

Group of Prof. Marc Pollefeys

Computer Vision and Geometry



Research Statement

The goal of computer vision is to extract information from images. It is an area that builds on solid mathematical foundations, closely relates to machine learning and finds some of its key applications in robotics and computer graphics. The area has gained a lot of attention in recent years. While the fundamental problem of full scene understanding is far from being solved, a lot of progress has been made for specific tasks and many computer vision algorithms are now being deployed in real-world products, ranging from build-in face-detection in cameras over driver-assistance systems to visual tracking for augmented reality applications.

The Computer Vision and Geometry group works on developing algorithms that extract geometric information from images. Our goal is to compute the 3D shape and motion of observed humans, objects or scenes, as well as the camera motion and calibration parameters. Specifically, in the last few years, we have developed algorithms that allow camera systems to automatically calibrate themselves from input imagery, construct visual maps of the environment, visually (geo)localize images, detect changes in environments and obtain 3D models. We have also worked on algorithms for hand motion-capture and for human-pose estimation, as well as combining casually captured videos in immersive interactive visual representations of events.

While the group has an important focus on proposing novel algorithms and obtaining novel theoretical insights, we also believe it is important to apply these algorithms to real-world challenges. We have helped develop cars that drive autonomously using cameras as the main sensors to map and localize themselves in their environment, detect obstacles and identify empty parking spots around the vehicle. We were the first to demonstrate a vision-based

fully autonomous micro-aerial vehicle that would explore and map out its environment, avoid obstacles and operate both indoors and outdoors in cluttered environments. Similarly, we were the first to develop a pure software solution to turn a standard mobile phone into an interactive 3D scanner and have worked with Google on integrating some of those capabilities in Project Tango devices.

Recently, the main focus of the group has shifted from purely geometric estimation problems to joint estimation of geometric and semantic properties. We have proposed a method to jointly perform 3D reconstruction, recognition and segmentation. The approach allows a strong coupling between the estimation of geometric and semantic properties of the scene by performing class-specific anisotropic regularization (e.g. facades are likely to be vertical; ground is likely to be close to horizontal). We formulate the problem as a volumetric multi-class segmentation problem and solve it with convex optimization of a (tight) continuous relaxation of a joint energy combining data and regularization terms. We are working on extending this formulation to handle much more general scenes and hope to make significant advances towards complete visual scene understanding.

Group Homepage

<http://cvg.ethz.ch/>

Research Areas

- Visual Computing
- Data Management and Machine Learning
- Pervasive Computing and Cyberphysical Systems

Keywords

Computer vision, 3D modeling, robotic perception, computer graphics, machine learning, Pervasive Computing & Cyberphysical Systems

Curriculum Vitae

Degrees

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- 1999** PhD in Applied Science, KU Leuven, Belgium
 - 1994** MSc in Electrical Engineering, KU Leuven, Belgium

Professional Career

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- 2007-** Full Professor, Department of Computer Science, ETH Zurich, Switzerland
 - 2005-09** Associate Professor, UNC-Chapel Hill, USA
 - 2002-05** Assistant Professor, UNC-Chapel Hill
 - 1999-02** Postdoc, KU Leuven, Belgium
 - 1994-99** Research Assistant, KU Leuven

Visiting Position

2007 Visiting Associate Professor, Stanford University

Major Honors and Awards

2014, 2013, 2011, 2010 Google Research Award

2012 IEEE Fellow

2012 HP Innovation Award

2011 Kevin Koeser, Christopher Zach, Marc Pollefeys, DAGM Best Paper Award

2008 ERC Starting Grant

2005 Packard Fellowship for Science and Technology

2003 NSF Career Award

1999 Benno Heigl, Reinhard Koch, Marc Pollefeys, Joachim Denzler and Luc Van Gool, DAGM Best Paper Award

1998 Marc Pollefeys, Reinhard Koch and Luc Van Gool: Marr Prize (ICCV Best Paper Award)

Major Honors and Awards: Group Members

2015 Thomas Schöps, Qualcomm Innovation Fellowship

2014 Alexander Schwing, ETH Medal, PhD thesis

2013 Bernhard Zeisl, Qualcomm Innovation Fellowship

2012 Lorenz Meier, Qualcomm Innovation Fellowship

2010 Roland Angst, Google PhD Fellowship

Major Activities, Service, Outreach (last 10 years)

ETH

- Head of Institute of Visual Computing, 2009-2015
- Member of ETH research commission, 2014-present

Service

- General chair, European Conference on Computer Vision, Zurich, 2014
- Program chair, IEEE Int. Conf. on Computer Vision and Pattern Recognition, Miami, 2009
- Editorial board member, International Journal of Computer Vision, 2005-2013
- Associate editor, IEEE Transactions on Pattern Analysis and Machine Intelligence, 2005-2009
- Editorial board member, Foundations and Trends in Computer Vision, 2003-present
- Editorial board member, Encyclopedia of Computer Vision, 2009-2014
- IEEE CS Fellows committee, 2013-present

Keynotes and Invited Talks

- Keynote, Embedded Vision Workshop, 2015
- Invited talk, Workshop on Computer Vision for Vehicle Technology, 2015
- Invited talk, Workshop on Semantics for Visual Reconstruction, Localization and Mapping, 2015

- Keynote, CeBIT Global Conference, 2015
- Invited talk, REAL, 2015
- Keynote, Digital Landscape Architecture, 2014
- Invited talk, 4th IEEE Workshop on Consumer Depth Cameras for Computer Vision, 2014
- Keynote, ICCV Workshop on 3D Representation and Recognition (3dRR), 2013
- Invited talk, International Workshop on Dynamic Shape Capture and Analysis (4DMOD), 2013
- Invited talk, CVPR Workshop on Visual Analysis and Geo-Localization of Large-Scale Imagery, 2013
- Keynote, IEEE IVMSP Workshop on 3D Image/Video Technologies and Applications, 2013
- Invited talk, ICRA Workshop on 3D Representation and Recognition, 2013
- Keynote, SPAR Europe, 2012
- Keynote, Symposium on Geometry Processing, 2012
- Keynote, EuroGraphics Symposium on Rendering, 2011
- Keynote, International Symposium on Visual Computing, 2010
- Keynote, European Conference on Visual Media Production, 2009
- Invited talk, International Symposium of Robotics Research, 2009
- Keynote, Digital Media and its Applications in Cultural Heritage, 2008
- Keynote, Int. Fall Workshop on Vision, Modeling and Visualization (VMV), 2008
- Keynote, 3DTV-CON, 2008

Research Bodies

- European Research council, computer science starting grant panel, 2014
- Flemish Fund for Scientific Research, Belgium, computer science panel, 2009-present

Teaching

At Bachelor's level, I co-teach "Linear Algebra" for computer scientist in the first year with a professor from the Mathematics Department and I also co-teach "Visual Computing" with Markus Gross for third-year Bachelor's students and students of computational sciences.

At Master's level, I co-teach the core focus course "Computer Vision" with Luc Van Gool (Department of Electrical Engineering) and the specialized Master's course on 3D photography. I also participate in the organization of the seminar on "Computer Graphics and Vision", as well as the doctoral seminar on "Visual Computing".

Selected Publications

L. Ladicky, J. Shi and M. Pollefeys, **Pulling things out of perspective**, Proc. IEEE Int. Conf. on Computer Vision and Pattern Recognition (CVPR), 2014

C.Zach, C. Haene and M. Pollefeys, **What Is Optimized in Convex Relaxations for Multi-Label Problems: Connecting Discrete and Continuously-Inspired MAP Inference**, IEEE Transactions on Pattern Analysis and Machine Intelligence, Issue No. 01 - Jan. (2014 Vol.36), pp. 157-170

C. Haene, C. Zach, A. Cohen, R. Angst and M. Pollefeys, **Joint 3D Scene Reconstruction and Class Segmentation**, Proc. IEEE CVPR, 2013

R. Angst and M. Pollefeys, **Multilinear Factorizations for Multi-Camera Rigid Structure from Motion Problems**, International Journal of Computer Vision, June 2013, Vol. 103, Issue 2, pp. 240-266

F. Fraundorfer, H. Lionel, D. Honegger, G.H. Lee, L. Meier, P. Tanskanen and M. Pollefeys, **Vision-Based Autonomous Mapping and Exploration Using a Quadrotor MAV**, Proc. IEEE/RSJ Int. Conf. on Intelligent Robots & Systems (IROS), finalist Best Paper Award, 2012

J.-M. Frahm, P. Georgel, D. Gallup, T. Johnson, R. Raguram, C.Wu, Y.-H. Jen, E. Dunn, B. Clipp, S. Lazebnik and M. Pollefeys, **Building Rome on a Cloudless Day**, Proc. European Conference on Computer Vision (ECCV), 2010

L. Ballan, J. Puwein, G. Brostow and M. Pollefeys, **Unstructured Video-Based Rendering: Interactive Exploration of Casually Captured Videos**, ACM Transactions on Graphics (SIGGRAPH), 2010

D. Gallup, J.-M. Frahm and M. Pollefeys, **Piecewise Planar and Non-Planar Stereo for Urban Scene Reconstruction**, Proc. IEEE CVPR, 2010

M. Pollefeys, D. Nister, J.-M. Frahm, A. Akbarzadeh, P. Mordohai, B. Clipp, C. Engels, D. Gallup, S.-J. Kim, P. Merrell, C. Salmi, S. Sinha, B. Talton, L. Wang, Q. Yang, H. Stewenius, R. Yang, G. Welch and H. Towles, **Detailed Real-Time Urban 3D Reconstruction From Video**, International Journal of Computer Vision, Vol. 78, Issue 2, pp. 143 - 167, July 2008

J. Yan and M. Pollefeys, **A General Framework for Motion Segmentation: Independent, Articulated, Rigid, Non-rigid, Degenerate and Non-degenerate**, Proc. ECCV, 2006

Research Group

My research group consists of Postdocs and PhD students. Postdocs typically help supervise PhD students, perform some teaching at MSc level and help coordinate research projects. I like to keep a balance between more theoretically and more practically-oriented PhD students. The group is funded approximately by one third from base ETH resources, one third from competitive Swiss and EU research funds and one third through collaboration with industry (including gifts).

Group Members (current)

PhD students 15

Postdocs 2

Senior Scientist 1

Projects (last 5 years)

Name of project	Partners	Funding source	Duration
3D image understanding for urban scenes	Konrad Schindler (ETH)	SNSF	2015-2017
Geometric and semantic structuring of 3D point clouds	Konrad Schindler (ETH) & Hexagon	KTI	2014-2016
3D face scanning and verification on mobile devices	U. Basel, OneVisage (start-up)	KTI	2014-2016
Built2Spec	Multiple partners	CH/EU	2015-2018
V-MAV	TU Munich & TU Graz	SNSF	2014-2017
Human-centric flight	Otmar Hilliges (ETH) & Microsoft	Microsoft	2014-2017
Google Tango	Roland Siegwart (ETH) & Google	Google	2013-2015
V-charge	Roland Siegwart (ETH), VW, U. Oxford, U. Parma, TU Braunschweig, Bosch	EU	2011-2015
sFly	Roland Siegwart (ETH), TU Crete, INRIA, CSEM	EU	2009-2012
4DVideo		ERC/EU	2008-2013
Reconstructing reflective surfaces		SNSF	2012-2016
Building Explorer		Google	2010-2016
Multi-view analysis of video footage	LiberoVision/Vizrt	KTI	2011-2013
Terrain analysis, feature extraction and model deformation for cartographic generalisation and visualisation	Lorenz Hurni (ETH)	SNSF	2010-2015

PhD Theses Completed (last 5 years)

PhD student	Job after graduation	Year
Lionel Heng	DSO National Laboratories, Singapore	2014
Jens Puwein	LiberoVision (acquired by Vizrt), Zurich, Switzerland	2014
Aparna Taneja	Disney Research Zurich, Switzerland	2014
Kim Hee Lee	National University Singapore	2014
Alexander Schwing	University of Toronto, Canada	2013
Georges Baatz	Google, Zurich, Switzerland	2012
Roland Angst	Stanford University, CA, USA	2012
Changchang Wu (UNC)	University of Washington, Seattle, USA	2010
David Gallup (UNC)	Google, Seattle, USA	2010
Brian Clipp (UNC)	ARA, Durham, USA	2010

Current Main Collaborators

Roland Siegwart	Department of Mechanical Engineering, ETH Zurich, Switzerland
Otmar Hilliges	Department of Computer Science, ETH Zurich, Switzerland
Konrad Schindler	Department of Civil, Environmental and Geomatic Engineering, ETH Zurich, Switzerland
Thomas Vetter	Graphics and Vision Research Group, University of Basel, Switzerland
Jan-Michael Frahm	Department of Computer Science, University of North Carolina at Chapel Hill, USA
Markus Gross	Department of Computer Science, ETH Zurich, Switzerland