

Tekkotsu as a Framework for Robot Learning Research

David S. Touretzky
Computer Science Department
Carnegie Mellon University
Pittsburgh, PA 15213
dst@cs.cmu.edu

Ethan J. Tira-Thompson
Robotics Institute
Carnegie Mellon University
Pittsburgh, PA 15213
ejt@andrew.cmu.edu

Tekkotsu (the name means “framework”, literally “iron bones” in Japanese) is an open source application development framework for mobile robots originally created for the Sony AIBO. It has since been extended to support a variety of other platforms, and is available for free at Tekkotsu.org. Tekkotsu promotes a high level approach to robot programming we call “cognitive robotics” by providing primitives that make it easy to implement new applications. These include a “dual coding” vision system with map builder, particle filter-based localization, forward and inverse kinematics solvers, and an extensive collection of GUI tools for teleoperation and monitoring. Tekkotsu is implemented in C++, with the GUI tools in Java for portability.

Although primarily intended for undergraduate robotics education, Tekkotsu has also proven useful as a research platform because of its powerful and well-integrated primitives. We have in the past used Tekkotsu to demonstrate classic machine learning problems such as the two-armed bandit, and negative patterning (XOR learning). The images below are screenshots from demo videos available at Tekkotsu.org. Current projects include addition of a SIFT-style object recognition facility, and development of visually-guided motor primitives for grasping and manipulation of small objects using a Lynx Motion arm. (The arm is part of a new prototype robot called Regis.) We encourage machine learning researchers to consider Tekkotsu if they wish to test their algorithms on real robots.

Touretzky, D.S., Daw, N.D., and Tira-Thompson, E.J. (2002) Combining configural and TD learning on a robot. *Proceedings of the Second International Conference on Development and Learning*, IEEE Computer Society, pp. 47-52.

Touretzky, D.S., Halelamien, N.S., Tira-Thompson, E.J., Wales, J.J., and Usui, K. (2007) Dual-coding representations for robot vision in Tekkotsu. *Autonomous Robots*, 22(4):425–435.

Supported by National Science Foundation awards CNS-0540521, DUE-0717705, and CNS-0742106.

Two-armed bandit learning demonstration. On each trial, the AIBO robot must choose whether to press the left or right side of the keyboard. Reward or non-reward is indicated by a sound and a color change of a bouncing ball on the display. The head moves to track the ball.



Combining configural and TD learning to demonstrate negative patterning (XOR). A red or blue ball stimulus is followed a few seconds later by a reward signal (thumbs up gesture). But both balls together are not followed by reward. The robot learns to make an appropriately-timed reward response (tail wag) only to single balls.



Regis prototype created specifically for research on visually guided manipulation in Tekkotsu. Features include a 600 MHz/128 MB gumstix processor, “goose neck” webcam (4-dof arm with camera at the tip), and a front-mounted 6-dof “crab arm” manipulator lying in the plane of the workspace for unobstructed visual monitoring.

