

Preface

There are books on cognitive science and cognitive systems engineering. The books on cognitive science mostly deal with the psychological aspects of human cognition. The titles on cognitive systems engineering usually focus attention on human-machine interaction models. Unfortunately, there is no book on cognitive engineering that can bridge the gap between cognitive science and cognitive systems engineering. The book *Cognitive Engineering: A Distributed Approach to Machine Intelligence* fills this gap.

Beginning with the psychological perspectives of the human cognition, *Cognitive Engineering* gradually explores the computational models of reasoning, learning, planning, and multi-agent coordination and control of the human moods. Humans usually perform the above cognitive tasks by activating distributed modules in their brain. To incorporate the humanlike ability of distributed processing, a specialized distributed framework similar to Petri nets has been selected.

Chapter 1 of the book introduces the basic psychological processes, such as memory and attention, perception, and pattern recognition using the classical theories proposed by the philosophers over a century. The chapter finally proposes Petri nets as a distributed framework for cognitive modeling.

Chapter 2 presents a distributed model of logic programming using extended Petri nets. The model facilitates concurrent resolution of program clauses. The extended Petri net, which is designed to support the model, provides a massive parallelism without sacrificing resource utilization rate.

Chapter 3 examines the scope of fuzziness in Petri nets. It reviews the existing literature on fuzzy reasoning, fuzzy learning, and consistency analysis of fuzzy production rules using Petri nets. The chapter also assesses the scope of fuzzy Petri nets in abductive reasoning, reciprocity, duality, and nonmonotonicity.

Chapter 4 proposes forward reasoning in both acyclic and cyclic fuzzy Petri nets. The acyclic model propagates fuzzy beliefs of propositions from the axioms (starting events) to the terminal (query) propositions in the network. The cyclic model is concerned with belief revision through local computation in the network. A reachability analysis for the acyclic model to prove its deadlock freedom and a stability analysis of the cyclic model to prove its conditional stability are presented.

Chapter 5 is an extension of Chapter 4 to demonstrate the application of the belief-revision model in an illustrative expert system for criminal investigation. A detailed analysis of time-complexity of the algorithms used to build up the proposed expert system is also included.

Chapter 6 is concerned with designing learning models for causal networks. The stability analysis for the learning dynamics is also given. Application of the proposed learning models in an illustrative weather prediction problem has been undertaken.

Chapter 7 deals with unsupervised learning in a fuzzy Petri net. Two distinct models of unsupervised learning have been proposed. Stability analysis of the models has been included. Application of the models in knowledge acquisition problem of expert systems has also been studied. The relative merits of the models have been compared in the concluding section.

Chapter 8 is concerned with supervised learning in a fuzzy Petri net. The convergence analysis of the model is presented. The application of the model in object recognition from noisy training instances has been demonstrated.

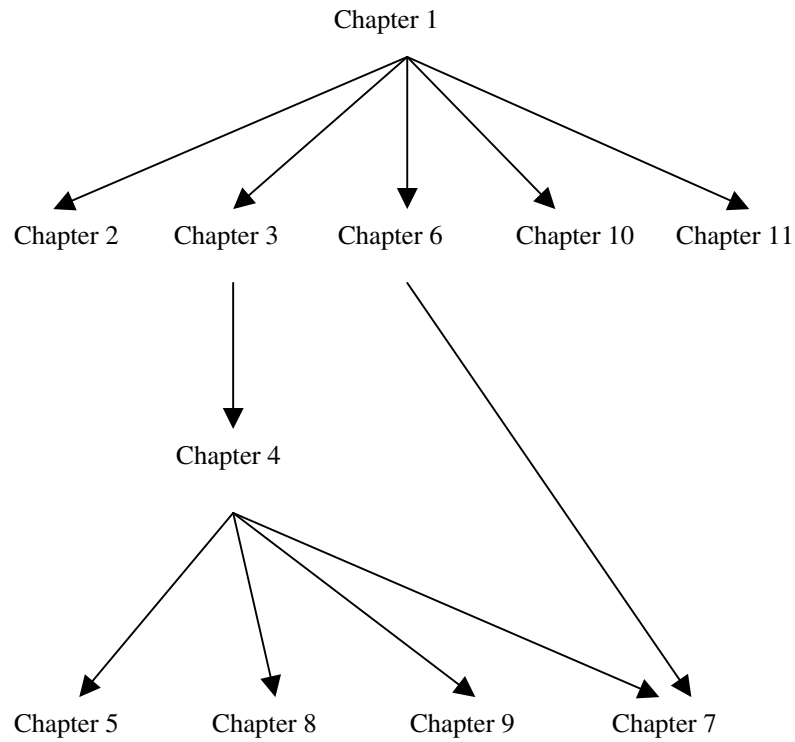
Chapter 9 is an extension of the fuzzy Petri net model presented in Chapter 4. The extension is needed to represent discrete membership functions instead of singleton membership (belief) at the places of the network. Further extension of the model for abductive reasoning, bi-directional iff type reasoning, reciprocity, and duality have been studied.

Chapter 10 proposes a cybernetic approach to the modeling of human mood detection and control. The mood detection has been performed through analysis of facial expressions of the subjects using Mamdani-type fuzzy relational model. The mood control is accomplished by presenting appropriate music, video clips, and audio messages to the subject. A fuzzy relational model is employed to determine the appropriateness of the above items in a given context.

Chapter 11 deals with multi-agent planning and coordination of mobile robots. Principles of multi-agent planning have been briefly introduced. A case study on material transportation problem has been undertaken to familiarize the readers with the design aspects of a typical multi-agent robotic system. Relative merits of the proposed multi-agent system with respect to its single-agent implementation have been studied using a timing analysis.

The book will serve as a unique resource to the students and researchers of cognitive science and computer science. Graduate students of mathematics, psychology, and philosophy having a keen interest to pursue their research in cognitive engineering will also find this book useful.

Most of the chapters in the book are self-contained. To avoid cross-referencing, terms defined in a chapter are sometimes redefined in a later chapter, as and when needed. For convenience of the readers, we provide a traversal graph, where an arrow from chapter i to chapter j indicates that chapter j should be read after completion of chapter i .



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