UT Austin Villa

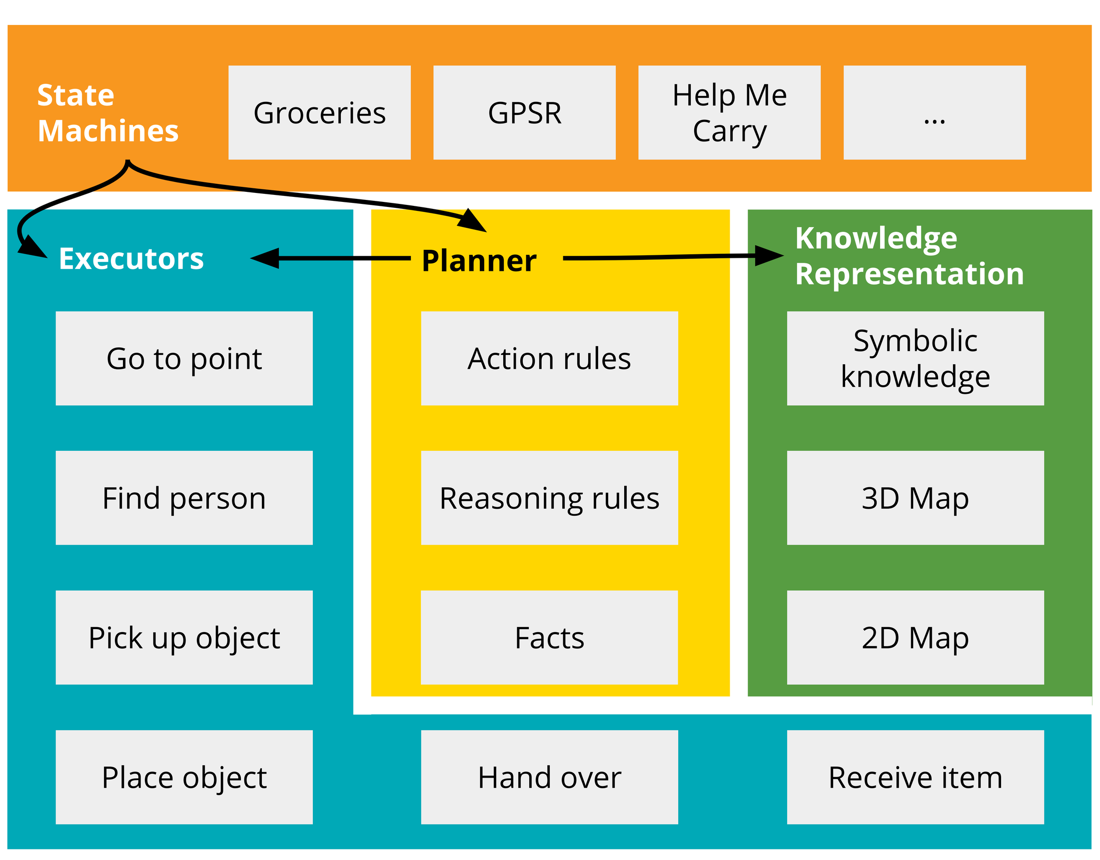
The University of Texas at Austin
RoboCup@Home, DSPL, Montreal 2018

TEXAS
The University of Texas at Austin

Abstract

UT Austin Villa@Home has made significant developments in knowledge representation and reasoning, automatic semantic labeling of maps, and high-performance perception. The Building-Wide Intelligence project develops a fleet of autonomous service robots in a live deployment at UT Austin, and our RoboCup@Home team has both leveraged this research as well as contributed back into this framework. We have also deployed systems from the Human-Centered Robotics Group's for complex manipulation and control problems such as door opening and person following.

Top-Level Architecture

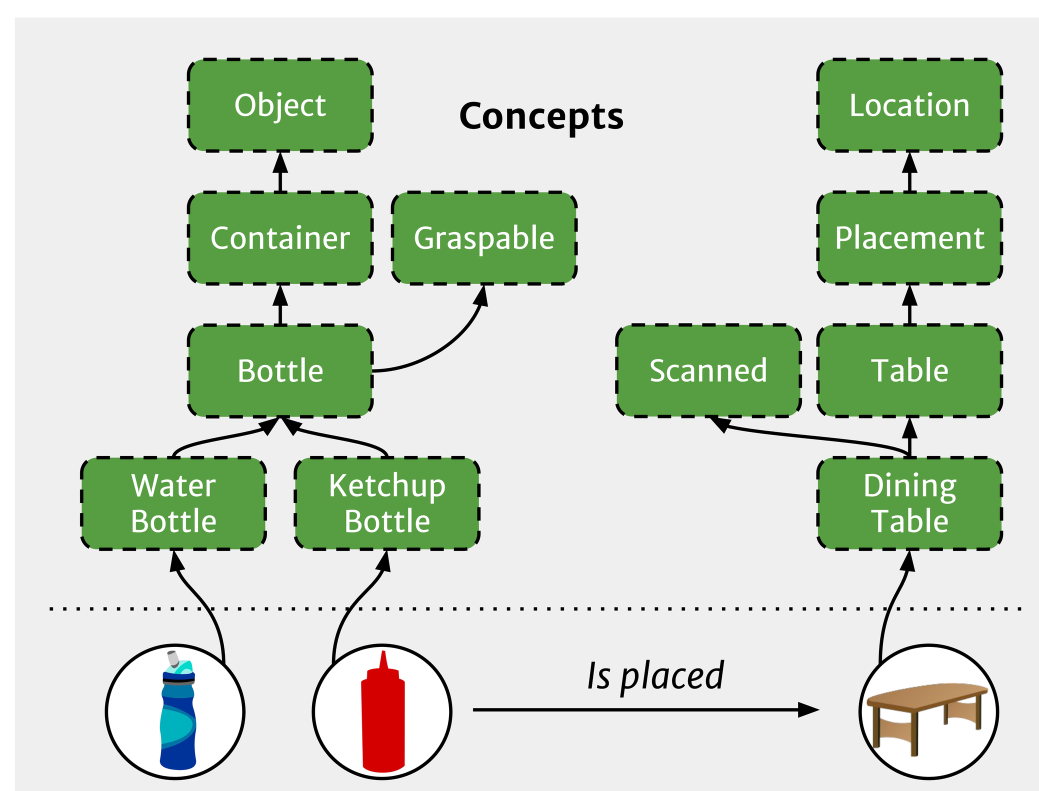


- **Goal:** Build a unified system that solves the challenge of building a domestic service robot, rather than the just RoboCup@Home tasks. Tasks will soon be just instructions given to this system.

- Features:
  - State machine modeling built on SMACH. Facilitates clear, fast, debuggable construction of known subplans.
  - Flexible semantics and KRR provides symbols for planning and abstract reasoning in a comprehensive framework.
  - Modular action executors allow both state machines and plans to control the robot
  - Integrated planner Used for both planning and abstract reasoning.
- Intended to be deployed across three major laboratories at UT in 2018-2019

Our testing arena in the historic Anna Hiss Gymnasium at UT Austin.

Knowledge Representation



- **Goal:** Highly-flexible custom KR system, integrating semantics, world and domain knowledge, perception, and reasoning.
- Representation
  - Entities provide unique IDs
  - Attributes describe relations between entities or store data about them
    - Sole source of meaning for entities
  - Concepts describe abstract ideas
  - "is-a" attributes allow attribute inheritance
- Reasoning
  - Actions model their preconditions and effects on attributes of entities
  - Can plan to gain knowledge of object attributes such as names of people, locations of objects

Person Detection & Following

- **Problem:** Need to find and track a human target in a crowded environment
- Multi-modal sensor-fusion technique combining face recognition, human detection (Openpose), leg detection, and clothing detection (template matching)
- Behavior-tree based decision-making to find a target with gaze-control during navigation

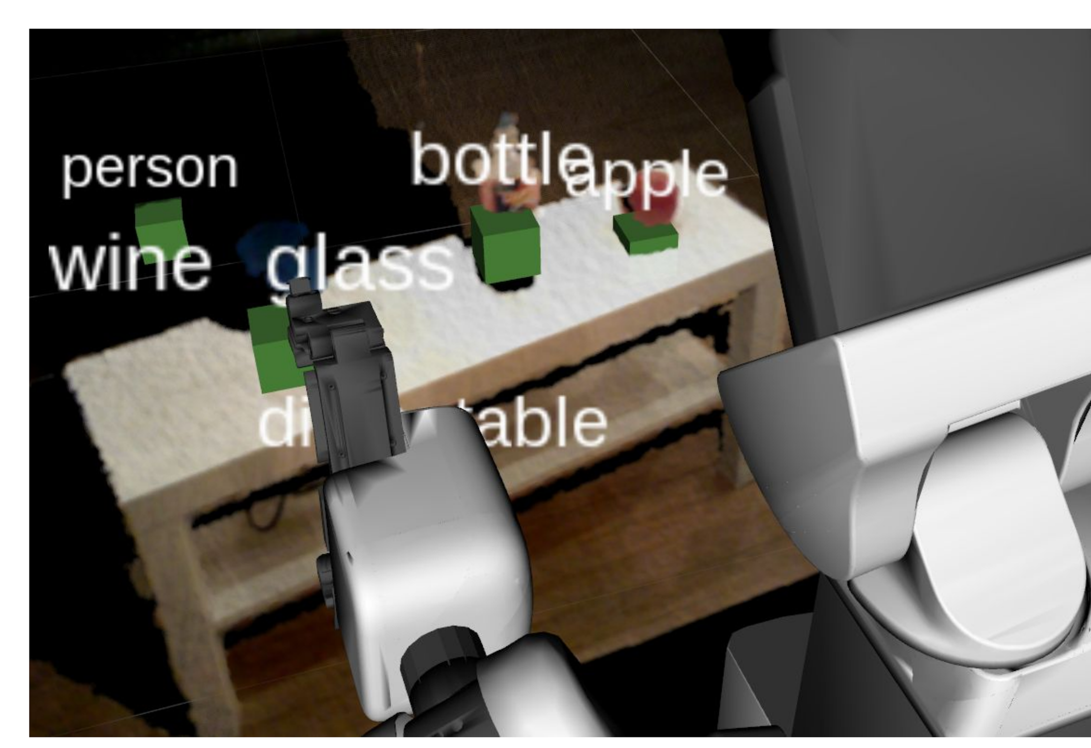
Fast Perception

- **Problem:** While ROS is very flexible, inefficiencies in representation and processing can create latency and reduce perceptual bandwidth
  - Example: Transferring point cloud data

- Our fast perception system
  - Uses efficient representations throughout
  - Event-based, like ROS
  - Implemented as C++ templates
  - Facilitates simple multi-threading
  - Greater use of zero-copy
  - Easy to integrate data recording, network transfer, and data compression

- **Result:** Point-cloud data can be captured, reconstructed, and rendered at the frame rate of the capture device with very low latency

Semantic Mapping



- **Goal:** Automatically semantically label objects and locations in the robot's environment
- **In review at IROS:** Use building signage to automatically annotate a SLAM-generated map with location names
  - Homography computation permits fast, accurate 3D pose registration of signage
- Prototype extension to the general object setting using depth information coupled with 2D object detection
- Robot passively perceives and integrates the labels and poses of the objects in its environment over time

The University of Texas at Austin
Mechanical Engineering
Cockrell School of Engineering

The University of Texas at Austin
Department of Computer Science
College of Natural Sciences

The University of Texas at Austin
Electrical and Computer Engineering
Cockrell School of Engineering

The University of Texas at Austin
Aerospace Engineering and Engineering Mechanics
Cockrell School of Engineering

Principal Investigators: Raymond Mooney, Scott Niekum, Luis Sentis, Peter Stone, Andrea Thomaz
Team Leader: Justin Hart, hart@cs.utexas.edu
Team Members: Nicolas Brissonneau, Daniel Brown, Arnau Canyadell, Jason Cox, Yuchen Cui, Rolando Fernandez, Jamin Goo, Sam Gunn, Jeffrey Huang, Yuqian Jiang, Kwan Suk Kim, Minkyu Kim, Gilbert Martinez, Neil Patil, Mayuri Raja, Rishi Shah, Stone Tejeda, Buck Tower, Christine Tu, Nick Walker, Thomas Wei, Harel Yedidsion, Oleg Zilman