WEICHEN DAI

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EDUCATION

Zhejiang University *2015.09-Present*
College of Control Science and Engineering - Control Science and Engineering - Ph.D. Candidate

Carnegie Mellon University *2020-Present*
The Robotics Institute - Sebastian Scherer - Visiting Scholar(Online)

University of Illinois at Urbana-Champaign (UIUC) *2018.10-2019.01*
Mechanical Science and Engineering - Naira Hovakimyan - Visiting Scholar

Zhejiang University of Technology *2011.09-2015.06*
College of Information Engineering - Automation - B.S.

RESEARCH INTERESTS

My research interests lie in the general area of visual navigation, perception, and intelligent autonomous systems, particularly in visual odometry and simultaneously localization and mapping (SLAM).

PUBLICATION

"RGB-D SLAM in Dynamic Environments Using Point Correlations". IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI, SCI, IF 17.86). **Weichen Dai**, Yu Zhang, Ping Li, Zheng Fang, and Sebastian Scherer. [IEEE]

- A segmentation method using point correlations is proposed to separate static and dynamic points. It can exploit temporal information from multiple frames to extend the captured view and is not limited to RGB-D sensors as long as the sensor can provide point-correlation measurements.
- A SLAM method using RGB-D sensors is proposed to improve the robustness and accuracy of motion estimation in dynamic environments.

"Multi-Spectral Visual Odometry without Explicit Stereo Matching". International Conference on 3D Vision (3DV2019). **Weichen Dai**, Yu Zhang, Donglei Sun, Naira Hovakimyan, and Ping Li. [IEEE]

- A new multi-spectral visual odometry method without explicit stereo matching is proposed. Besides odometry results, the method can also provide a metric semi-dense 3D-reconstruction together with multi-spectral information for each map point, even if the two spectra share no similarity.
- The new method overcomes the problem of temporary image unavailability of uncooled LWIR cameras.
- Quantitative and qualitative evaluations of the new method on a multi-spectral dataset are conducted. Experimental results indicate that without using explicit stereo matching the proposed method can still prevent metric scale drift and yield satisfactory odometry in challenging environments.

"Feature Regions Segmentation based RGB-D Visual Odometry in Dynamic Environments". Annual Conference of the IEEE Industrial Electronics Society (IECON2018). Yu Zhang, **Weichen Dai**, Zhen Peng, Ping Li, and Zheng Fang. [IEEE]

"Control Design for an Aerial Manipulator toward Payloads Pick-and-Place". AIAA SciTech 2019. Donglei Sun, Neng Wan, **Weichen Dai**, Yu Zhang, and Naira Hovakimyan. [ARC]

"An Accurate and Efficient Monocular Mixed Match SLAM". China Control Conference (CCC2017). **Weichen Dai**, Yu Zhang, and Ping Li. [IEEE]

"Comparison of Multivariate Calibrations for the Determination of Soluble Solids Content of Tea Beverage Using UV-VIS-NIR Spectroscopy". Applied Mechanics and Materials (SCI). Weiqiang, Luo, Haiqing Yang, and **Weichen Dai**. [AMM]

MANUSCRIPTS UNDER REVIEW

"A Dataset for Evaluating Multi-spectral Motion Estimation Methods". RA-L (under review). **Weichen Dai**, Yu Zhang, Shenzhou Chen, Donglei Sun, and Da Kong. [Link] [Arxiv]

- A new multi-spectral dataset with hardware-synchronized color and thermal images is provided for the evaluation of multi-spectral motion estimation systems.
- The additional depth images can be used to study stereo matching between the visible and LWIR spectra.

REVIEWER EXPERIENCE

Conference reviewer: International Conference on Intelligent Robots and Systems (*IROS*), International Conference on Ubiquitous Robots (*UR*), China Control Conference (*CCC*), International Conference on Aircraft Utility Systems (*AUS*), Chinese Control and Decison Conference (*CCDC*).

Journal reviewer: IEEE Robotics and Automation Letters (RA-L).

COMPETITION/INTERNSHIP

Unmanned Aerial Competition for China High Resolution Earth Observation Conference 2018.6 - 2018.8
Shanghai Jiao Tong University *First Place*

- The task of the competition is divided into two parts. In part 1, the drone uses the recognition algorithm to identify circles and landmarks to complete the apron's taking-off and landing. In part 2, the search task of the woodpile forest was completed using the SLAM algorithm, and finally, the apron was identified, and the drone will land on it.

3D Construction 2016.3 - 2016.6
NetEase Inc *3D Vision Engineer*

- RGB-D data is collected using Kinect. The precise pose of the frame is initialized from the steering gear and optimized by 3D point cloud registration algorithms. Using the TSDF model, 3D point clouds are fused, and a mesh map is constructed based on it. Finally, the high and low-frequency information of the image texture is merged separately to ensure the natural transition between adjacent meshes.

PATENTS

201810092158.4 (Under Review) - A Low-Cost Calibration Borad For Multi-Spectral Setups

- The proposed calibration board overcomes the problem that low-cost milling technology cannot obtain high-precision corner points. The proposed design uses the principle of different reflectivity of metal and non-metal to collect consistent texture under different spectra.

202010259485.1 (Under Review) - A map segmentation, device and motion estimation method.

- The patent proposed a method to segment moving objects from the static background. The ego-motion estimation only exploits the static information from the segmentation result.

Supplementary Materials

SLAM IN DYNAMIC ENVIRONMENTS

A Segmentation Using Point Correlations, "RGB-D SLAM in Dynamic Environments Using Point Correlations"
https://ieeexplore.ieee.org/document/9145704

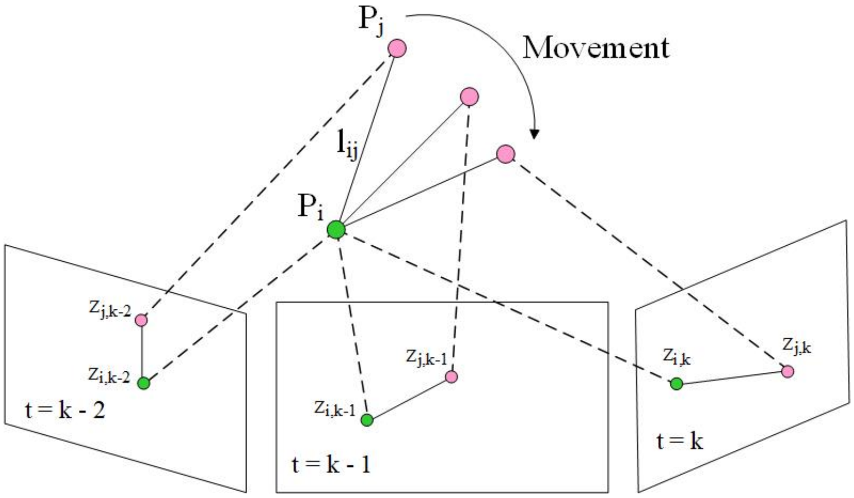


Figure 1: Example of the inconsistent measurements between static and dynamic points.

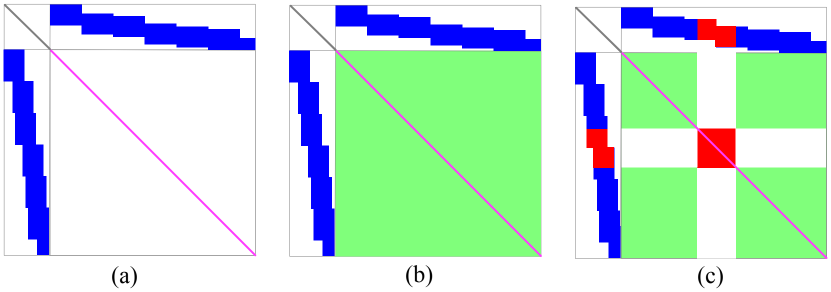
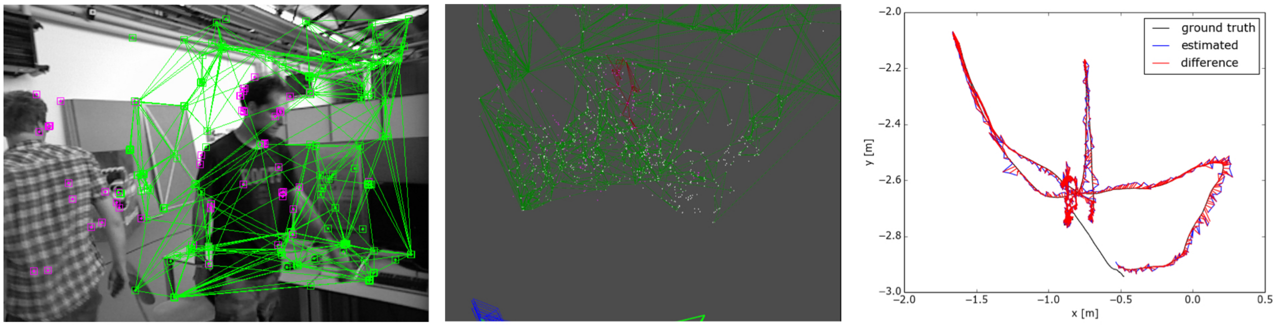


Figure 2: Example of a Hessian structure. (a) Hessian structure of bundle adjustment in Eq. (3). Because the geometry–geometry block is diagonal, the Hessian can be efficiently solved using the Schur complement. (b) Hessian structure of the objective function in Eq. (14). The geometry–geometry block of the Hessian structure is the green block with the pink diagonal. (c) The result after the inconsistent edge observations are removed from the Hessian structure. The green blocks indicate the point correlations, and the blue blocks indicate the geometry–pose correlations. The red blocks indicate moving objects in the camera image. Therefore, if inconsistent measurements in the point correlations can be determined, the two point clusters with different motion consistencies are separated.



(a) (b) (c)

Figure 3: Example taken from the fr3/waling-halfsphere sequence. (a) Result showing the determination of static points by the front end. (b) Result of 3D edge culling during the determination of feature static points by the back end. (c) Estimated trajectory compared with the ground truth.

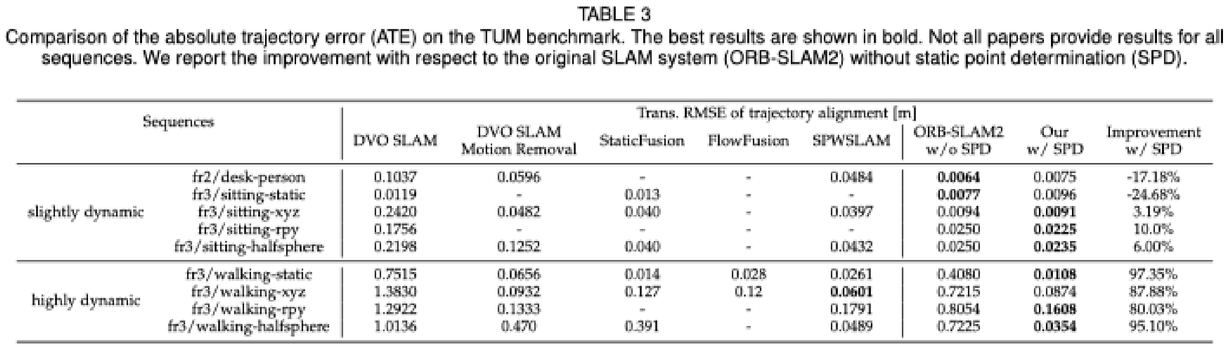


TABLE 3
Comparison of the absolute trajectory error (ATE) on the TUM benchmark. The best results are shown in bold. Not all papers provide results for all sequences. We report the improvement with respect to the original SLAM system (ORB-SLAM2) without static point determination (SPD).

Sequences		Trans. RMSE of trajectory alignment [m]							
		DVO SLAM	DVO SLAM Motion Removal	StaticFusion	FlowFusion	SPWSLAM	ORB-SLAM2 w/o SPD	Our w/ SPD	Improvement w/ SPD
slightly dynamic	fr2/desk-person	0.1037	0.0596	-	-	0.0484	**0.0064**	0.0075	-17.18%
	fr3/sitting-static	0.0119	-	0.013	-	-	**0.0077**	0.0096	-24.68%
	fr3/sitting-xyz	0.2420	0.0482	0.040	-	0.0397	0.0094	**0.0091**	3.19%
	fr3/sitting-rpy	0.1756	-	-	-	-	0.0250	**0.0225**	10.0%
	fr3/sitting-halfsphere	0.2198	0.1252	0.040	-	0.0432	0.0250	**0.0235**	6.00%
highly dynamic	fr3/walking-static	0.7515	0.0656	0.014	0.028	0.0261	0.4080	**0.0108**	97.35%
	fr3/walking-xyz	1.3830	0.0932	0.127	0.12	**0.0601**	0.7215	0.0874	87.88%
	fr3/walking-rpy	1.2922	0.1333	-	-	0.1791	0.8054	**0.1608**	80.03%
	fr3/walking-halfsphere	1.0136	0.470	0.391	-	0.0489	0.7225	**0.0354**	95.10%

Figure 4: Comparison of the absolute trajectory error (ATE) on the TUM benchmark. The best results are shown in bold. Not all papers provide results for all sequences. We report the improvement with respect to the original SLAM system (ORB-SLAM2) without static point determination (SPD).

MULTI-SPECTRAL MOTION ESTIMATION

Dataset, "A Dataset for Evaluating Multi-spectral Motion Estimation Methods"
https://arxiv.org/abs/2007.00622
Dataset Link: https://github.com/NGCLAB/multi-spectral-dataset

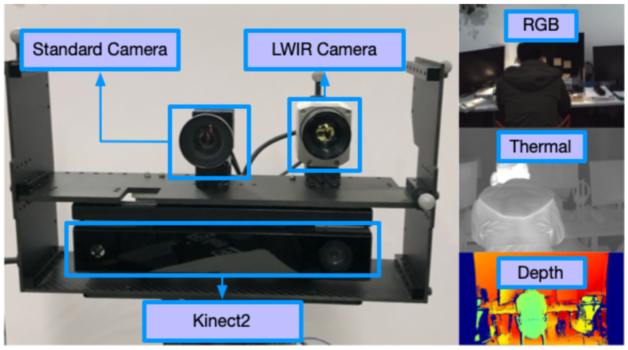
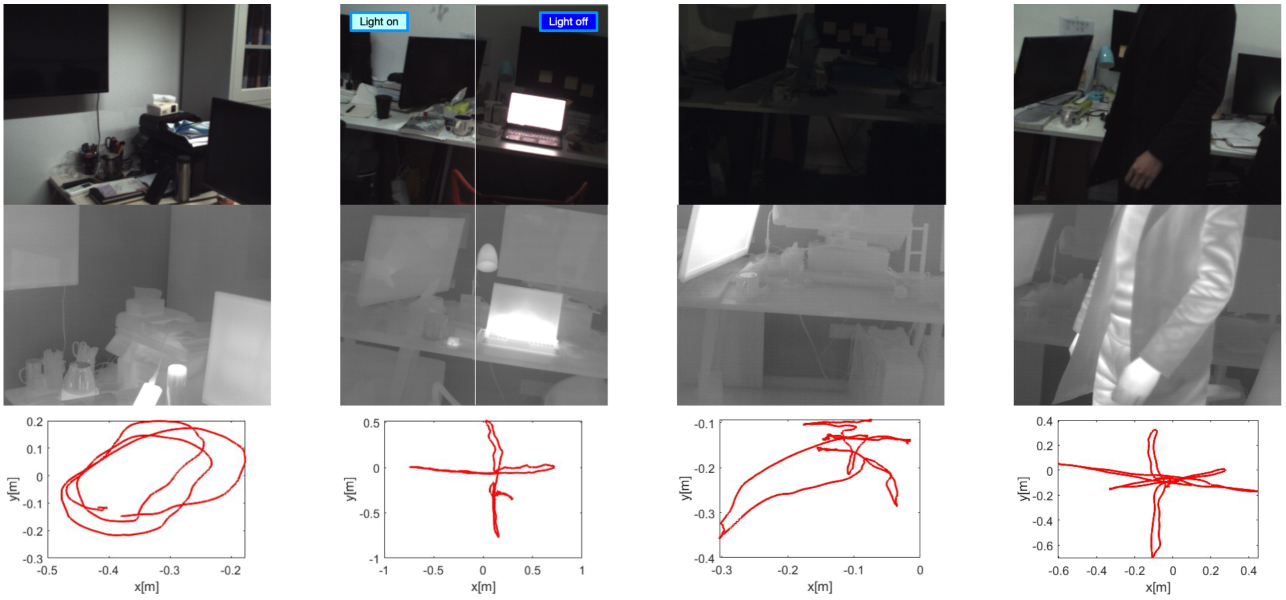


Figure 5: The multi-spectral setup with Kinect2. *Left*: devices include an RGB camera, an LWIR camera, a Kinect2, and the markers of motion capture systems. *Right*: example color image, thermal image, and depth image from Kinect2.



(a)

(b)

(c)

(d)

Figure 6: Example of sequences. The images from top to bottom rows are color images, thermal images, depth images, and ground-truth trajectories. The color of depth images indicates the distance to the Kinect2.

Data Fusion, “Multi-Spectral Visual Odometry without Explicit Stereo Matching”
https://ieeexplore.ieee.org/abstract/document/8885483

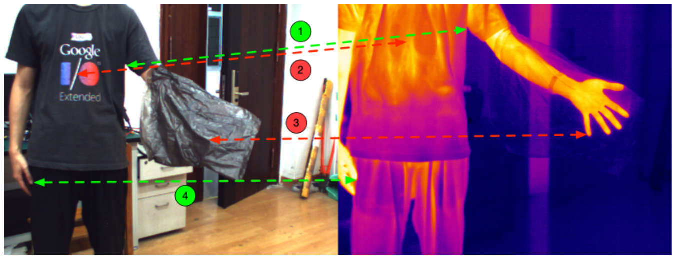


Figure 7: Potential (green) and unfeasible (red) correspondences. For potential correspondences ① and ④, the gradient patterns between different correspondences are different. For unfeasible correspondences ② and ③, there is no shared texture. Both types of stereo correspondences are difficult to find using stereo matching.

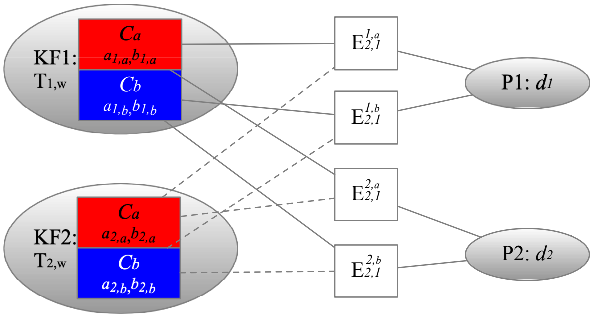


Figure 8: Factor graph for the full cost function. The red and the blue colored data are from the cameras of different types. Two map points are initialized from different cameras and observed in two keyframes. Each factor is related to one point and two keyframes of the same camera. Constraints from the initialized keyframes and the observed keyframes are represented in solid and dashed lines respectively.

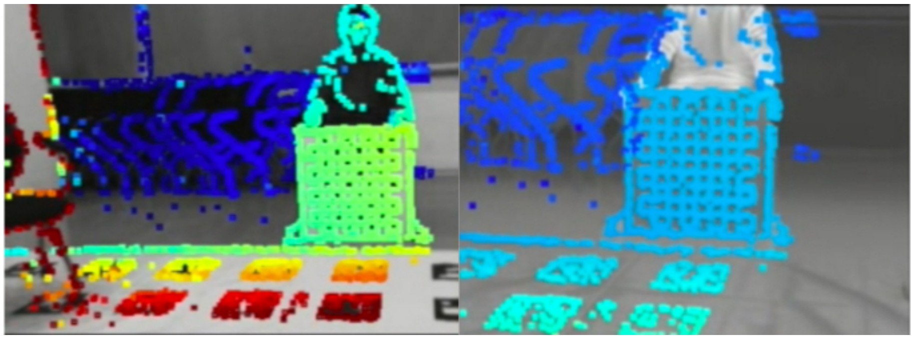


Figure 9: Depth map of multi-spectral images on Sq7. The right image shows the LWIR depth map. Each colored point in the depth map is obtained from the reprojection of that map point. The color indicates the distance from the 3D point to the optic center of that camera. The warmer the color, the smaller the distance.

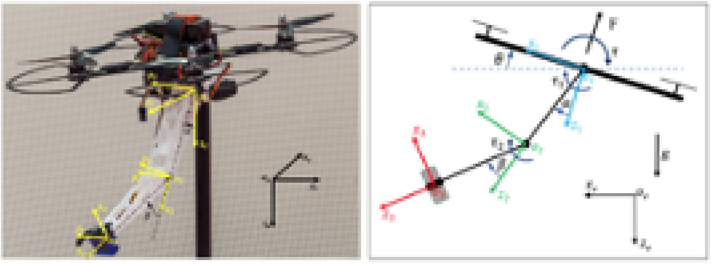
UNMANNED SYSTEM

Unmanned Aerial Competition for China High Resolution Earth Observation Conference

Figure 10: Part 1.

Figure 11: Part 2.

Aerial Manipulator “Control Design for an Aerial Manipulator toward Payloads Pick-and-Place”



(a) Coordinate systems

(b) Diagram of the system in the plane of symmetry

Figure 12: System Sturcture.