SPENCER: A socially-aware robot guide

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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

Diagram showing the components of a software architecture, including:

- **User Interface**: touchscreen interface, boarding pass reader
- **Controlling Kernel**: supervisor (task execution and monitoring), task planner, human-aware motion planner and controller
- **Situation Assessment**: situation monitors
- **Social Processing**: spokesperson detection, social activity detection, social relation analysis, online behavior adaptation
- **Human Detection**: people detection and tracking, head pose detection, human attribute classification, rough posture estimation, upper-body analysis, motion capture
- **Simultaneous Localization and Mapping**: socially annotated mapping, localization, initial map server, interface to airport data, gmapping, aml
- **Learning**: simple normative behaviors, complex normative behaviors
- **Evaluation Through User Studies**: behavior evaluation, visual simulation, debugging and logging tools

The diagram also shows continuous data flow (typically via ROS messages) and collective dat flow (typically via SCI services).
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

Layout for Schiphol SPENCER deployment

After Shengen control

Corridor to Lounge 1

Lounge 1

Gates C

Gates B

Non-Shengen Passengers

Amsterdam Passengers

Conveyor belts

Gate
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!
Thank You!