spencer

SPENCER:
A socially-aware robot guide

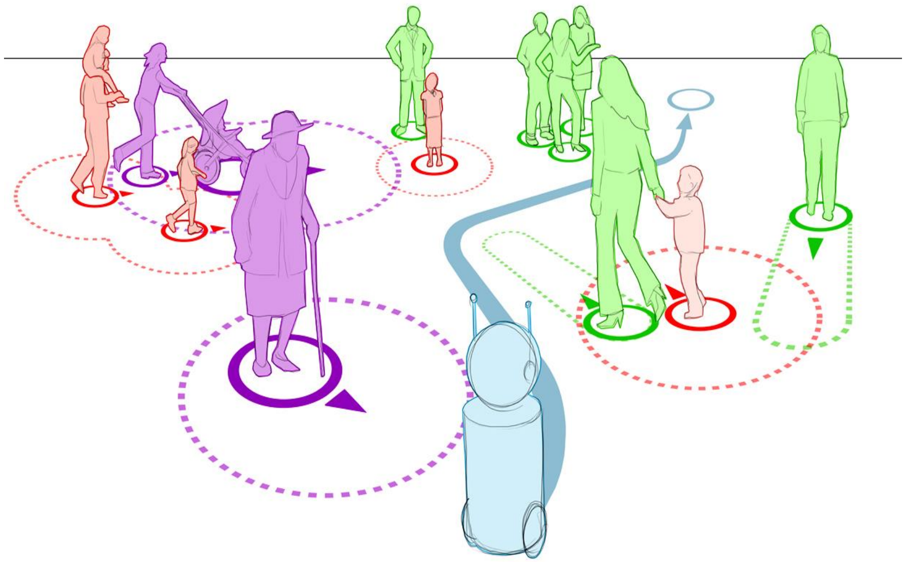
Harmish Khambhaita

(LAAS-CNRS)

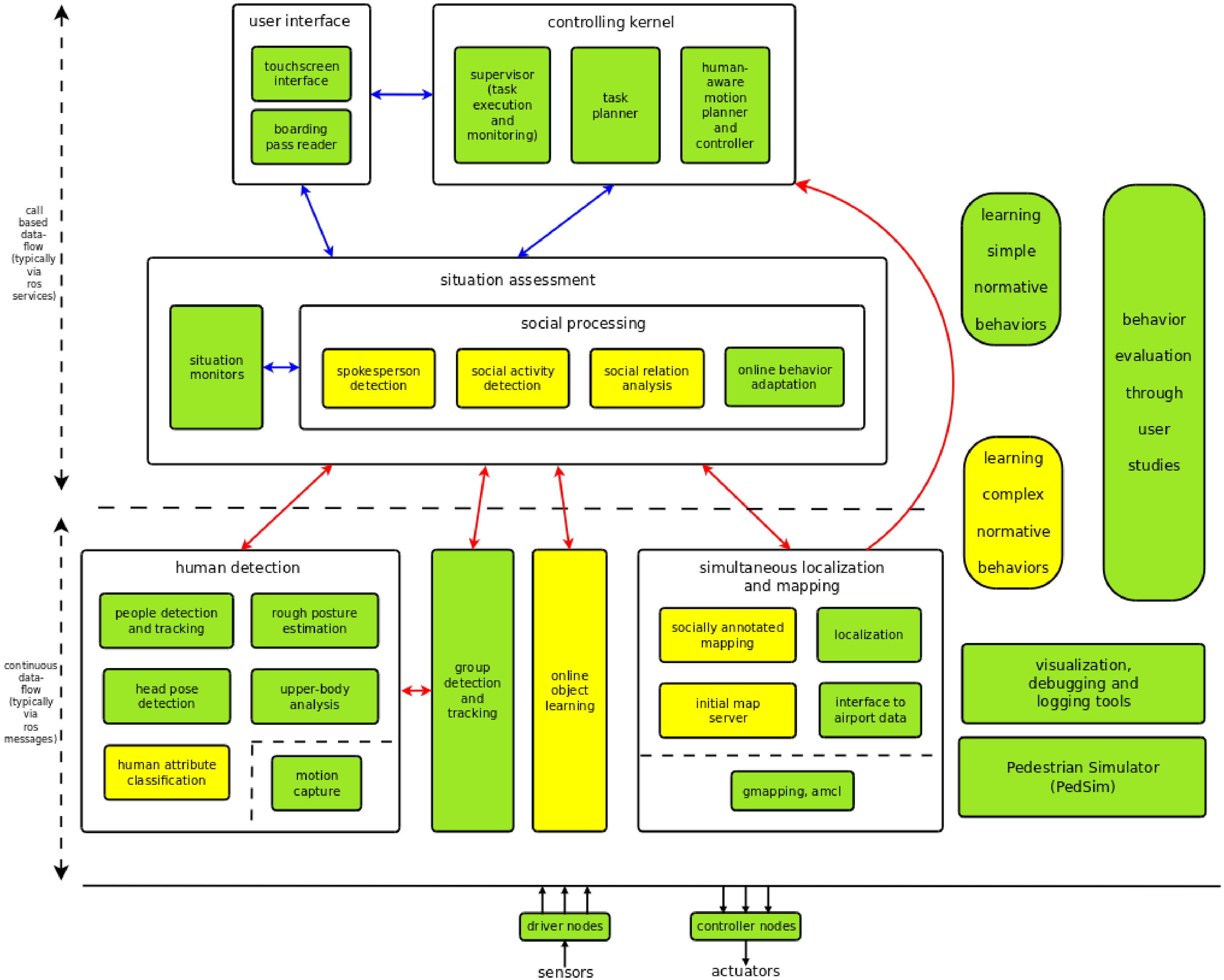
UNIVERSITEIT TWENTE. ÖREBRO UNIVERSITET RWTH AACHEN UNIVERSITY BLUEBOTICS KLM

Motivation and Goals

- **Socially-aware** task, **motion** and interaction **planning** in populated environments.
- Robust detection, **tracking** and multi-person analysis of individuals and groups of people.
- Learning **socially annotated maps** in highly dynamic environments.
- Normative human **behavior learning** and modeling.
- Empirical **evaluations** of robot behaviors in Amsterdam-Schiphol airport.

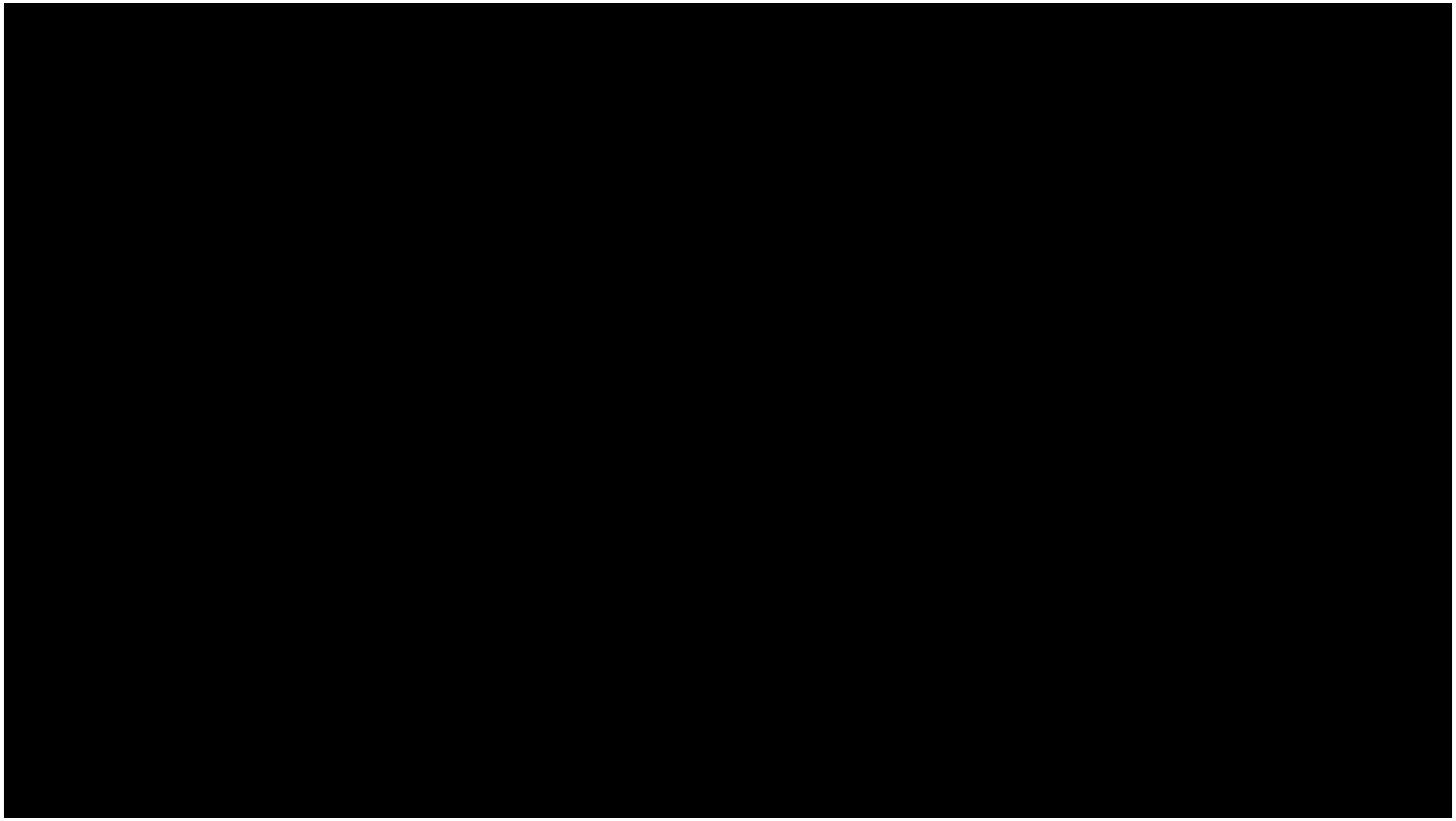


Software Architecture



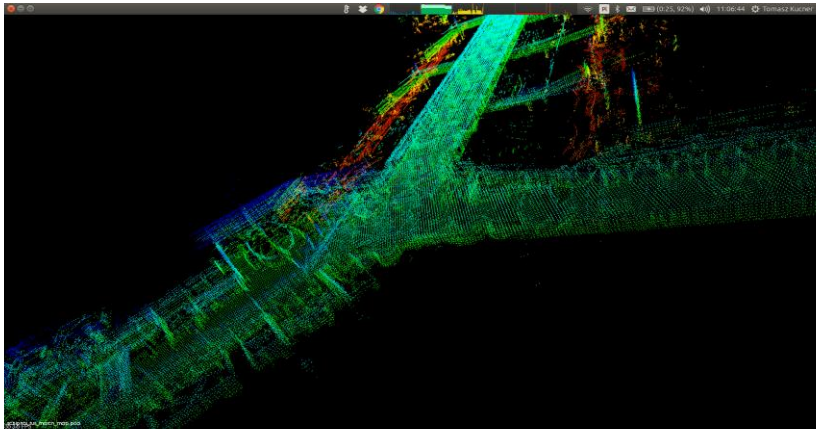
People and Group Tracking

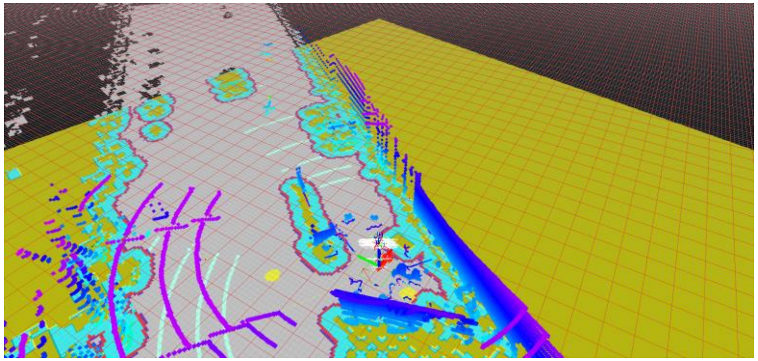
- Combined people detectors based on 2D laser and RGB-D data.
- Group detection and tracking based on learned social relations.
- Body and head-pose classification.



Mapping and Localization

- Efficient mapping approach combining Normal-Distribution transform (NDT) and occupancy grids.
- Localization using a dual-timescale NDT-MCL.
- Grid-maps for motion planning.



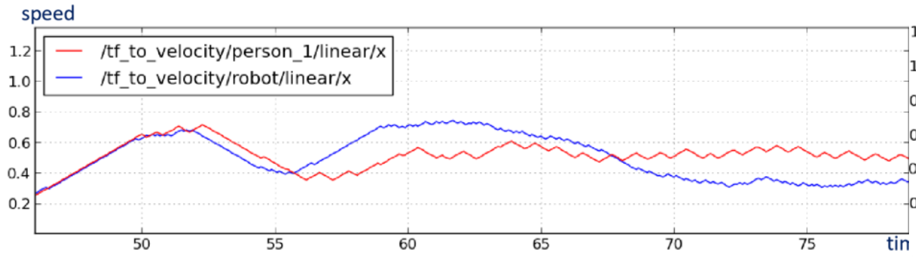


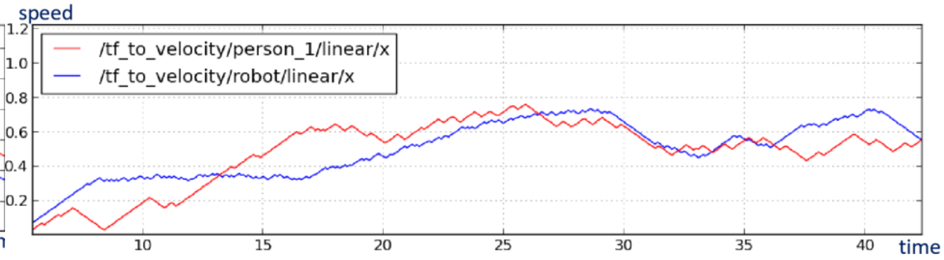
CNRS Contributions

- On-line adaptive social robot behaviors
  - robot adapts its speed to user and context
- Improving navigation legibility by using
  - directional costs in human-robot path-crossing scenarios
  - pan-tilt head to communicate motion intent
- Supervision system and task-planner
- Learning normative behaviors
  - for approaching and engaging with individual person
  - adapting to the dynamics of group of people
- Software Integration

Speed Adaptation

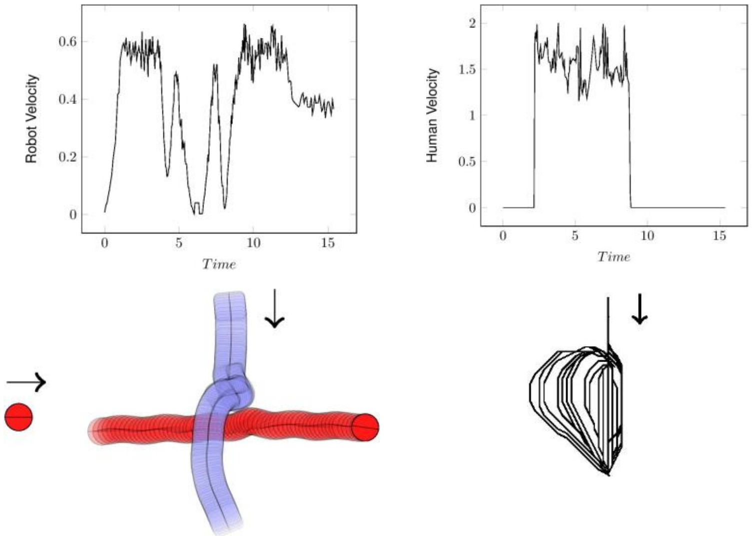
- Adapting robot speed to human's speed instead of stop-and-go motion.
- Proactively suggesting new speed and helping if user abandons task.

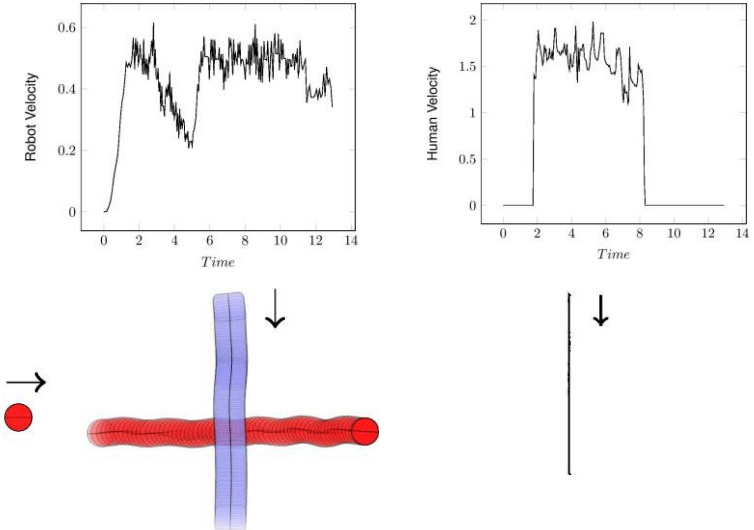




Legibility of Robot Motion

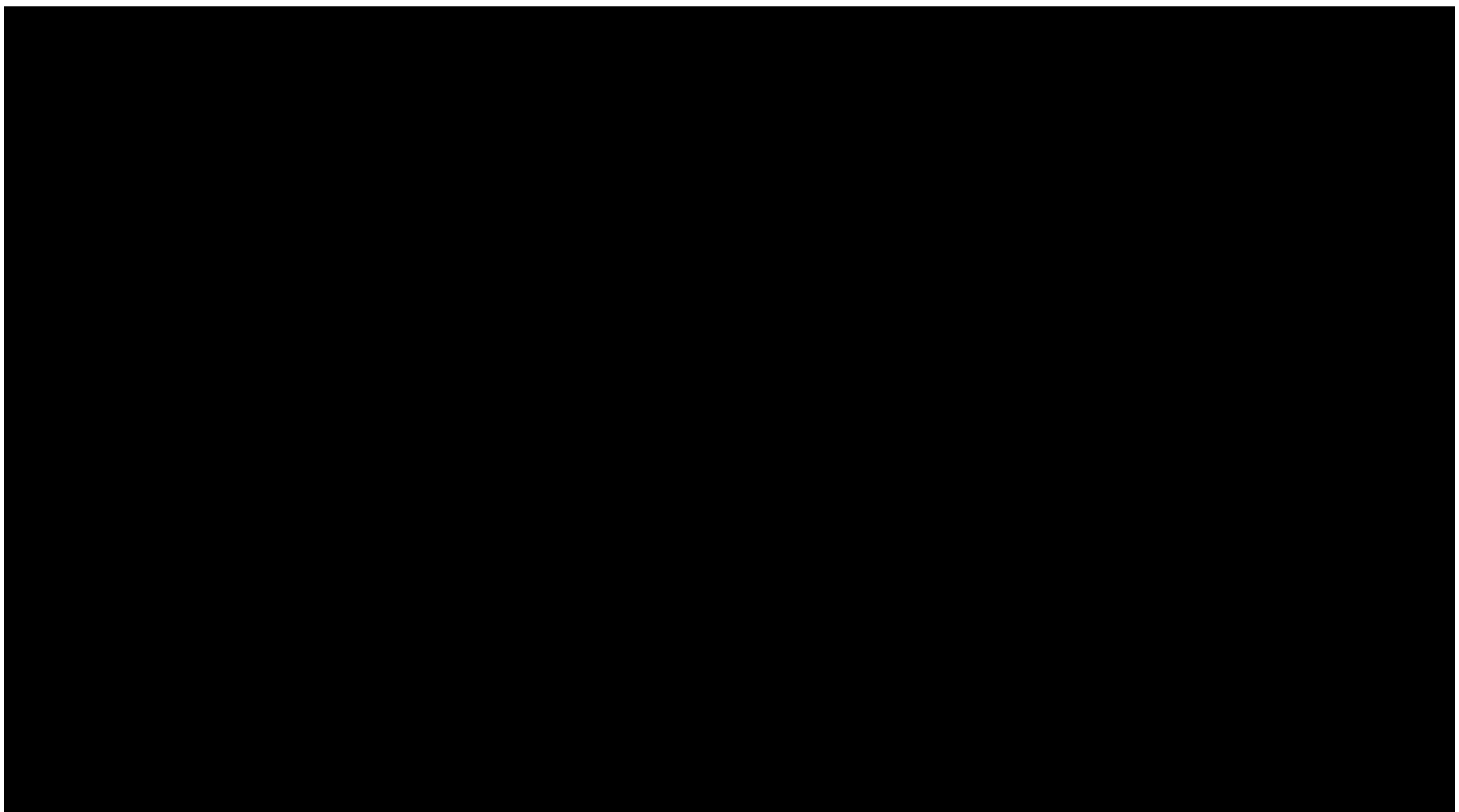
- Using directional cost model for motion planning





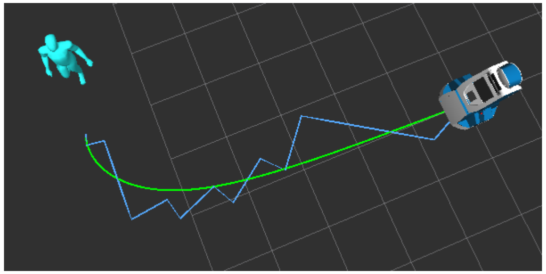
Head Behavior

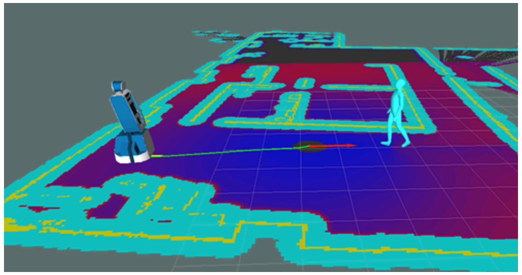
- Using head to convey navigation intent of the robot.
- Gaze point calculation using a multi-criteria decision-making approach
- Robot exhibits two behaviors while navigating: Looking at immediate future path & glancing at nearby humans.



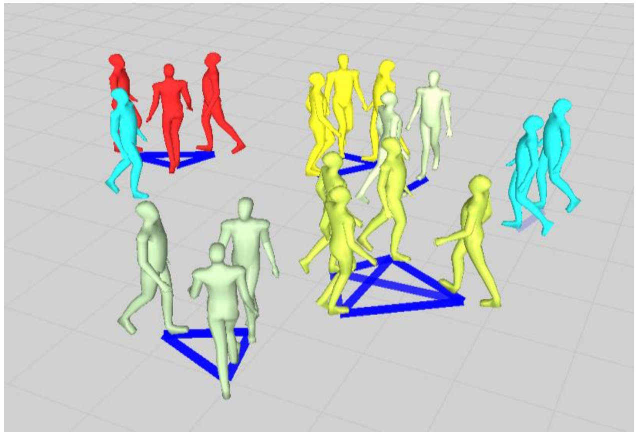
Learning normative behaviors

- Inverse Reinforcement Learning based algorithm to learn human-approaching trajectories from demonstrations.



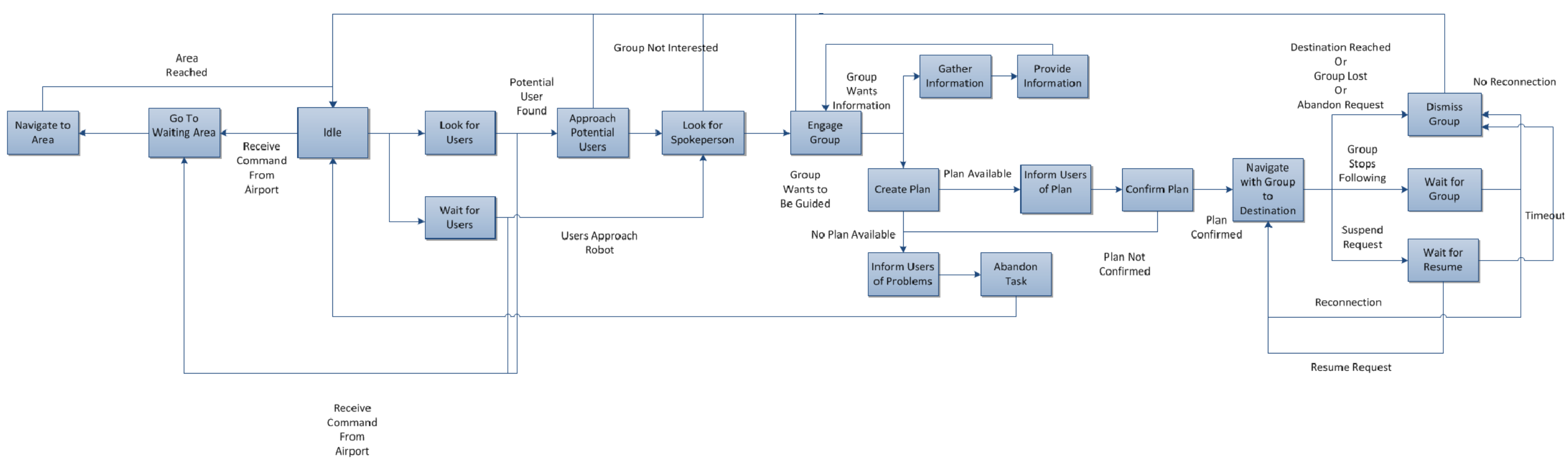


- On-line learning of group dynamics.

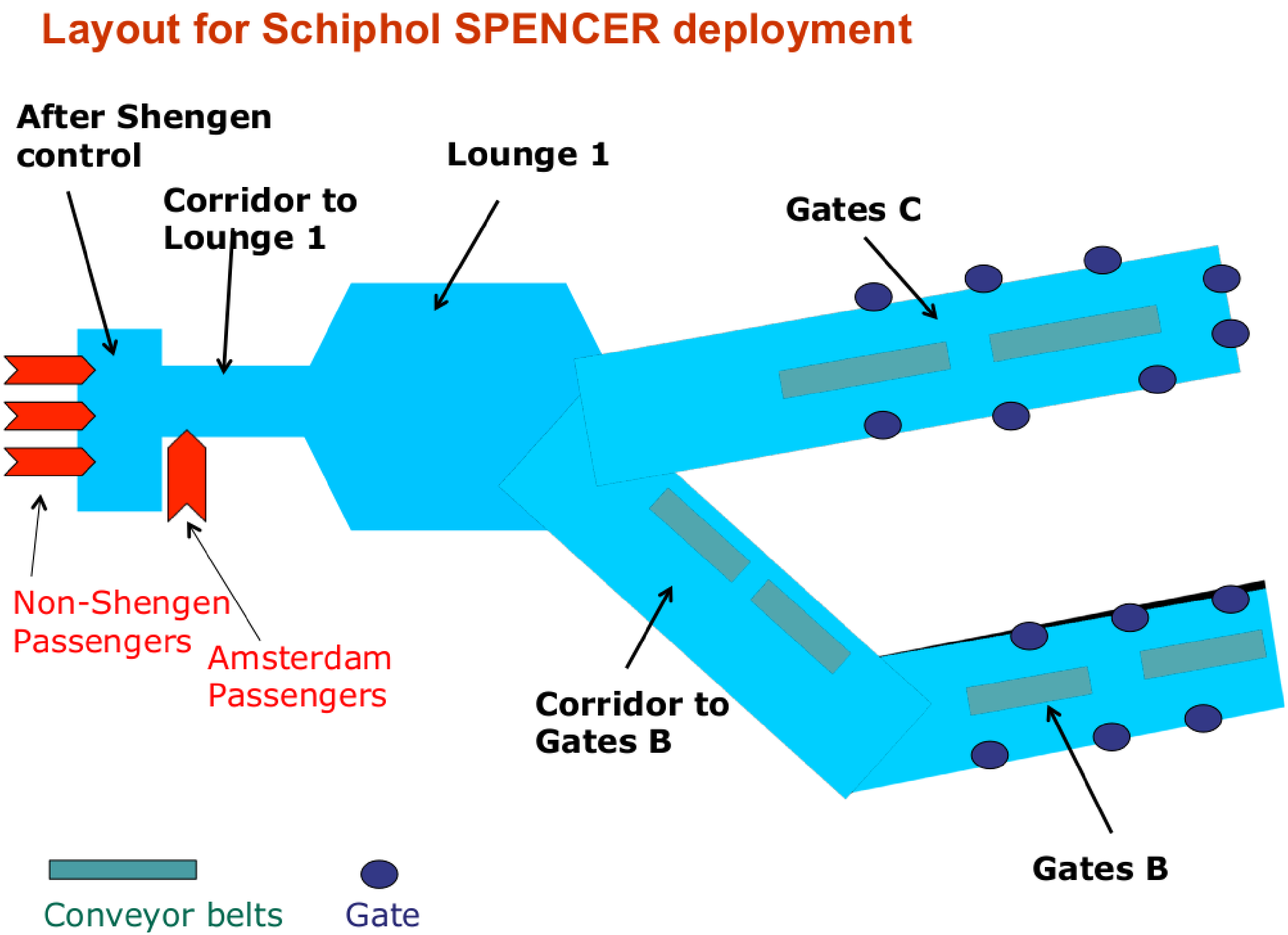


Supervision and Task-Planning

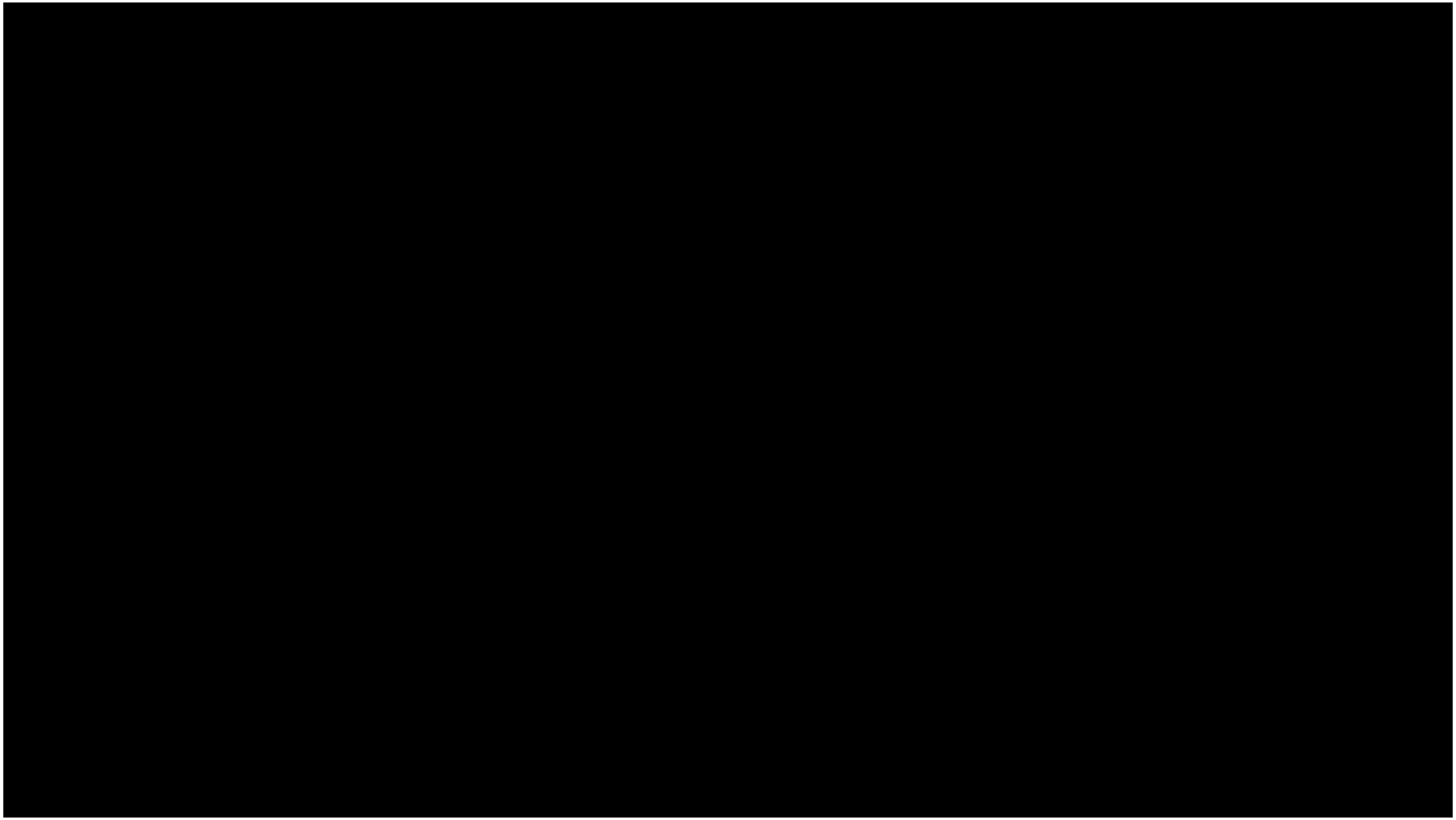
- Execute and refine collaborative tasks with humans in a flexible and robust way.
- Monitoring their actions and adapting its plans to provide a natural and efficient interaction.
- Hierarchical MOMDPs (Mixed Observability Markov Decision Process) base collaborative planners.
- Switching of maps for efficient navigation.



Final Deployment Scenario



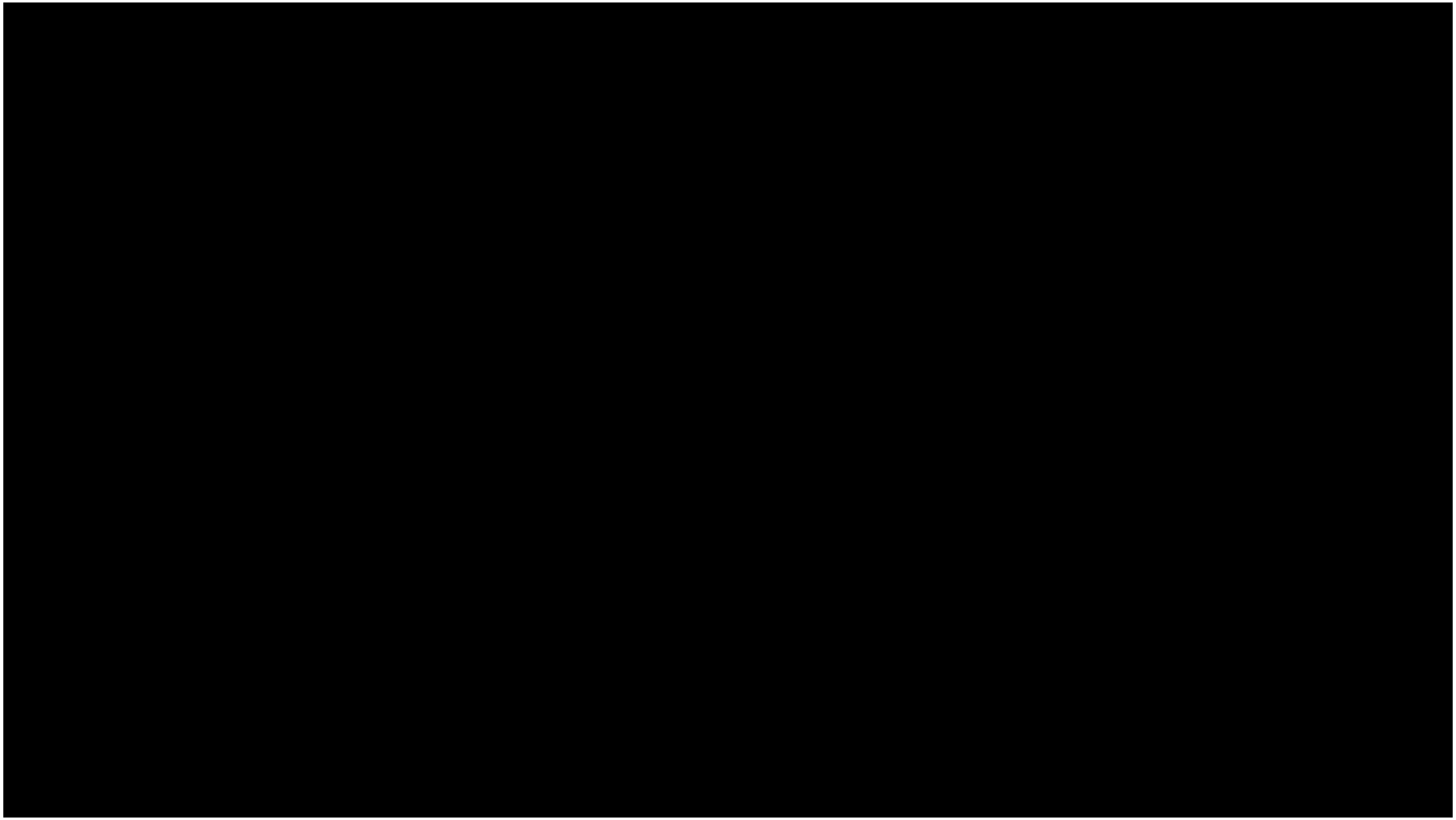
Guiding



SPENCER achievements

- All major components are **integrated** and **tested** on the platform.
- Several successful runs of **full guiding process** in Schiphol airport.
- **Legible** and **socially acceptable navigation** in large indoor environment.
- **Robust people detection** and tracking in crowded areas.
- Reliable **3D localization** in semi-dynamic environments.
- Generally positive response from people and participants of guiding user-studies.
- No human was severely harmed!

Open Problems



Thank You!