DR 3.3: Tailored Shared Situation Awareness Interfaces

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This document describes the work done in Year 3 in WP3: the development of persistent models for distributed joint situation awareness. This includes the ongoing TDS development itself from technical point of view as well as in conjunction with the ontology-based approach for an improved SA. We discuss the next steps taking into account the results of different tests concerning the impact of the TDS on operation management from operators' view. Under the aspect of sentient dialogue for tailored SA we address how the collaboration between humans and robots could promote the use

from end users perspective. Another aspect of system improvement in a complex information relationship is the introduction of dialogue with the TDS and other speech processing functionality. Last but not least the benefit of a technical extension by using the DIORAMA App for smart phones and tablets in addition to the TDS is presented.

Executive Summary

This report presents the results of ongoing efforts regarding the development of persistent models for distributed joint situation awareness in Workpackage 3 in Year 3, specifically Task 3.3: Sentient dialogue for tailored Situation Awareness. The progress during the year, improvements and new integrated developments were evaluated by professional and voluntary end-users during the TRADR exercise in Prague and the TRADR evaluation in Dortmund.

We present details about the technical improvements of the TDS based on tests of its practical use by end users. This includes in particular improvements of performance, handling and situation awareness; keeping the overview despite new layers for more information; assigning priorities for the layers; and photo viewing and personal messages for keeping the user up to date. We discuss in detail improvements of situational awareness by a personalized TDS and an ontology-based approach with a concrete example. Also the improvements in the speech interaction processing are presented and its influence on the handling of the TDS.

Work on the TDS development has been slowed down by lack of personnel at FDDo despite ongoing hiring efforts. We therefore plan to transfer resources to another partner to contract a suitable developer (this is discussed in the Periodic Report).

Role of persistent models for joint situation awareness in TRADR

Time is the limiting factor in the response of incidents. Injured has to be rescued, dangers eliminated and natural and urban assets protected. The TRADR project aims a system that enables the users, organizations in charge of incident response, to explore and monitor the impacted area by a human-robot team. Robots shall support the humans at high risk places and equipped with sensors even those which are sensitive outside of the natural human senses deliver information for a situational awareness for the humans but also for themselves. This is an essential condition for an autonomous behave of the robots and a goal for the project. Achieving this objective persistent models for distributed joint situation awareness will support the awareness development process by information gathering and transferring it in a tailored structure. The overall focus will be the information quality and distribution at the right time to the needing/requesting person. In Year 3 of WP3 of the TRADR project the robots shall learn to continue tasks by using information previously gathered and realize similar situations so that they request active for needed information. The following chapters demonstrate the progress in this WP.

Contribution to the TRADR scenarios and prototypes

This work package contributes directly to the overall project vision of natural interactive human-robot cooperation, and particularly to Objective 3, user-adaptive human-robot communication for human-robot teaming. The results from this work package are directly integrated with the TRADR system (through WP6), as they are the focal point of user interaction with the TRADR system. Furthermore, through WP7, they have featured extensively in the scenario-based evaluation with end-users in Year 3. More specifically, the TDS prototype has been tested with end-users during the T-JEx andT-Eval experiments. In addition, task support functionalities for situation awareness have been further explored and new speech processing and dialogue functionalities have been developed.

Persistence

Persistence in WP3 is addressed by enabling end-users to interact with (relevant) information that is persistent within the TRADR system. In effect the TDS serves as a looking glass and filter into the TRADR databases, as to support persistent SA and allow tactical decisions to be made effectively. Thus, the TDS provides access into information retained over the course of multiple sorties.

1 Tasks, objectives, results

1.1 Planned work

The work in Year 3 was planned to address Milestone MS3.3: "Adaptive multimodal user interface for sentient robot control and information". The result should be a software module prototype that could interpret and attune dialogues to facilitate anticipatory actions.

1.2 Actual work performed

WP3 made progress on these main aspects in Year 3:

- Continued development of the TDS, including improvements of performance, handling, situation awareness; keeping the overview despite new layers (grid, trace, working areas) for more information; assigning priorities for the layers; photo viewing and personal messages for keeping the user up to date
- Situation awareness by a personalized TDS, ontology-based approach
- Integration of speech interaction processing

We present an overview of these efforts in the following sections.

1.2.1 Progress of the Tactical Display System

The communication interface between the system and the outside, called TDS, is a GUI for mission management and robot operation planning, respectively their execution control. Compared with Year 2 we aimed to extend the scope of TDS functions and improve user friendliness. A second issue is the response time for queries to the HLDB. It needs long time and thus reduces the practical usability of the TDS. This provokes double entries which confuses the user and reduced the quality of the whole system.

Below we describe the improvements of TDS that were made in Year 3. Several new layers have been added to the existing layered map, new ways of informing the user are introduced whilst stability and user friendliness is improved.

Improved awareness. Continuing the TDS concept of a modular design information are distributed on different layers. Users can decide if they would like to see the information or not by fading in or out the specific layer. This can concern places, health status of victims, fire or other dangers as well as paths driven by the robots. New layers added in Year 3 should improve the mission management by subdividing the incident area, marking parts and tracing the actors.

The Grid layer is one new layer introduced in Year 3. The grid design is a fixed structure as an overlay over the map without a GPS relation between them. A better orientation in the field and identification of a part of the incident area can be achieved by using the cell coordinates or colourings cells transparently. The grid is an overlay of only the disaster area and its location and functionality can be changed for what is needed for the current mission. Next to providing rescuers with clear naming conventions (such as “There is a victim is grid B3”) it provides three possible modes of which one can be used at a time: Hot Zones (for the Team Leader to warn infield rescuers of unstable areas), Explored (automatically filled from HLDB, indicating which area has been visited by either a robot or infield rescuer) and Traversability (indicating roughness/accessibility of terrain). More details regarding how the grid layer may increase situation awareness is described in Section 1.2.2.

Another new layer is the Trace layer, in which the route taken by an actor is displayed based on earlier received locations. A slider is present as input for the user to indicate from how long ago locations should be shown. Another option in this layer is to show the current heading of actors for better orientation. The tracing of actors especially the UGVs improves the mission management in a number of ways. Users are able to get a more specific impression of the incident structure while a relationship between images or information. The driven path is also clearly shown. More details about how adding traces may influence situation awareness are provided in Section 1.2.3.

The last added layer is to display the assigned working areas for the actors. This area can be of arbitrary size or shape and can be added by the Team Leader. The assigned area is a way for an infield rescuer or robot operator to know for which area he/she is responsible to explore. The working areas of all actors can be shown, or only the one for the logged in user.

The user may now choose between a grid or a freehand tool to mark and assign special areas. Both solutions are the result of the end users demands noticed at the Y2 evaluation.

For Points of Interests, a feature for assigning priorities has been added. The priority can be given on a scale of five levels. This makes it easier for a Team Leader to direct more attention to the problem areas. Depending on the concept for allocation of responsibilities the levels could be used for autonomous robot behavior. Every level could stand for a range of tasks dependent on the nature of the incident. Level 1 could mean e.g. victim detection, detection of explosive atmosphere, radioactivity. Level 2 search for leakages and so on. The combination of level and task thus could determine the behavior of the robots’ autonomy.

Finally, the user is actively kept up to date with new information using personal messages. Depending on the role with which the used has logged in and depending on some external event, a message is shown (a notification, warning or alert) informing the user about this new data. It is important that the users will not receive too many messages which would disturb their concentration. In future experiments we have to identify the realy important messages and to develop a stepped approach in presenting them to the users.

Photo viewing. A simple photo viewer has been added to view images, taken by the robots, in high resolution and with zooming capabilities. This opposed to the thumbnail like images as before on which important information often was missed. The detailed view offers more clarity in the determination of POIs and pushes the situational awareness for both the humans and the robots. Something far more profound is the collaboration between the robots. The POIs can be assigned to different robots for closer exploration. In result a self-organized robot management could be established, controlled and confirmed by the operators.

Error handling and recovery. To improve stability of the system, a lot of error detecting and correcting code has been added. The TDS now detects immediately that the connection with the TRADR core has been lost and warns the user of this, while trying to reconnect. Afterwards it can be checked what went wrong exactly as extensive logging is implemented.

Database. The database has been updated to use less and more intelligent queries. This saves lots of traffic on the network (data duplication) and results in better TDS performance. When a query does not return satisfactory data, a fallback query is executed to still have less but the most up to date values.

Improving user friendliness. Some small changes have been made to the TDS improving user friendliness and preventing possible confusions during missions:

- Displayed names of actors and Points of Interest have been standardized. Each POI has a clear name ("Fire", "Victim") appended with a unique number.
- Buttons and text have been enlarged to be touch device friendly and easily visible on every screen.
- A "View settings" widget has been added to change TDS appearance, grid opacity and map settings and other display related settings.
- Statuses of actors can now be changed from the actor overview widget, which becomes directly visible for other users.
- A victim can now be marked as Saved
- Auto-generated documentation is added for other possible developers and later use
- A small widget containing statistics (Number of POIs per type displayed) has been added

Testing and developing support. The TDS was programmed to only perform actions when receiving information from the HLDB. As the functionality became more complex, testing was also getting harder. For this reason, a small module has been added to test (new) functionality; the TDS tester. From this window within the TDS the following types of data can be inserted into the HLDB as if it were to come from real sources: images, actor locations and actor movements. This can also be used to do simulated training as was also done during ITEX, where this module was used to process data from a simulation running in Unity. Another module was added to perform certain database commands without having knowledge of the system (clearing or resetting the databases), and without needing RQT.

1.2.2 Increasing situation awareness by a personalized tactical display system's interface

Feedback from the end-user evaluations in Y2 (ITEX 2015 and TEval 2015) resulted in a list of feedback and suggestions from the end-users about SA support from the TDS. The specific feedback was:

- S1 It is very difficult to gain situation awareness regarding one's own position on the map and regarding other team members and robots
- S2 The TDS does not add additional value for the robot operators at the moment
- S3 The map should have a grid (with coordinates) to more easily communicate about location and direction
- S4 It should be possible to see the position of the robots and the UAV on the map
- S5 It should be possible to add markings and symbols on the map, e.g., for barrels (and use it as a tactical worksheet)
- S6 It would be good if it was possible to mark dangerous areas on the map ITEX Delft
- S7 Ability to see where robots have been is missing
- S8 Briefing: divide area up into parts which respective team-members explore
- S9 TDS: implement idle status, explored area, whether an area is safe

The suggestions make clear that, in its current form, the TDS offers insufficient information and structure to communicate effectively about the

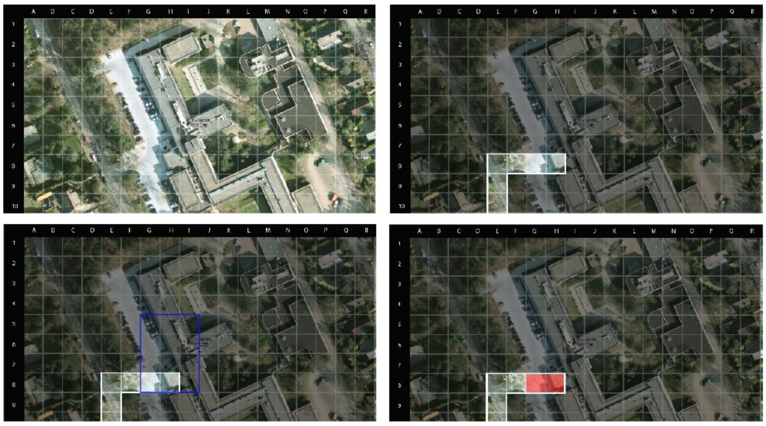

Figure 1: Grid Features: Top left (Labelled squares), top right (Highlight explored areas), bottom left (Display assigned areas per operator), bottom right (Display danger zones)

mission at hand (S2, S3), lacks possibilities to gain a clear overview of the situation (S4, S5, S6, S7, S9), does not sufficiently support task allocation (S8) and does not sufficiently support Situation Awareness (S1). The TDS, then, needs to provide team members with more detailed information and more options, plus an efficient template to facilitate communication. In presenting this information to team members the Cognitive Task Load Bottleneck needs to be avoided, so it is imperative that the information is presented in a fashion that does not create a huge increase in cognitive load.

Taking the feedback and suggestions into account, the following functionalities have been added to the TDS to support SA:

- Grid with labelled squares (S1, S3)
- Highlight areas that have been explored (S7)
- Display assigned area per operator (S2, S8)
- Display areas as safe or unsafe (S2, S6)

Feedback S4 and S5 were already part of the TDS and not specifically part of this research. See Figure 1 for the design patterns of the functionalities. These design patterns were implemented and evaluated in TDS. For screenshots of the implementation see Figure 2. The TDS implementation was tested in a virtual environment (Unity) by 24 participants (mostly students). Each participant played four use cases: two as team leader and two as robot operator. They conducted the use case in each role with SA enhancement and without. For detailed information on the set-up see [25].

the evaluation performed for this research gave good indication through user feedback (both verbal and the suggestion form) that the proposed fea-

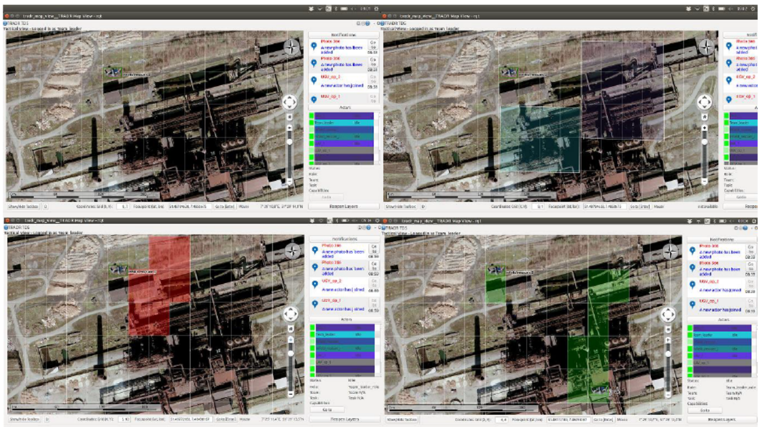

Figure 2: Added SA enhancement, grid coordinates (top left), assigned zones (top right), danger zones (bottom left) and explored (bottom right)

tures will indeed be an asset to USAR missions, increased performance and overall improved usability of the TDS, additional research is needed before any real verdict can be made on the effect the new user interface had on situation awareness and task load. In order to test these effects, larger, more comprehensive experiments need to be conducted with multiple team members, a longer more difficult scenario and functionality of all features working fully and properly. We did find that the SA enhanced condition correlated with significantly more reported mental effort in participants. We believe that part of that can be attributed to the preliminary stage in which the TDS SA enhancement has been implemented: no clean graphical user interface and no full functionality of the implemented functions. Additional research is required to test conclusively what the effects of these changes on mental effort are in USAR scenarios.

1.2.3 Situation Awareness enhanced tactical display system features for first and successive USAR sorties

The TDS shows a map of the hot zone to the team leader and robot operators [29]. Additional information is automatically updated (like location of the team members in the hot zone) or added by the user (for example pictures, problems, goals etc.). specifically, the purpose of the graphical user interface is to display role-dependent tailored information to enhance the Shared SA, Team SA, Distributed SA [7], and Individual SA. The actors within the team are one UAV, two UGV's, three operators, one team leader, and one field rescuer. Research on which problems exist in deploying a robot team to a USAR mission shows that the UGV operators lack understanding of orientation (TRADR Joint exercise), where they are moving towards and what they see [22]. It is also observed that the operators rarely seem to use the TDS, even though the purpose of utilizing the TDS is to increase their SA. However, it is not clear why the TDS does not improve SA. A reason could be that the workload to operate the robot and explore the surrounding is too high and thus the operators cannot find the attention span to also control the TDS. Another likely scenario is that the TDS does not show adequate information (like heading direction and not user-centered design of the TDS. To increase SA with the use of the TDS three features have been designed: 1, location trace, 2, heading direction, 3, timeliness of location trace and/or direction. In this study we conducted experiments on how workload can be decreased while SA is enhanced using these graphical features.

Firstly, from the evaluation of earlier results, graphical features are selected and further improved towards a final design [8],[21]. This design[1] was implemented in the TDS and an experimental validation study was conducted. The experiment consisted of a within-subject design in which (about) 30 fire-fighters operate a ground robot. The experiment starts with the baseline, followed with the additional features of which the order is counterbalanced across participants. On two computer screens the UGV operator(s) operated the robot and the TDS. The participants operated a UGV in a virtual disaster zone and went through all features (location trace, heading direction, timeliness) which represent the independent variables. As dependent variable, during and after each condition SA was measured (QASAGAT (during a pause in each feature condition) and SPASA (after each feature condition) questionnaires). As performance measure we used the performance (number of victims found) and workload was measured using the NASA-TLX and BSMI questionnaire after each condition. The task was in each condition the same: "explore the virtual environment and locate victims and fires within 8 minutes".

Regarding the outcomes of the research, sometimes more data equals less understanding because this is either less clear or make understanding of the map harder. This seams to be the result of the data analysis. One significant result shows that condition 4 (temporal directional trace) creates a better understanding of the situation. Workload and performance are not significant. Often problems arose for the participants in operating the TDS. Suggestion from these tests are that more user-centered design needs to be implemented, such as e.g. dragging an icon onto the map, deleting this or move it to another location. After these more basic functions, more advanced SA studies can be executed.

The full report of this research can be found in [30] (Annex Overview 2.2).

[1] the named location trace, heading direction and timeliness of location trace and heading direction

1.2.4 Ontology-based situation awareness support for shared control,

Tele-operation of Unmanned Ground Vehicles (UGV) is difficult: It requires adequate perception and prediction of (1) the location and movements of the UGV and its parts (e.g., arms), and (2) the (dynamic) environment in which it operates, see [20]. So Situation Awareness (SA) is important for tele-operation. We are developing an ontology as a common human-robot knowledge base for tele-operation. As an example, we discuss a UGV that has to pick up a sample with its arm. What makes the tele-operation difficult is the SA of the operator on all aspects important to perform the tasks of navigating to the location and picking up the sample: the location, orientation and movement of the UGV; location, orientation and movement of the arm; environment and objects in the environment; task progress, operation constraints (e.g. low bandwidth) and the state of the operator (e.g. task load). We aim to establish joint human robot SA for optimal task performance. To guide and establish the design and development of an optimal human-robot SA, we used the we used the situated Cognitive Engineering (sCE) method [23]. The sCE method is used for a theoretical and empirical grounding AND iterative, incremental development. Therefore, we are developing a generic SA ontological model, and tested it for the use case. For more details see [28].

1.2.5 User needs and functional flow

In an industrial project, system development is directed towards the combination of technologies, that best fits the context in which the system is applied. The problem space (user needs in a certain environment) is the starting point. The technologies within the system are a means to an end, and may be replaced by other technologies. In TRADR, the system prototype is applied in the wide context of disaster response, and evaluated by users throughout the course of the project. Herein, a user-centric design methodology is used (Kruijff G.-J. , 2013, p. 5); development is directed by user needs, to maximise impact of the system. To gain insight into the current (and proposed) system, we have modeled the system in different levels of abstraction, to increase and more effectively demonstrate its potential impact in disaster response.

To do this, we have modeled different levels of abstraction, e.g., the functional flow and the physical view of the system.

The functional flow displays the logical sequence in which functions are carried out, because the one requires input of the other. However, this does not mean only one function can be carried out at a time. Figure 3 presents the functional block diagrams of the systems, which are discussed in detail in the remainder of the section.

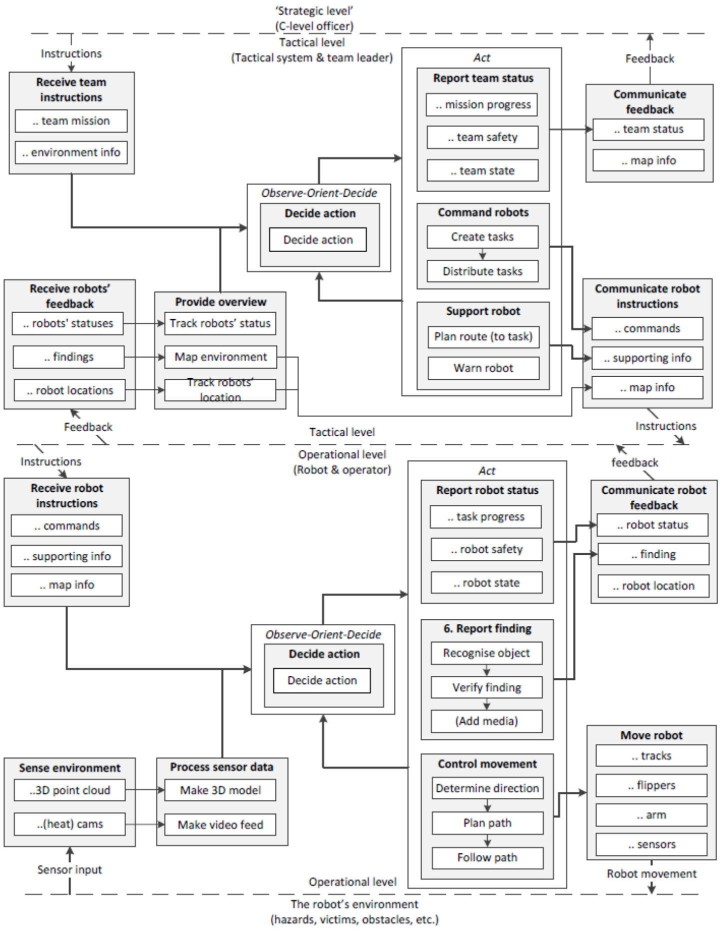

Figure 3: Overview of the functional flow of both the tactical system (top) and an operational system (bottom). The borders of different hierarchical levels are illustrated with dashed lines, and the levels above and below the TRADR team are shown as well. Following the functional flow, instructions flow down the command chain from the top left to the bottom right. Feedback flows up the command chain from the bottom left to the top right.

Figure 4 represents a schematic overview of some major physical parts of the TRADR system: the central computer, the robot, the connection, the user interface, and humans. Functions have been allocated to these different parts. Furthermore, some utility (infrastructure) functions are depicted, which do not have a number. Utility or infrastructure functions are "functions that provide service to other functions in the system, without direct benefit to the customer"[1]. Other functions, such as those performed by the robot's battery are not displayed.

1.2.6 Team support system

As described in earlier deliverables, the TRADR system should optimally support the human team members in their task execution, and optimize the team cooperation in human-robot teams. We do this by

- abstract optimal task allocation (regarding both task redistribution if necessary and determining optimal degree of autonomy of robot), depending on human and robot status (such as task load, capabilities, context changes etc)
- supporting the human's SA by adapting the communication (e.g., presentation of information on interface, depending on role and current SA).

In Figure 5, an overview is given of the model that is the basis to reach this goal. As input to determine the task allocation, three important concepts have been identified, that need further specification: *task analysis*, *environment models*, and *actor models*. In the last years, a lot of research has been done on individual aspects of these different concepts, such as the online evaluation of cognitive task load of the robot operator [6], modeling dynamic task allocation [11], and determining the emotions of the the robot operator [19].

However, the different aspects have not been integrated into a general model for optimal team support. We have started this work, and plan to continue the (conceptual) integration in the final year of TRADR.

1.2.7 Speech Interaction Processing

We continued to work on the Dialog Framework and extended it to support multimodal interaction with TDS. The dialog framework can now carry out extended multimodal interaction (a combination of speech and mouse clicks on TDS) with users, supporting the to insert victims and points of interest in the map and additional information about them. We have also worked on analyzing the human-human communication in the team, with the goal to automatically process it in order to extract mission progress information, such as the reported status of the robots, keeping track of tasks assigned

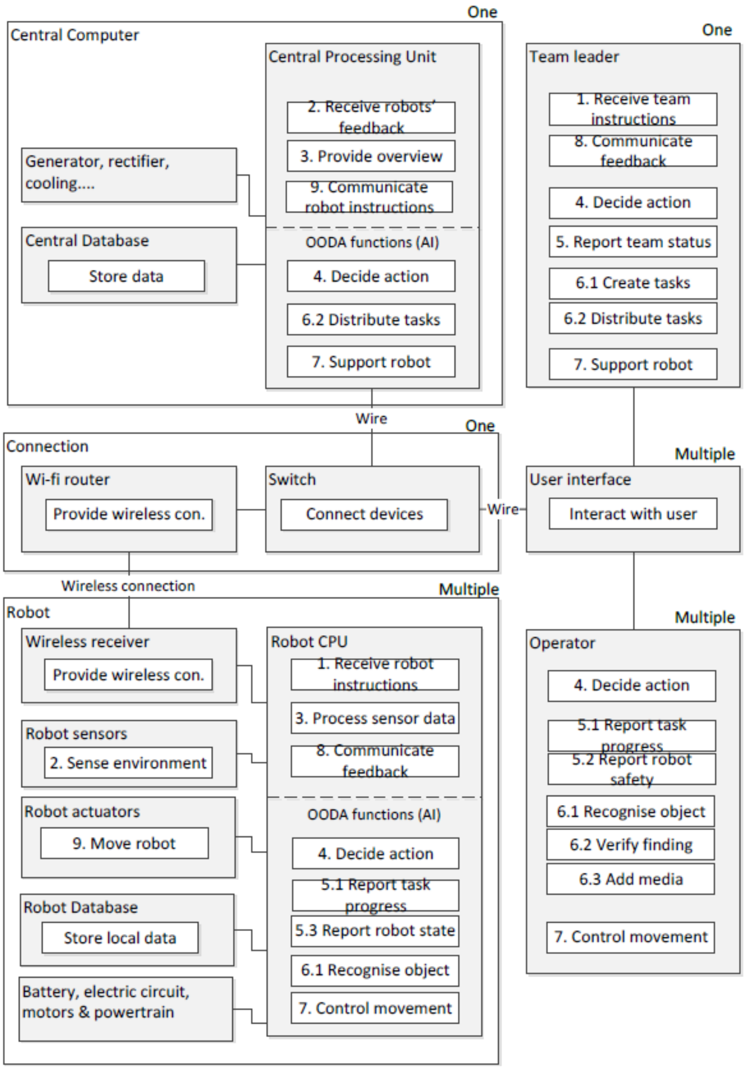

Figure 4: Physical view of the TRADR systems (central computer and robot), users and the connecting infrastructure. Functions are allocated to different physical components or users. Numbered functions are those that appear in the functional flow. Other functions are utility (infrastructure) functions. Some functions are shared between system and user

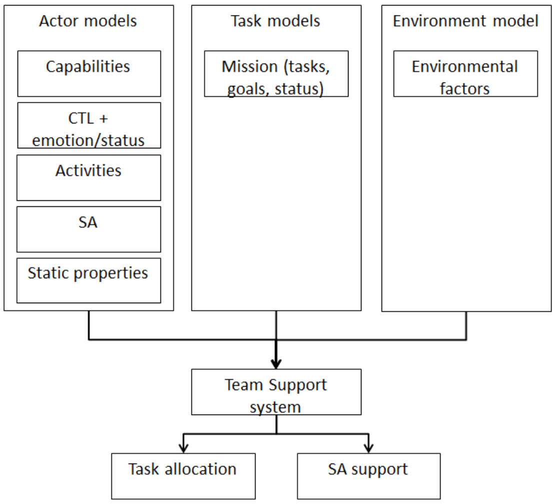

Figure 5: Overview of Team Support Model.

to various team members, and information about detected casualties and points of interest. We present the results of an analysis of the dialogue acts in our team communication corpus and initial results on understanding human-human utterances by recognizing user intents to keep track of tasks assigned to various users. Last but not least, we have integrated the latest state-of-the-art ASR system Nuance Mix Cloud ASR, resulting in significant improvements of ASR accuracy. Details of the work carried out can be found in [27] (Annex Overview 2.4).

1.3 Relation to the state-of-the-art

1.3.1 Another system to support SA during USAR missions

To show how the TDS is related to state-of-the-art, we would like to discuss another interesting system that is under development to support SA in USAR missions. The DIORAMA system [9] is a system designed to generate situation awareness in order to improve USAR missions. The DIORAMA system consists of Android smartphones and tables running the DIORAMA application, active RFID (radiofrequency identification) readers and tags and the DIORAMA server. While the DIORAMA system is not created for human-robot collaboration, the Android program on the phones and tablets has a strong relevance to communication systems in USAR. DIORAMA focusses on presenting the available information in an efficient fashion to the team members by means of the application running on tablets and smartphones, and research has been done on the effect of the application on the SA of team members. The results were positive, finding an increase in SA and efficiency when using the application compared to not having access to

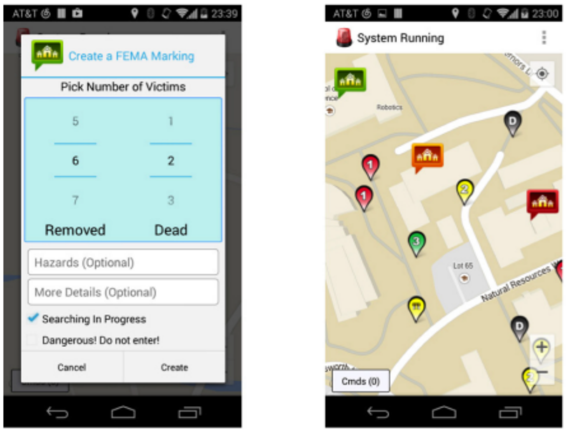

Figure 6: DIORAMA Interface (left) Indicate Victims/Points of Interest, (right) Area Map with Markers

that particular information.

1.3.2 Situation Awareness enhanced tactical display system features for first and successive USAR sorties

Improving communication produces SA which results in better decision making and thus better performance [13, 26, 17]. As result to that, coordination and cooperation of a team is not possible without shared situation awareness and mutual feedback and is more crucial the larger the teams become [2]. Teams including robots are effective and efficient if communication enhances the strengths of the human and robot, real world decision making and operating under difficult circumstances, respectively [3]. Though, communication cannot solve all issues. Perceptive disorientation, sensory noise, and control delays make teleoperation difficult to use even with much practice [12]. This would be improved if the robots are more automated (and social) and cooperate with the human team members [14, 15, 24]. However, a highly dynamical real world like USAR situations make automation very difficult [22]. A study on how a team of two people can operate 24 robots shows that suggested search guidance and direct communication improves efficiency over automated search guidance and tele-communication, respectively [10]. Comprehending data from robot operation in a real USAR situation, currently, requires a new guiding interface and is a team effort since a high situation awareness is provided by discussing this with a partner [4, 5]. It is suggested that only robot automation and clearer interfaces can make this an easier task, which is why automation should not be seen as a substitute for humans, but as a help for decision making [16]. For instance, sensors could be used to infer victims and hazardous materials [18].

1.3.3 Speech interaction processing

Speech interaction processing has been booming in recent years, finally reaching levels of robustness and reliability that make speech-based applications usable in everyday life. Most of the widely spread speech-based interfaces are speech only (or combined with text input), but there are also recent multimodal systems that aim at multimodal interaction with maps, focusing mainly on navigation or annotation of pre-existing objects / POIs on maps where POIs are already represented in the system and users request for navigation related operations (e.g. ?Show me the nearest restaurant restaurant? etc). We have come across one older application where users make new POI entries on a map using multimodal inputs (speech and digital pen) and annotate them. They however do not support an extended dialog about the POIs. So our interaction approach is novel in this regard. More details and references are presented in [27] (Annex Overview 2.4).

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2 Annexes

2.1 M. van Rood (2016), "Increasing situation awareness in USAR human-robot teams by enhancing the user interface"

Bibliography M. van Rood (2016), "Increasing situation awareness in USAR human-robot teams by enhancing the user interface". Thesis on situation awareness support.

Abstract This thesis describes the design and evaluation of personalized situation awareness support (role and user) by showing a labeled grid with highlighted explored areas, assigned area per operator and safe/ unsafe areas in TDS.

Relation to WP This thesis contributes to T3.3 Sentient dialogue for tailored SA, since the design of situation awareness support is tailored to specific roles and taking into account task load of the user.

Availability Unrestricted.

2.2 S. Speckens (2017), "Situation Awareness enhanced tactical display system features for first and successive USAR sorties"

Bibliography S. Speckens (2017), "Situation Awareness enhanced tactical display system features for first and successive USAR sorties". MSc thesis, Department of Industrial Engineering & Innovation Sciences, Eindhoven University of Technology, The Netherlands.

Abstract This thesis describes the influence of the presentation in the TDS of timeliness of robot and robot-camera direction and location trace on confidence, accuracy, timeliness and workload of a UGV operator.

Relation to WP This thesis contributes to T3.3 Sentient dialogue for tailored SA, since the design of situation awareness support is tailored to specific roles and taking into account task load of the user.

Availability Unrestricted.

2.3 N.J.J.M. Smets, M.A. Neerincx, C.M. Jonker, F. Baberg (2017), "Ontology-based situation awareness support for shared control"

Bibliography N.J.J.M. Smets, M.A. Neerincx, C.M. Jonker, F. Baberg (2017), "Ontology-based situation awareness support for shared control". Extended abstract HRI 2017

Abstract Situation Awareness (SA) during tele-operation in robot-assisted disaster management has a major impact on the effectiveness and efficiency. Data perceived by the human and robot agents should be processed and shared in such a way that these agents can understand and direct the other agent's behaviors. E.g., for safe and effective tele-operation, the human (team leader and/or operator) and robot need to be aware of (1) the state, location, position and movement of the robot platform and its arms, and (2) the state of robot's environment (such as obstacles, etc.). This paper presents an SA-ontology that formalizes the effects of SA-components on the shared control performance. It is based on literature research, interviews with subject matter experts and a field test during a disaster management exercise. The SA-ontology captured all information needs for the teleoperation, and provided further requirements for SA-support functions.

Relation to WP This abstract contributes to T3.3 Sentient dialogue for tailored SA, the SA-ontology formalizes the effects of SA components on the shared control performance.*TBD*

Availability Restricted. Not included in the public version of this deliverable.

2.4 Sengupta, S., Nabizadeh, N., Racioppa, S., Kruijff-Korbayová, I. (2017), "Speech Interaction Processing in TRADR"

Bibliography Sengupta, S., Nabizadeh, N., Racioppa, S., Kruijff-Korbayová, I. (2017), "Speech Interaction Processing in TRADR". Unpublished technical report.

Abstract This report describes the usage and analysis of speech as an input to (a) interact with the TDS system and (b) keep track of tasks performed by the team in the context of a rescue mission with the TRADR system. For (a) we describe the design of the multimodal interaction functionality developed so far. It enables the users to input information about points of interest by a combination of mouse clicks and speech and refine it in short dialogues. For (b) we examined the human-human conversations of the TRADR missions to understand the communicative acts that need

to be modeled in order to track the tasks assigned in the team. The report also describes the integration of a cloud-based speech engine (Nuance Mix NLU ASR) to improve the accuracy of speech recognition, and presents the results of an evaluation of this ASR with the audio data collected from the previous years.

Relation to WP This technical report describes enhancements made to the speech processing framework which contribute to improving Joint Situation Awareness.

Availability Restricted. Not included in the public version of this deliverable.