BEHAVIORAL DEVELOPMENT FOR A HUMANOID ROBOT

Towards Life-Long Human-Robot Partnerships

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EXTENDED ABSTRACT

A significant research effort was conducted at Sony's Intelligence Dynamics Laboratory (SIDL), involving personnel from Georgia Tech, MIT, CMU, Osaka University, and SIDL, working towards the implementation of a theory of designed development for a humanoid robot. This research involves numerous insights gleaned from cognitive psychology (drawn from both new and old theories of behavior) and integrating these techniques into Sony's humanoid robot QRIO architecture with the long-term goal of providing highly satisfying longterm interaction and attachment formation by a human partner. Included are models of deliberative (willed) reasoning and its interfacing with a reactive (automatic) controller (Glasspool 00, Shallice and Burgess 96, Ulam and Arkin 07). In particular aspects of skill transference from planned to routine activity are incorporated (Cooper and Glasspool 01, Cooper and Shallice 97, Chernova and Arkin 07). In addition, a multi-method learning technique inspired by assimilation models of Piaget provides for runtime incorporation of disparate learned skills into the existing behavioral substrate (Takamuku and Arkin 07). Finally non-verbal communication mechanisms that overlay ongoing behavior performance and utilize both proxemics (spatial separation) and kinesics (body language) are described (Brooks and Arkin 07). All of the underlying models, their implementation and the results obtained on QRIO are presented.

REFERENCES

Brooks, A. and Arkin, R.C., "Behavioral Overlays for Non-Verbal Communication Expression on a Humanoid Robot", *Autonomous Robots*, Vol. 22, No.1, pp. 55-75, Jan. 2007.

Chernova, S. and Arkin, R.C., "From Deliberative to Routine Behaviors: A Cognitively-Inspired Action Selection Mechanism for Routine Behavior Capture", *Adaptive Behavior*, Vol. 15, No. 2, pp. 199-216, June 2007.

Cooper, R., & Glasspool, D., "Learning action affordances and action schemas", *Connectionist Models of Learning, Development, and Evolution*, 133-142, 2001.

Cooper, R., and Shallice, T., "Modeling the selection of routine action: Exploring the criticality of parameter values", in *Proceedings of the 19th annual conference of the cognitive science society* p. 130-135, 1997.

Glasspool, D., "The integration of control and behavior: Insights from neuroscience and AI", in *Proceedings of the How to Design a Functioning Mind Symposium at AISB-2000*, pp. 77–84, 2000.

Shallice, T. and Burgess, P., "The domain of supervisory processes and temporal organization of behavior", in *Philosophical Transactions of the Royal Society of London B,* vol. 351, pp. 1405–1412, 1996.

Takamuku, S. and Arkin, R.C., "Multi-method Learning and Assimilation", *Robotics and Autonomous Systems*, Vol. 55, No. 8, pp. 618-627, 2007.

Ulam, P. and Arkin, R.C., "Biasing Behavioral Activation with Intent", to appear in *Intelligent Service Robotics*, 2008.

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