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SPENCER:

Social situation-aware perception and action for cognitive robots

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DELIVERABLE 6.3

Demonstration and experiments after integration week IV

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Dissemination Level: PUBLIC

Contents

Abstract

This deliverable reports on the outcome of the fourth SPENCER integration week and the achievement of the third SPENCER milestone. The goal of the integration week was to further advance in the integration of the SPENCER system, in particular on software components that add advanced functionalities to the robot as opposed to previous integration events. This goal has been achieved successfully in an emulated airport environment. Further issues that arose from the fully integrated system have been identified and addressed such as the integration of a 3D laser scanner on the robot.

1 Introduction

The overall goal of the fourth SPENCER integration week was to further integrate the components of the architecture. The outcome of this integration week was defined to be project milestone MS3, for which the DoW specifies the following:

> *Second demonstration of the SPENCER platform at the location of the integration partner CNRS. The robot executes the specified use-case in most details. The final use-case and environment is realized with scripted behavior of people that simulate the airport environment of the deployment site. The system is fully integrated based on the third instantiation of the integration architecture with reduced functionality of the isolated components. This is the output of plenary integration week IV."*

From the good experiences made in previous report D6.2, we again decided to organize two initially un-planned pre-integration meetings before the actual plenary integration. For the latter, the following tasks were treated with highest priority:

- Integrating navigation with the people tracker.
- Integrating the planner used to approach persons in a human-aware way.
- Further integrating the components with the supervision and task planning modules.

In addition, in previous discussions we found the need to add a new Velodyne hardware sensor to the robot, in order to help mapping operations. This sensor was installed and tested during the week.

The following sections will explain the work conducted during the integration week in more details.

2 Pre-Integration Week IV-A

To recover from the delays caused by unseen problems during previous integration events, two pre-integration meetings, each lasting a full week, were carried out, as described next.

- Partners ALU-FR, ORU and CNRS met in Toulouse to solve the lower-level problems regarding safety layer. During this event we worked on the following issues.

  - Testing the integration of the new USB hardware relay with the driving controller, and the safety layer.
  - Solving low-level communication issues for safety-relevant components.
  - Load-balance CPU-intensive components across different PCs and laptops.
  - Preliminary implementation of the map-switching mechanism with the supervision system.
  - Updated the simple GUI for the screen to accommodate hardware relay.

- Partners ALU-FR and CNRS met in Toulouse to integrate the motion planning and supervision components. Concretely, we developed and tested

  - Integration of HANP local-planner with the SRL global-planner.
  - Integration of the motion planning components with the people tracker and evaluating behavior of the local-planner with multiple humans moving around the robot.
  - Communication between the map-switching mechanism with the global-planner.
  - A small component for selecting driving direction of the robot, either forward or backward.
  - Data collection with first tests for the learning algorithm to approach a human in the nearby area.

3 Integration Week IV

We scheduled the integration week seven weeks after the pre-integration events, in order to give additional time for partners to prepare. All SPENCER partners were required to arrive to the event with working and tested individual components.

Despite the capability of the localization module to handle largely dynamic environments, we found that there could potentially occur cases where too many dynamic objects are present. Therefore, to provide a more stable system, we decided to mount an additional Velodyne 3D laser sensor on the robot. This serves as a risk mitigation measure, as we anticipate a high degree of environment dynamics at Schiphol airport, which makes highly reliable localisation and mapping potentially difficult. The first day of the integration week was used for testing and integrating this new sensor with the robot. This task was managed by ORU and BLUE. Then, the Velodyne sensor was integrated with the SPENCER mapping system. The resulting 3D NDT maps, which were generated with combined Velodyne and laser sensors, are shown in Figure 2.

Furthermore, LAAS-CNRS tested a socially acceptable head-behavior module for the SPENCER robot. A continued use of the robot head revealed some mechanical problems with the construction and fixation of the head hardware on the robot. Additional steps were taken during the integration event to make the head mechanism more robust to long-term uses in the future.

3.1 Integrated Components

All core components of the architecture that provide the targeted functionalities for a demonstration at the Schiphol airport, namely the supervision system, mapping and localization components, mo-

Figure 1: Mounting of the Velodyne sensor and fixing the head mechanism

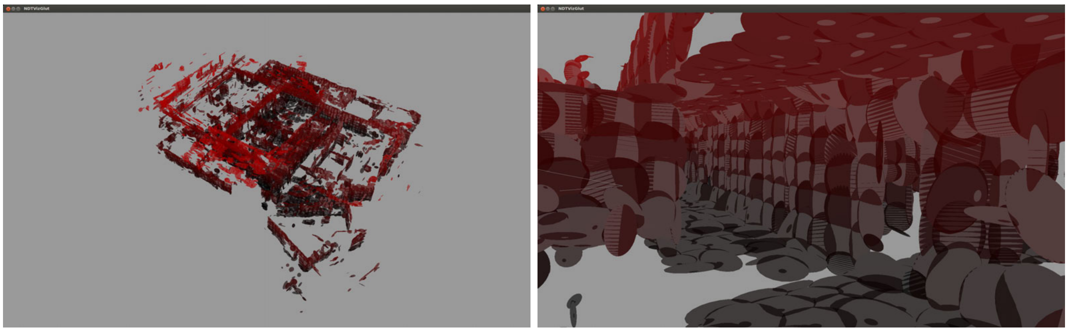

Figure 2: Map of Adream building of LAAS-CNRS generated with use of the Velodyne sensor.

tion planners, people detection and tracking system, as well as simple learned behaviors were fully integrated and tested. They are shown in dark green color in Fig. 3. The components shown in light green are integrated in to the SPENCER architecture however not fully tested. These components are already developed to the quality required for the demonstration. The components shown in yellow in Fig. 3 were integrated only partially, for reasons of minimizing the risk of failures. For example, they include modules that are still under development such as the online object detection, the social behaviour analysis and the spokesperson detection modules.

The safety module for basic collision checking was further developed and integrated with the new safety relay as well as the RGBD-based collision checker. Due to the unavailability of real passenger data from the KLM IT system at this point, we decided to use a simulated version of the airport data module (shown in blue in Fig. 3).

Concretely, the following integration activities were carried out during the course of the integration week.

- A new ALU-FR + RWTH people tracker has been deployed on the robot.
- Tests on integration motion planning and supervision systems with three use cases: moving to a point, moving to a list of point, cancelling a goal when stopping with the remote switch has been carried out by ALU-FR and CNRS.
- The learned social compliance cost-map layer was integrated with the motion planning system.
- Testing RGBD based collision checking for the safety layer, by ORU and ALU-FR.

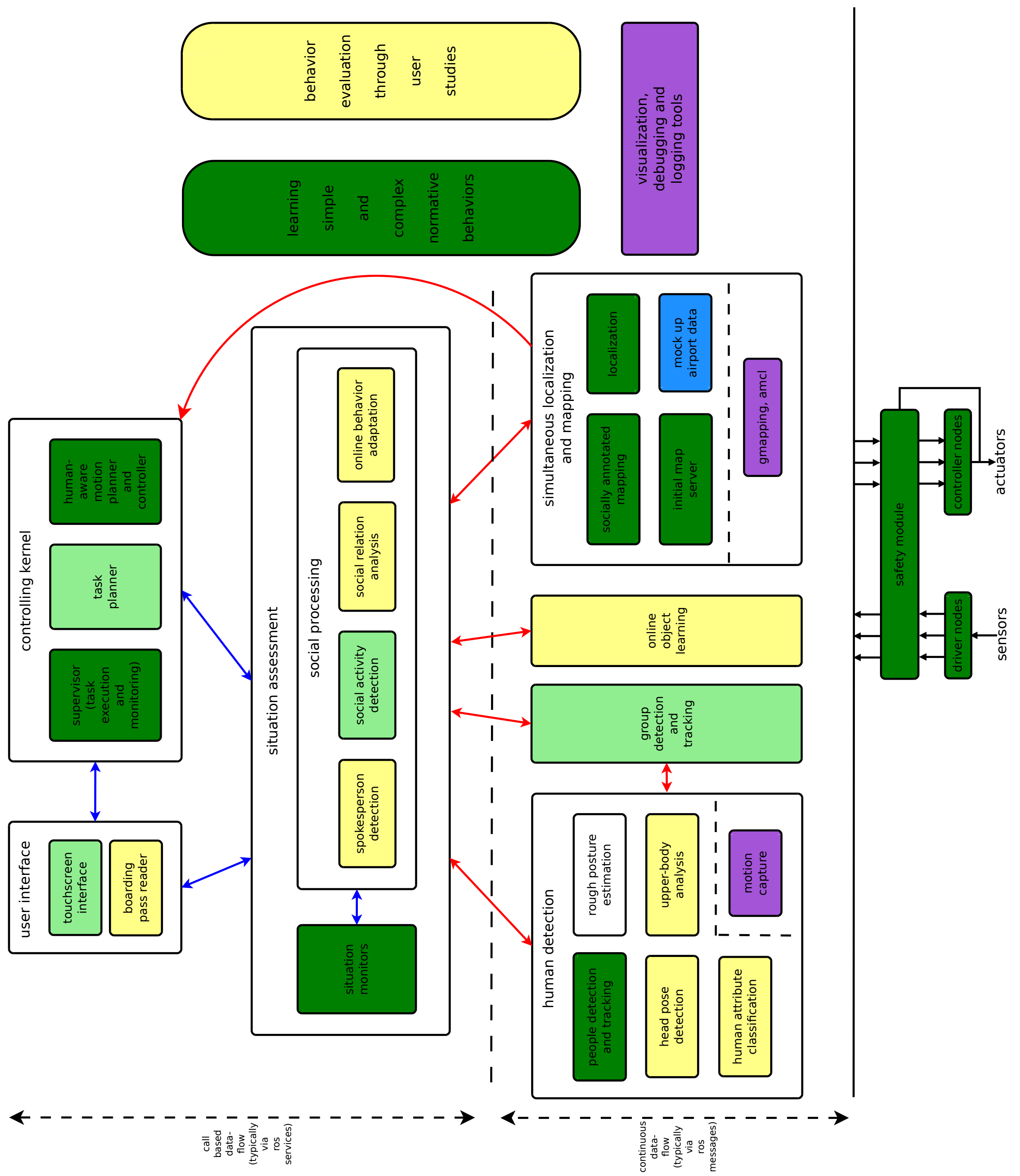

Figure 3: SPENCER architecture. The dark green modules are the core components that have been fully integrated and tested during the fourth integration week. The light green components are partially integrated but not fully tested. The yellow components have already been implemented and will be integrated in future integration events. The purple components were used for testing, visualization and debugging.

- CNRS and ALU-FR discussed the issue of dealing with a “human wall” and implemented a first version of social norm logic to detect and avoid these situations.
- CNRS and ALU-FR integrated a first version of plan negotiation in supervision.
- RWTH collected several “rosbag” training-data files to learn head/body orientation.
- TUM, ALU-FR and CNRS worked on the integration of the boarding pass reader with the SPENCER system.
- UT performed tests of the spokesperson detection system.
- ALU-FR and CNRS implemented a recovery behavior to escape the robot in case of collision errors arriving from the laser or rgbd collision checker modules.
- CNRS ran first simulated tests on integrating the learned approaching behavior in to the motion planning system.
- ORU coded a small package to build a local occupancy map from an RGB-D point cloud, which will be later integrated with the motion planners.
- ORU and ALU-FR ran some tests on the RGB-D collision checker in direct sunlight and collected issues that need to be solved before the next integration event.
- RWTH and ALU-FR took first steps towards having per-track prediction of head-orientation and skeleton configuration.

This integration event was the first time when we tested the full SPENCER system required for a demonstration at Schiphol. Accordingly, we encountered some additional issues related to the timing of inter-component communication and imbalanced CPU usage of different components. These have been identified and are currently addressed in further ongoing tests.

3.2 The Demonstration

According to the specification of milestone MS3 we emulated the Schiphol airport environment by semantically annotating the map created in the lab of integration partner CNRS, e.g. with gates, conveyor belts, and information screens. Fig. 4 (left) shows a sketch of the target area at Schiphol airport. Fig. 4 (right) replicates a small scaled version of this demonstration areas in Toulouse. In this environment, the robot executed the Schengen barrier use-case using the fully integrated architecture. Fig. 5 shows some still images from a video that was shot during the experiments.

As an improvement over previous integration results, the robot was for example able to

- guide a single person to a semantic destination, with the person following.
- guide a single person to a semantic destination, with the person stopping during navigation. The robot was able to detect that the person stopped following and paused its navigation, waiting for the human to resume following.

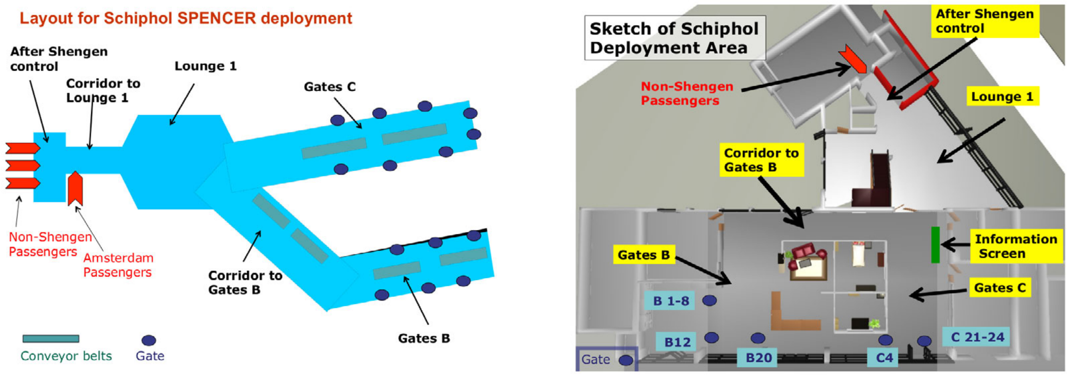

Figure 4: Semantically annotated maps. Left: Schematic picture of the target environment at Schiphol airport. Right: Semantically annotated map of the lab environment in Toulouse. All semantic labels have been transferred from the Schiphol environment.

- guide a single person to a semantic destination, with the person abandoning the task during navigation. The robot was able to detect that the person had abandoned following it, and returned to a predefined base.

At this advanced stage of integration, new issues became evident, which we addressed using these actions:

- Map Annotation: The team used the tools provided by ORU in order to semantically annotate the map, introducing sub-areas linked in order to represent a graph. This tool reads the semantic annotation graph input by the user and produces different sub-map files. Each sub-map is built from two linked nodes in the graph, producing a number of small overlapping maps.

- Map Switching: the map switching mechanism was introduced in order to deal with very large maps for motion planning and localisation. The Schiphol airport has a large surface, which can make motion planning and place recognition slow. The idea of this mechanism is planning on smaller, overlapping sub-maps, created during map annotation. In a first test, the task planner generated a path to make the robot navigate through a list of sub-areas. While navigating, the supervisor detected when the robot arrived to a new sub-area, and switched map to the new sub-map, which will include the reached sub-area and the next sub-area chosen by the task planner.

- Crowd Block Detection: The team implemented a mechanism to allow the robot to detect when it is currently blocked by a crowd of people, and can't move. We plan to integrate a negotiation mechanism, where the robot will ask the group to move in order to proceed with its navigation.

- Approach Planner: integration of the planner developed by CNRS to approach persons in a human aware way was tested in a separate experiment.

Figure 5: Example image frames from a recorded video. *Top left:* robot and passengers at the starting point of guidance. *Top right:* robot avoiding previously unknown obstacles in its path. *Bottom left:* robot slowing down to avoid collision with a human. *Bottom right:* robot leaves the passengers at the goal position.

Figure 6: Impressions from the second SPENCER integration week IV