

# Resume –Yuchao Dai

## Contact Information

**Affiliation:** Research School of Engineering, College of Engineering and Computer Science, The Australian National University  
**Contact:** +61 (02) 6125 7323 0432766082  
**E-mail:** [yuchao.dai@anu.edu.au](mailto:yuchao.dai@anu.edu.au) [daiyuchao@gmail.com](mailto:daiyuchao@gmail.com)  
**Homepage:** <http://users.cecs.anu.edu.au/~yuchao/>  
**Address:** Building 115, North Road, the Australian National University, 2601, ACT, Australia

## Research Interests

Geometric computer vision (multi-view geometry, structure from motion, non-rigid structure-from-motion), 3D computer vision, Deep Learning, SLAM (Simultaneous Localization and Mapping), Multi-camera system, Human computer interaction, Compressive sensing, Optimization

## Highlights

- **ARC DECRA Fellowship (2014-2017)**
- **IEEE CVPR 2012 Best Paper Award (the only one out of 1933)**
- **DICTA 2014 DSTO Best Fundamental Contribution to Image Processing Paper Prize**
- **Ten-year research experience in geometric computer vision and optimization**
- **Teaching experience in computer vision, image processing, and programming**
- **Significant contributions to 3D computer vision, in particular non-rigid structure from motion and multi-view camera geometry**

## Work Experience

- 2014.5-Present. ARC DECRA Fellow. Research School of Engineering, College of Engineering and Computer Science, the Australian National University. Project: **Advancing Dense 3D Reconstruction of Non-rigid Scenes by Using a Moving Camera.**
- 2012.5-2014.5. Research Fellow, Research School of Computer Science, College of Engineering and Computer Science, the Australian National University. Project: **Touch-less Human-Computer Interaction with Application to Medical Image Visualization.** Supervisor: A/Prof. Henry Gardner, A/Prof. Hongdong Li.

## Education

- 2007.9—2012.5. School of Electronics and Information, Northwestern Polytechnical University, PhD, Thesis: *Research on Structure and Motion Recovery in Multi-view Geometry (Rotation Averaging, Rigid Structure from Motion, Non-rigid Structure from Motion, Structure and Motion Recovery for Multi-camera System under Generalized*

**Camera Model, Global Optimization with  $L_{\infty}$  Norm**). Supervisors: Prof. Mingyi He, Prof. Richard Hartley, A/Prof. Hongdong Li.

- 2008.10-2009.10. Research School of Information Sciences and Engineering (RSISE), Australian National University supported by the China Scholarship Council. Research Topic: Structure and motion recovery in multi-view geometry (**Camera-Rig Calibration, Rigid Structure from Motion, Structure and Motion Recovery for Multi-camera System under Generalized Camera Model, Global Optimization with  $L_{\infty}$  Norm**). Co-Supervisors: Prof. Richard Hartley, A/Prof. Hongdong Li, Prof. Mingyi He.
- 2005.9-2008.4, School of Electronics and Information, Northwestern Polytechnical University, Master of Engineering. Thesis: Research on Camera Calibration, Image Registration and 3D Measurement in Multi-view System (**Multi-camera Calibration, Image Registration**), Supervisor: Prof. Mingyi He.
- 2001.9-2005.7, Dept. of Electronic Engineering, Northwestern Polytechnical University, Bachelor of Engineering (First 3 years studied in advanced class which educates the most excellent students of NPU directly for the Master degree). Thesis: Research on Stereo Vision System. Supervisor: Prof. Mingyi He.

## Grants

- 2014-2017, ARC DECRA Project DE 140100180 **Advancing Dense 3D Reconstruction of Non-rigid Scenes by Using a Moving Camera, Sole CI.**
- 2015-2019, NSFC International Major Project **Imaging and Processing in Joint Hyperspectral and Multiview Observation of Complex and Dynamic Targets, CI.**
- 2015-2016, Industrial Project with World Class Auto Company on **Autonomous Driving, CI.**
- 2017, Industrial Project on Virtual Reality/Augmented Reality. **CI.**
- 2012.5-2015.12, ARC Linkage Project LP100100588 **Advancing Medical Image Analysis through High Performance Heterogeneous Computing, Numerical Simulation, and Novel Human Computer Interfaces**, leded by A/Prof. Henry Gardner and A/Prof. Hongdong Li.
- 2008.01-2012.05, NSFC Project **Multi-view and Large-view Hyperspectral Detection and Image Processing**, leded by Prof. Mingyi He.

## Teaching Experience

- ✓ Computer Vision for both undergraduate and graduate (**ENGN 4528/6528**) 2015, 2016 at the ANU
- ✓ Course convener for Individual Project (**ENGN 4200**) at ANU 2016, 2017
- ✓ Computer Networking, Object Oriented Programming (C++), Website Develop and Management at NPU

## Workshop and Tutorial Organization

- Asian Conference on Computer Vision (ACCV 2016) Tutorial on “Multi-view Geometry for Rolling Shutter Cameras”
- International Conference on Multimedia and Expo (ICME 2017) Workshop on “Large Scale 3D Human Activity Analysis Challenge In Depth Videos”

- Session Chair of ChinaSIP 2014

## Refereed Publications

- Refereed Journal Articles

- [1] Suryansh Kumar, **Yuchao Dai**, Hongdong Li. Spatio-Temporal Union of Subspaces for Multi-body Non-rigid Structure-from-Motion. **Pattern Recognition**. 2017. In Press.
- [2] Liu Liu, Hongdong Li, **Yuchao Dai** and Quan Pan. Robust and Efficient Relative Pose with a Multi-camera System for Autonomous Driving in Highly Dynamic Environments. **IEEE Transactions on Intelligent Transport System**. 2017. Accepted.
- [3] Dingfu Zhou, Yuchao Dai and Hongdong Li. Ground Plane based Absolute Scale Estimation for Monocular Visual Odometry. **IEEE Transactions on Intelligent Transport System**. 2017. Under Review.
- [4] Dingfu Zhou, Yuchao Dai and Hongdong Li. Pixel-variant Local Homography for Fisheye Stereo Rectification Minimizing Resampling Distortion. **Pattern Recognition**. 2017. Ready to submit.
- [5] Dingfu Zhou, Vincent Fremont, Benjamin Quost, **Yuchao Dai** and Hongdong Li. Moving Object Detection and Segmentation in Urban Environments from a Moving Platform, Image and Vision Computing. Minor Revision.
- [6] **Yuchao Dai**, Hongdong Li, Mingyi He. A simple prior-free method for non-rigid structure-from-motion factorization. Invited submission to International Journal of Computer Vision (**IJCV**), 107(2): 101-122, 2014. (ISI **Impact Factor**=**4.270**, ERA ranking A) (IJCV is top journal in Artificial Intelligence and Image Processing.)
- [7] **Yuchao Dai**, Hongdong Li, Mingyi He. Projective Multi-view Structure and Motion from Element-wise Factorization. **IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI)**, 35(9): 2238-2251, 2013. (ISI **Impact Factor**=**6.077**, ERA ranking A\*) (TPAMI is top journal in Artificial Intelligence and Image Processing.)
- [8] Richard Hartley, Jochen Trunpf, **Yuchao Dai**, and Hongdong Li. Rotation Averaging. **International Journal of Computer Vision (IJCV)**. 103(3):267-305, 2013. (ISI **Impact Factor**=**4.270**, ERA ranking A) (IJCV is top journal in Artificial Intelligence and Image Processing.)
- [9] **Yuchao Dai**, Mingyi He, Hongdong Li, Bo Li. Generic smoothness constrained 3D trajectory reconstruction of moving object from monocular video. *Scientia Sinica Informationis*, 2012, 42(8):988-1006.
- [10] Shaohui. Mei, Mingyi He, and **Yuchao Dai**. A novel Double Signal Subspace Projection algorithm for Virtual Dimensionality Estimation. *Journal of Northwestern Polytechnical University*, vol. 30, no. 5, pp. 640-646, 2012. (In Chinese)
- [11] Jing Zhang, Mingyi He, **Yuchao Dai**, and Xiaogang Qu. Multi-Feature Fusion Based Circular Traffic Sign Detection. *Pattern Recognition and Artificial Intelligence*, vol. 24, no. 2, pp. 226-232, 2011. (In Chinese, Top Journal in China)
- [12] Mingyi He, Lin Bai, **Yuchao Dai** and Jing Zhang. Band Regrouping Based Lossless Compression of Hyperspectral Images. *Journal of Applied Remote Sensing*, no 4, 2010. (ISI Impact Factor =0.818 )

- Refereed conference papers and other articles

- [13] Suryansh Kumar, **Yuchao Dai** and Hongdong Li. Monocular Dense 3D Reconstruction of a Complex Dynamic Scene from Two Perspective Frames. ICCV 2017 Accepted.
- [14] Pan Ji, Hongdong Li, **Yuchao Dai** and Ian Reid. "Maximizing Rigidity" Revisited: a Convex Programming Approach for Generic 3D Shape Reconstruction from Multiple Perspective Views. ICCV 2017 Accepted.
- [15] Liu Liu, Hongdong Li and **Yuchao Dai**. Efficient Global 2D-3D Matching for Camera Localization in a Large-Scale 3D Map. ICCV 2017 Accepted.
- [16] Jing Zhang, Bo Li, **Yuchao Dai** and Mingyi He. Integrated Deep and Shallow networks for salient object detection. **ICIP 2017**, Accepted.
- [17] **Yuchao Dai**, Huizhong Deng and Mingyi He. Dense Non-rigid Structure-from-Motion Made Easy - A Spatial-Temporal Smoothness based Solution. **ICIP 2017**, Accepted.
- [18] Zhipeng Xiao, Hongdong Li, Dingfu Zhou, **Yuchao Dai**. Accurate Extrinsic Calibration between Monocular Camera and Sparse 3D Lidar Points without Markers. IEEE Intelligent Vehicles Symposium (**IV 2017**) Accepted.
- [19] Liyuan Pan, **Yuchao Dai**, Miaomiao Liu and Fatih Porikli. Simultaneous Stereo Video Deblurring and Scene Flow Estimation. **CVPR 2017** Accepted.
- [20] Jing Zhang, **Yuchao Dai**, Fatih Porikli. Deep Salient Object Detection by Integrating Multi-level Cues. **WACV 2017**.
- [21] Bo Li, **Yuchao Dai**, Xuelian Cheng, Mingyi He. Skeleton Based Action Recognition Using Translation-Scale Invariant Image Mapping and Multi-scale Deep CNN, ICME Workshop 2017, Accepted. (Our team was ranked top 3 in the challenge)
- [22] Bo Li, Huahui Chen, Yucheng Chen, **Yuchao Dai**, Mingyi He. Skeleton Boxes: Solving Skeleton Based Action Detection with A Single Deep Convolutional Neural Network, ICME Workshop 2017, Accepted.
- [23] Liyuan Pan, **Yuchao Dai**, Miaomiao Liu and Fatih Porikli. Depth Map Completion by Jointly Exploiting Blurry RGB Videos and Sparse Depth Maps. Under Review.
- [24] Jing Zhang, **Yuchao Dai**, Fatih Porikli and Mingyi He. Multi-Scale Salient Object Detection with Pyramid Spatial Pooling. APSIPA ASC 2017, Under Review.
- [25] **Yuchao Dai**, Hongdong Li, Laurent Kneip. Rolling Shutter Camera Relative Pose - Generalized Epipolar Geometry. **CVPR 2016**.
- [26] Jiaolong Yang, Hongdong Li, **Yuchao Dai**, Robby Tan. Robust Optical Flow Estimation of Double-Layer Images under Transparency or Reflection. **CVPR 2016**.
- [27] Suryansh Kumar, **Yuchao Dai**, Hongdong Li. Multi-body Non-rigid Structure-from-Motion. **3DV 2016**.
- [28] Xibin Song, **Yuchao Dai**, Xueying Qin. Deep Depth Super-Resolution: Learning Depth Super-Resolution using Deep Convolutional Neural Network. **ACCV 2016**.
- [29] Dingfu Zhou, **Yuchao Dai**, Hongdong Li. Reliable Scale Estimation and Correction for Monocular Visual Odometry. IEEE Intelligent Vehicles Symposium (**IV 2016**).
- [30] Huizhong Deng, **Yuchao Dai**. Pushing the limit of Non-rigid Structure-from-Motion by Shape Clustering. *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)* 2016.
- [31] **Yuchao Dai**, Hongdong Li. Simultaneous Correspondences Estimation and Non-rigid Structure Reconstruction. **DICTA 2016**.
- [32] Bo Li, Chunhua Shen, **Yuchao Dai**, Anton van den Hengel, Mingyi He; Depth and Surface Normal Estimation from Monocular Images Using Regression on Deep Features and

- Hierarchical CRFs. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2015, pp. 1119-1127
- [33] Jiayan Qiu, **Yuchao Dai**, Yuhang Zhang, and Jose Alvarez. Hierarchical Aggregation based Deep Aging Feature for Age Prediction. *DICTA 2015*.
- [34] **Yuchao Dai** and Hongdong Li. Rank minimization or nuclear-norm minimization: Are we solving the right problem? *DICTA 2014 (DSTO Best Fundamental Contribution to Image Processing Paper Prize)*.
- [35] Pan Ji, Hongdong Li, Mathieu Salzmann, **Yuchao Dai**. Robust Motion Segmentation with Unknown Correspondences. *ECCV (6) 2014*: 204-219
- [36] Jae-Hak Kim\*, **Yuchao Dai\***, Hongdong Li, Xin Du, Jonghyuk Kim: Multi-view 3D Reconstruction from Uncalibrated Radially-Symmetric Cameras. *IEEE International Conference on Computer Vision (ICCV 2013)*: 1896-1903 (\* equal contribution)
- [37] Jialong Yang, **Yuchao Dai**, Hongdong Li, Henry Gardner, Yunde Jia: Single-shot extrinsic calibration of a generically configured RGB-D camera rig from scene constraints. *ISMAR 2013*: 181-188.
- [38] **Yuchao Dai**, Hongdong Li, Mingyi He. A simple prior-free method for non-rigid structure-from-motion factorization. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2012)*. 2018-2025. **ORAL** (Accept Ratio: 47/1933 = 2.43%). **Winner of CVPR Best Paper Award**.
- [39] **Yuchao Dai**, Mingyi He, Hongdong Li, Richard Hartley, Factorization-based Structure-and-motion Computation for Generalized Camera Model. *IEEE International Conference on Signal Processing, Communications and Computing*, (ICSPCC 2011), 1-6.
- [40] **Yuchao Dai**, Hongdong Li, Mingyi He. Element-wise Factorization for N-View Projective Reconstruction. *European Conference on Computer Vision (ECCV 2010)* (Awarded a student travel grant). 396-409. (Accept Ratio: 322/1174=27.4%)
- [41] Richard Hartley, Jochen Trunpf, **Yuchao Dai**, Rotation averaging and weak convexity. In *Proceedings of the 19th International Symposium on Mathematical Theory of Networks and Systems (MTNS)*, pages 2435-2442, 2010.
- [42] Mingyi He, **Yuchao Dai**, Jing Zhang and Lin Bai. Rotation Invariant Feature Descriptor Integrating HAVA and RIFT. *Asia-Pacific Signal and Information Processing Association Annual Summit and Conference 2010 (APSIPA ASC 2010)*, 935-938.
- [43] Shaohui Mei, Mingyi He and **Yuchao Dai**, Robust spatial purity based Endmember Extraction in the presence of rare ground objects. *Asia-Pacific Signal and Information Processing Association Annual Summit and Conference 2010 (APSIPA ASC 2010)*, 165-168.
- [44] Shaohui Mei, Mingyi He and **Yuchao Dai**, Virtual Dimensionality estimation by Double Subspace Projection for hyperspectral images. *2nd IITA International Conference on Geoscience and Remote Sensing, IITA-GRS 2010*. 234-237.
- [45] **Yuchao Dai**, Jochen Trunpf, Hongdong Li, Nick Barnes and Richard Hartley, Rotation Averaging with Application to Camera-Rig Calibration, *Asian Conference on Computer Vision 2009 (ACCV 2009)* 335-346. (Accept Ratio: 175/670=27.1%)
- [46] **Yuchao Dai**, Hongdong Li, Mingyi He and Chunhua Shen, Smooth and Efficient Approximation for L-Infinity Norm, *Digital Image Computing: Techniques and Applications, 2009 (DICTA 2009)*, 339-346.
- [47] **Yuchao Dai**, Mingyi He and Hongdong Li, Two Efficient Algorithms for Outlier Removal in Multi-view Geometry Using L-Infinity Norm, *International Conference on Image and Graphics 2009 (ICIG 2009)*, 325-330.
- [48] Mingyi He, Lin Bai, **Yuchao Dai**, Jing Zhang, Hyperspectral image lossless compression algorithm based on AP adaptive band regrouping, *Satellite Data Compression, Communication and Processing V, SPIE*, 2009.

- [49] Mingyi He, **Yuchao Dai**, Jing Zhang, Image Registration by Integrating Similarity and Epipolar Constraints, *3rd IEEE Conference on Industrial Electronics and Applications*, Singapore, June 2008 (ICIEA 2008), 1870-1874.
- [50] Lin Bai, Mingyi HE, **Yuchao DAI**, Lossless Compression of Hyperspectral Images Based on 3D Context Prediction, *3rd IEEE Conference on Industrial Electronics and Applications*(ICIEA 2008), Singapore, June 2008, On page(s): 1845-1848.

## Talks and Seminars:

- 2016-12-27 Recent Progress in Modeling Temporal-Dynamic Camera, Shaanxi Normal University, China
- 2016-05-25 Generalized epipolar geometry for temporal-dynamic camera, VALSE, webseminar
- 2016-05-10 Rolling shutter relative pose: Generalized epipolar geometry, ANU
- 2016-03-29 Depth estimation from single image, Shanghai Maritime University, China
- 2015-11-13 Monocular depth estimation by using deep convolutional neural network, NPU, China
- 2014-11-25 Rank Minimization or Nuclear-norm Minimization: Are we solving the right problem? DICTA 2014, Wollongong.
- 2014-11-18 Non-rigid structure from motion with unknown correspondence, Peking University, China
- 2014-11-17 Depth estimation from a single image, Peking University, China
- 2014-06-13 Simultaneous Correspondence and Multi-body Segmentation, NPU, China
- 2013-10-04 Single-shot extrinsic calibration of a generically configured RGB-D camera rig from scene constraints. ISMAR Paper presentation
- 2013-01-23 Deep theoretical analysis and efficient implementation of structure from motion problem with compressive sensing theory, NICTA/ANU CVG Retreat.
- 2012-08-07 Multi-view Structure and Motion Recovery, NICTA Computer Vision Journal Club.
- 2012-03-20 Non-rigid Structure from Motion without any prior, NPU ShaanXi Key Lab of Information Acquisition and Processing
- 2011-05-10 Rigid Structure from Motion through Element-wise Factorization, NPU School of Electronics and Information
- 2009-11-25 Multi-camera Calibration and Image Registration, NPU ShaanXi Key Lab of Information Acquisition and Processing

## News Report:

<http://www.arc.gov.au/media/mga14/Examples/DECRA%20-%20examples%20-%20ACT.pdf>

Visionary scientists win award in CECS <http://cecs.anu.edu.au/news/details?SID=401>.

Chips are up for 3D computer scientists <http://news.anu.edu.au/?p=15711/>.

## Supervision Experience:

Postdoctoral Fellow Supervision:

- Dingfu Zhou: Monocular vision for autonomous driving, ANU

Visiting Scholars:

- Dr. Shunping Ji: Professor of Wuhan University, China
- Dr. Tao Gao: A/Professor of Chang'an University, China
- Dr. Shigang Liu: Professor of Shaanxi Normal University, China

#### PhD:

- Suryansh Kumar, Monocular Dense Reconstruction for Dynamic Scene, ANU (PhD candidate) Primary Supervisor
- Yiran Zhong, Dynamic Scene Understanding with Sparse Lidar, ANU (PhD candidate) Supervisor
- Lili Yang, Depth Map Enhancement and filtering, ANU (Visiting PhD student from Xidian University, China)
- Xibin Song, Depth image super-resolution via deep learning, ANU (Visiting PhD student from Shandong University, China)
- Bo Li, Single Image Depth Estimation via Deep Learning, Northwestern Polytechnical University, PhD candidate
- Liyuan Pan, Generalized Stereo Motion Deblurring, ANU (Visiting PhD student from Northwestern Polytechnical University, China)
- Liu Liu, 6-DoF Motion Estimation for Multi-camera and IMU, ANU (Visiting PhD student from Northwestern Polytechnical University, China)
- Jing Zhang, Saliency Detection, ANU (Visiting PhD student from Northwestern Polytechnical University, China)

#### Master:

- Huizhong Deng, Complex Non-rigid structure from motion, ANU (MPhil student)
- Jiayan Qiu, Semantic labeling of indoor images with deep learning, ANU (MPhil student), Now PhD Candidate at the University of Sydney
- Wei Zhou, Long term dense correspondences, ANU (Master student), Now PhD Candidate at the University of Sydney
- Runze Li, Deep Geometric Computer Vision, ANU (Internship with Master from Melbourne University)
- Xiaoqing Qiu, Hand Detection and Recognition from Color Image, ANU (Master student)
- Xietong Lu, Natural human-computer interaction with Kinect and Leap Motion, ANU (Master student)

#### Honors:

- Zheyu Zhuang, Simultaneous Localization and Mapping (SLAM), ANU, Now PhD Candidate at ANU
- Yihui Yu, Weather Condition Classification with Deep Learning, ANU
- Ye Tao, Large Scale Structure-from-Motion, ANU (R&D)
- Peiyan Yang, Efficient Large-scale Stereo Matching, ANU
- Si Zhang, Bad Weather Removal from a Single Image, ANU
- Zhongqi Wang, 3D Motion Estimation from RGB-D Data, ANU, Now PhD Candidate at New York University
- Jurong Huang, Hand Pose Estimation from Depth Map, ANU

- Shun Yao, Depth image super-resolution, ANU
- Ben Sengchansavang, Solving Sudoku without a pen, ANU
- Mace Vidler, Interactive Image Segmentation on Mobile platform, ANU
- Muyang Li, Multi-frame Optical Flow Estimation, ANU
- Weizhuo Yao, Saliency Detection, ANU
- Shiyang Zhang, Calibrating Kinect and Leap Motion, University of Auckland (Summer Scholar)
- Jue Wang, Multi-frame motion segmentation, ANU. Now PhD Candidate at ANU/Data61
- Ximeng Zhou, Object Detection from RGB-D, ANU
- Wenhao Lin, Interactive image segmentation with salient detection, ANU
- Xiaohan Yu, Dense scene flow estimation from Kinect, ANU
- Wei Zhou, Depth estimation from single color image, ANU
- Lu Wang, Interactive image segmentation, ANU
- Harish Moro, Kinect Calibration, ANU
- Bo Li, Articulated trajectory reconstruction from monocular video sequence, NPU
- Jing Zhang, Traffic sign detection, segmentation and recognition, NPU

## Research Experience & Highlights

My research fields are non-rigid structure from motion, rigid structure from motion, global optimization and human-computer interaction. I have made significant contributions to these fields. I have published papers in these areas, including papers accepted by the ERA A\*/A venues such as the **IEEE Transactions on Pattern Analysis and Machine Intelligence** and the **International Journal of Computer Vision**. I won the **Best Paper Award** in the IEEE conference on Computer Vision and Pattern Recognition (**CVPR**) 2012, which is one the most coveted best paper awards in computer vision. Most recently, I was awarded the **DSTO Best Fundamental Contribution to Image Processing Paper Prize** at DICTA 2014. My contributions to the research field of this proposal can be summarized as follows.

**Non-rigid Structure from Motion:** I investigated a “prior-free” approach for solving the non-rigid structure-from-motion (NRSFM) factorization problem. Other than using the basic low-rank condition, this method does not assume any extra prior knowledge about a non-rigid scene. Yet, it runs reliably, produces optimal result, and does not suffer from the inherent ambiguity associated with other non-rigid factorization, achieving state-of-the-art performance. This work was published in CVPR 2012 and was awarded the Best Paper Award (the only one from 1933 submissions to CVPR in that year, the first CVPR best paper award in mainland China, <https://sites.google.com/a/cvpr2012.org/home/program-details/awards>). Comments to this work given by the CVPR’12 General Chair was “[this is] a **ground-breaking work whose contribution cannot be underestimated**” (S.C. Zhu, UCLA, General Chair for IEEE CVPR 12.) Additionally, I and my coauthors were invited to submit a journal version of this work to the International Journal of Computer Vision and this paper has been published in 2014.

**Rigid Structure from Motion:** In this work, I gave an optimal solution to projective factorization for structure and motion recovery, based on the principle of low-rank factorization. This method has thus been shown to be universally applicable to all situations where structure from motion is



desired but where no initial point is needed. In fact, I have shown that a globally-optimal solution can be found up to a relaxation gap. Unlike traditional projective factorization methods, this new method can handle real-world difficult cases like missing data or outliers in a unified manner. Furthermore, I proposed fixed-point-continuation-based and alternative-direction-based implementations to tackle real-world large-scale projective factorization problems. This work was published in European Conference on Computer Vision (**ECCV 2010**) and a longer journal version with theoretical analysis and scalability algorithms has been published in the top journal in artificial intelligence and computer vision, the **IEEE Transactions on Pattern Analysis and Machine Intelligence**.

**3D reconstruction from uncalibrated radially-symmetric cameras:** In this work, we presented a new multi-view 3D Euclidean reconstruction method for arbitrary uncalibrated radially-symmetric cameras, which needs no calibration or any camera model parameters other than radial symmetry. It is built on the radial 1D camera model, a unified mathematical abstraction to different types of radially-symmetric cameras. We formulated the problem of multi-view reconstruction for radial 1D cameras as a matrix rank minimization problem. Efficient implementation based on alternating direction continuation is proposed to handle scalability issue for real-world applications. Our method applies to a wide range of omnidirectional cameras including both dioptric and catadioptric (central and non-central) cameras. Additionally, our method deals with complete and incomplete measurements under a unified framework elegantly. Experiments on both synthetic and real images from various types of cameras validate the superior performance of our new method, in terms of numerical accuracy and robustness. This work was published in **International Conference on Computer Vision (ICCV 2013)**.

**Rotation Averaging:** I have studied rotation-averaging on the manifold of 3-dimensional rotations and its application to large-scale structure-from-motion and multi-camera rig calibration. I presented a method for calibrating the rotation between two cameras in a camera rig in the case of non-overlapping fields of view and in a globally-consistent manner. The work was published in ACCV 2009, and a long journal version discussing various kinds of rotation averaging problems as well as convergence and algorithms has been published in the **International Journal of Computer Vision**. This will be a fundamental contribution to the understanding of various problems related to rotation averaging in different contexts.

**Trajectory Reconstruction from Monocular Sequence:** In this work, I proposed a method for generic smoothness-constrained 3D trajectory reconstruction of a moving object from monocular image sequences. By introducing a generic smoothness constraint on the 3D trajectory, an unconstrained optimization model for 3D trajectory reconstruction was achieved and a closed-form solution was derived. Compared with the predefined basis methods, such as discrete cosine transform and polynomial basis methods, my proposed method is more generic and can be applied to the incomplete measurement case, thus having broad applicability. In my work, I also provided a geometric explanation and proved the uniqueness of the 3D trajectory reconstruction. This work was published in Scientia Sinica Informationis-top journal in China.

**Extrinsic Calibration and Alignment of RGB-D Camera:** With the increasing use of commodity RGB-D cameras in vision applications, it is of significant practical interest to calibrate the relative displacement between the depth camera and the rigidly-connected RGB camera. The

main challenge comes from the difficulty in automatically establishing cross-modality feature-correspondences between the depth and color images. In this work, we propose three new, correspondence free methods for self-alignment of a depth-and-color camera rig. Our novel approaches consider the problem as geometric 3D-3D registration and 2D-3D registration respectively. Under this formulation the requirement of cross modality correspondences is relaxed and, it turns out higher accuracy is also achieved. None of our three techniques relies on cross-modality correspondences, yet good performance has been achieved. This work has been published in **ISMAR 2013**.

**Theoretical Analysis to Rank Minimization and Nuclear-norm Minimization:** Due to the inherent computational complexity of rank problems, the non-convex rank function is often relaxed to its convex relaxation, i.e. the nuclear norm. Thanks to recent progress made in the field of compressive sensing (CS), vision researchers who are practicing CS are fully aware, and conscious, of the convex relaxation gap, as well as under which condition (e.g. Restricted Isometry Property) the relaxation is tight (i.e. with nil gap). We however wish to alert the potential users of the low-rank method that: focusing too much on the issue of relaxation gap and optimization may possibly adversely obscure the “big picture” of the original vision problem. In particular, this paper shows that for many commonly cited low-rank problems, nuclear norm minimization formulation of the original rank minimization problem do not necessarily lead to the desired solution. Degenerate solutions and multiplicity seem often or always exist. Even if a certain nuclear-norm minimization solution is a provably tight relaxation, this solution can possibly be meaningless in its particular context. We therefore advocate that, in solving vision problems via nuclear norm minimization, special care must be given, and domain-dependent prior knowledge must be taken into account. This paper summarizes recent relevant theoretical results, provides original analysis, and uses real examples to demonstrate the practical implications. This work has been published in DICTA 2014 and was awarded the **DSTO Best Fundamental Contribution to Image Processing Paper Prize**.

**Monocular Depth Estimation by Using DCNN and Hierarchical CRFs:** Predicting the depth of a scene from a single image is a challenging and essentially under-determined task. This paper proposes to tackle this problem by using deep convolutional neural network (DCNN) and hierarchical continuous conditional random fields (CRFs). In this way, the number of training images required has been greatly reduced. Our framework works at two levels, namely the super-pixel level and the pixel level. First, we design a DCNN to learn the mapping from multi-scale image patches to absolute depth value at the super-pixel level. Second, the estimated depth at the super-pixel level is refined to the pixel level by using hierarchical CRFs. The CRF formulation exploits various potentials on the depth map, which include a data term, a smoothness term among neighboring super-pixels and an auto-regression term characterizing the local structure of the estimated depth map. The inference problem can be efficiently solved because it admits a closed-form solution. Furthermore, we demonstrate that the proposed framework can be easily extended to surface normal estimation. Experiments on the Make3D, NYU Depth V2 and KITTI datasets show competitive if not superior performance compared with current state-of-the-art methods. This work has been published in **CVPR 2015**.

**Rolling Shutter Camera Relative Pose: Generalized Epipolar Geometry:** The vast majority of modern consumer-grade cameras employ a rolling shutter mechanism. In dynamic geometric computer vision applications such as visual SLAM, the so-called rolling shutter effect therefore needs to be properly taken into account. A dedicated relative pose solver appears to be the first problem to solve, as it is of eminent importance to bootstrap any derivation of multi-view geometry. However, despite its significance, it has received inadequate attention to date. This paper presents a detailed investigation of the geometry of the rolling shutter relative pose problem. We introduce the rolling shutter essential matrix, and establish its link to existing models such as the push-broom cameras, summarized in a clean hierarchy of multi-perspective cameras. The generalization of well-established concepts from epipolar geometry is completed by a definition of the Sampson distance in the rolling shutter case. The work is concluded with a careful investigation of the introduced epipolar geometry for rolling shutter cameras on several dedicated benchmarks. This work has been published in **CVPR 2016**.

**Simultaneous Stereo Video Deblurring and Scene Flow Estimation:** Videos for outdoor scene often show unpleasant blur effects due to the large relative motion between the camera and the dynamic objects and large depth variations. Existing works typically focus on the deblurring for monocular video sequences. In this paper, we propose a novel approach to deblurring from stereo videos. In particular, we exploit the piece-wise planar assumption about the scene and leverage the scene flow information to deblur the images. Unlike the existing approach which used a pre-computed scene flow, we propose a single framework to jointly estimate the scene flow and deblur the image, where the motion cues from scene flow estimation and blur information could reinforce each other, and produce superior results than the conventional scene flow estimation or stereo deblurring methods. We evaluate our method extensively on two available datasets and achieve significant improvement in flow estimation and removing the blur effect over the state-of-the-art methods. This work has been accepted by **CVPR 2017**.

## Professional Activities

- Australian Research Council (ARC) Future Fellow, Discovery Project, DECRA, Linkage Project, LIFE Project Reviewer
- Member, Institute of Electrical & Electronics Engineers (IEEE), 2010-Present.
- Member, Computer Vision Foundation (CVF), 2013-Present.
  
- Reviewer of IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI)
- Reviewer of International Journal of Computer Vision (IJCV)
- Reviewer of IEEE Computer Vision and Pattern Recognition (CVPR)
- Reviewer of IEEE International Conference on Computer Vision (ICCV)
- Reviewer of European Conference on Computer Vision (ECCV)
- Reviewer of Asian Conference on Computer Vision (ACCV)
- Reviewer of British Machine Vision Conference (BMVC)
- Reviewer of International Conference on 3D Computer Vision (3DV)
- Reviewer of IEEE Transactions on Neural Network and Learning System (TNNLS)
- Reviewer of IEEE Transactions on Image Processing (TIP)

- Reviewer of IEEE Transactions on Intelligent Transport System (ITS)
- Reviewer of Pattern Recognition (PR)
- Reviewer of IEEE Transactions on Circuits and Systems for Video Technology (TCSVT)
- Reviewer of IEEE Transactions on Multimedia (TMM)
- Reviewer of IET Computer Vision
- Reviewer of IEEE Signal Processing Letter
- Reviewer of International Conference on Control, Automation, Robotics and Vision (ICARCV).
- Reviewer of IEEE Conference on Industrial Electronics and Applications (ICIEA).
- Reviewer of International Conference on Visual Information Engineering (VIE)
- Reviewer of Optics Express

## Project & Research Experience

- 1) 2014-Present, ARC DECRA Project DE 140100180 **Advancing Dense 3D Reconstruction of Non-rigid Scenes by Using a Moving Camera, Sole CI.**
- 2) 2015-2019, NSFC International Major Project **Imaging and Processing in Joint Hyperspectral and Multiview Observation of Complex and Dynamic Targets, CI.**
- 3) 2012.5-Present, ARC Linkage Project LP100100588 **Advancing Medical Image Analysis through High Performance Heterogeneous Computing, Numerical Simulation, and Novel Human Computer Interfaces**, leded by A. Prof. Henry Gardner and A. Prof. Hongdong Li.
- 4) 2010/01-2012/05, **Multi-View Interactive Image Acquisition, Processing and Display for 3DTV.** Natural Science Foundation of Shaanxi Province. **Principal Investigator.**
- 5) 2008/01-2011/12. **Multi-view and Large-view Hyperspectral Detection and Image Processing.** National Natural Science Foundation of China key project. **Participant**
- 6) 2011/01-2012/05, **Non-rigid structure and motion recovery. Principal Investigator.**
- 7) 2009/06- 2012/05, **Global Optimization and its application in multi-view geometry.** Co-supervisors: Prof. Mingyi He, A. Prof. Hongdong Li
- 8) 2008/10-2009/10, **Structure and Motion Recovery for Large Scale Image Collection Application, Rotation Averaging, Motion Averaging.** Co-Supervisors: Prof. Richard Hartley, Prof. Mingyi He, A/Prof. Hongdong Li
- 9) 2009/10-2011/01 , **Structure and Motion Recovery for Generalized Camera Model.** Supervisor: Prof. Mingyi He, Prof. Richard Hartley, A/Prof. Hongdong Li.
- 10) 2006/09—2007/12, **Image Registration based on feature extraction.** Supervisor: Prof. Mingyi He.
- 11) 2006/06—2006/09, **System of Water Meter Character Recognition.** Supervisor: Prof. Mingyi He.
- 12) 2006/11—2007/03, **System of Human Face Recognition** Supervisor: Prof. Mingyi He.
- 13) 2005/11—2006/06, **Application System of Three-dimensional Data Simplification** Supervisor: Prof. Mingyi He.
- 14) 2005/10—2005/12, **Multi-/hyper-spectral object auto-detection (team member).** Supervisor: Prof. Mingyi He.
- 15) 2004/03—2006/12, **Strategy and Tactic Subsystem of Robot Soccer (FIRA and Robocup).** Supervisor: Northwestern Polytechnical University.
- 16) 2006/03—2006/06, **Strategy and Tactic System of Robot Soccer.** Sponsor: Microsoft potential development project.

## Scholarships & Awards

### **International:**

- 1) **CVPR 2012 Best Paper Award (1/1933, CVPR is the top conference in machine vision and image processing)**
- 2) **DICTA 2014 DSTO Best Fundamental Contribution to Image Processing Paper Prize.**
- 3) Doctoral Consortium CVPR 2012.
- 4) Travel Grant from ECCV 2010.
- 5) Honorable Mention, Mathematics Contest in Modeling (MCM), COMAP, USA, 2005.
- 6) Honorable Mention, Interdisciplinary Contest in Modeling (ICM), COMAP, USA, 2004.

### **National:**

- 7) Excellent PhD Thesis, Shaanxi Province, 2014
- 8) One year visit to Australian National University, China Scholarship Council, 2008
- 9) Second Prize of Shaanxi Provincial Science and Technology advancement, 2011.
- 10) Second Prize, National Scholarship for Outstanding Student, 2002.
- 11) Second Prize, Bao Steel Scholarship for Outstanding Student, 2004.
- 12) Second Prize, Aviation Experiment Scholarship, 2006.
- 13) First Prize, China Undergraduate Mathematical Contest in Modeling, 2004.
- 14) Third Prize, China Undergraduate Mathematical Contest in Modeling, Shaanxi, 2003.
- 15) Third Prize of Science and technology advancement award by Commission of Science Technology and Industry for National Defense of China, 2006.
- 16) First Prize, FIRA China Cup, 2004.
- 17) Second Prize, Robocup China Open, 2005.
- 18) First Prize, FIRA China Cup, 2006.
- 19) Third Prize, Robocup China Open, 2006.

### **Campus:**

- 20) Excellent PhD Thesis, NPU, 2014
- 21) Excellent Graduate Student, NPU, 2012
- 22) Travel grant, NPU, 2010.