



DR 8.7: Proceedings of the TRADR Summer School Yr3 -

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This deliverable describes the third year TRADR summer school, which was organized jointly in cooperation between TRADR and the European Robotics League – Emergency (follow-up of euRathlon). The topic of the school was *Heterogeneity in Robotic Systems*. The school took place August 22th-26th 2016 at the University of Oulu, Finland. The program included lectures by invited speakers, hands-on exercises using the TRADR UGVs, a session of presentations by the participants, UAV and AUV demonstrations and two social events.

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Executive Summary

This deliverable describes the third TRADR summer school. The theme of the school was chosen to be *Heterogeneity in robotic systems*. The school aimed to provide participants with a full overview and hands-on experience with multi-domain (ground, water, air) real robotic systems for deployment in disaster-response scenarios. Focus was specifically on multi-modal heterogeneous mapping, semantic analysis and reasoning and (collaborative) planning under uncertainty.

The summer school was organized jointly in cooperation between TRADR and the European Robotics League – Emergency (follow-up of euRathlon). It took place from the 22nd to the 26th August at University of Oulu's facilities in Oulu (Finland).

55 participants from organizations across 17 different countries attended the school. 11 of these participants were affiliated to TRADR project (20%).

The program consisted of six invited lectures (two introductions presented ERL-Emergency and TRADR, respectively; four lectures addressed the topics of multi-modal heterogeneous mapping, semantic analysis and reasoning and (collaborative) planning under uncertainty), a session where the participants presented their work, demonstrations of UAV and AUV technology, hands-on exercises using the TRADR UGVs and culminating in a challenge competition held on the on the last day of the school and two social events.

The summer school contributed to TRADR visibility in the robotics community, enabled TRADR to establish closer links with ERL-Emergency, inspired vivid discussions and lead to new collaborations.

Role of the Summer school in TRADR

The general role of the yearly TRADR summer schools is to gain new knowledge and disseminate experience. The Year 3 instance was no exception. The TRADR participants acquired new knowledge from speakers outside the TRADR consortium on the topics of multi-modal heterogeneous mapping, semantic analysis and reasoning and (collaborative) planning under uncertainty. They also gained further practical experience by working on the assignments of the hands-on sessions, which were outside of their main area of expertise. Last but not least, the practical sessions and the final challenge also increases the readiness of the TRADR team members to participate in an ERL-Emergency challenge in the future. The non-TRADR participants additionally gained deeper awareness of TRADR goals and results, and have had an opportunity to actively use TRADR technology, in particular the UGVs and UAVs, as well as the mapping SW.

Contribution to the TRADR scenarios and prototypes

The Year 3 summer school addressed topics of immediate relevance to the TRADR scenarios and prototypes. In particular, the practical assignments and the final challenge involved mapping, navigation and the detection of points of interest, which are essential to any search and rescue mission. The intensive exchange with the ERL-Emergency team during the preparation phase and the school itself has also provided inspiration for the elaboration of the scenarios in TRADR and running our evaluations.

1 Tasks, objectives, results

1.1 Planned work

The project proposal plans summer schools organized yearly. For Year 3 it was decided that TRADR organizes the summer school in cooperation with ERL-Emergency (formerly euRathlon) in order to broaden the potential impact of the school, reach out and develop ties to the ERL-Emergency community, to give them insight into TRADR results and let the TRADR experiences contribute to the future shaping of the ERL-Emergency challenges.

1.2 Actual work performed

The summer school took place at University of Oulu's facilities in Oulu (Finland) from Monday, August 22th to Friday August 26th, 2016.

1.2.1 Preparation

The Program Committee consisted of representatives of TRADR and ERL-Emergency:

- Juha Röning (University of Oulu, Finland)
- Ivana Kruijff-Korbayová (DFKI, Germany)
- Marta Palau Franco (UWE, Bristol, UK)
- Abel Gawel (ETH Zurich, Switzerland)
- Marko Kauppinen (University of Oulu, Finland)
- Ville Pitkänen (University of Oulu, Finland)

A call for participation was announced at the European Robotics Forum 2016 (21-23 March 2016, Ljubljana) and published on the euRathlon website¹ on 30th March 2016, it was also distributed through several relevant mailing lists, published on the TRADR website and advertised in

¹ <http://www.eurathlon.eu/index.php/workshop/summerschool2016/>

social media like Facebook, Google+, and Twitter, LinkedIn. On May 4th 2016 an article about the summer school was published on RoboHub².

The deadline for applications was originally 20th May and was extended to 31st May 2016.

A total of 59 applications were received, reviewed by the organizers and all were accepted.

A registration fee was collected from each participant to cover some of the expenses of the event. Two different registration fees were established:

- Participation plus accommodation in a shared cottage: 230 €.
- Participation without accommodation: 60 €.

Both registration options included the breakfasts and lunches of the five days of the summer school, as well as the transportation between the summer school venue, city center (for those who made their own accommodation arrangements) and the pre-arranged cottage accommodation. The registration fees also covered two evening banquets. The pre-arranged cottage accommodation was for the nights between Sunday 21st August and Friday 26th August.

Local organization of the summer school was taken care of by staff members of the University of Oulu, under the lead of Prof. Juha Rönning.

1.2.2 Participants

55 registered participants attended the summer school. The table below shows the distribution of the participants across 17 different countries all over the world: 9 came from Germany, 4 from Italy, 29 from eight other European countries, one from China, and one from the USA, 3 from Saudi Arabia, one from UAE, one from Turkey, 2 from Slovakia, 4 from Norway. 11 of the participants were from the TRADR project partners.

Also the six speakers and the four organizers participated in the summer school. Figure 1 shows a group photo.

²<http://robohub.org/call-for-aurathlontradr-summer-school-2016-on-heterogeneity-in-robotic-systems/>

Austria, 1	China, 1	Czech Republic, 4	Finland, 4
France, 5	Germany, 9	Italy, 4	Norway, 4
Saudi Arabia, 3	Slovakia, 2	Spain, 6	Sweden, 1
The Netherlands, 2	Turkey, 1	UAE, 1	UK, 6
USA, 1			



Figure 1. Participants and organizers of the ERL-Emergency/TRADR Summer school

1.2.3 Venue

The summer school took place at the XXX, University of Oulu. Lectures were delivered in a lecture room (Figure 2). Two labs with computer equipment were available for the hands-on sessions (see more below). Test with robots took place outside. The final challenge took place in the botanical garden of the University (see more below). Breakfasts and lunches were served in a self-service cafeteria.



Figure 2. The classroom where lectures were held. Photo: European Robotics League.

1.2.4 Scientific Program

The scientific program of the summer school consisted of the following items (Figure 3 shows some of the speakers):

- Presentation about ERL-Emergency Robots competition and the European Robotics League by Dr. Marta Palau Franco (University of West England, Bristol, United Kingdom).
- Presentation about the TRADR project by Dr. Ivana Kruijff-Korbayová (DFKI, Germany)
- Four lectures by invited speakers (see below)
- Session of presentations by some of the participants (see below)
- Hands-on practice sessions, with an introduction by Abel Gawel from ETH Zurich (Switzerland) and leading up to a challenge (see below)
- Lecture on aerial safety by Antonio Jimenez Bellido from FADA-CATEC (Spain)

- A presentation and a demo about the practicalities of ground and marine robots by Antti Tikanmäki, representative of Probot Ltd. and Anssi Kemppainen, representative of Aquamarine



Figure 3. Some of the invited speakers (left-to-right: Ivana Kruijff-Korbayová, Matthijs Spaan, Cesar Dario Cadena Lerma, Marta Palau Franco and Abel Gawel). Photo: European Robotics League.

The program and the complete schedule are included in the annex. In response to the feedback on the 2015 euRathlon summer school, the total number and time of lectures was decreased, in order to give the students more time for practical exercises.

The lecture slides are included in the annex.

Invited Lectures

To core of the academic program of the summer school were lectures by three invited speakers on a selection of topics in multi-modal heterogeneous mapping, semantic analysis and reasoning and planning under uncertainty.

- Jan Peters (Technische Universität Darmstadt, Germany): Learning in complex robotic systems
- Matthijs Spaan (Delft University of Technology, The Netherlands): Planning under uncertainty
- Cesar Dario Cadena Lerma (ETH Zurich, Switzerland): Robust SLAM and multimodal mapping

Session of Presentations by the Participants

During the call for applications, the applicants were encouraged to submit a research paper. Although this was non-compulsory, 10 papers were submitted. To allow further discussion of the papers among the attendees, a poster session was included in the program on the fourth day of the summer school. For this purpose, the paper-submitting attendees were also asked to bring a poster to the summer school venue. Because only 3 physical posters were actually brought, it was decided to change the poster session to a presentation-format event where each student who had brought a poster or had other presentation material had 10 minutes to present their work. Nine presentations were given (Figure 4).



Figure 4. Some examples of the students' presentations.

Hands-on sessions

About half of the summer school time was devoted to hands-on practice sessions in which the students developed algorithms for controlling land robots with a strong focus on SLAM and multi-source persistent data integration. These practical sessions were held indoors in the University of Oulu's facilities and outdoors in a nearby (less than 1km of walking) botanical garden where

electricity, shelter and internet access were also provided. The hands-on practices culminated to a challenge scenario that each of the teams performed on the last day at the botanical garden.

A total of 42 workstations with the necessary pre-installed software were provided to the students. In addition, prior the summer school, the students were given a list of software and installation instructions they could install on their own laptops if needed.

The students were provided with two TRADR UGVs and one UAV provided by Ascending Technologies. The students could modify and develop software for the two UGVs, but the UAV was piloted only by the trained representative of Ascending Technologies. Before the summer school, these UGVs and UAV were also used to gather preliminary data for software development during the exercises. The raw data was used to form initial maps that were given to the students to work on for testing and performing simulations. This was done to reserve the students' time for more meaningful tasks as the data collection and generation of 3D point cloud maps from raw sensor data requires several hours of work.

Day 1

During the registration process the students were asked to provide a brief description of their programming experience. This information was used on the first day to form eight balanced teams of six or seven people. The balancing was done mainly in regard of C, Python and ROS experience. At least one person in each group had to have a basic knowledge of these to ensure that the practical sessions would be finished on time. As agreed before the summer school, four members from TRADR did not join any student team and acted as assistant teachers and organizers throughout the summer school.

On the first day the student teams were presented with a challenge scenario (Figure 5) they would perform and compete on the fifth, and last, day of the summer school. The scenario consisted of a simulated toxin leak at the botanical garden. The teams' task was to find and localize the toxic materials (represented by balloons) using the UGV, UAV and the pre-recorded maps of the area. To fulfill this task, the teams needed to fulfill the following sub-tasks:

- Map the area using the available heterogeneous robots.
- Update and refine the map based on new data.
- Develop strategies to safely navigate the UGVs in the danger zone.

- Navigate the UGV(s) to designated points of interest with the highest degree of autonomy possible.
- Detect objects automatically if possible.
- Have the UGV perform automatic collision avoidance if possible.

The hands-on practices were focused on teaching the students how to develop and implement the algorithms needed to fulfil these sub-tasks.

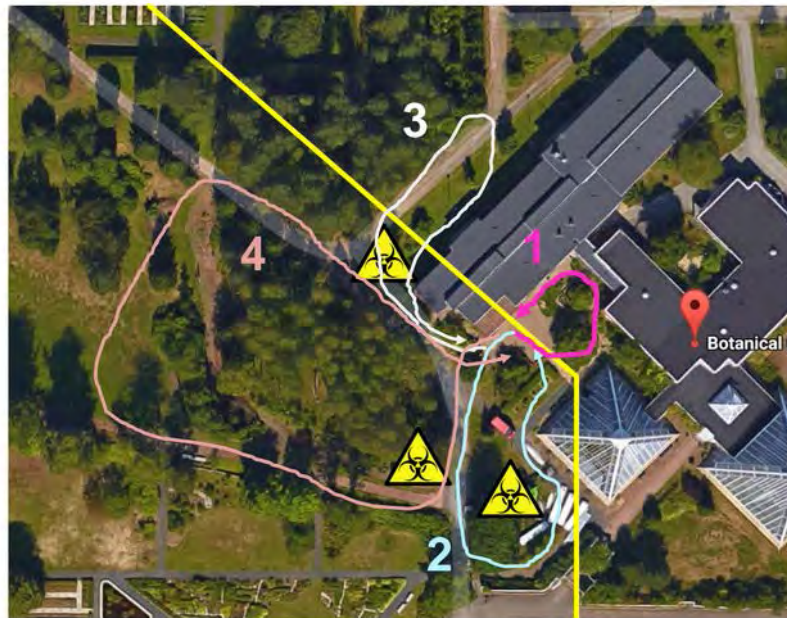


Figure 5. Aerial view used to describe the challenge scenario. Source: TRADR

The students spent the rest of day 1 on learning the tools (Github, simulators, ROS, etc.) that would be essential on the following days. They were also taught the basics of SLAM and map merging.

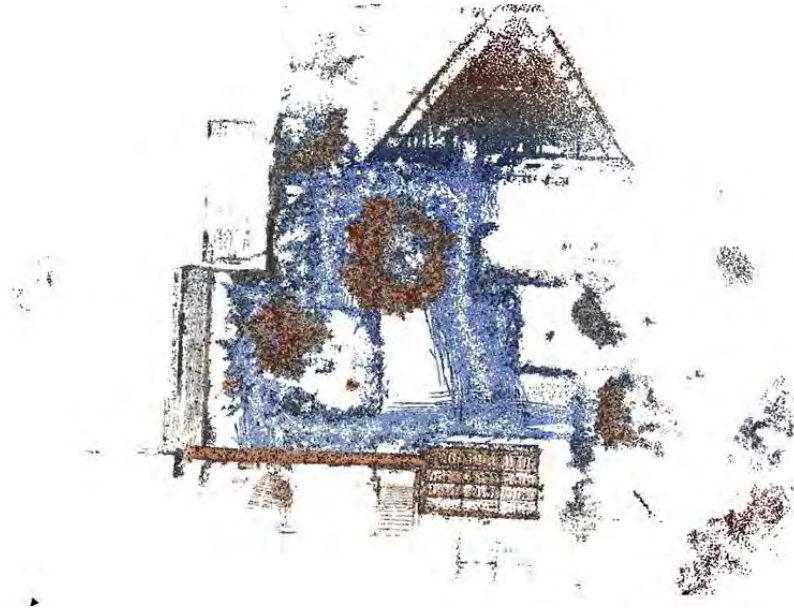


Figure 6. Sub-map of the challenge area constructed from pre-recorded laser scan data. Source: TRADR

Day 2

On the second day of the practical exercises the students deepened their understanding of SLAM and map merging. In addition robot control, localization and waypoint driving were taught using the simulators.

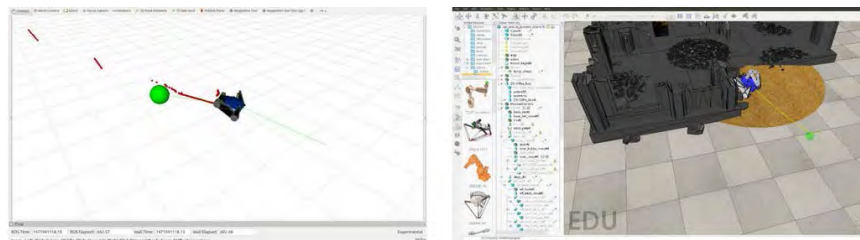


Figure 7. The used waypoint planner and simulator. Source: TRADR

Day 3

On day 3 the students focused on extending the path planning of the robot, with a focus on making the planner responsive to sensor data. Obstacle avoidance was also refined. Half of the teams also tested their algorithms with real robots at the botanical garden. The original plan was that all the teams would go to the botanical garden for the first time on day 4 but ominous weather forecasts forced this change of plans. The teams at the botanical garden used real robots, connected to them, viewed live sensor data, and ran the waypoint planner and waypoint follower, i.e. practiced for the challenge scenario in outdoor environment.



Figure 8. Overlay of UAV and UGV maps. Source: TRADR

Day 4

On day 4 the other half of the teams practiced at the botanical garden while the half that went the day before stayed at the University refining their algorithms. In addition to the practice, the teams were given demonstration and lectures about the practicalities of marine and ground robots by representatives of Aquamarine Robots Ltd. and Probot Ltd.



Figure 9. (Left) The marine robot of Aquamarine Robots Ltd. (Right) Antti Tikanmäki from Probot Ltd giving a lecture on the practicalities of ground robots. Photo: European Robotics League.

Day 5

The final day was spent on the challenge scenario. The toxic leaks were simulated with bright balloons and rough estimates of their locations were given to the teams. Compared to days 3 and 4, the environment was changed by adding obstacles (chairs, tables, etc.). Two teams cooperated together each time. They had 30 minutes to complete the mission, during which they had full access to the UGV. The teams also had a limited 5 minutes access to the UAV, flown by the trained operator, to get a rough overview of the environment.



Figure 10. Teams fulfilling the tasks of the challenge scenario.

At the summer school closing ceremony on the final day all students received a certificate of attendance, and the team partnership that performed best in the challenge was awarded.



Figure 11. (Left) Abel Gawel announcing the winning team. (Right) Chair Prof Juha Röning handing out the Diplomas for the summer school participation.

1.2.5 Social program

The social program consisted of a welcome reception on Monday evening, including the distribution of welcoming kits; sauna and dinner on Wednesday night; a dinner for the invited speakers and organizers on Thursday night.

1.2.6 Results

The 2016 TRADR summer school was a big success. Only 4 registered participants dropped out. The program was run according to the announced schedule, with the one exception of changing the poster session into a session of presentations by the participants. All speakers delivered their lectures and the participants gave very positive feedback on the quality of the presentations and the usefulness of the exercises (more details below).

There were many opportunities for in-depth among the participants and the lecturers. Not the least, the social program facilitated that participants got to know each other, established new friendships and collaborations, some of which will certainly be beneficial for the remaining work in TRADR. Another positive outcome was the high visibility of the TRADR project in the ERL-Emergency community

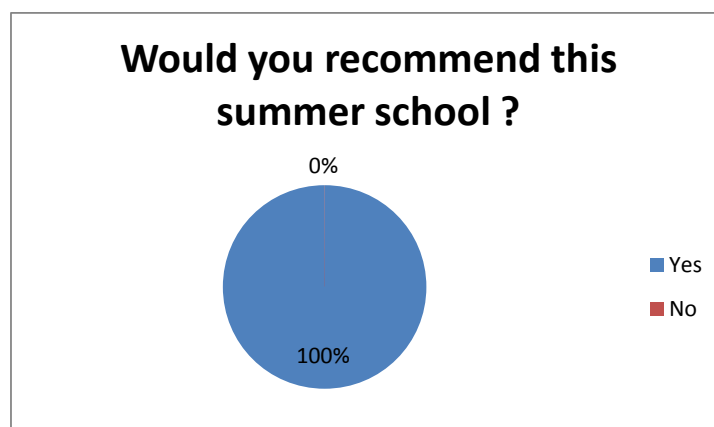
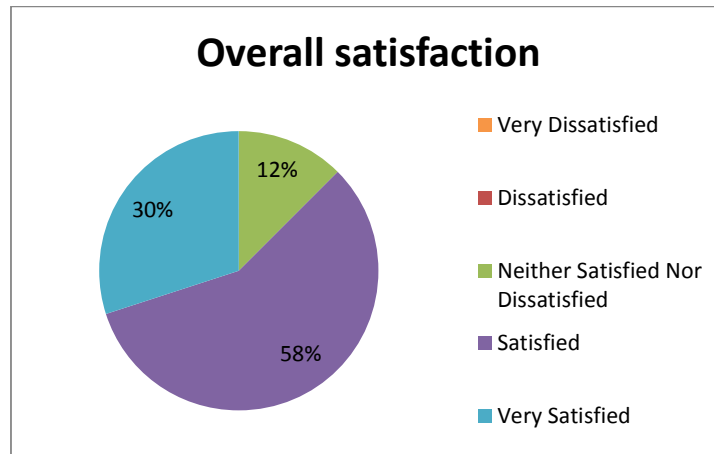
Satisfaction survey

A satisfaction survey was distributed to the participants to receive their feedback for the assessment of the event and their suggestions for future improvements. 40 surveys were returned. The results of the survey have been gathered in the charts and pie graphs.

Overall, the organizing committee is very satisfied with the results as the large majority of the participants were satisfied or very satisfied with the event and all of them would recommend it to others. The participants were especially pleased with the execution of the practical sessions. The most common criticism was the short time given to the session of presentations by the participants (originally the poster session) and lack of food/snacks in the afternoons.

	Very Dissatisfied	Dissatisfied	Neither Satisfied Nor Dissatisfied	Satisfied	Very Satisfied	Blank
Trained/well qualified tutors			1	15	24	
Poster session		8	12	18	2	
Invited speakers			1	24	14	1
Hands on experience - Practical sessions		1	5	21	13	
Hands on experience - Challenge demos		1	11	16	12	
Convenient program times	2	2	10	17	8	1
Registration process			2	14	24	
Organization aspects			2	20	17	1
Facilities		3	4	16	16	1
Meals	2	6	9	15	8	
Accommodation	1	2	5	13	18	1
Social events		1	5	12	21	1
Overall satisfaction with the summer school			5	23	12	

	Yes	No	Blank
Has the summer school fulfilled your expectations?	35	3	2
Would you recommend this summer school to someone else?	39	0	1



1.2.7 Post-Summer School Dissemination

A summary video about the summer school has been made and can be seen on the TRADR project YouTube channel³.

³ <https://www.youtube.com/watch?v=CeY-claYYvE>

2 Annexes

2.1 Schedule

ERL Emergency/TRADR Summer School 2016
University of Oulu, Oulu, Finland

	Monday 22.08	Tuesday 23.08	Wednesday 24.08	Thursday 25.08	Friday 26.08
7:30	Bus departs Nallikari	Bus departs Nallikari	Bus departs Nallikari	Bus departs Nallikari	Bus departs Nallikari
7:45	Bus departs pick-up point at city center	Bus departs pick-up point at city center	Bus departs pick-up point at city center	Bus departs pick-up point at city center	Bus departs pick-up point at city center
8:00-8:50	Distribution of welcoming kits, Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9:00-10:15	Welcoming words - Juha Röning Introduction to TRADR and EURATHLON - Ivana Kruijff-Korbayová and Marta Palau Franco	Learning in complex robotic systems - Jan Peters	Planning under uncertainty - Matthijs Spaan	PRACTICE Outdoor multi-robot object location	PRACTICE Final demonstration of the teams' work
10:15-11:00	PRACTICE Basics of SLAM - Abel Gawel				
11:00-11:15	Break	Break	Break	Poster session Lunch	Break
11:15-12:30	PRACTICE Basics of SLAM (Contd.) - Abel Gawel	Aerial safety regulations - Antidio Viguria - CATEC	PRACTICE Path planning and outdoor persistent map refinement using UGVs		Summer school closing
12:30-13:30	Lunch	Lunch	Lunch	PRACTICE Outdoor multi-robot search and rescue mission utilizing all the previously implemented methods	Lunch
13:30-15:30	Robust SLAM and multimodal mapping - Cesar Cadena	PRACTICE Outdoor navigation and SLAM using UGVs (Contd.)	PRACTICE Path planning and outdoor persistent map refinement using UGVs (Contd.)		
15:30-15:45	Break	Break	Break	Break	
15:45-17:45	PRACTICE Outdoor navigation and SLAM using UGVs - Abel Gawel	PRACTICE Generating maps from provided raw aerial data	PRACTICE Path planning and outdoor persistent map refinement using UGVs (Contd.)	Introduction to Probot Ltd. - Antti Tikanmäki Introduction to Aquamarine Robots - Anssi Kemppainen	
17:45-18:00	Discussion of day 1	Discussion of day 2	Discussion of day 3	Discussion of day 4	
18:15	Bus departs to Nallikari, city center	Bus departs to Nallikari, city center	Bus departs to Nallikari, city center	Bus departs to Nallikari, city center	
20:00-23:00	Welcoming event			Farewell event	

2.2 Lecture materials

This annex includes the lecture materials.