CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF ELECTRICAL ENGINEERING
DEPARTMENT OF CYBERNETICS
CENTRE FOR MACHINE PERCEPTION

NIFTi – Natural Human-Robot Cooperation in Dynamic Environments

2010 – 2014, EC project FP7-ICT-247870 NIFTi

Presentation by Michal Reinstein
Presented results of the whole NIFTi Consortium

NIFTI – PROJECT COOPERATION

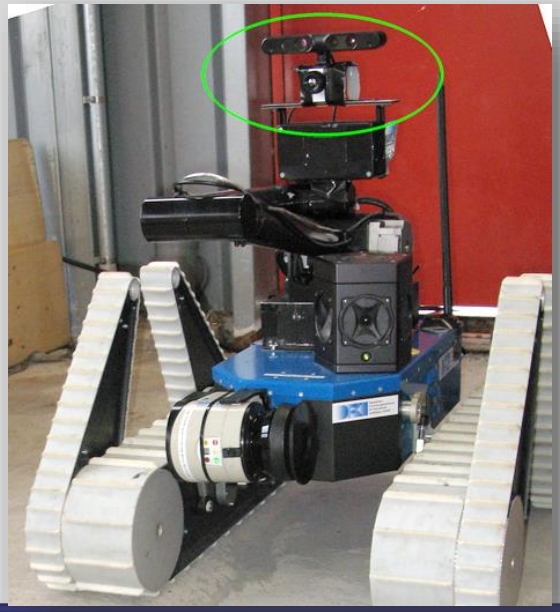
Benif.#	Beneficiary name	Benef. short name	Country
1. (crd.)	Deutsches Forschungszentrum für Künstliche Intelligenz GmbH	DFKI	Germany
2.	Netherlands Organization for Applied Scientific Research	TNO	The Netherlands
3.	Fraunhofer Institut Intelligente Analyse- und Informationssysteme	Fraunhofer	Germany
4.	BlueBotics SA	BLUE	Switzerland
5.	Eidgenossische Technische Hochschule Zürich	ETHZ	Switzerland
6.	Czech Technical University Prague	CTU	Czech Republic
7.	'Sapienza' University of Roma	ROMA	Italy
8.	Institut für Feuerwehr und Rettungstechnologie FDDo	FDDo	Germany
9.	Corpo Nazionale Vigili del Fuoco	VVFF	Italy

This presentation covers results of all the consortium members

NIFTI – PROJECT AIMS

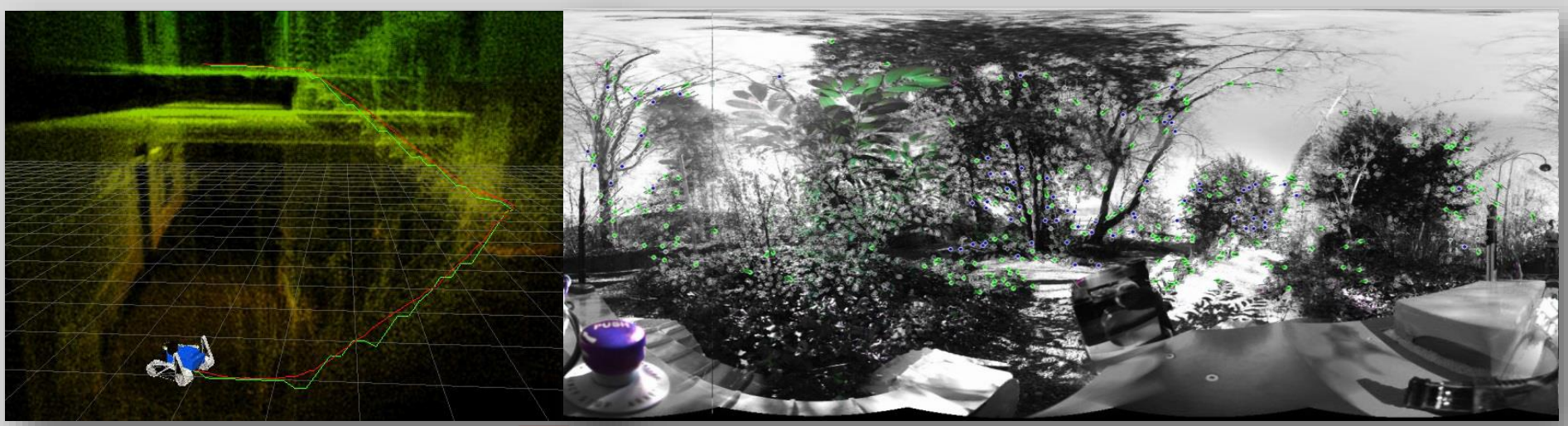
- Developing a novel rover platform to meet the demands of operating in dynamic environments
- Minimizing task load for human and optimizing workflow
- Integration – bringing human factor into rescue robots
- Situation awareness – conceptual understanding of environment
- Flexible planning w.r.t. dynamic changes in environment
- User adaptive human-robot communication
- Continuous evaluation with end user organizations

NIFTI PLATFORM

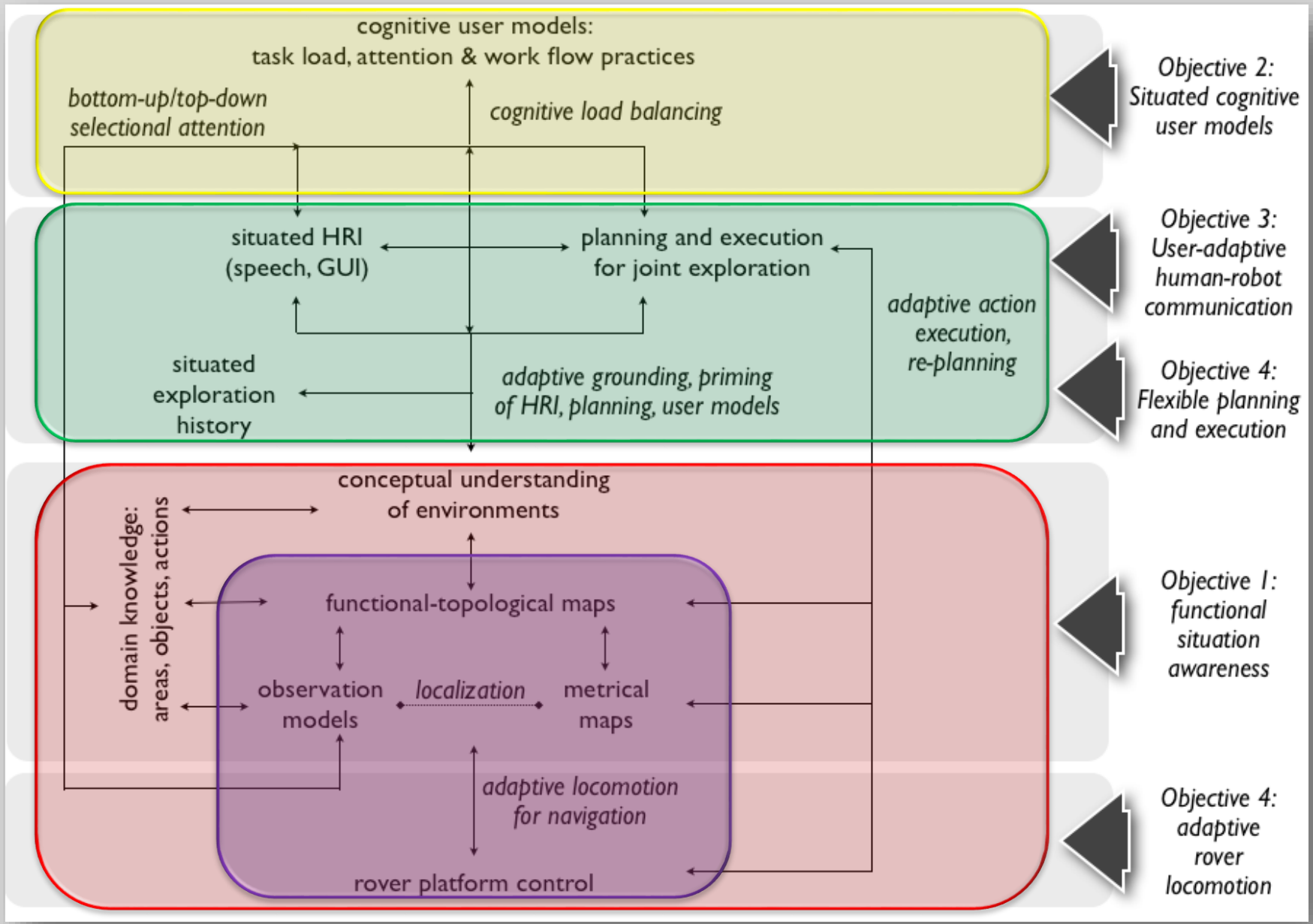


- Embeded PC: Kontron KTGM45/mITX Plus
- Rotating 2D laser scanner: SICK LMS-151
- Omnicam: Point Grey Ladybug 3
- IMU/GPS: X-sens MTI-G
- ASUS Xtion Pro
- Thermocam Micro-Epsilon TIM160
- UBUNTU 12.04 (64 bit) & ROS

FROM DATA TO UNDERSTANDING

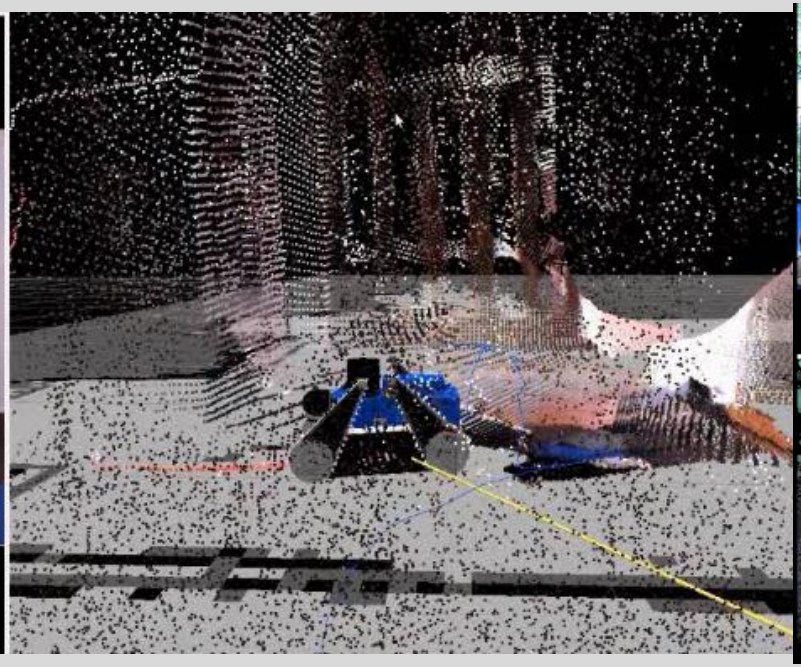


INTEGRATED INTELLIGENCE



METRIC MAPPING

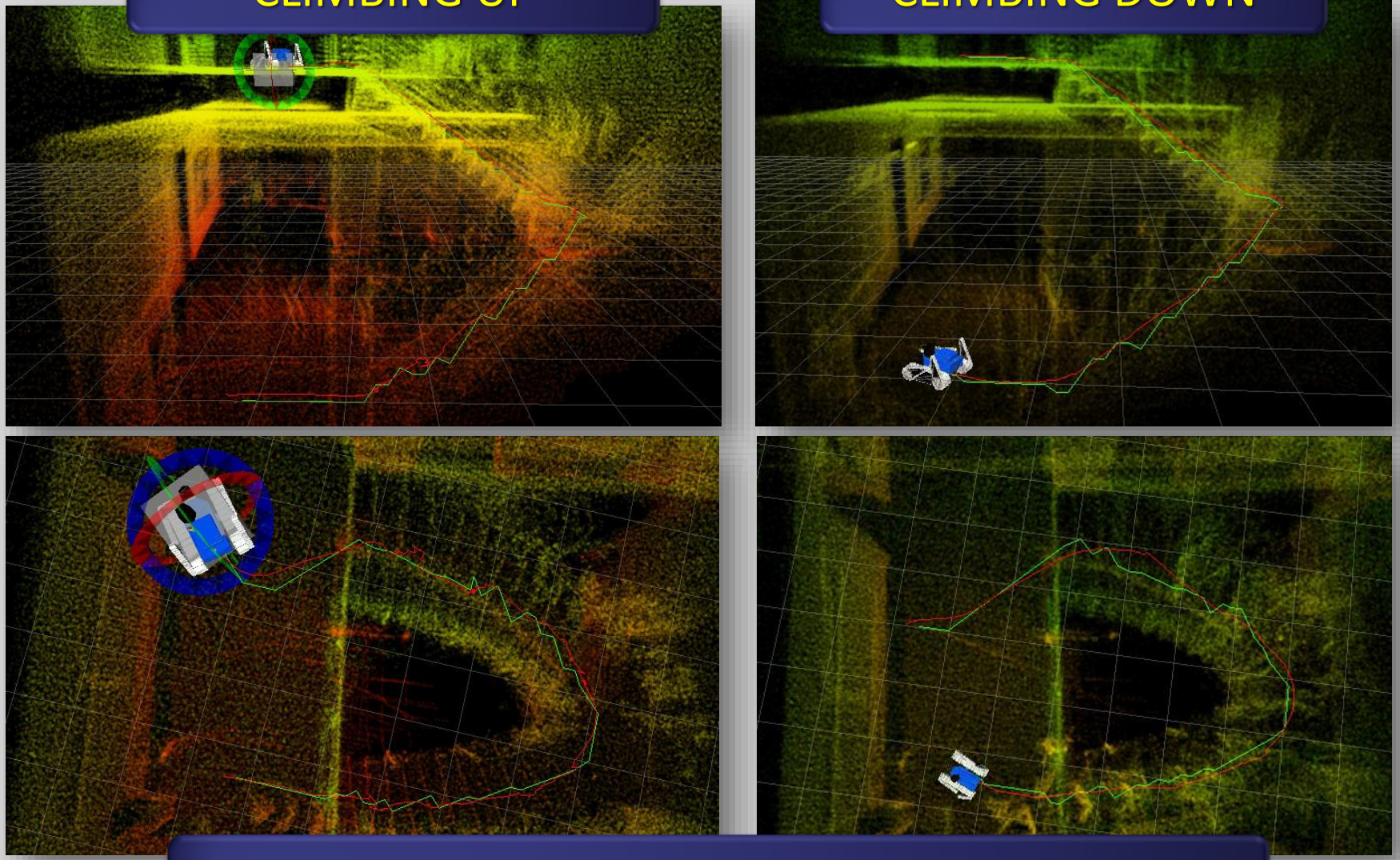
- Rotating laser provides range data assembled into point clouds using ICP algorithm
- Results in 3D metric map used for SLAM together with EKF based data fusion of IMU & vision & laser & odometry data
- Local trajectory planning & traversability analysis



TRAJECTORY PLANNING

CLIMBING UP

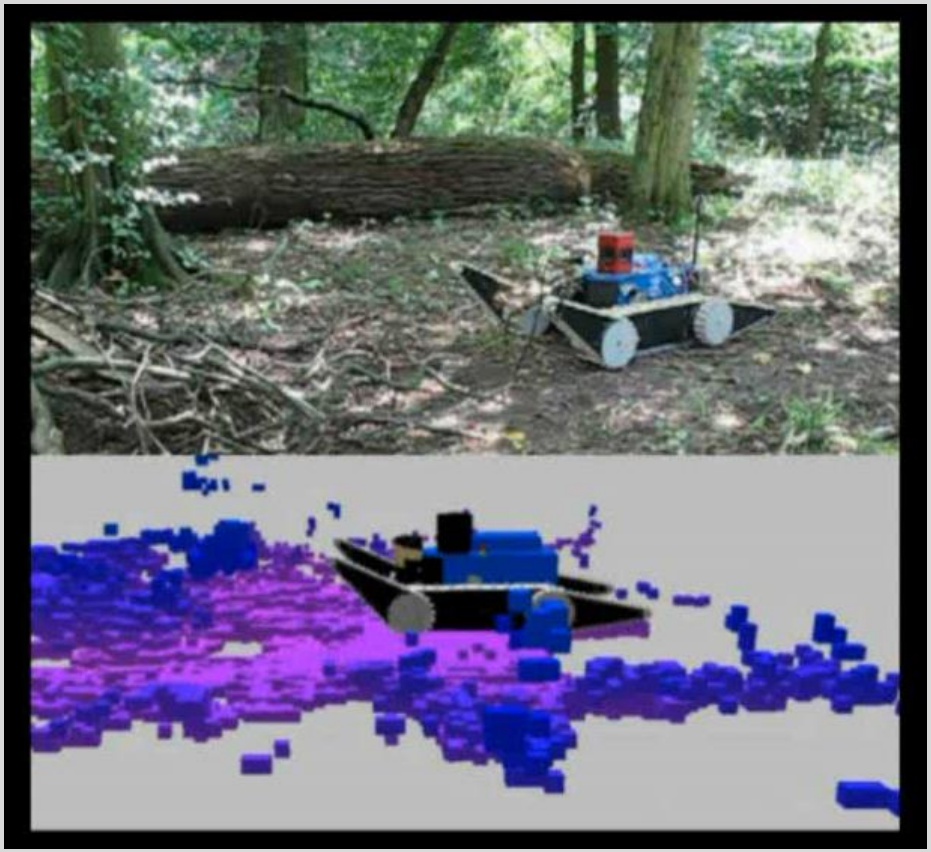
CLIMBING DOWN



Tensor voting approach with D* Lite algorithm

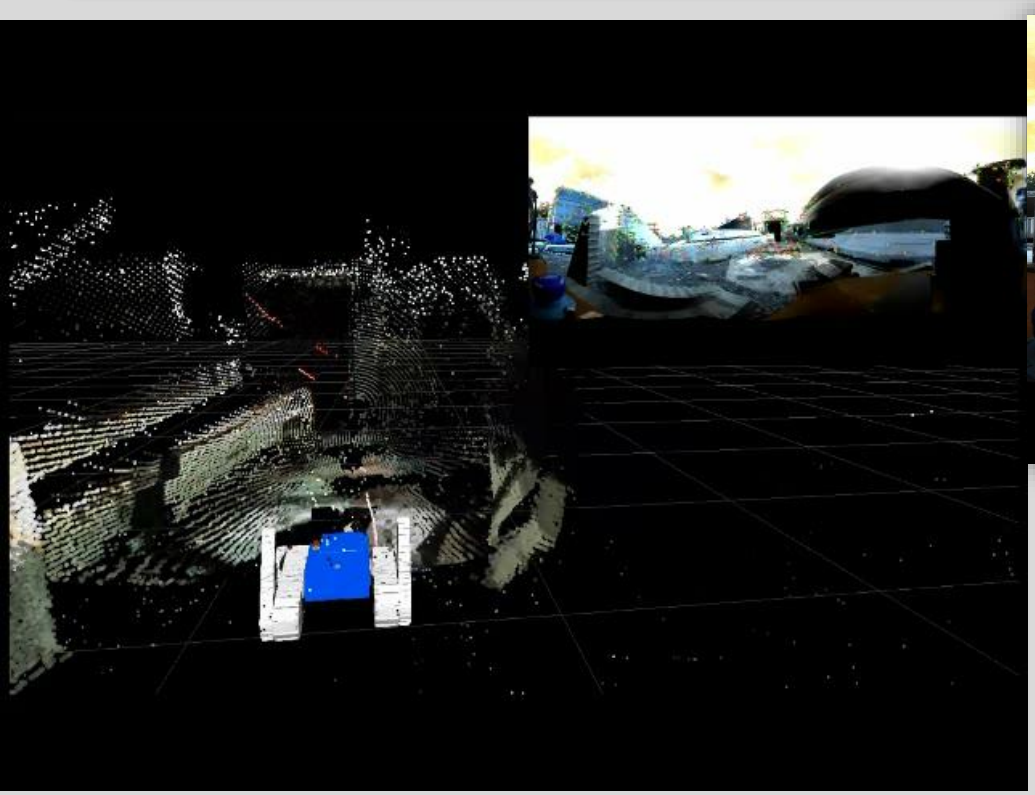
MOTION CONTROL

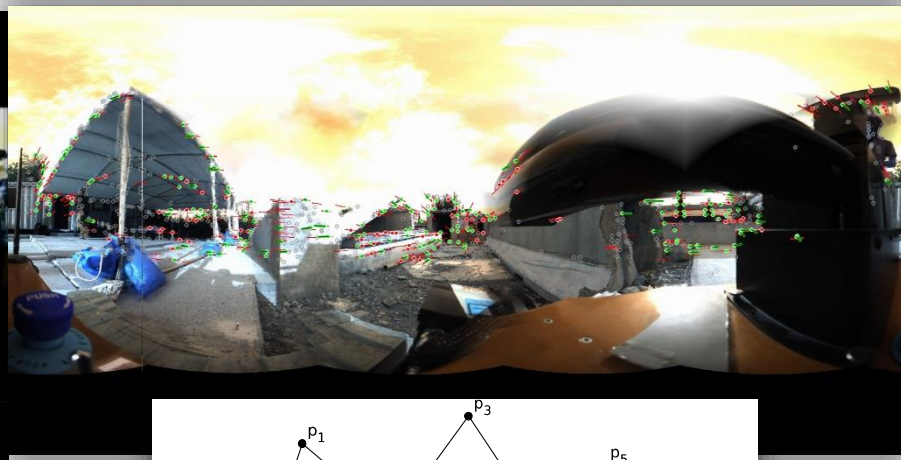
Adaptive Traversability = means of motion control based on autonomous adaptation of robot morphology (via reinforcement learning) to traverse unknown terrain with obstacles in an optimal way and with minimal cognitive load for the operator.

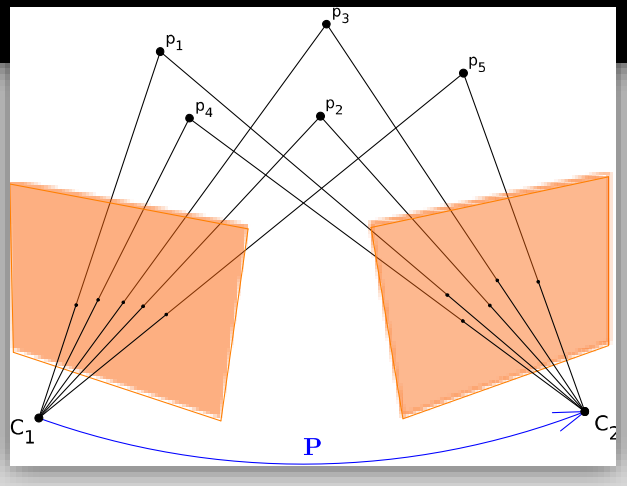


VISUAL NAVIGATION

- AIM: UGV position and orientation estimation at 2-3Hz from consecutive panoramic images constructed from spherical approximation of the LB3
- ALGORITHM: image matching by searching for correspondences, landmark reconstruction and sliding bundle adjustment to refine landmark 3D positions and robot poses.

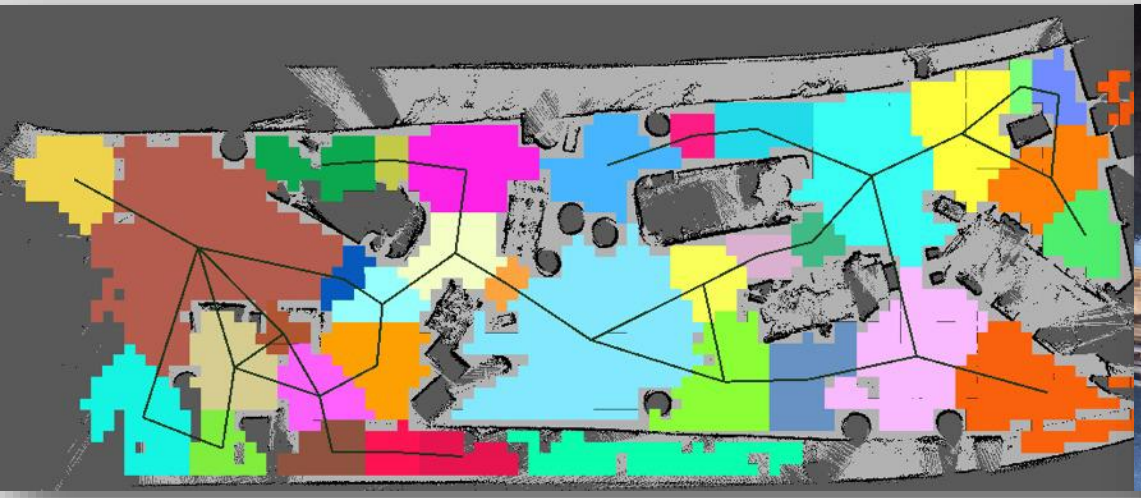






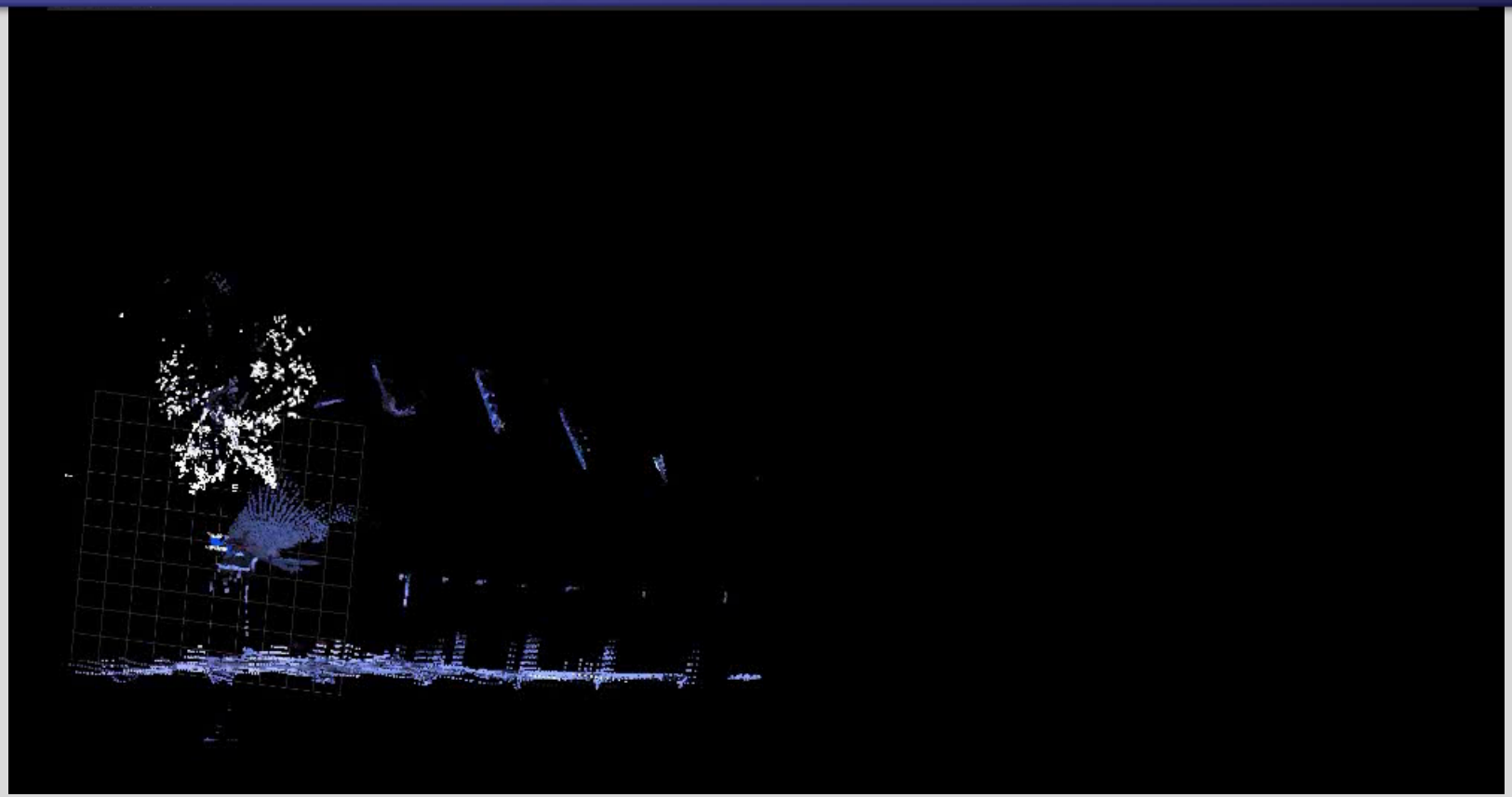
TOPOLOGICAL MAPPING

- Voronoi diagram
- Identification of changes in metric map
- Incremental segmentation into discrete regions
- Graph-based structure over centroids of segmented regions
- Required for higher level planning

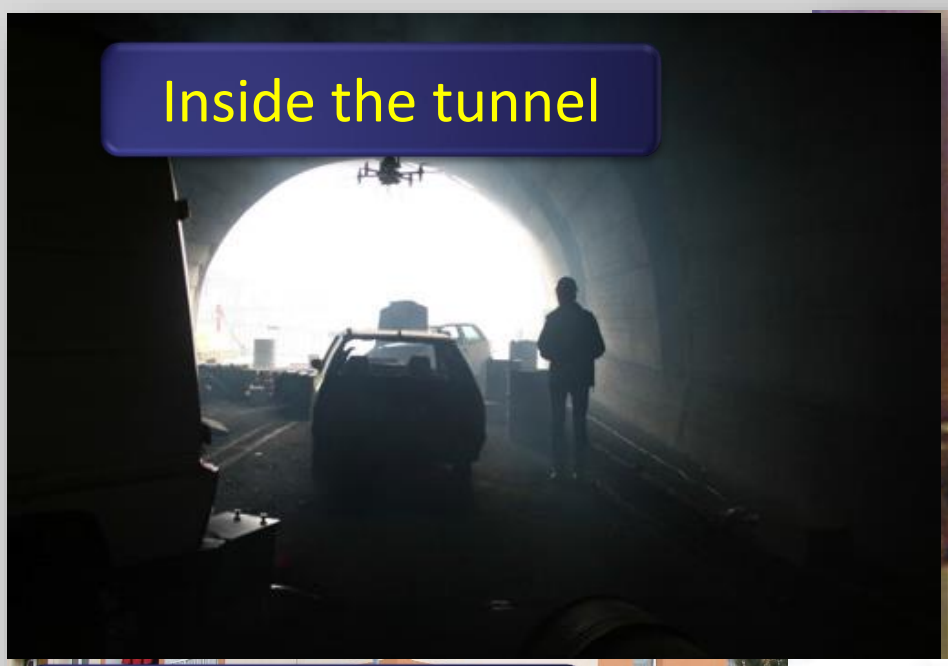


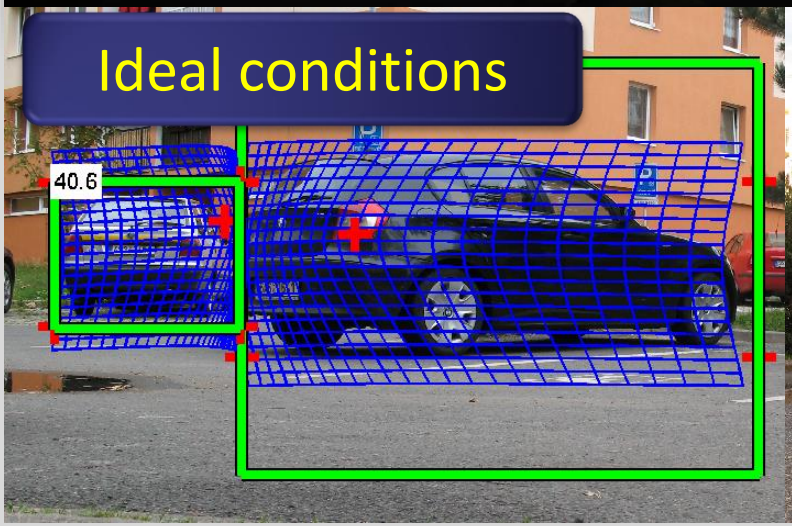
OBJECT DETECTION & LOCALIZATION - CARS

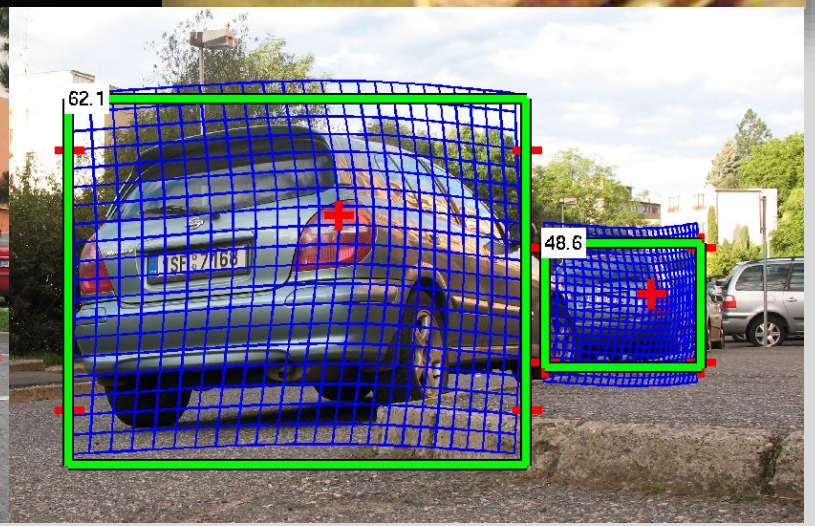
- Computer vision techniques on both 2D & 3D data
- Associating detections with laser to filter false positives
- False positives negatively impact situation wareness



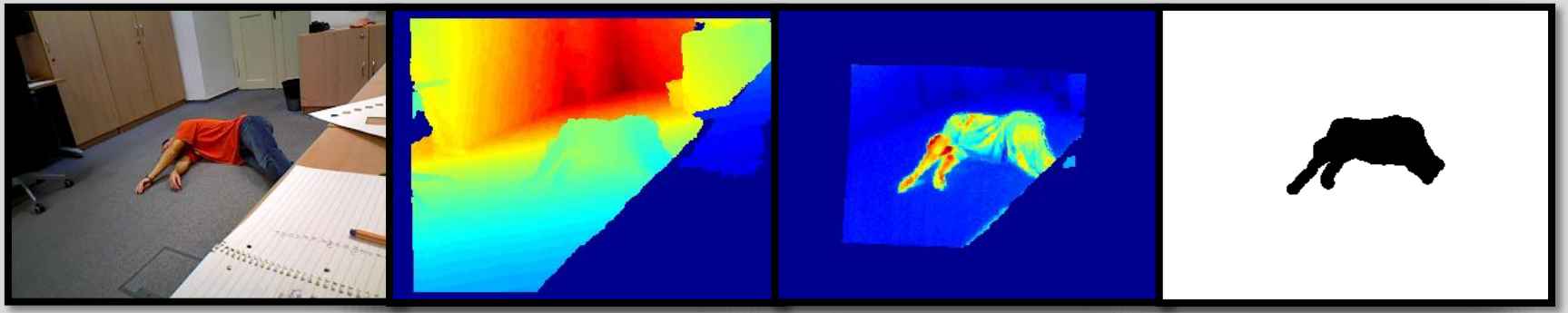
OBJECT DETECTION & LOCALIZATION - CARS



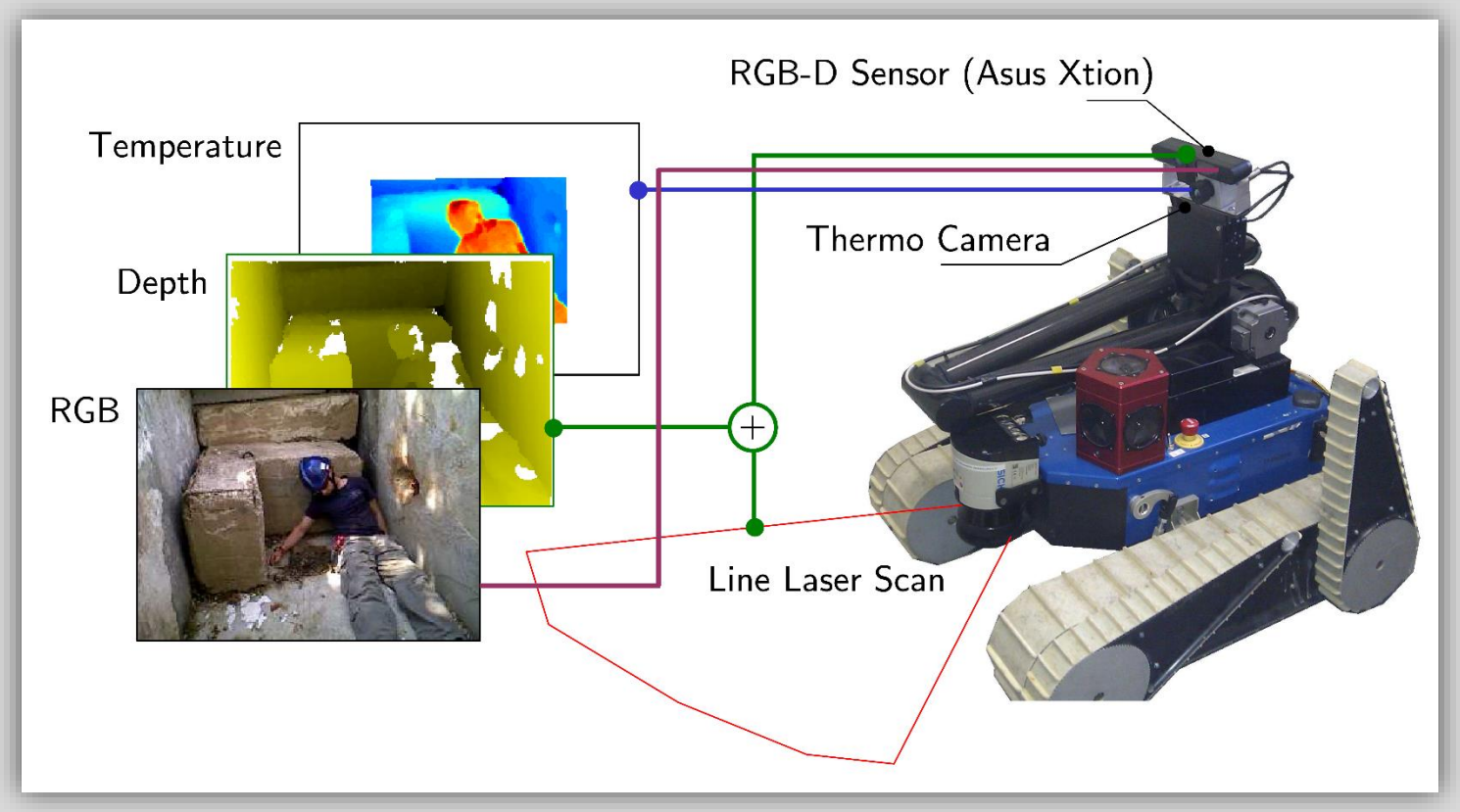




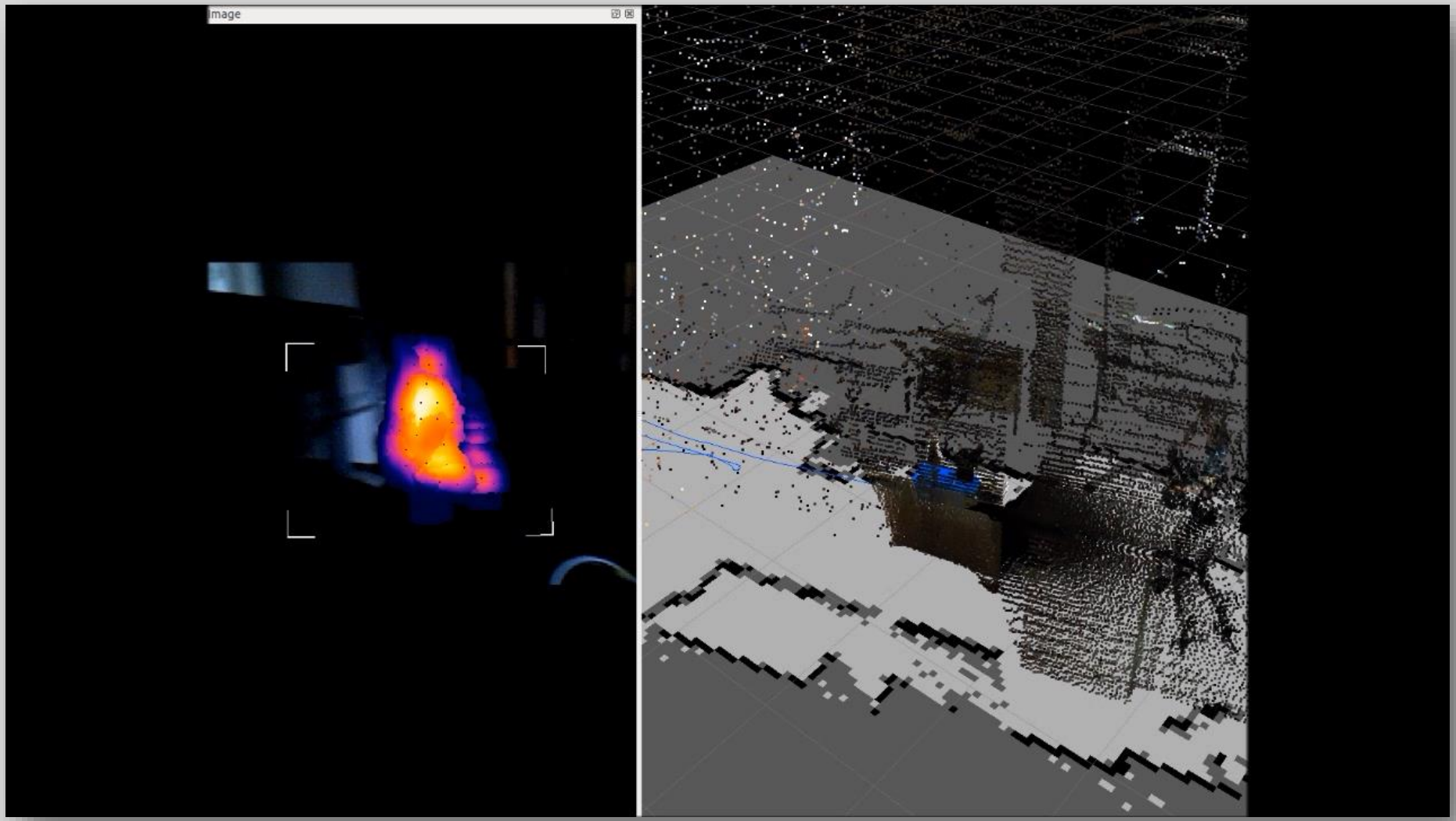
OBJECT DETECTION & LOCALIZATION - VICTIMS



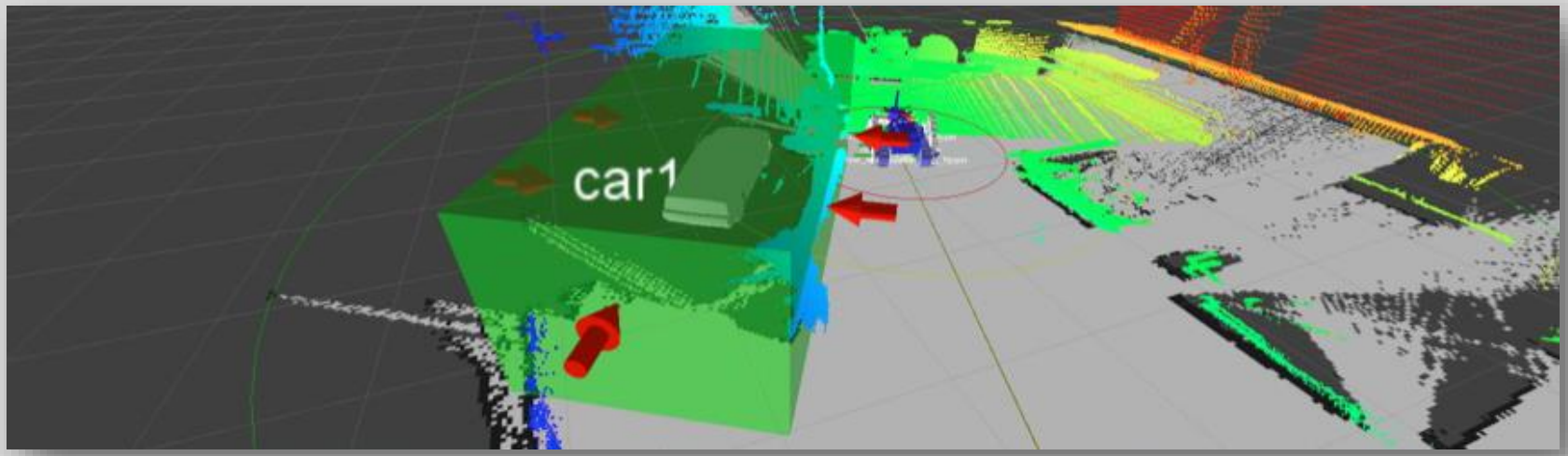
RGB CAMERA | DEPTH SENSOR | THERMOCAM | MASK

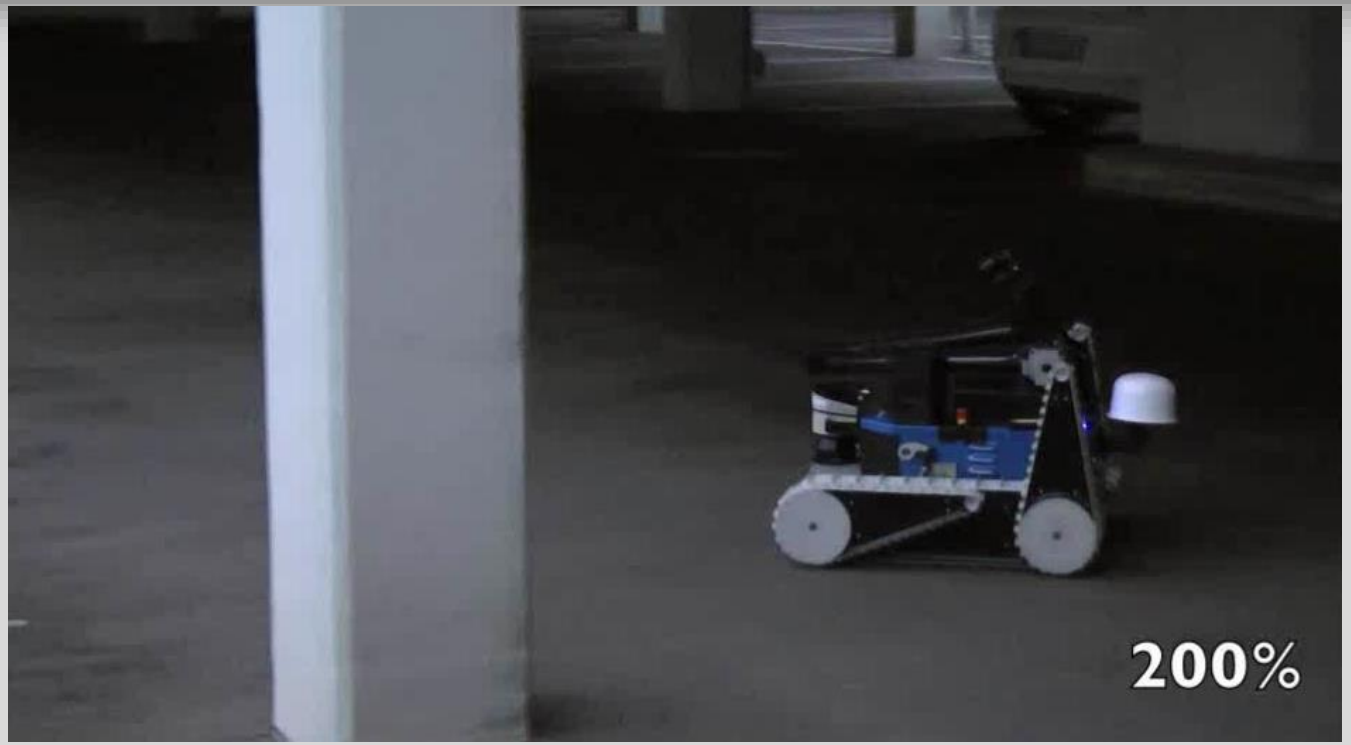


OBJECT DETECTION & LOCALIZATION - VICTIMS

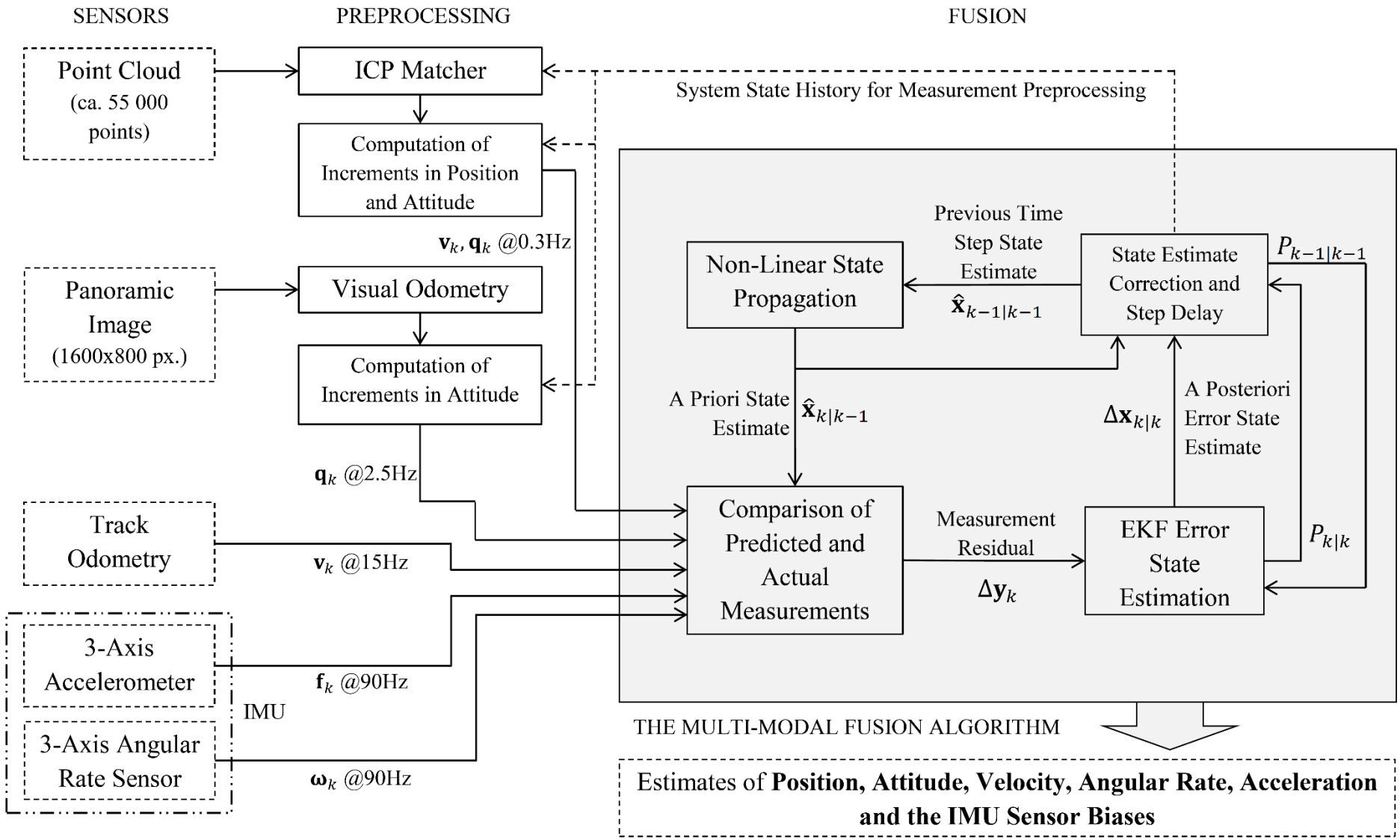


FUNCTIONAL MAPPING

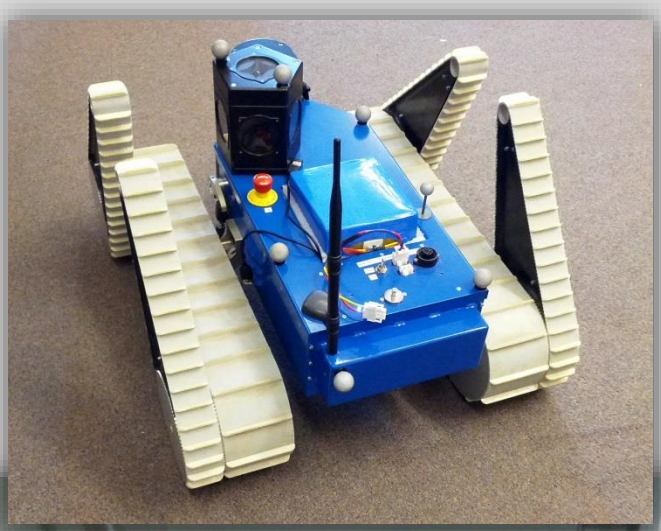




MULTIMODAL DATA FUSION



VICON EXPERIMENTS



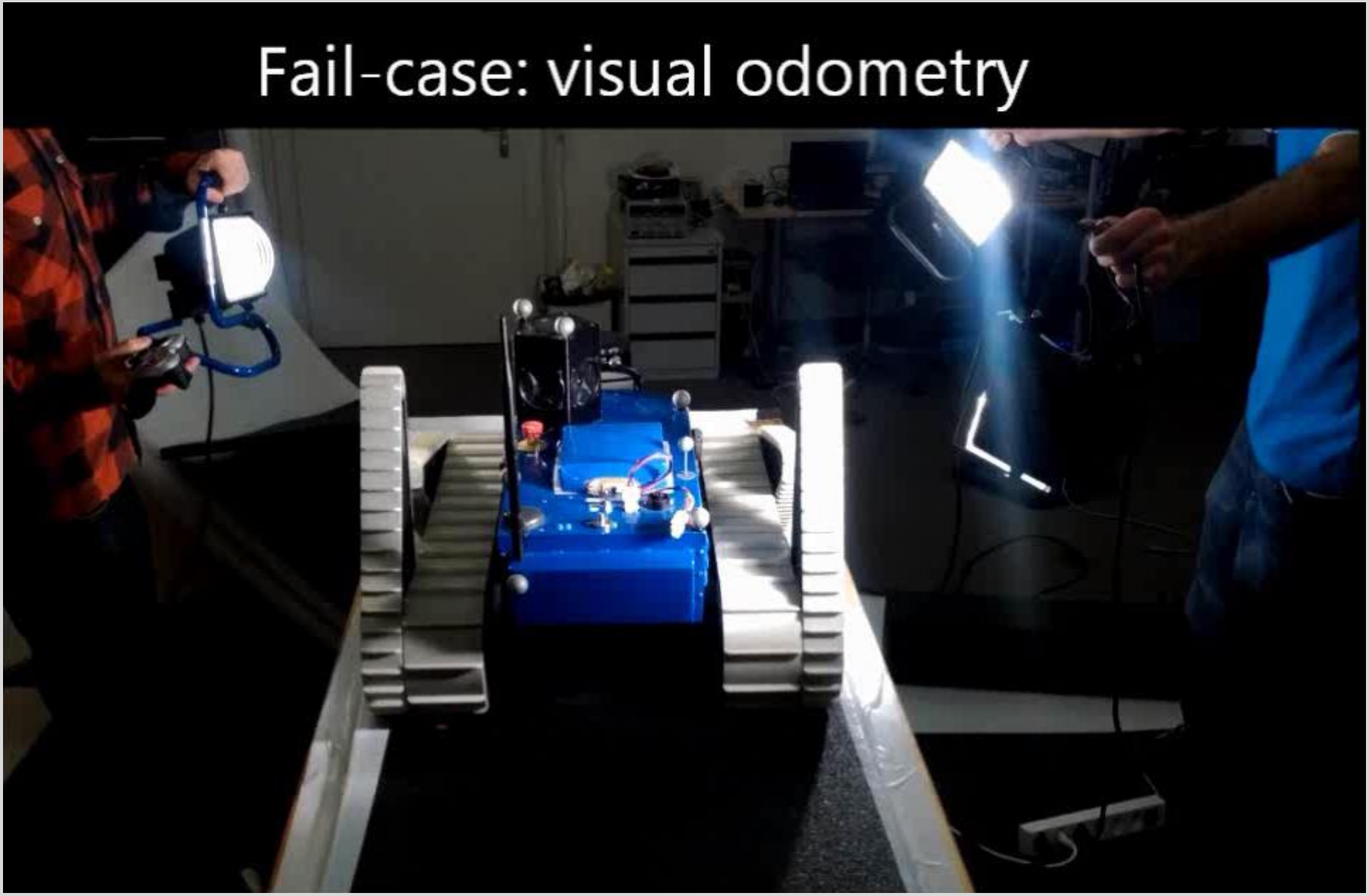
- 6DOF pose data at 100Hz
- Latency of about 10 ms
- Usually 4 markers per robot
- 12 cameras
- Precision approx. 1 mm

Vicon Room at ASL, ETH, Zurich

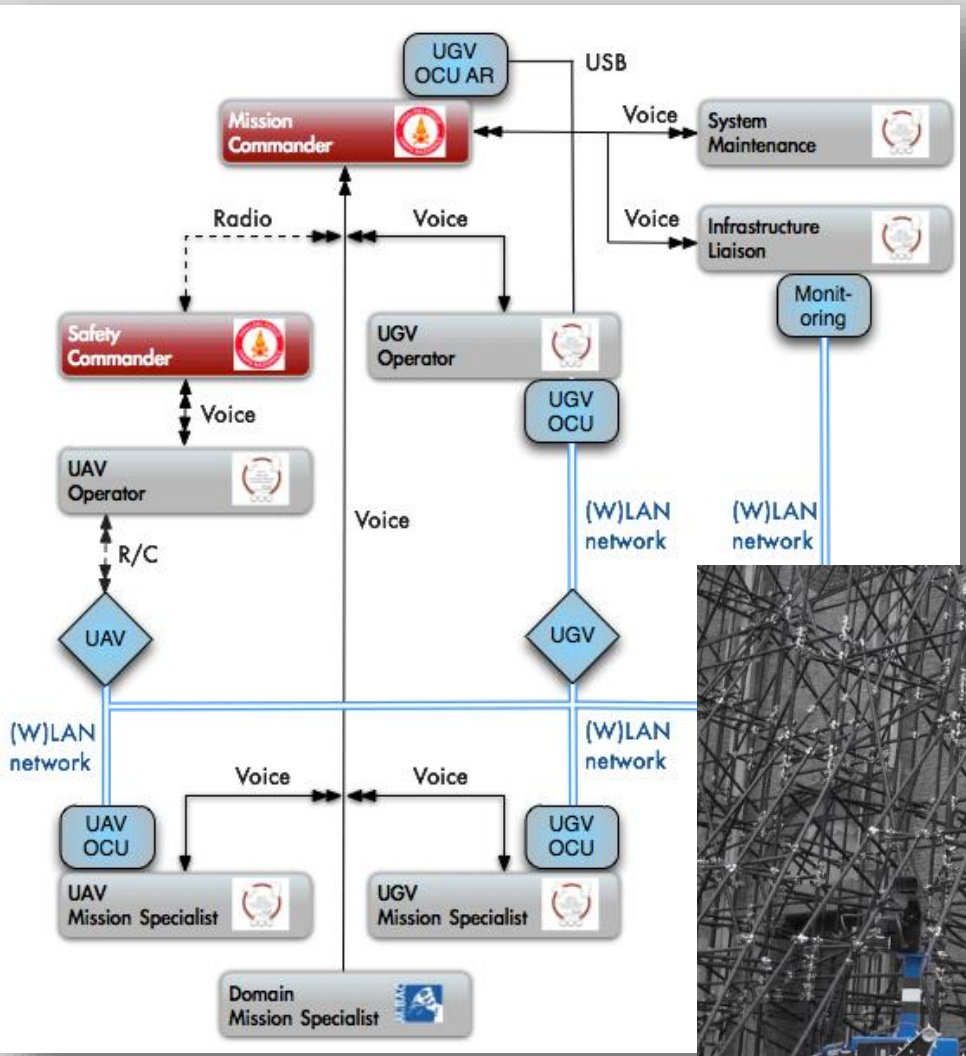
LEICA GEOSYSTEMS EXPERIMENTS

- 3DOF position data at 5-10 Hz
- Automatic target tracking
- Delay 200ms
- Range 3.5 km
- Precision approx. 1-3mm

FAIL-CASE EVALUATION

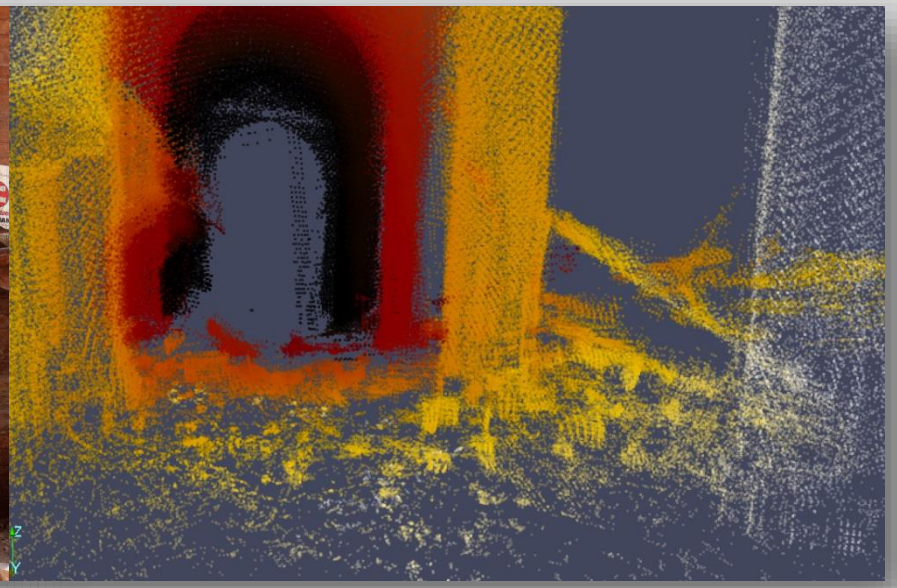


USAR MISSION – MIRANDOLA, IT 2012



May 20 – June 18, 2012,
Mirandola, Emilia-Romagna region, Italy
246 seismic activities
3 – 6.1 Richter scale

USAR MISSION – MIRANDOLA,ITALY 2012



USAR MISSION – MIRANDOLA,ITALY 2012

PERCEPTION AND SENSOR RELIABILITY

- GPS-denied environment
- Disturbance of mag. field - magnetic compass unreliable
- UAV stability strongly affected by strong wind
- Limited visibility due to dust produced by propellers
- Pan-tilt-mounted Kinect-like sensor suffered from dynamic adaptation due to changes in lighting conditions
- LadyBug3 omnicam feed important for driving
- 3D map view crucial for adjusting the robot's morphology for traversing obstacles

USAR MISSION – MIRANDOLA,ITALY 2012

SYSTEM INTEGRATION

- System maintenance impossible by a single person (*system- and infrastructure-related state monitoring*)
- Cognitive overload of UGV & UAV Operators (*piloting without LOS and in confined spaces*)
- No mistakes were allowed (*retrieval impossible*)
- Tactical situation awareness issues regarding information flow between the UAV / UGV teams: *geo-referenced video was lacked*
- UAV and UGV teams never operated simultaneously (*networking and environmental issues*)

CONCLUSIONS

ACCEPTED AUTONOMY IS THE MOST CRUCIAL ASPECT

- robot autonomy in service of the human users
- reduction of cognitive load by improving autonomous navigation, sensor data interpretation, and collaborative decision making

For more information about the NIFTi:

- www.nifti.eu
- http://www.youtube.com/user/EUFP7NIFTi
- http://europa.eu/rapid/press-release_MEMO-12-620_en.htm