

CTU-CRAS-NORLAB at DARPA SubT Challenge – Publications

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This short text summarizes the main publications of CTU-CRAS-NORLAB team during DARPA SubT Challenge.

Team Description

The CTU-CRAS-NORLAB team¹ joins two universities, three departments, and four research groups. Czech Technical University has been represented by the following groups: Vision for Robotics and Autonomous Systems (VRAS)², Multi-robot systems (MRS)³, both from Department of Cybernetics, and Computational Robotics (ComRob)⁴ from Department of Computer Science. Laval University is represented by Northern Robotics Laboratory (NORLab)⁵. The work performed within the DARPA SubT Challenge has been centered around PhD students and the joint work pushed many PhD theses well forward. Several topics were also supported by undergraduate students while they were working on their bachelor and master theses. While many system-related tasks were performed jointly, and many tasks have been shared among several groups, the main responsibilities were roughly allocated as follows:

- VRAS group: Project management, communication sw (shared database), object detection and localization, terrain negotiation, tracked robots, payload design, ...
- MRS group: UAV control, mapping, planning, UAV hw development, ...

¹<http://robotics.fel.cvut.cz/cras/darpa-subt/>

²<http://cyber.felk.cvut.cz/vras>

³<http://mrs.felk.cvut.cz>

⁴<https://comrob.fel.cvut.cz>

⁵<https://norlab.ulaval.ca>

- ComRob: Multirobot exploration, communication hw, legged and wheeled robots. System calibration, ...
- NORLab: 3D mapping and localization for ground robots.

Publications

- Tunnel circuit system paper
Rouček T. et al. (2020) **DARPA Subterranean Challenge: Multi-robotic Exploration of Underground Environments**. In: Mazal J., Fagiolini A., Vasik P. (eds) *Modelling and Simulation for Autonomous Systems*. MESAS 2019. Lecture Notes in Computer Science, vol 11995. Springer, Cham. https://doi.org/10.1007/978-3-030-43890-6_22
- Tunnel and urban circuit system paper
Rouček T. et al. (2021) **System for multi-robotic exploration of underground environments CTU-CRAS-NORLAB in the DARPA Subterranean Challenge**. Accepted to *Field Robotics*. <https://arxiv.org/abs/2110.05911>
- MRS UAV system
Tomas Baca, Matej Petrlik, Matous Vrba, Vojtech Spurny, Robert Penicka, Daniel Hert and Martin Saska. **The MRS UAV System: Pushing the Frontiers of Reproducible Research, Real-world Deployment, and Education with Autonomous Unmanned Aerial Vehicles**. *Journal of Intelligent & Robotic Systems* 102(26):1–28, May 2021. <http://dx.doi.org/10.1007/s10846-021-01383-5>
- Decentralized exploration
Jan Bayer and Jan Faigl. **Decentralized Task Allocation in Multi-robot Exploration with Position Sharing Only** *International Symposium on Swarm Behavior and Bio-Inspired Robotics*. SWARM 2021. <https://comrob.fel.cvut.cz/papers/swarm21mre.pdf>
- Decentralized exploration
Jan Bayer and Jan Faigl. **Decentralized Topological Mapping for Multi-robot Autonomous Exploration under Low-Bandwidth Communication**, *European Conference on Mobile Robots*. ECMR 2021. <https://doi.org/10.1109/ECMR50962.2021.9568824>
- Communication modeling
Martin Zoula, Miloš Pragr, and Jan Faigl. **On Building Communication Maps in Subterranean Environments**. *Modelling and Simulation for Autonomous Systems*. MESAS 2021, pp. 15-28. https://doi.org/10.1007/978-3-030-70740-8_2

- Predicting terrain shape
Vojtech Salansky, Karel Zimmermann, Tomas Petricek, Tomas Svoboda. **Pose consistency KKT-loss for weakly supervised learning of robot-terrain interaction model.** *IEEE Robotics and Automation Letters*. Vol 6, No 3, July 2021. <https://doi.org/10.1109/LRA.2021.3076957>
- Tunnel domain UAV approach
Matej Petrlík, Tomas Baca, Daniel Hert, Matous Vrba, Tomas Krajník and Martin Saska. **A Robust UAV System for Operations in a Constrained Environment.** *IEEE Robotics and Automation Letters* 5(2):2169-2176, April 2020. <http://dx.doi.org/10.1109/LRA.2020.2970980>
- Urban domain UAV approach
Vit Kratky, Pavel Petracek, Tomas Baca and Martin Saska. **An autonomous unmanned aerial vehicle system for fast exploration of large complex indoor environments.** *Journal of Field Robotics*, pages 1-24, May 2021. <http://dx.doi.org/https://doi.org/10.1002/rob.22021>
- Cave domain UAV approach
Pavel Petracek, Vit Kratky, Matej Petrlík, Tomas Baca, Radim Kratochvíl and Martin Saska. **Large-Scale Exploration of Cave Environments by Unmanned Aerial Vehicles.** *IEEE Robotics and Automation Letters* 6(4):7596-7603, October 2021. <http://dx.doi.org/10.1109/LRA.2021.3098304>