TRADR Newsletter January 2014

Long-Term Human-Robot Teaming for Robot Assisted Disaster Response

TRADR is an EU-funded 4-year Integrated Project in the FP7 Programme, ICT: Cognitive Systems Interaction, Robotics (Project Nr. 60963) which builds on the research and experience of the NIFTi project. The duration of this project is 50 months, from November 2013 to December 2017.

Using a proven-in-practice user-centric design methodology, TRADR develops novel S&T for human-robot teams to assist in disaster response efforts, *over multiple sorties during a mission*. The novel S&T makes experience *persistent*. Various kinds of robots collaborate with human team members to *explore* the environment, and *gather* physical samples. Throughout this collaborative effort, TRADR enables the team to gradually develop its understanding of the disaster area over, multiple possibly asynchronous missions *(persistent environment models)*, to improve team members' understanding of how to work in the area *(persistent multi-robot action models)*, and to improve team-work *(persistent human-robot teaming)*. The TRADR use cases involve response to a medium to large scale industrial accident by teams consisting of human rescuers and several robots (both ground and airborne). TRADR missions will ultimately stretch over several days in increasingly dynamic environments

Partners

DFKI is the coordinator of the TRADR consortium, which consists of 12 partners from 6 countries; among which there are 5 universities, 3 research institutes, one industry partner and three end-user organizations. The end-user organizations are the representatives of the fire-brigades from Germany, Italy and the Netherlands. Eight of the partners have already collaborated very successfully in the NIFTi project. The following are the list of partners that are a part of TRADR project: For more information on them, please visit the project website.

DFKI TU Delft Fraunhofer IAIS KTH ETH Zürich

Sapienza Università di Roma Ascending Technologies Stadt Dortmund Institut für Feuerwehr- und Rettungstechnologie Ministero dell'Interno gezamenlijke brandweer GB TNO

Scientific Objectives

To realize its main concepts, TRADR formulates three scientific objectives.

Objective 1: Persistent environment model

Develop S&T for the gradual construction of models of dynamic environments, fusing multi-modal observations from different kinds of robots, possibly operating asynchronously across multiple sorties during a mission. The result is a single worldcentric model. It is persistent across these sorties, and is dynamic in the sense that its contents may change or be extended to reflect new observations.

Objective 2: Persistent models for multi-robot acting

Develop S&T for the gradual adaptation and grounding of individual- and multi-robot task-level planning and execution within and across sorties, to reflect experience with operating in the disaster area. The result is the capability for multiple robots to learn how to better achieve exploration- or manipulation goals in a previously unknown, harsh environment.

Objective 3: Persistent models for human-robot teaming

Develop S&T for the gradual adaptation of an individual robot's social skills to reflect experience with collaborating within a human robot team. The result is the capability for a robot to become a better team player over time. This supports the persistent growth of a team over multiple sorties.

Unique Contributions

TRADR builds on the experience of the consortium in NIFTi. Key results from NIFTi will be carried over to TRADR. Yet, TRADR is not a continuation of NIFTi. TRADR presents a unique set of contributions, both over NIFTi and the state-of-the-art at large:

- Develops a capability for persistent multi-robot situation awareness.
- Develops a capability for persistent, long-term human-robot teaming.
- Advances the use of a user-centric methodology in designing intelligent systems

Roadmap and Work Packages

TRADR adopts a scenario-based roadmap, to drive iterative S&T development and integration. The roadmap defines a single scenario setting, namely a large-scale industrial disaster. Within this setting, the roadmap then defines yearly uses cases which deal with situation assessment (e.g. through observation, and sample gathering) under increasingly more complex circumstances. This is a kind of disaster where persistence is key to a successful mission. Missions take longer than a single drive onto the scene, we need multiple robots to investigate the disaster from different angles (literally), and we need to use them over a number of sorties to gradually build up an assessment. The TRADR consortium includes several end user organizations who provide training facilities to set up such a use case. See Figure 2 for examples.

Figure 2: Examples of training sites in Germany (FDDO), Italy (CNVVF), and the Netherlands (GB)

Road Map Yr1:

Multiple asynchronous sorties to assess a large-scale static disaster area

The goal in Yr1 is to enable a fixed human-robot team to gradually build up situation awareness of a static disaster site over multiple, asynchronous sorties. The team consists of approximately three human team members operating from a remote command post, a NIFTi ground rover (UGV), and a quadcopter/microcopter (UAV), resulting in a Human-to-Robot ratio > 1 : 1. Situation awareness focuses on determining and exploiting interesting observation and sample sites, to result in a 3D visualisation of the environment model and one or more physical samples to be returned to the command post.

Road Map Yr2:

Multiple asynchronous sorties to assess a large-scale dynamic disaster area

In Yr2, TRADR moves to dealing with a dynamic environment. The goal is for a fixed team to build up situation awareness of a dynamic disaster site over multiple, synchronous or asynchronous sorties. Dynamic events are localized, such as contained fires, limited out pour of liquids, falling over small structures or objects (e.g. barrels, small containers). Sorties can be synchronous or asynchronous, and can involve one or more robots (1 UAV, up to 2 UGVs) so that the Human-to- Robot ratio starts approaching 1 : 1.

Road Map Yr3:

Multi-robot task adaptation

In Yr2 TRADR brings multiple robots into the field, during individual missions. This yields valuable insights in how environment models get fused, and may be used. In Yr3 TRADR builds on these insights to move task adaptation from a strictly individual focus, to a multi-robot setting: How could a robot learn from its use of information provided by others, to adapt its own tasks as well as anticipate requests for such collaboration in (future) plans? For example, if a UGV uses a UAV-provided overhead shot of an obstacle to determine how to cross said obstacle, could the UGV learn from that to request similar information from the UAV next time it faces a similar obstacle? In Yr3 TRADR restricts this learning for information gathering-and-use strategies to a within-sortie planning and execution context..

Road Map Yr4:

Persistence in long-term human-robot teaming for robot-assisted disaster response

In Yr4, TRADR achieves its project-wide objectives. Over the years, more and more robots were introduced, including multiple ways in which robots could collaborate among themselves (squads; synchronous and asynchronous collaboration). Persistence in modeling the environment covers an ever-increasing complexity in local and global dynamic events, appearing on an ever-larger spatio-temporal scale. Robots have come to learn with these situations, and in general how human team members tend to act under those circumstances. In the last year, we once more scale complexity to further reduce the human-to-robot ratio, and increase the temporal scale. Furthermore, we introduce full flexibility in how a human-robot team is composed at any given time: Different robot and human team members may be active at a given point of (day/night) time, to reflect the toll a long deployment typically takes on teams. We do assume that human team members rotate, (i.e. no swift starts in the middle of a deployment).

Work Packages

WP1:
Persistent models for perception

The key objective of WP1 is to provide sensory data from all involved robots registered in space and time, to keep creating and updating robot centric representations, and ground them into the world coordinate frame. The obtained representations are furnished to other WPs, which maintain higher level situation awareness. Various robots that differ in sensory equipment explore the site differently from changing viewpoints in different times.

WP2:
Persistent models for acting

The overall aim of WP2 is to provide various levels of autonomy for the robotic platforms. It is anchored by by the representations built in WP1 and enacts the collaborative plans of WP4. The autonomy sought for is implemented by persistent models that abstract the particularities of each robotic agent to propose behaviors that will be adapted to the environment, the robot and the task. Several levels of autonomy are considered based on the models of human-robot teaming of WP5, ranging from standard teleoperation, through intelligent teleoperation and shared control to full autonomy.

Figure 3: Example of Yr1 use-case setting: Large-scale static disaster area

WP3:
Persistent models for distributed joint situation awareness

The objectives of this work package are: Promote trustworthy and relevant tactical information about the physical environment. Provide a hierarchical representation of experiences which supports tactical decision making. Support awareness of known and unknown tactical information. Provide dialog-based support of communication and multi-modal interaction

WP4: Persistent models for multi-robot collaboration

WP4 deals with persistent collaboration among members of a robot team willing to act both together and individually. The objectives of WP4 are: (A) Develop a statistical-logical theory of flexible collaborative planning; (B) Based on the above theory of collaborative planning, WP4 develops a framework that exploits both logical and statistical inference from several knowledge levels and their partial integration;(C)Implementation of the above framework requires to design algorithms that can cope with both the issues of team knowledge maintenance and updating, by knowledge and information sharing operations, and team-activity dynamic maintenance via the cycle of predict-what needed and decide-to-collaborate.

WP5:
Persistent models for human-robot teaming

The objectives of this package are to develop a logical-probabilistic framework for explaining: how a robot can determine interactive behavior for team-level coordination; how conflicts between actors can arise from the team, how these conflicts can be used to improve alignment between (robot's) private expectation and the other's behavior and how this can be reflected in an improved ability to determine interactive behavior. Finally, to implement the resulting decision making framework and learning framework to evaluate them on bench marks (within WP5) and integrate them into the overall TRADR system (WP7).

Figure 4: Example of Yr2 use- case setting: Large-scale dynamic disaster area

WP6:
System framework and integration

This package (a) specifies and sets up the TRADR technical system framework; (b) Develops adaptive control on the system level; and (c) Integrates WP components continuously into a single architecture.

Figure 3: Example of Yr3 use case setting: Several days-long assessment of a large-scale

WP7:
User needs analysis and scenario-based evaluation

The objectives are: (A) Perform a deep domain analysis of USAR environments with end-users, starting at project beginning and reiterating and refining after every evaluation; (B) Integrate WP components into a single cognitive architecture, and evaluate on system-level; (C) Perform end-user evaluation of the integrated systems

Figure 4: Example of Yr4 use case setting: Large-scale static disaster area.

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