Zhenhua Xu

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Education

Hong Kong University of Science and Technology **Sep. 2018 – Present**
4th year Ph.D. candidate of CSE, supervised by Prof.Ming Liu and Prof.Huamin Qu *Hong Kong, China*

University of California, Los Angeles **Jul. 2017 – Sep. 2017**
CSST (Cross-disciplinary Scholars in Science and Technology) program (GPA 4.0/4.0) *LA, USA*

Harbin Institute of Science and Technology **Sep. 2014 – Jun. 2018**
Bachelor in Electronics and Information Engineering (Score 91.19/100, ***ranking 1/89****)* *Harbin, China*

Zhengzhou Foreign Language School **Sep. 2011 – Jun. 2014**
Zhengzhou, China

Research Keywords

Automatic creation of vectorized map, Line-shaped object detection, Imitation learning, Autonomous driving, Robotics

Research Topics

Automatic creation of vectorized maps in aerial images for autonomous driving | *Robotics*

- Vectorized maps (e.g., navigation map and high-definition map) are critical for autonomous vehicles since they provide the navigation and planning algorithms of autonomous vehicles with essential information of static line-shaped objects in the surroundings, such as road boundaries, road curbs, road networks, etc. However, manually creating vectorized maps is inefficient and labor-intensive. Therefore, approaches to automatically create vectorized maps of target objects with high efficiency and effectiveness are required.
- We propose to realize automatic vectorized map creation by detecting the graph of target objects. Thus, our problem is formulated as *"detecting the graph structure of target line-shaped objects from images"*. We analyze this problem from the perspective of semantic segmentation, decision making and graph prediction. Deep learning models and techniques are utilized, such as deep segmentation networks and transformers.
- **Segmentation perspective:** Deep semantic segmentation can obtain pixel-wise predictions of the line-shaped objects, but it suffers from degraded topology-level correctness since it cannot fully utilize spatial and topology information of the image. We propose to design more powerful network structures and loss functions to handle the aforementioned problems. A demo video is available at CP-Loss demo.
- **Decision making perspective:** To conquer the problem of segmentation-based approaches, we propose to train an agent network that iteratively creates the graph of target objects (e.g., road curbs). The agent moves along the target object vertex by vertex, and the trajectory of the agent is outputted as the graph of the target object. Then the problem of object detection turns to a robot navigation problem, which can be solved by imitation learning at this stage. This category of approaches presents a much more powerful performance on topology correctness. A demo video of our work for road curb detection is available at iCurb demo. A demo video of our work for road network graph detection is available at RNGDet demo.
- **Graph prediction perspective:** Another idea to detect the graph of target objects is by two-step graph prediction. We first obtain the heatmap of graph vertices (i.e., keypoints of the object), and then predict the adjacency matrix of the vertices based on transformer. A demo video of our work for city-scale road boundary detection is available at csBoundary demo.
- Several papers are accepted by top journals and conferences in the robotics community (e.g., RA-L, ICRA, IROS).

Research Plans

Automatic creation of High-definition map | *Robotics*

- High-Definition (HD) maps can provide precise geometric and semantic information of static traffic environments for autonomous driving, so almost all autonomous driving systems require high-quality HD maps. Different from the aforementioned navigation maps, HD maps have centimeter accuracy, thus manually creating HD maps would significantly delay the autonomous vehicle deployment and raise the cost. However, at this stage, there are still very few industrial products or academic research works on the automatic creation of HD maps, leaving this important problem unexplored. Considering the huge market and academic potential, this could be a great research direction in the following decays.
- Target journals/conferences: RA-L, TITS, TIP, etc./ICRA, IROS, CVPR, ICCV, ECCV, etc.

Automatic map update| *Robotics*

- In real-world applications, due to the development of cities, the map may change as time goes by (e.g., some new roads are built and some old roads are removed). Different from the map creation task, in this problem, we need to detect map changes and update the map without harming the topology correctness. The map changes could be detected from aerial images, point cloud data, traffic data, etc. This problem is also of great value but there is still a lack of related industrial solutions or academic works.
- Target journals/conferences: RA-L, TITS, TIP, etc./ICRA, IROS, CVPR, ICCV, ECCV, etc.

AI-assisted annotation tool | *Human-Computer-Interaction*

- Although we manage to automatically create the vectorized map, the map obtained by AI approaches may still have some errors due to the scene transfer issue, overlapping issue or sensor noise. Thus the corrections made by human experts are indispensable. Therefore, an AI-assisted system that can help human experts to annotate the map is needed. The system should provide experts with automatically generated prior map for efficiency; and the system can also keep evolving based on the corrections made by the experts. The system should have user-friendly interface and interaction pipeline.
- Target journals/conferences: RA-L, TOCHI, TVCG, etc./ICRA, IROS, CHI, VIS, etc.

Publications

[1] Y. Liu, **Z. Xu**, H. Huang, L. Wang, and M. Liu, "FULL-Scale Self-supervised Monocular Depth with Self-Distillation and Post Optimization," IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Under review.

[2] **Z. Xu**, Y. Liu, L. Gan, Y. Sun, L. Wang, and M. Liu, "RNGDet: Road Network Graph Detection by Transformer," IEEE Transactions on Geoscience and Remote Sensing (TGRS), Accepted, 2022.

[3] **Z. Xu**, Y. Liu, L. Gan, X. Hu, Y. Sun, L. Wang, and M. Liu, "csBoundary: City-scale Road-boundary Detection in Aerial Images for High-definition Maps," IEEE Robotics and Automation Letters (RAL), 2022.

[4] Y. Liu, **Z. Xu**, and M. Liu, "Star-Convolution for Image-Based 3D Object Detection," in 2022 IEEE/RSJ International Conference on Robotics and Automation (ICRA), 2022.

[5] **Z. Xu**, Y. Sun, L. Wang, and M. Liu, "CP-loss: Connectivity-preserving Loss for Road Curb Detection in Autonomous Driving with Aerial Images," in 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2021.

[6] **Z. Xu**, Y. Sun, and M. Liu, "Topo-Boundary: A Benchmark Dataset on Topological Road-Boundary Detection Using Aerial Images for Autonomous Driving," IEEE Robotics and Automation Letters (RAL), vol. 6, no. 4, pp. 7248–7255, 2021.

[7] **Z. Xu**, Y. Sun, and M. Liu, "iCurb: Imitation Learning-Based Detection of Road Curbs Using Aerial Images for Autonomous Driving," IEEE Robotics and Automation Letters (RAL), vol. 6, no. 2, pp. 1097–1104, 2021.

[8] T. Liu*, Q. Liao*, L. Gan, F. Ma, J. Cheng, X. Xie, Z. Wang, Y. Chen, Y. Zhu, S. Zhang, Z. Chen, Y. Liu, M. Xie, Y. Yu, Z. Guo, G. Li, P. Yuan, D. Han, Y. Chen, H. Ye, J. Jiao, P. Yun, **Z. Xu**, H. Wang, H. Huang, S. Wang, P. Cai, Y. Sun, Y. Liu, L. Wang, and M. Liu, "The Role of the Hercules Autonomous Vehicle During the COVID-19 Pandemic: An Autonomous Logistic Vehicle for Contactless Goods Transportation," IEEE Robotics and Automation Magazine (RAM), 2021.

[9] Q. Wang, **Z. Xu**, Z. Chen, Y. Wang, S. Liu and H. Qu, "Visual Analysis of Discrimination in Machine Learning," in IEEE Transactions on Visualization and Computer Graphics, vol. 27, no. 2, pp. 1470-1480, Feb. 2021, doi: 10.1109/TVCG.2020.3030471.

[10] Y. Zhang, S. Yang, H. Li, **Z. Xu**. "Shadow tracking of moving target based on CNN for video SAR system." IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium. IEEE, 2018.

[11] **Z. Xu**, Y. Zhang, H. Li, H. Mu, Y. Zhuang. "A new shadow tracking method to locate the moving target in SAR imagery based on KCF." International Conference in Communications, Signal Processing, and Systems. Springer, Singapore, 2017.

Awards and Honors

- **2018-2022** HKPF (Hong Kong PhD Fellowship, 26,600 HKD/month)
- **2018** Outstanding Graduate of Harbin Institute of Technology
- **2018** Guanghua Scholarship
- **2017** CSST (Cross-disciplinary Scholars in Science and Technology)
- **2017** National Scholarship
- **2016** Meritorious Winner in MCM/ICM
- **2014-2018** Renmin Scholarship
- **2014-2018** University Merit Student
- **2013** Provincial 1st prize in National High School Mathematics League (NO.49 in Henan province)

Technical Skills

Computer Science: Python, LaTex, Ubuntu, C/C++, ROS, MATLAB
Language: Chinese, English (TOEFL 105)

Academic services

- **Reviewer:**
  IEEE Robotics and Automation Letters (RA-L),
  IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS),
  IEEE/RSJ International Conference on Robotics and Automation (ICRA),
  The British Machine Vision Conference (BMVC),
  Autonomous Vehicle Vision (AAV)
- **Teaching assistant:**
  COMP3711 (Design and Analysis of Algorithms),
  COMP3311 (Database Management Systems)