

Developing a Framework for Team-based Robotics Research

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Abstract

This demonstration shows a number of useful tools that have been created by student researchers while developing a framework for experimentation in human-robot-team-based interaction and coordination.

Description

Our long term research goals involve exploration of shared decision-making between robot teams and human operators, interacting in real-time, dynamic environments. Two related application areas are modeled: *urban search and rescue* (Murphy, Casper, and Micire 2001; Jacoff, Messina, and Evans 2000) and *humanitarian de-mining* (Santana, Barata, and Correia 2007; Habib 2007). In both instances, teams of robots are deployed to explore terrain that is potentially unsafe for human responders and locate targets of interest. In the first case, robots explore an enclosed space, such as a collapsed building, and search for human victims who may be physically trapped. The goal is to locate these victims and transmit their positions to human operators, so that human first responders can remove the victims to safety. In the second case, robots explore an open space, such as a field in a war zone, searching for anti-personnel mines that may be hidden from view. The goal is to locate these mines and transmit their positions to human operators, so that they can be disarmed and the area rendered safe for human traversal. Despite the inherent differences between these two application areas, aspects of the underlying approaches to human-robot-team-based interaction and coordination are similar.

We have designed an experimental framework with which to examine these aspects. An overview is shown in Figure 1. The framework is constructed using software components derived from the Player/Stage project¹ (Vaughan and Gerkey 2007). Individual robots are controlled using Player drivers. Drivers have been written or adapted for four different robot platforms: the Surveyor SRV-1² robot, the Parallax Scribbler³ robot with the Fluke⁴ expansion board (“Fribbler”),

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¹<http://playerstage.sourceforge.net/>

²<http://www.surveyor.com/>

³<http://www.parallax.com/>

⁴http://wiki.roboteducation.org/IPRE_Fluke

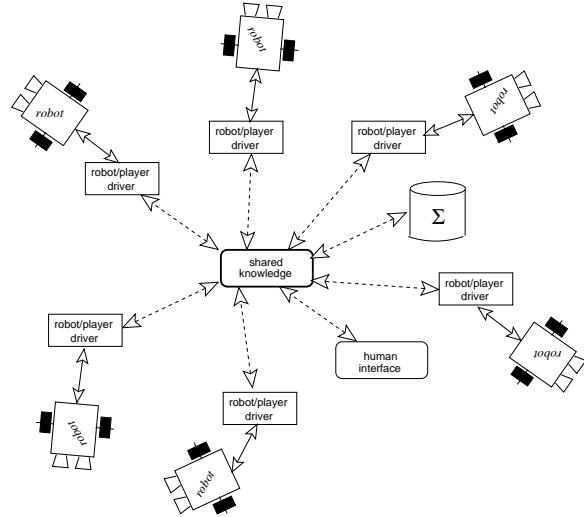


Figure 1: Overview of framework

the Sony AIBO ERS-7⁵ robot, and the LEGO Mindstorms NXT⁶ robot. A central facility stores shared knowledge obtained by the robot team, including a dictionary (labeled Σ in Figure 1) of known objects identified in the robots’ environment. A human operator can also interface with the shared knowledge facility. Robots make autonomous decisions about individual low-level tasks, while the human operator provides high-level team goals.

The development of this framework has been undertaken by a team of student researchers as part of a Research Experience for Undergraduates (REU) Site grant, funded by the National Science Foundation⁷. The students have designed and implemented a number of useful tools, each of which will be demonstrated, along with an exploration task that illustrates the functionality of the framework. Three of the tools are described below.

Shape tracing. Figure 2 illustrates a shape tracing exercise that each robot was required to complete. This utility

⁵<http://www.sonyaibo.net/>

⁶<http://mindstorms.lego.com/>

⁷REU Site: MetroBotics: undergraduate robot research at an urban public college, NSF CNS #08-51901, 7/2009–6/2012.

is useful for debugging a robot's basic motion control interface. Robots are given a fixed shape to trace, in this case a square (or rectangle), with the joint goals of returning to the point where they started from and not bumping into the obstacle inside their path base. All four types of robot can complete this task, as shown.

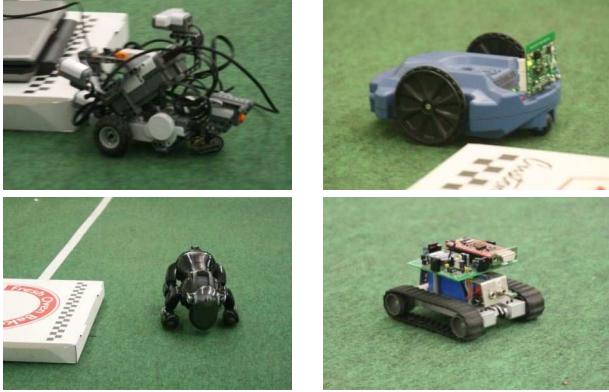


Figure 2: Different robots trace out a square path around a familiar object.

Color tracking. Figure 3 contains a screen shot of a utility that is useful for debugging the color tracking component of the system. The robot “imagines” (or “dreams”) that it sees the colors shown in the interface. The human user can click on any of the buttons on the right side of the interface and cause the robot to turn its head to face an object in its “dream” that matches the chosen color. The AIBO, Fribbler and Surveyor robots all have cameras and can use this utility.

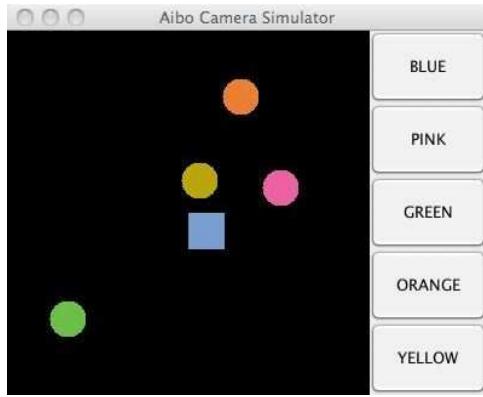


Figure 3: Screen shot of robot “dreaming” interface

Object identification. Three-dimensional colored objects are placed in the robots' environment. The human operator gives each robot a particular object to locate. The robots use color tracking to locate the object of interest and then they move toward the object. They need to be able to determine object shape as well as color. The LEGO Mindstorms NXT robot has a sonar and can navigate around an object, sensing distance to its different faces, and use these differing

distances to determine an object's shape. The robots with cameras employ edge detection and analysis of the geometry of objects in the system dictionary (Σ) to match a found object with known shapes. Thus, working together, the robot team can distinguish between objects that are the same color but different shapes (for example, see Figures 4a and 4b), as well as objects that are the same shape but different colors (Figures 4a and 4c).

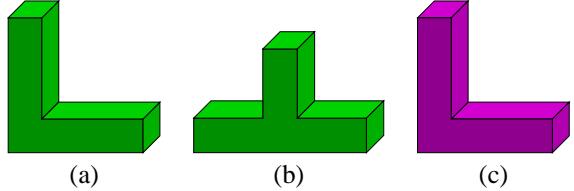


Figure 4: Objects in the robots' world

Summary

The demonstration will consist of one or more robots of each type mentioned above (AIBO, Fribbler, NXT, Surveyor) engaged in a scaled-down version of the two model application areas. Three-dimensional colored objects (such as those illustrated in Figure 4) will be scattered around the exhibition area. A human operator will select objects from the framework dictionary and assign one or more robots to locate the target object. Together, the team will explore the exhibition region autonomously, sending candidate images to the human operator for verification and reporting the position of the object within a local coordinate system inferred inside the exhibit area. In addition, the utilities (such as that illustrated in Figure 3) will also be demonstrated. Multiple student team members (see author list) as well as faculty supervisors (first three authors) will attend.

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