Designing and Building Vision-Based Robots

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Abstract

Knowledge-based image interpretation needs to be re-interpreted. The traditional approach, based on the classic Good Old-Fashioned Artificial Intelligence and Robotics (GOFAIR) paradigm, proposes that domain-specific knowledge is used by the robot/agent at run-time to disambiguate the retinal array into a rich world representation. The argument is that the impoverishment and ambiguity of the visual stimulus array must be supplemented by additional knowledge. This approach has failed to make substantial progress for several reasons. One difficulty is the engineering problem of building robots by integrating off-line knowledge-based vision systems with on-line control-based motor systems. Especially in active vision systems this integration is difficult, ugly and inefficient. I argue that, with a radical re-interpretation of 'knowledge-based', we *can* design, build and verify quick and clean knowledge-based situated robot vision systems.

We need practical and formal design methodologies for building integrated perceptual robots. The methodologies are evolving dialectically. The symbolic methods of GOFAIR constitute the original thesis. The antithesis is reactive Insect AI. The emerging synthesis, Situated Agents, has promising characteristics, but needs formal rigor and practical tools. The critiques and rejection by some of the GOFAIR paradigm have given rise to the Situated Agent approaches of Rosenschein and Kaebling, Brooks, Ballard, Winograd and Flores, Lavignon and Shoham, Zhang and Mackworth and many others.

The Constraint Net (CN) model is a formal and practical model for building hybrid intelligent systems as Situated Agents. In CN, a robotic

system is modelled formally as a symmetrical coupling of a robot with its environment. Even though a robotic system is, typically, a hybrid dynamic system, its CN model is unitary. Many robots can be designed as on-line constraint-satisfying devices. A robot in this restricted scheme can be verified more easily. Moreover, given a constraint-based specification and a model of the plant and the environment, automatic synthesis of a correct constraint-satisfying controller becomes feasible, as Zhang and I have shown for a simple ball-chasing robot.

These ideas are illustrated by application to the challenge of designing, building and verifying active perception systems for robot soccer players with both off-board and on-board vision systems. This work is joint with Ying Zhang and many others in our laboratory.