

RECAU: REACTIVE-CAUSAL ARCHITECTURE FOR
INTELLIGENT AGENTS

A Thesis Submitted in Fulfillment of the Requirements
of the Degree of Doctor of Philosophy

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To the One...

For the One...

Acknowledgements

I would like to express my deep and sincere gratitude to Prof. Mehmet Ali Orgun, my supervisor –without his support this study could have never been accomplished. His wide knowledge and understanding have been of great value for me.

I wish to express my warm and sincere thanks to Dr. Abhaya Nayak, my co-supervisor whose support was encouraging.

I would like to thank my family, especially my mother Ümran Aydın. She has always supported me to realise my dreams. Without her, I could not go this far in my studies. I also would like to express my gratitude to my sister, Özge Aydın Sığmaz for her support in every respect.

I owe my deepest gratitude to my love Arzu Alvan, whose understanding and support are invaluable for me.

The financial support of Macquarie University is gratefully acknowledged.

Declaration

I certify that the work in this thesis entitled “ReCau: Reactive-Causal Architecture for Intelligent Agents” has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

Ali Orhan AYDIN

30 March 2011

Abstract

Intelligent agent technologies hold promise in recreating intelligence on machines. Agent and cognitive architectures are used as a methodology for designing modular decompositions for the tasks of an intelligent agent. To simulate intelligence, certain attributes must be satisfied while developing agent architectures. The most commonly acknowledged attributes of believable agents are situatedness, strong autonomy, action flexibility with social capabilities and affect display. This study aims to develop such an agent architecture by establishing a general framework.

Instead of rationality, the fundamental assumption in the proposed approach is that intelligent behaviour is produced in accordance with causality. Decision-making is explained as a process which is in accordance with causality. Accordingly, a general framework to simulate intelligent behaviour is proposed. In the proposed approach, intelligent entities are considered as beings driven by their motives, and to satisfy these motives they act intentionally. While explaining motives, the proposed approach adopts Maslow's theories of needs. The actions taken are considered as effects, while related input data are considered as causes. The needs are the nexus which provide the means to measure different alternatives. A degree of randomness is introduced in the process in order to make actions more flexible. To simulate strong autonomy, reinforcement learning is adopted to realise social learning theory. An emotion model integrated with theories of needs is also introduced to support affect display. Correspondingly, the satisfaction or dissatisfaction of needs results in the

generation of emotions.

Based on this framework, an agent architecture called Reactive-Causal Architecture (ReCau) is proposed. This architecture is a general purpose one which can be used to develop believable agents. The proposed architecture consists of three layers: reactive, deliberative and causal. To demonstrate the action flexibility provided by ReCau, a few experiments are undertaken.

To illustrate the decision-making mechanism of ReCau, the radar task simulation is performed. In the docking simulation, in a team with voting organisation structure ReCau agents' performance matches best the human data best. In this setting, while the resource access structure is blocked, performance of ReCau agents is 53.1 percent while it is 53.6 percent in the distributed resource access structure. In the team with voting organisation structure performance difference of ReCau and Human agents is around 3 percent. In the hierarchy with a single manager organisation structure and blocked resource access structure the difference is almost the same with the team with voting organisation structure. However, in the distributed resource access structure in hierarchy the difference is around 12 percent. These findings indicate that ReCau provides a highly realistic decision-making mechanism; since, the performance pattern of ReCau agents matches human data well. This contributes to the solution for the development of believable agents.

Keywords: Intelligent Agent Architecture, Agent-Based Social Simulation

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