Tekkotsu: A Framework for AIBO Cognitive Robotics

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Abstract

Cognitive robotics is an approach to robot programming that draws inspiration from ideas in cognitive science, such as visual routines (Ullman 1984), dual-coding representations (Paivio 1986), and perceivable affordances (Gibson 1977; 1979). We have implemented primitives based on these ideas as part of Tekkotsu, an open source application development framework for the Sony AIBO.

Introduction

Tekkotsu (the name means "framework", literally "iron bones" in Japanese) is an application development framework for the Sony AIBO robot dog (Tira-Thompson 2004). It provides a layer of abstraction above the Sony OPEN-R software interface and offers a variety of services, including an efficient event routing architecture, the ability to share C++ objects across processes, a hierarchical state machine formalism for constructing behaviors, and an extensive collection of wireless remote monitoring and teleoperation tools. The latter are written in Java for portability. Tekkotsu is an open source project and builds on the work of several other open source developers: it provides forward and inverse kinematics solvers based on ROBOOP (Gordeau 2005), simple object detection using CMVision (Bruce, Balch, & Veloso 2000), and two walking engines, one from CMPack-02 (Veloso *et al.* 2002) and one from the University of Pennsylvania (Cohen *et al.* 2004). Tekkotsu is currently in use at over 20 universities around the world, either in introductory robotics courses or for robosoccer. It is available at `www.Tekkotsu.org`.

Over the last two years we have been developing a new layer of Tekkotsu to support an approach to robot programming that we call "cognitive robotics". The idea is to provide a set of higher level primitives for perception and action, inspired by ideas from cognitive science, so that programmers can construct intelligent behaviors at a much more abstract level. Three components of our approach are described here: visual routines, dual-coding representations, and perceivable affordances.

Visual Routines

Ullman proposed that low-level vision might be implemented as a set of composable parallel operators he called visual routines (Ullman 1984). There is some evidence that such operations are performed in primary visual cortex (Roelfsema, Lamme, & Spekreijse 2000). Tekkotsu provides a set of visual routines that operate on 2D "sketches," starting with a color-segmented camera image (Halelamien 2004; Tira-Thompson *et al.* 2004). We use simple, uniform-colored objects (Figure 1) so that object segmentation can be done based on color alone. Tekkotsu's visual routine operators include color masking, connected components labeling, flood-fill, boundary distance, skeletonization, and neighbor sum, along with basic pixel-wise arithmetic, comparison, and boolean functions.

Sketches are automatically organized into a derivation tree, i.e., the result of applying an operator to a sketch is a new sketch that references the original sketch as its parent (Figure 2). A remote viewing tool allows the programmer to "look inside the dog's head" and examine the derivation tree and any of its component sketches.

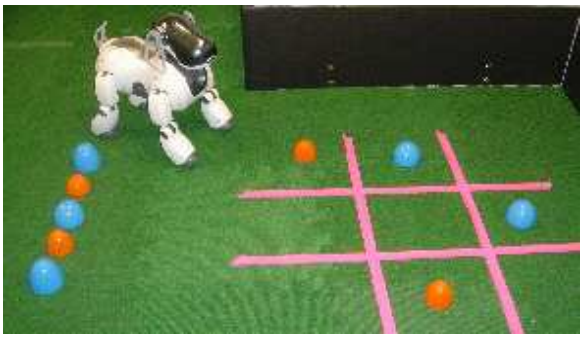

Figure 1: AIBO examining a tic-tac-toe board.

Dual-Coding Representations

Paivio's "dual coding theory" of representations posits parallel verbal and non-verbal (imagistic) systems with extensive referential connections between them (Paivio 1986). In Tekkotsu, sketches provide the imagistic representation, and "shapes" provide a complementary symbolic representation.