Stereo and Motion Analysis

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The .*enpeda*.. Project

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Test vehicle HAKA1

Stereo Vision

An 1-dimensional Correspondence Problem

Real-World Benchmarks

Robustness on Challenging Data

Optical Flow

A 2-dimensional Correspondence Problem

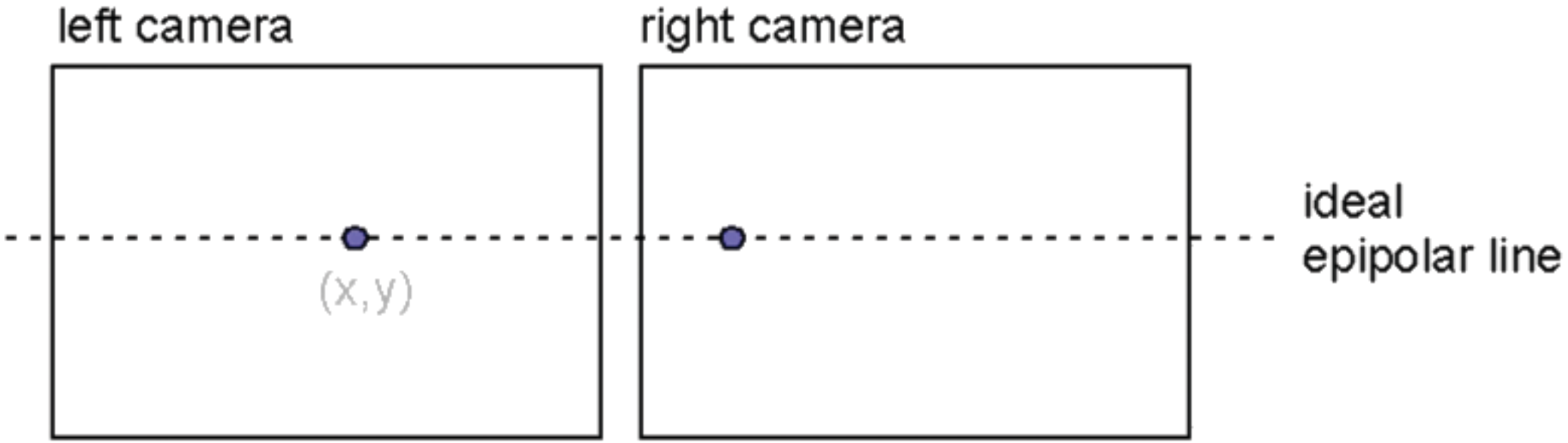
Real-World Benchmarks

Reliability on Easy Data

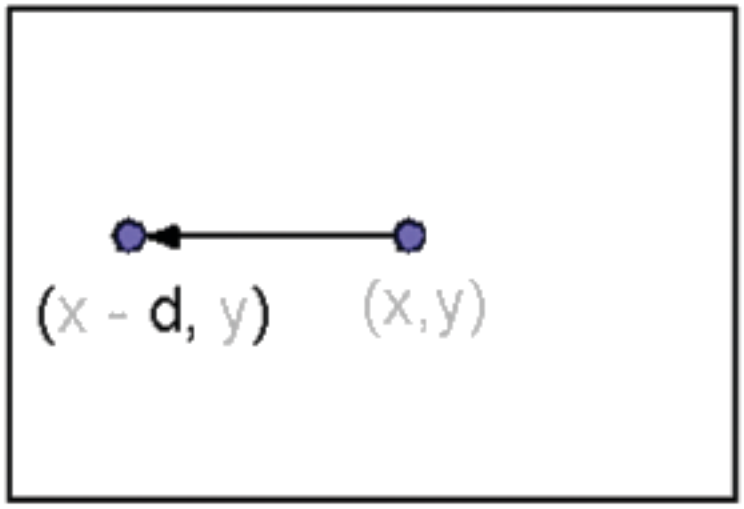
Conclusions

Stereo: an 1-dimensional Correspondence Problem

Detect corresponding points along epipolar lines



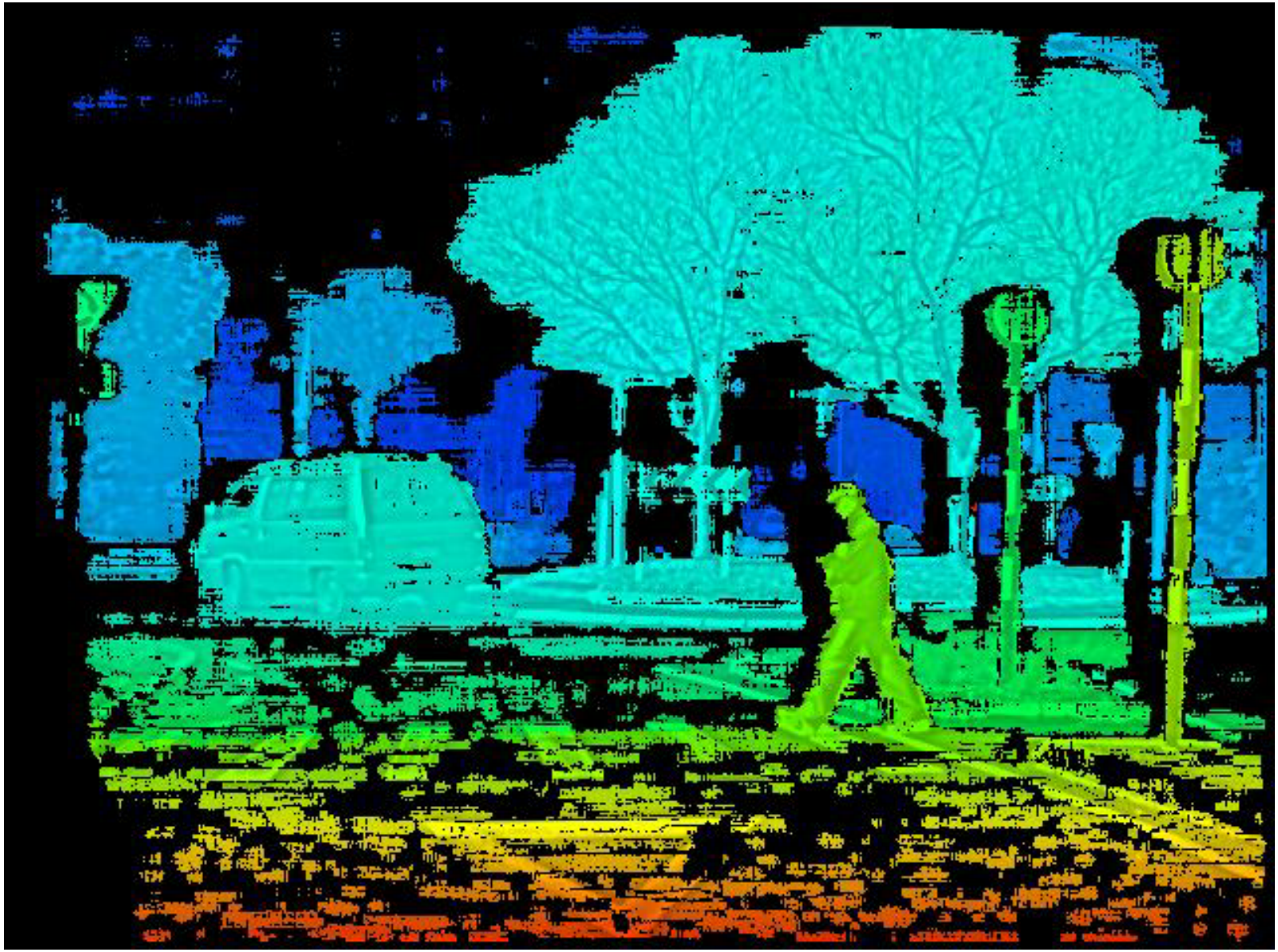
disparity d at (x,y) in left image



Rectified stereo video data

recorded at 25 Hz and 10 bit from HAKA1

Colors encode disparities (distances)



use of an SGM stereo matcher (8 path, census, 3x9)

[Simon Hermann 2011]

iSGM Designed in New Zealand

[Simon Hermann and Reinhard Klette, ACCV 2012]

iSGM is an iterative stereo matcher that extends the integration strategy of SGM

SGM is a method applied since 2007 in industrial vision systems due to its robust performance and real-time capability.

The KITTI Vision Benchmark Suite

The KITTI Vision Benchmark Suite

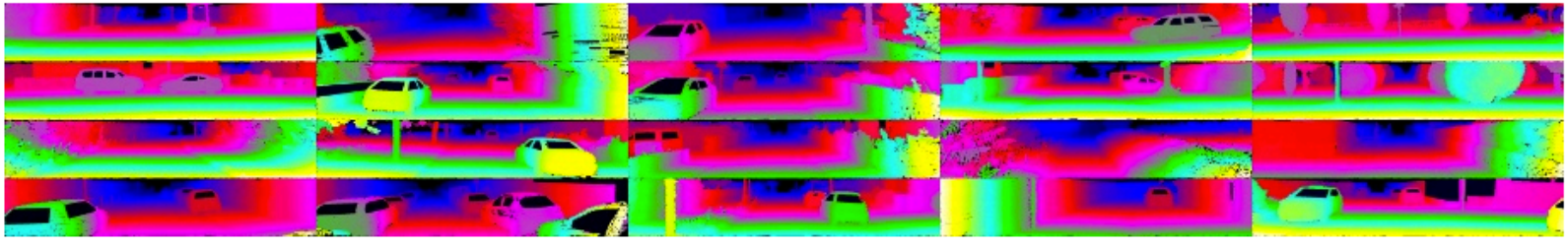
A project of Karlsruhe Institute of Technology and Toyota Technological Institute at Chicago

Karlsruhe Institute of Technology

home | setup | stereo | flow | odometry | object | tracking | raw data | submit your results

Andreas Geiger (KIT) | Philip Lenz (KIT) | Christoph Stiller (KIT) | Raquel Urtasun (TTI-C)

Dataset



The stereo / flow benchmark consists of 194 training image pairs and 195 test image pairs, saved in loss less png format. Our evaluation server computes the average number of bad pixels for all non-occluded or occluded (=all groundtruth) pixels. We require that all methods use the same parameter set for all test pairs. Our development kit provides details about the data format as well as MATLAB / C++ utility functions for reading and writing disparity maps and flow fields.

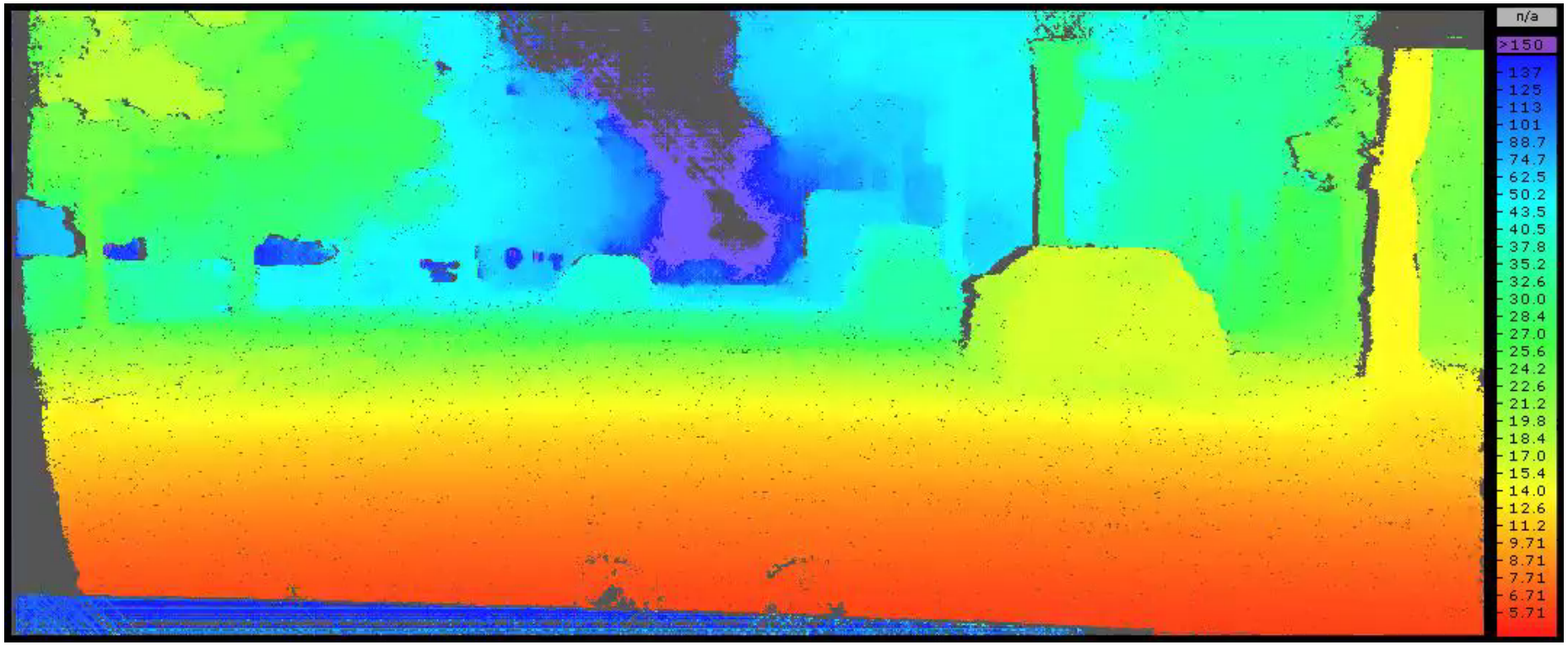
- Download stereo/optical flow data set (720 MB)
- Download multi-view extension (20 frames per scene, all cameras) (17 GB)
- Download stereo/optical flow development kit (1 MB)

[Andreas Geiger et al. 2012]

Evaluation

Our evaluation table ranks all methods according to the number of non-occluded erroneous pixels at the specified disparity / end-point error threshold. All methods providing less than 100 % density have been interpolated using simple background interpolation as explained in the corresponding header file in the development kit. For each method we show:

iSGM for KITTI’s good weather data (with ground truth)



Current Ranking on KITTI Stereo Page

Top-ranked methods can be considered to be equally good with respect to the KITTI reference index.

PCBP [Toyota Research Chicago]

iSGM [.enpeda.. group, Auckland]

SGM [German Air and Space Institute]

SNCC [Honda Research]

...

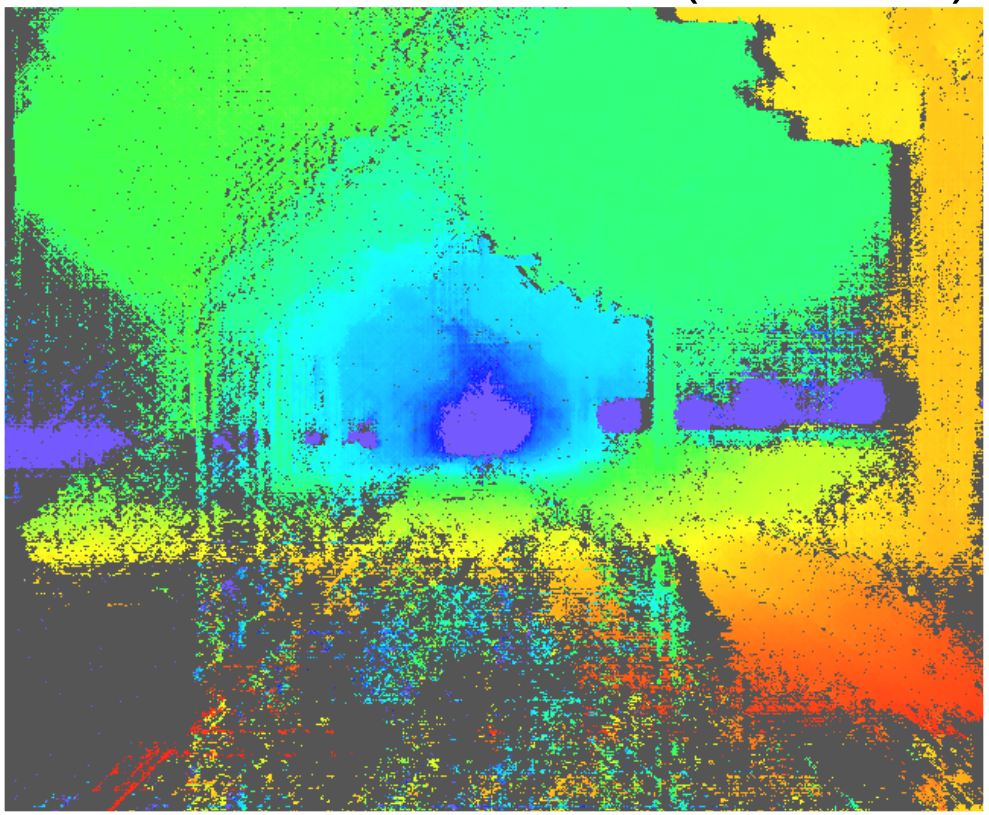
6 December 2012

Rank	Method	Setting	Out-Noc	Out-All	Avg-Noc	Avg-All	Density	Runtime	Environment
1	PCBP		4.13 %	5.45 %	0.9 px	1.2 px	100.00 %	5 min	4 cores @ 2.5 Ghz (Matlab + C/C++)
Koichiro Yamaguchi, Tamir Hazan, David McAllester and Raquel Urtasun. Continuous Markov Random Fields for Robust Stereo Estimation. ECCV 2012.									
2	iSGM		5.16 %	7.19 %	1.2 px	2.1 px	94.70 %	8 s	2 cores @ 2.5 Ghz (C/C++)
Simon Hermann and Reinhard Klette. Iterative Semi-Global Matching for Robust Driver Assistance Systems. ACCV 2012.									
3	SGM		5.83 %	7.08 %	1.2 px	1.3 px	85.80 %	3.7 s	1 core @ 3.0 Ghz (C/C++)
Heiko Hirschmueller. Stereo Processing by Semi-Global Matching and Mutual Information. IEEE Transactions on Pattern Analysis and Machine Intelligence 2008.									

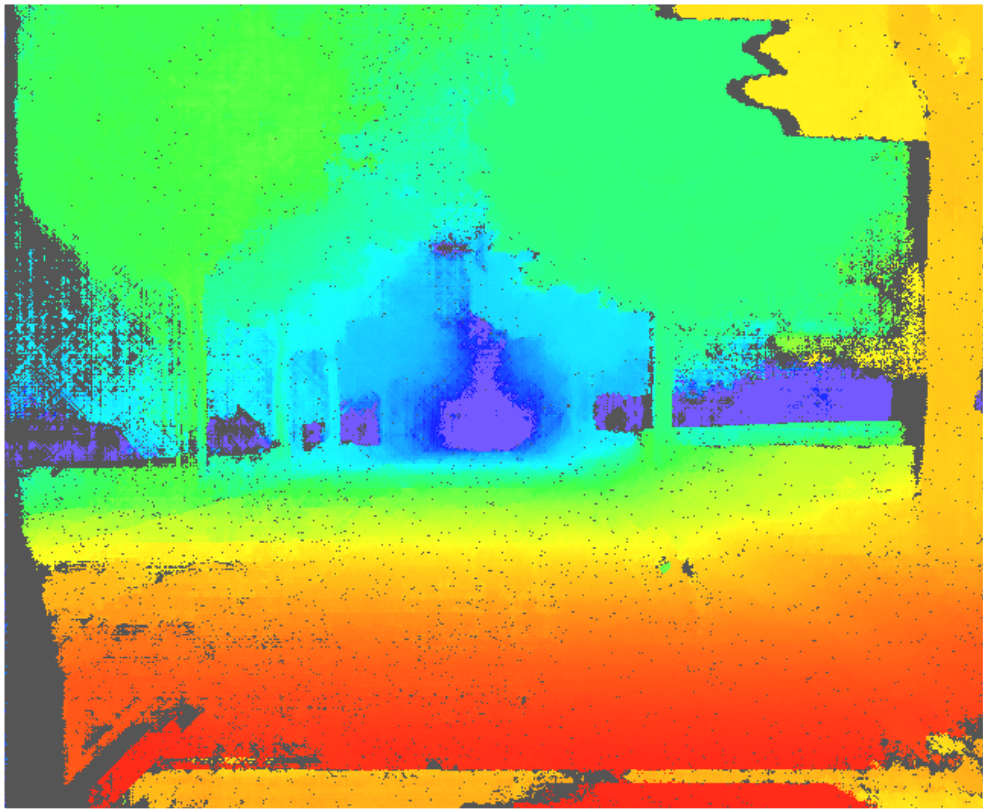
This task is practically solved with about 5% error

Rain: not KITTI but HCI/Bosch/ECCV 2012 data

SGM (standard)



iSGM



Bosch Robust Vision Challenge at ECCV 2012

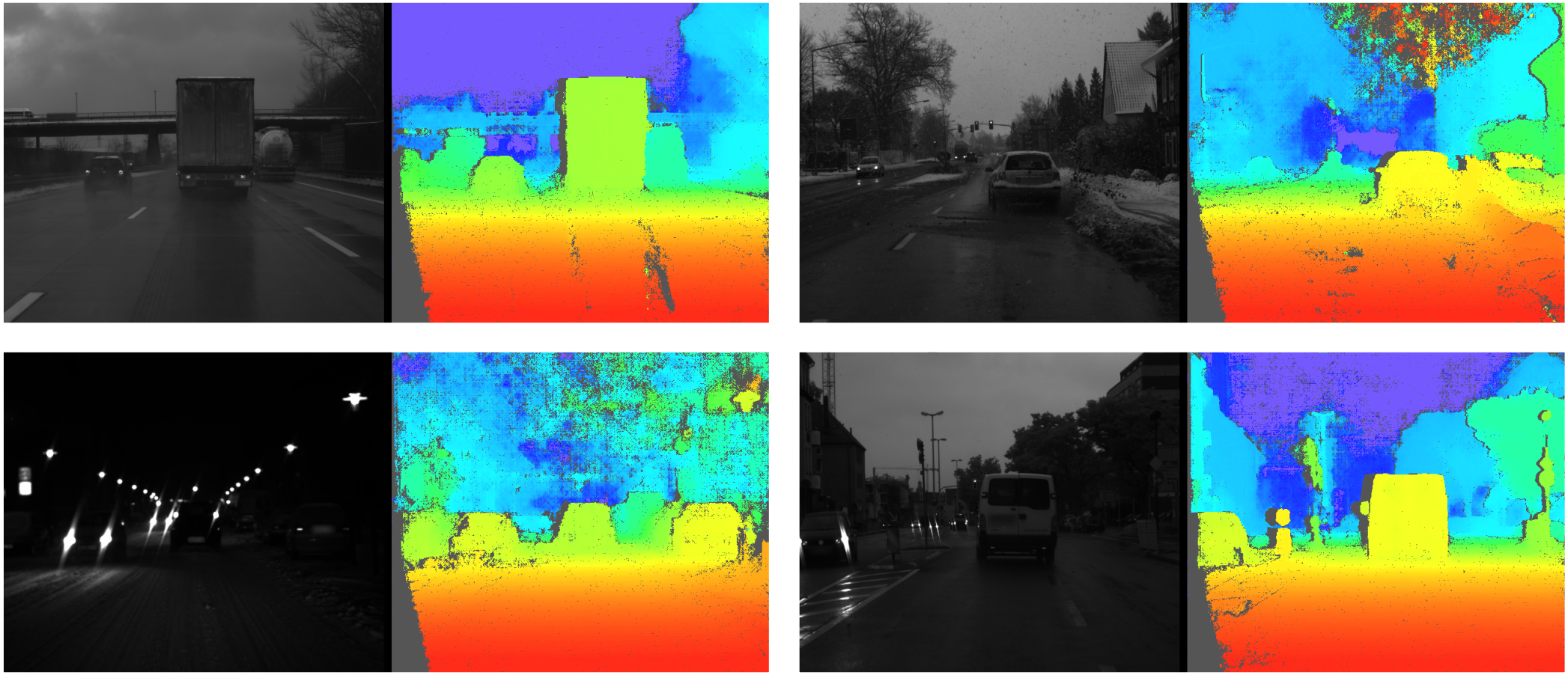
Challenging Video Data

[Meister, S., Jähne, B., Kondermann, D., Optical Engineering, 2012]

Decision by International Jury (no ground truth)

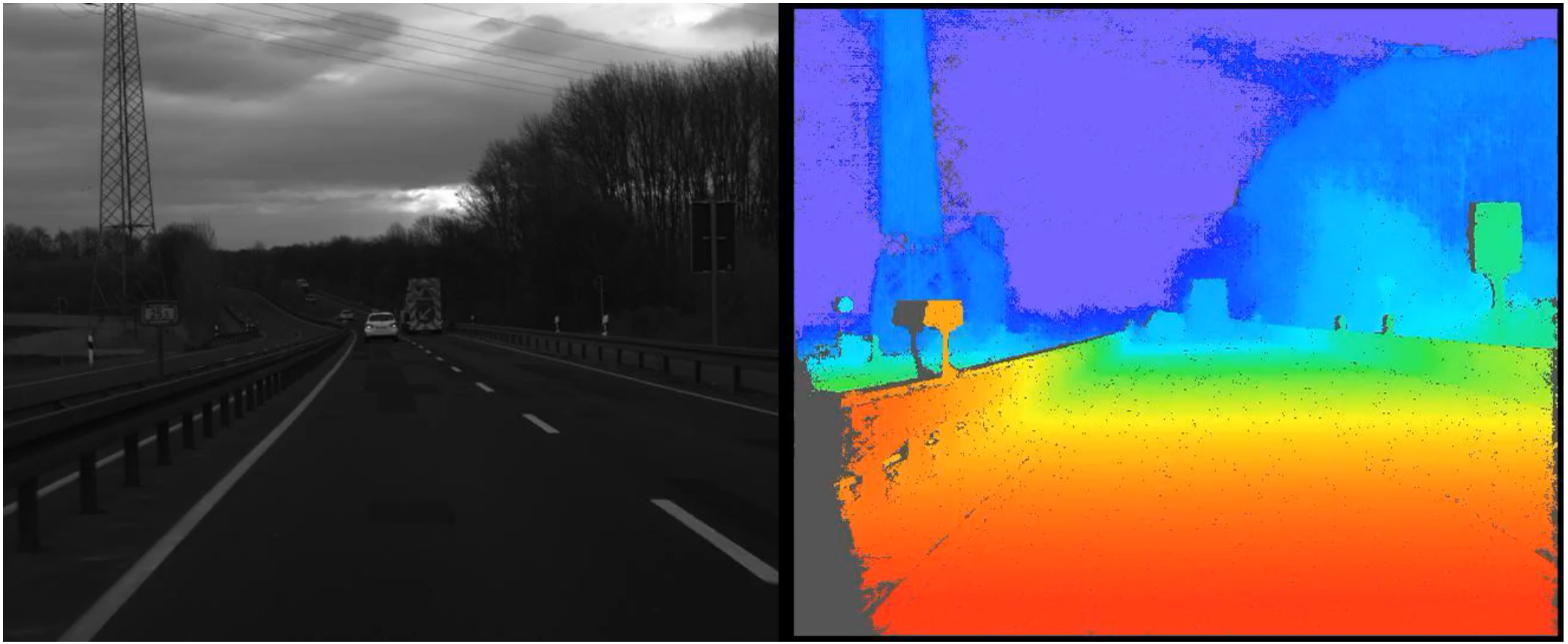
Microsoft Research:	Simon Baker, Ph.D.
Texas Instruments:	Goksel Dedeoglu, Ph.D.
Volkswagen Research Driver Assistance:	Jan Effertz, Dr.
Sony:	Oliver Erdler, Dipl.Ing.
Robert Bosch GmbH:	Wolfgang Niehsen, Dr.
The Foundry:	Phil Parsonage, M.Sc.
Robert Bosch GmbH:	Stephan Simon, Dr.
BMW Group:	Christian Unger, M.Sc.

iSGM results for the ‘Bosch Robust Vision Challenge’ at ECCV 2012



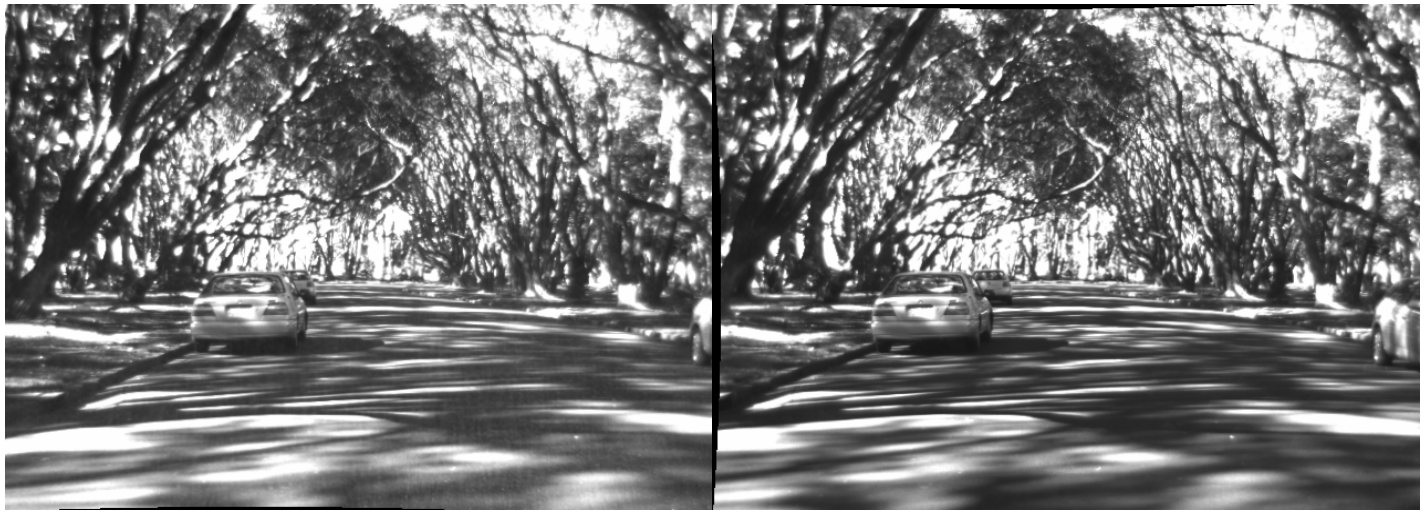
[Simon Hermann 2012]

From the winning iSGM submission



No ground truth, decision by subjective evaluation of jury

More of this ...

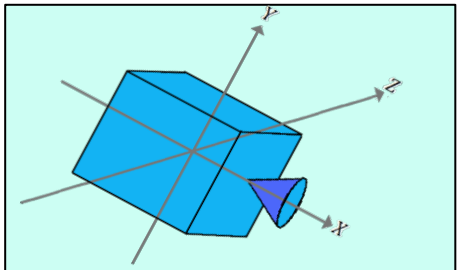


Stereo matching is practically solved for easy data; we need to focus on **robustness** (= accuracy not only for easy but also for challenging data)

How to evaluate on real-world data ?

Third image

1



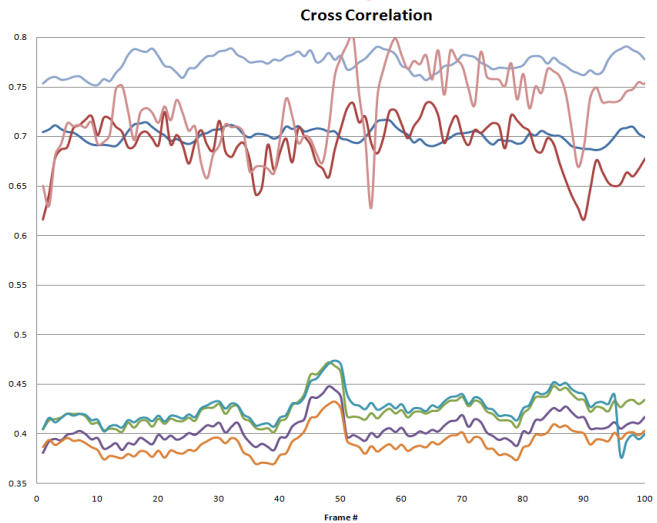
Pose of third camera

2

Depth Map

3

Virtual Image

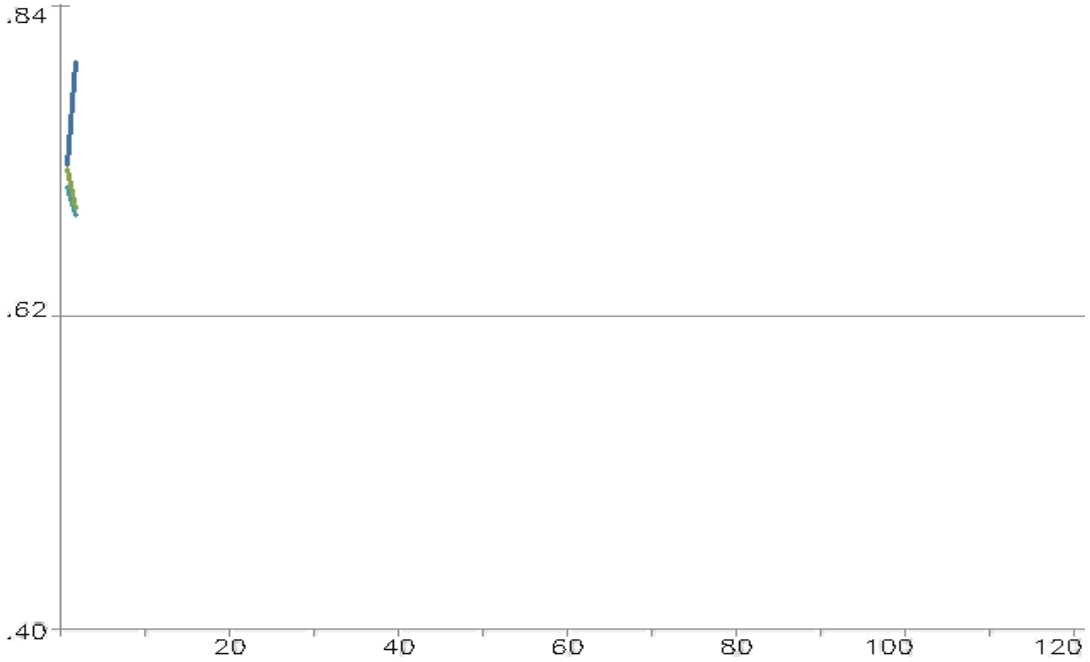


[Sandino Morales and Reinhard Klette 2009]

Example: BP techniques on 120 frames

BP on original data

BP on residuals w.r.t. smoothing



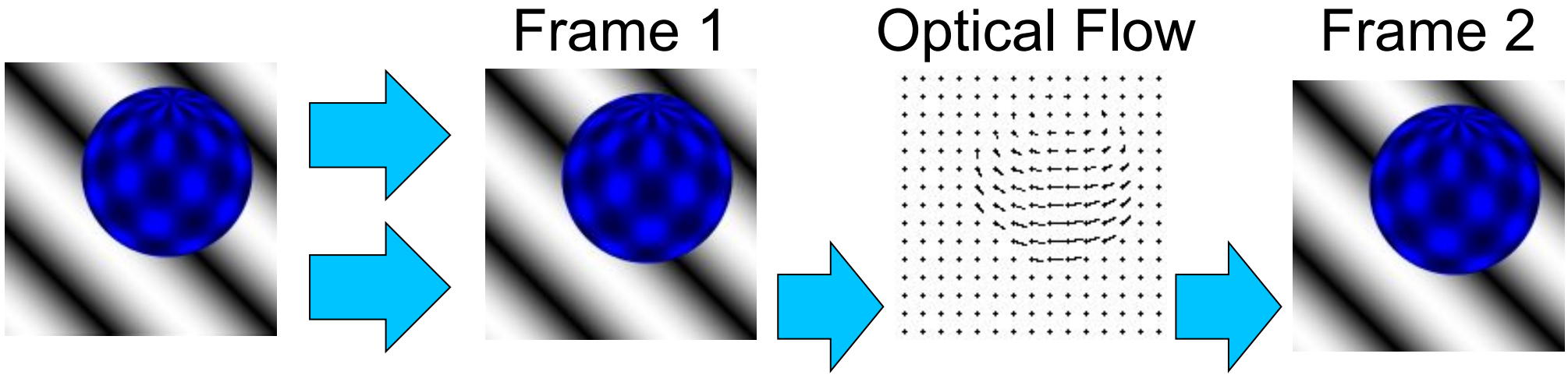
Original
Residual
Sobel

3D reconstruction using iSGM (5 fps)

Yi Zeng 2012

Motion: a 2-dimensional Correspondence Problem

Detect corresponding points in the image plane



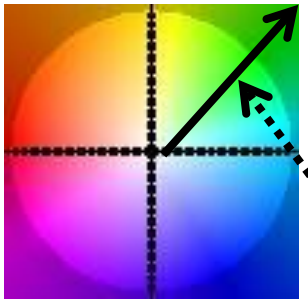
Middlebury College Optic Flow Data

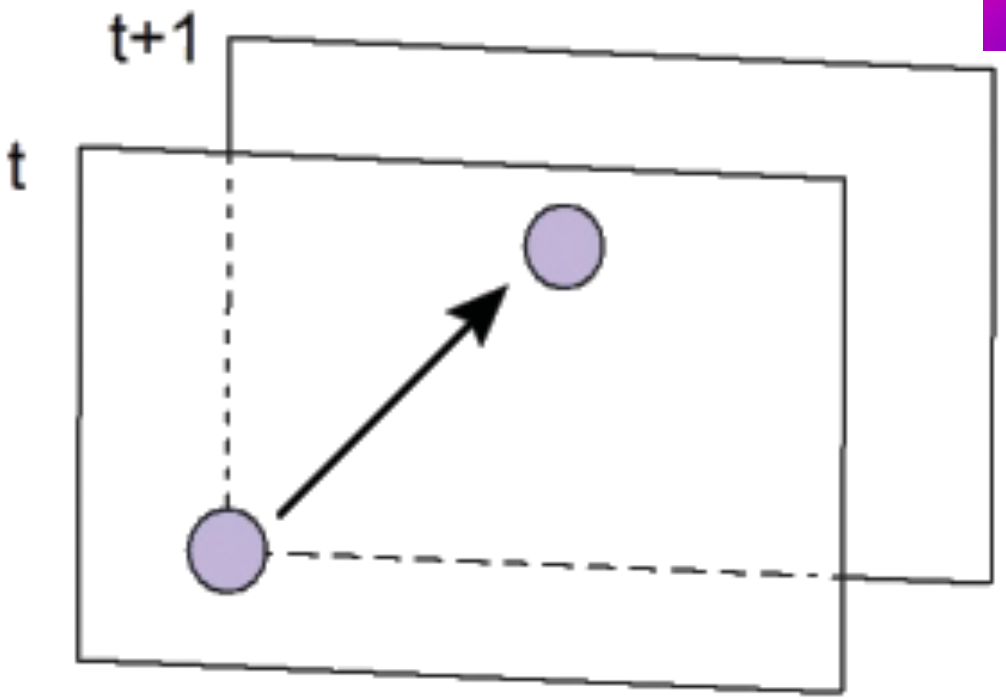
Image 1

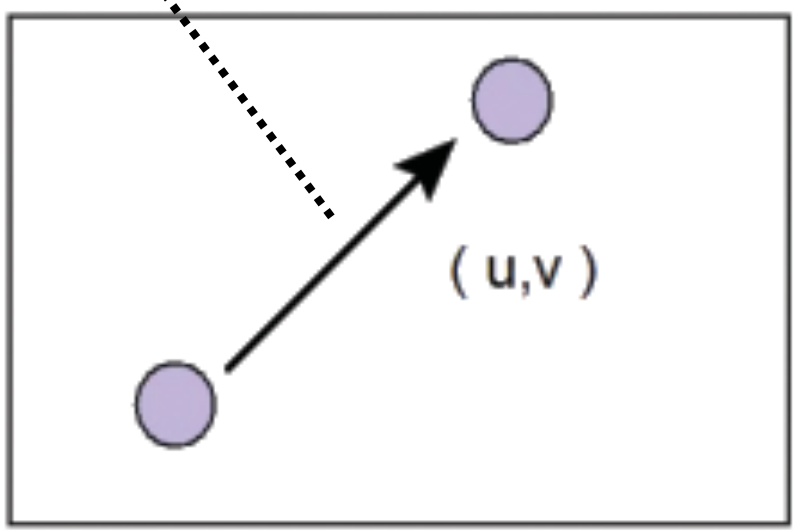
Image 2

Optical Flow – 2D Search

A color key







Original frames

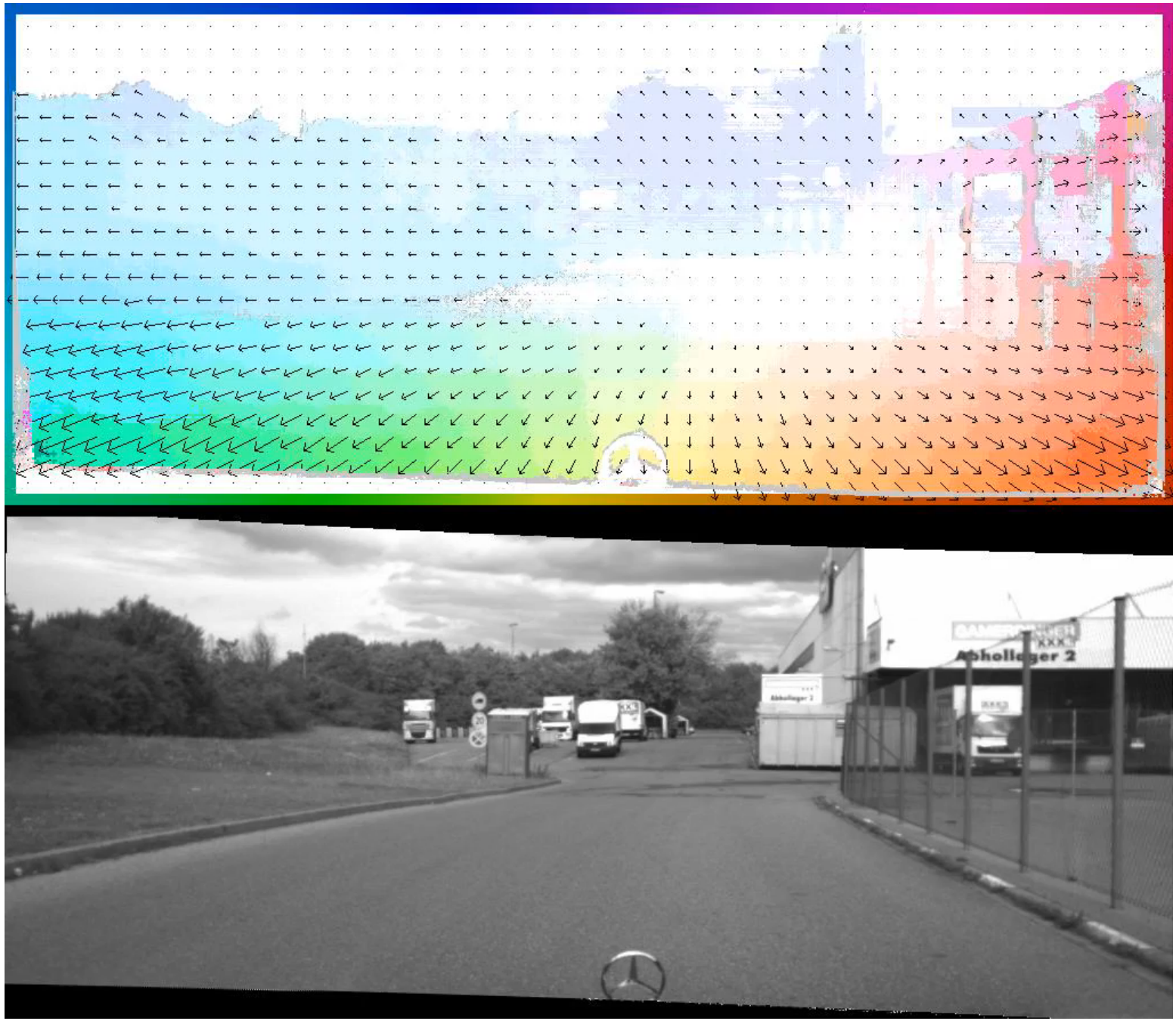
Optical flow

fSGM Designed in New Zealand

[Simon Hermann and Reinhard Klette, ACCV 2012 workshop]

- fSGM is a discrete optic flow estimator
- It uses dynamic programming in combination with the SGM integration strategy
- Maps 1D (`disparity') labels 1-1 on 2D flow vectors
- Combines mid-scale flow analysis with large-scale analysis

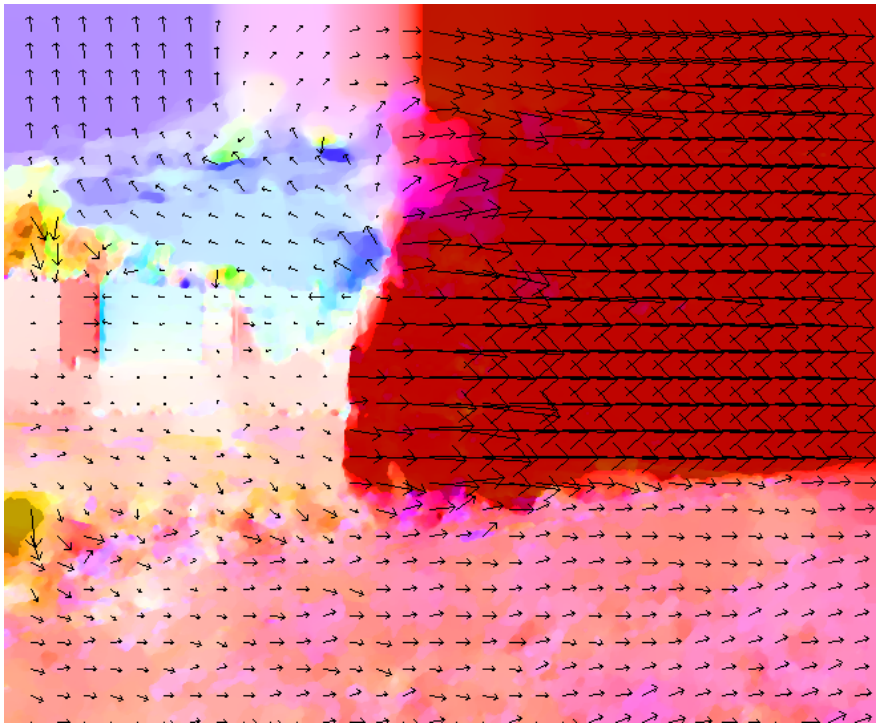
fSGM submission to ACCV 2012 (10 fps)



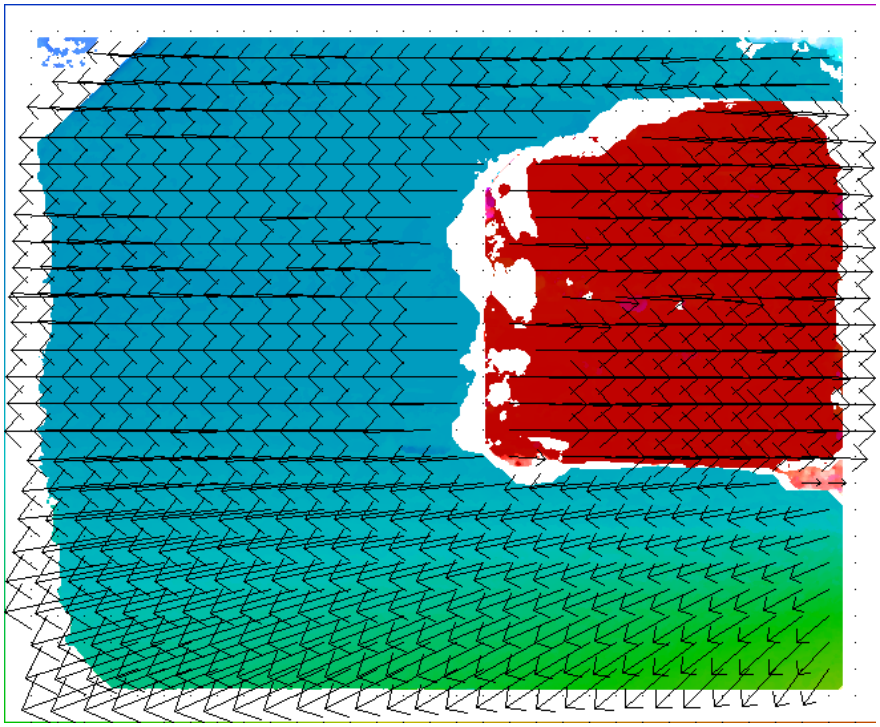
fSGM on HCI data

Example of a frame of HCI data on which fSGM outperfoms variational methods

TV-L1

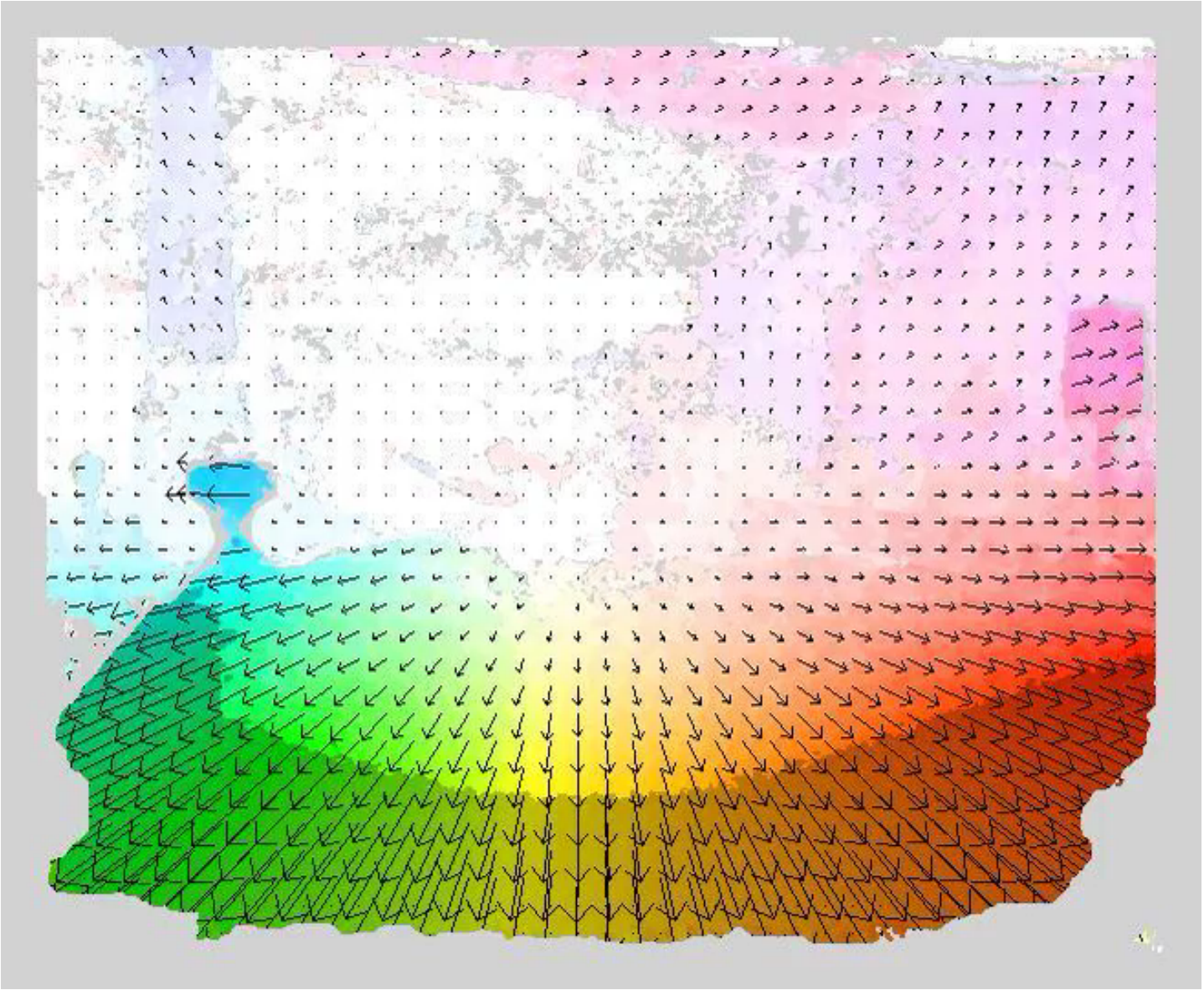


fSGM



[Simon Hermann 2012]

fSGM and iSGM together win at ECCV 2012



Optical flow result is still far from being satisfying

Conclusions

Quality of stereo analysis results: about 90% where we want to be; the challenge is difficult data; the focus must shift to robustness (= accuracy also on difficult data)

Real-world benchmarks needed with minutes or even hours of recorded data; the `third-eye' method supports quantitative evaluation

Optic flow: about 60% only, even for easy data not yet satisfactory solved; robustness not yet the main focus, accuracy on easy data still of interest

[Thanks to Simon Hermann, Sandino Morales, and Yi Zeng]