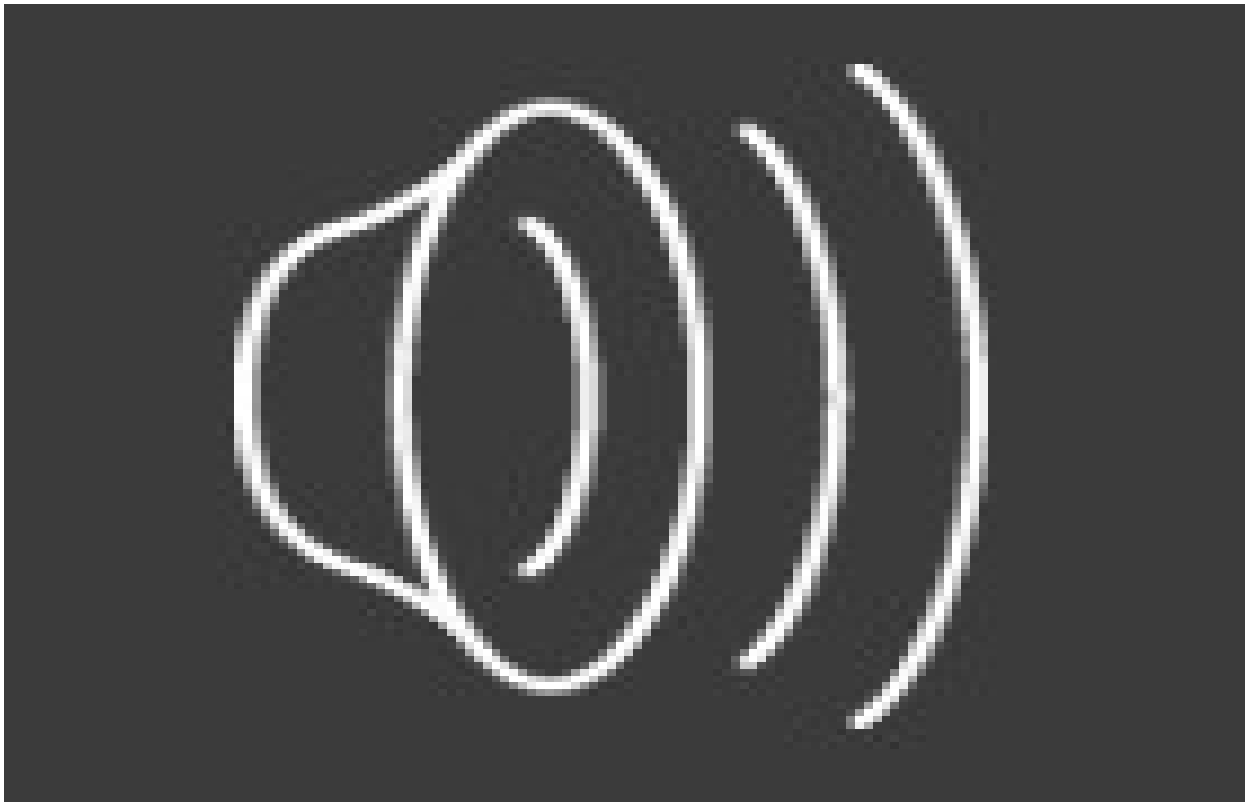
Evaluation Scenario



Evaluation

Setup

- Generated via Virtual Test Drive by Vires Simulationstechnologie

  ➡ Synthetic Dataset: High accuracy Ground Truth

- Scene:
  - 4 different environmental conditions
    1. Blue Sky
    2. Light Snow
    3. Mild Snow
    4. Heavy Snow

Evaluation
Setup

- 4 different environmental conditions

(a) Clear Blue Sky

(b) Light Snow

(c) Mild Snow

(d) Heavy Snow

Topics

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  - Sparse Optical Flow
  - Dense Optical Flow
- **Experiments and Evaluation**
  - Setup
  - **Evaluation Background**
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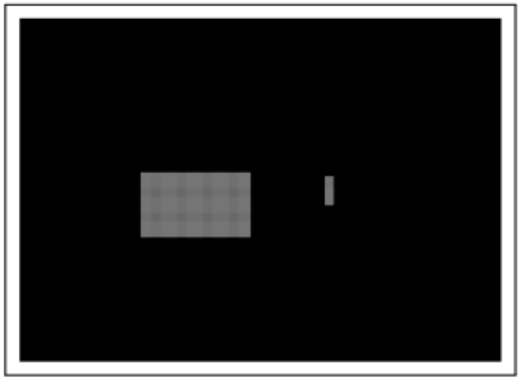
Evaluation Background

Pixel Robustness

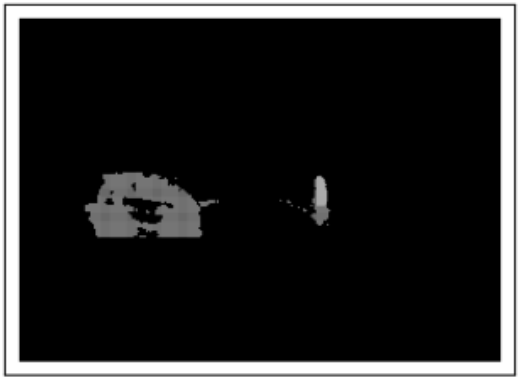
- Good Pixel: Flow Angle and Magnitude similar to Ground Truth
  - Similarity decided by Threshold
    - Magnitude difference < 1px
    - Angle difference < 5°
- 2 comparisons:
  - Ground Truth vs Optical Flow on Blue Sky (Base Stencil)
  - Optical Flow on Blue Sky vs Optical Flow during Snow

Evaluation Background

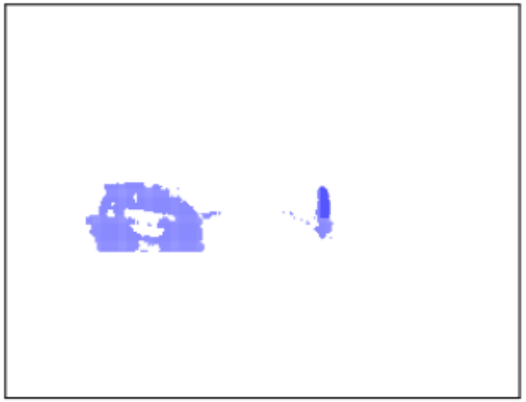
Pixel Robustness



(a) GT Stencil



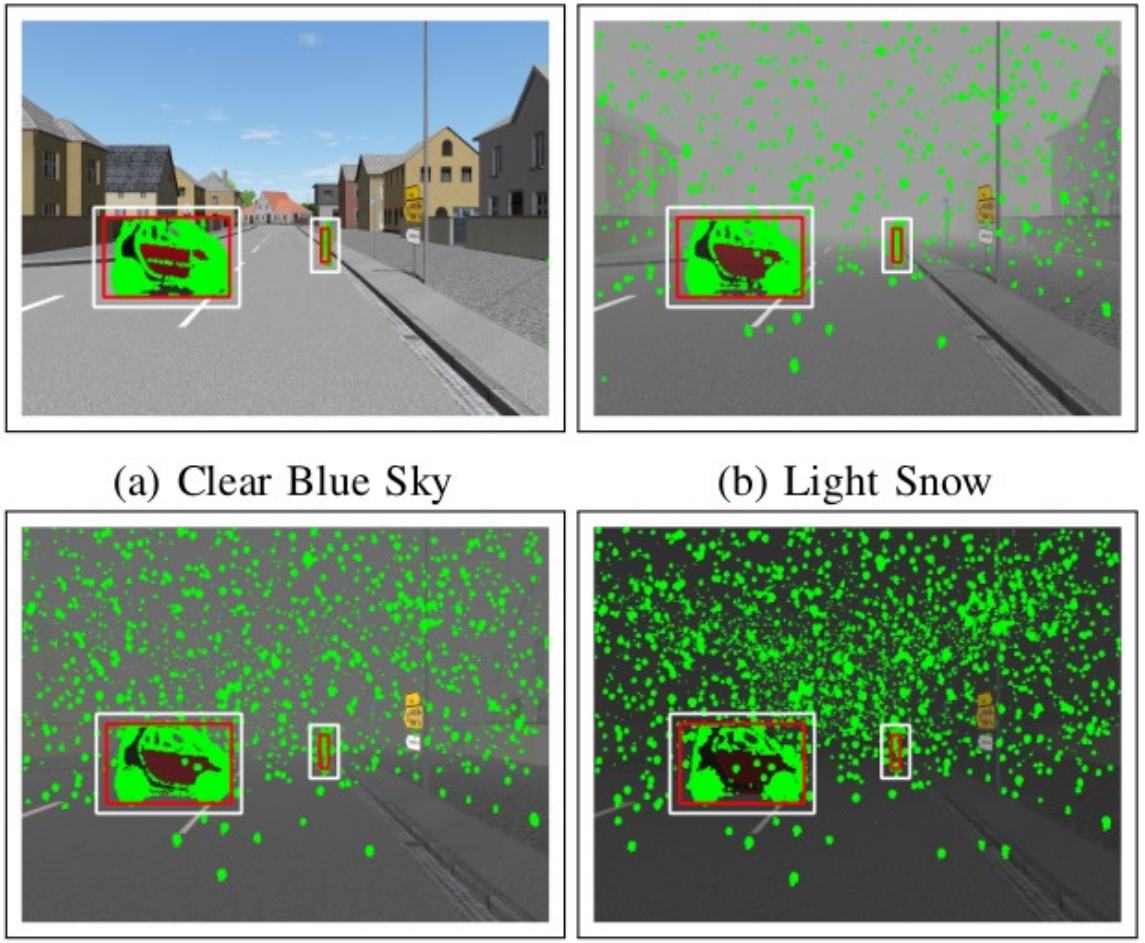
(b) Base Optical Flow Stencil



(a) Pixels in Clear Blue Sky conditions

(b) Pixels in Bad Weather conditions

Evaluation Background



(a) Clear Blue Sky

(b) Light Snow

(c) Mild Snow

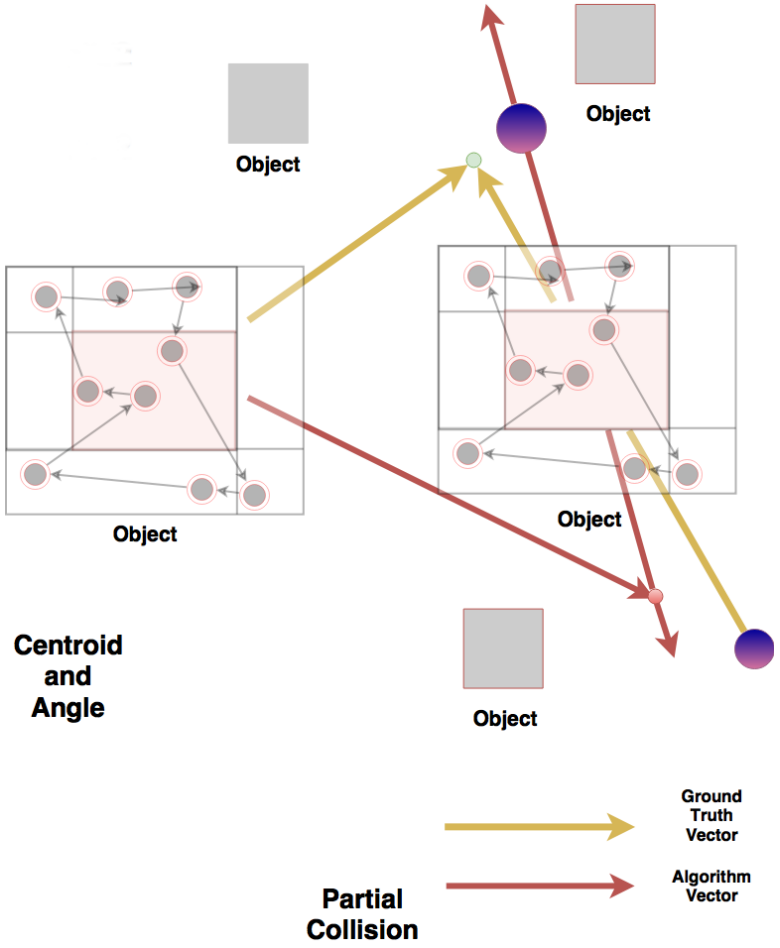
(d) Heavy Snow

Evaluation Background

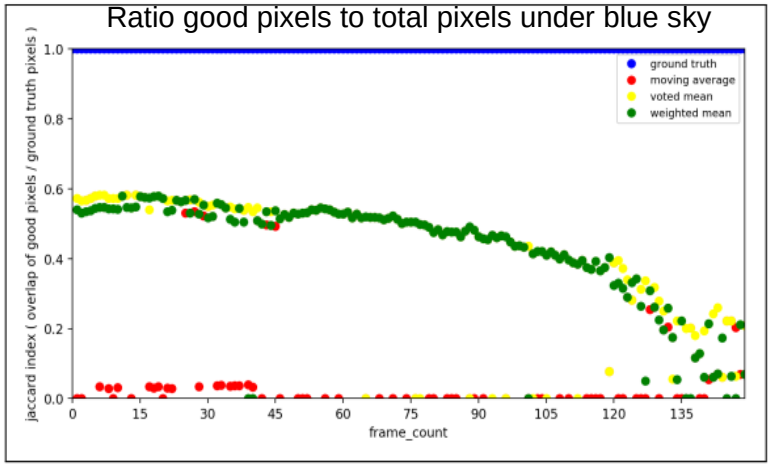
Vector Robustness

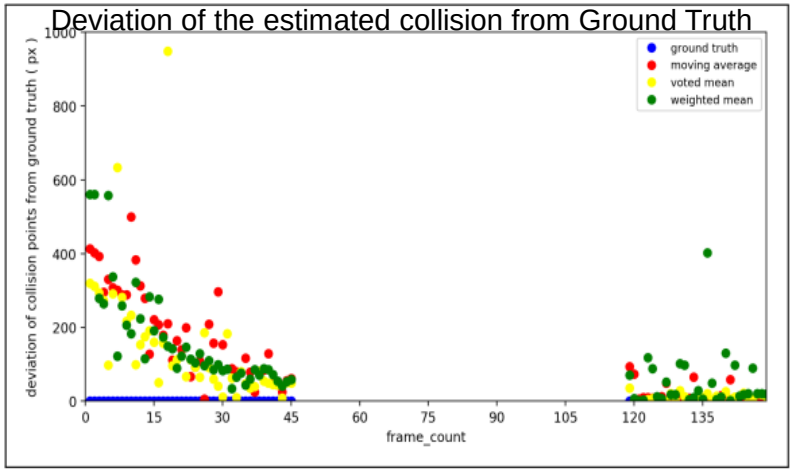
- Estimate collision points out of the Optical Flow
- Need to extract a global Optical Flow for a given Object **(Dataprocessing):**
  - Moving Average: Mean over the Optical Flow
  - Voted Mean: Histogram containing different Flow values. Mean over the highest bars.
  - Weighted Mean on Edges: Assign higher weight to Flow pixels located on edges, then compute Weighted Mean

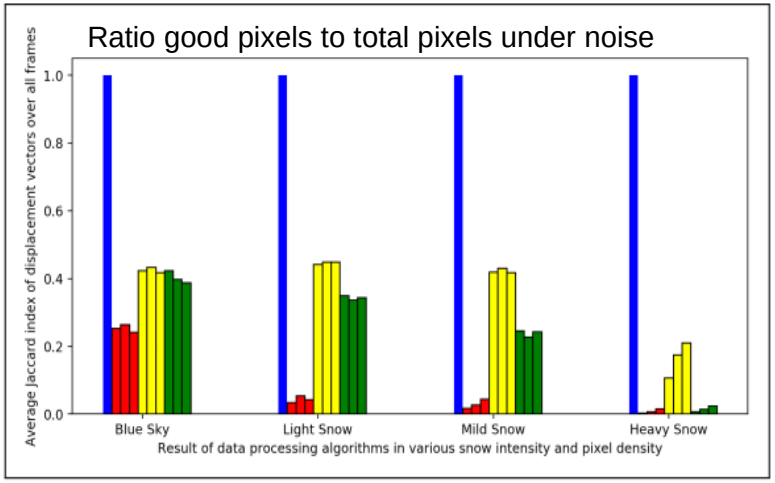
Collision Points – Vector Robustness

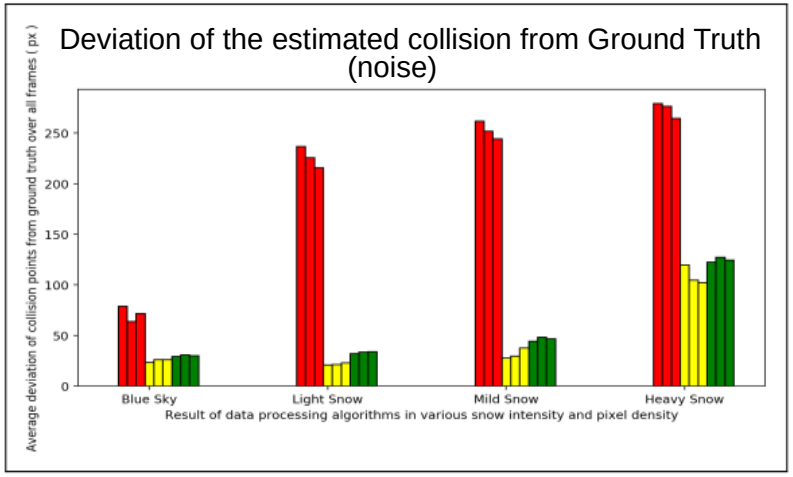


Results


Ratio good pixels to total pixels under blue sky
jaccard index (overlap of good pixels / ground truth pixels)
frame_count
ground truth
moving average
voted mean
weighted mean


Deviation of the estimated collision from Ground Truth
deviation of collision points from ground truth (px)
frame_count
ground truth
moving average
voted mean
weighted mean


Ratio good pixels to total pixels under noise
Average Jaccard index of displacement vectors over all frames
Blue Sky
Light Snow
Mild Snow
Heavy Snow
Result of data processing algorithms in various snow intensity and pixel density


Deviation of the estimated collision from Ground Truth (noise)
Average deviation of collision points from ground truth over all frames (px)
Blue Sky
Light Snow
Mild Snow
Heavy Snow
Result of data processing algorithms in various snow intensity and pixel density

Conclusion and Goals

- Optical Flow Evaluation for the automotive domain
  - Especially for testing noise and weather resistance
- Evaluating through Pixel and Vector Robustness
- Evaluation of different Data Processing Methods

- Goals:
  - Optical Flow on highly occluded scenarios, e.g legs behind a truck or heads through windshields
  - Combination with Kalman Filter etc...

Thank you

Marcel Früh

References

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