Towards General-Purpose Service Robots

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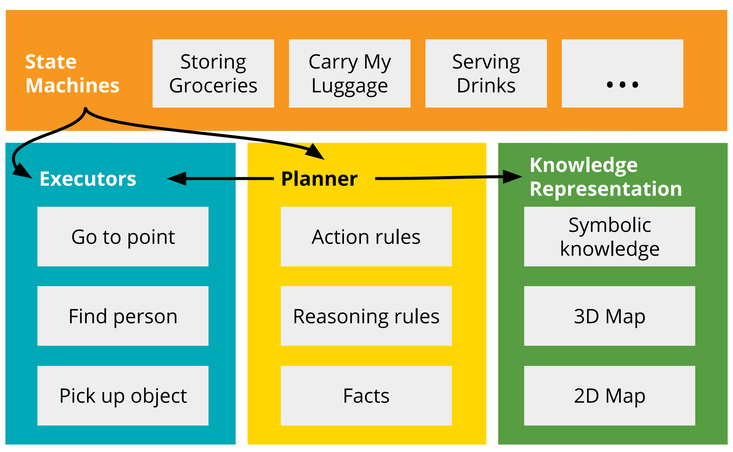
Abstract

UT Austin Villa@Home has made significant developments in efficient perception and manipulation, automatic semantic labeling, modeling human preferences, and knowledge representation and reasoning. Our focus in 2019 is robustness and portability to multiple robot platforms.

Top-Level Architecture



- **Goal:** Build a unified system for a domestic service robot, rather than the individual RoboCup@Home tasks. In realistic environments, tasks can be arbitrary instructions given to this system.
- Features:
  - State machine modeling built on SMACH, for construction of known plans
  - Integrated planner used for both planning and abstract reasoning
  - Flexible semantics and KR provide symbols for planning and abstract reasoning in a comprehensive framework
  - Modular skills allow both state machines and plans to control the robot
- **Published in AAAI FSS-18**:

LAAIR: A Layered Architecture for Autonomous Interactive Robots

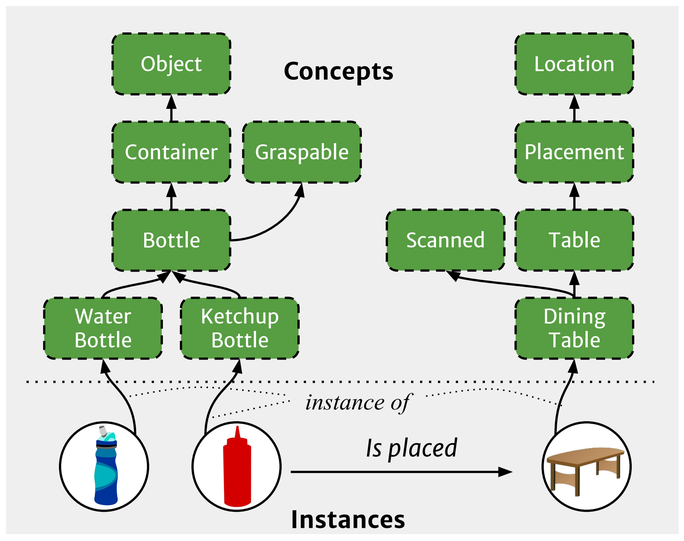
Interaction and Autonomy in RoboCup@Home and Building-Wide Intelligence

Command Understanding

- **Problem:** Understanding diverse user commands
- **Approach**: Neural semantic parsing with simplified command representation
  - Trained with crowdsourced paraphrased command dataset
- **Published in RoboCup Symposium 2019:**

Neural Semantic Parsing for Command Understanding in GPSRs

Knowledge Representation



- **Goal:** Flexible KR system, integrating semantics, world and domain knowledge, perception, and reasoning
- Representation
  - Instances and Concepts have unique IDs
  - Attributes describe relations between entities or store data about them
- Reasoning
  - Actions model their preconditions and effects on attributes of entities
  - Can plan to gain knowledge of entity attributes such as names, locations
- **Published in ICAPS-19:**

Open-World Reasoning for Service Robots

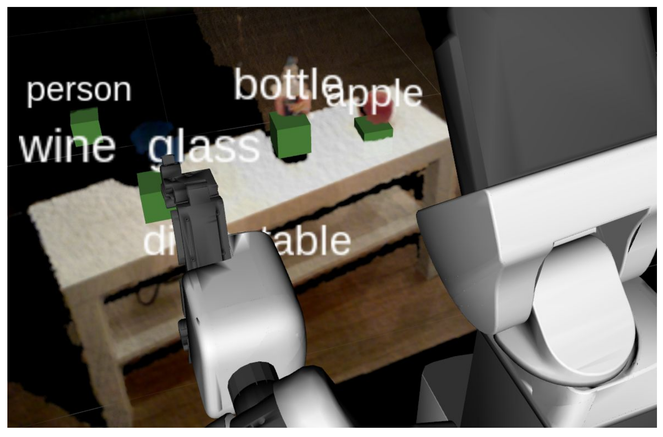
Manipulation

- **Problem:** A diverse array of objects need to be manipulated in time-constrained settings
- **Approach:** Generate and evaluate grasp directions and gripper orientations based on feasibility
  - Parallel motion planning built on top of MoveIt. Enables immediate execution after an object is perceived
- **Result:** Object pick and place with low latency between perception and action

Modeling Human Preferences

- **Problem:** Object placement in “Storing Groceries” requires knowledge of human preferences. Future applications will require similar knowledge.
- **Approach:** Collected Amazon Mechanical Turk human shelving preference dataset
- Fine-tuned Word2Vec model using shelving preferences
  - Leverage both linguistic prior and grounded knowledge

Semantic Perception



- Robot passively perceives and integrates labels and poses of the objects in the environment over time
- **Problem:** Inefficiencies in representation and processing in ROS create latency and reduce perceptual bandwidth
  - Example: Transferring point cloud data
- **Approach:**
  - Uses efficient representations
  - Efficient storage and querying infrastructure for semantic labels
  - Easy to integrate data recording, network transfer, and data compression
  - Extensible framework
- **Result:** Point-cloud data can be captured and reconstructed—even off-board—at the frame rate of the capture device with low latency.

Semantic Mapping

- **Goal:** Automatically semantically label objects and locations in the robot’s environment
- **Published in IROS 2018:** Use building signage to automatically annotate a SLAM-generated map with location names

PRISM: Pose Registration for Integrated Semantic Mapping

Person Detection & Following

- **Problem:** Need to find and track a human target in a crowded environment
- **Approach:** Multi-modal sensor-fusion with face recognition, human detection, leg detection, and clothing detection
  - Behavior-tree decision-making
- **Result**: Robust person following

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