Intelligent Agents
and Their Applications

Studies in Fuzziness and Soft Computing

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and 10 Tables

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DEDICATION

This book is dedicated to our students.

The proceeds of royalty will be donated to a Charity.

Foreword

An agent is normally defined as a computer program that continuously and autonomously acts on behalf of the user. In practice, varieties of artifacts, such as synthetic lifelike conversational characters on the computer display, computer programs that broker information on the information network, or computing units that collectively exhibit an intelligent behavior, are called agents.

Why are people so excited about agents? The current enthusiasm about the agent technology may be traced back to the beginning of the 1990s, five years after Minsky's "The Society of Mind" was published, a few years after Apple's Knowledge Navigator promotion video was released to the public, and four years prior to Communications of the ACM's special issue on intelligent agents (Volume 37, No. 7, July 1994). More than ten years after those "good old days," the enthusiasm does not appear to cease, but on the contrary is becoming even widespread in society. In the beginning, strong suspicion coexisted with the enthusiasm. Critics thought the agent technology was no more than a fad that would soon disappear. After a while, it became mode and fashion, and today it is a well-recognized standard branch of the information and communication technology.

Agent technology entertains researchers with thousands of challenging goals. Compared with those of ten years ago, researchers now address more practical goals ranging from knowledge management and supply chains to collective robotics. These real world problems urge them to solve real, hard issues that are not only significant in practical applications but also truly interesting from the theoretical points of view. Today's agent technology stands on a large amount of innovations driven by real world applications and evaluations. Practitioners are happy with agents, too. Agent technology presents a huge potential for

business. In fact, agent technology has been successfully applied to numerous business applications ranging from entertainment and education to electronic commerce and reliable intelligent manufacturing.

Indeed, a closer look at agent technology reveals that it is a result of the confluence of many technologies, including object-oriented programming, distributed computing, and artificial life. Thousands of species of animals and plants inhabit the portion of the sea where the tide is so strong that it refreshes the environment. In a similar manner, agent technology provides many interesting "foods" for researchers that result from this new interaction between different disciplines.

Why can the agent technology retain coherency instead of dispersion as a result of strong perturbations? It is because the goal of agent technology is intuitively very clear to us even though there is a technical difficulty in defining the agent-hood. The goal of agent technology is to design a new type of artifact that can cohabit with us. It is dramatically different from designing tools. It is more like characterizing dependable partners. The advance of information and communication technology has made this goal feasible.

The most important aspect of the agent technology is that it encompasses intelligence and interaction. It successfully integrates two separate disciplines, Artificial Intelligence (AI) and Human Computer Interaction (HCI), which should have been studied together; there was an unfortunate gulf between the two. AI has placed emphasis on developing artifacts with intelligence. A significant amount of AI research effort has been spent on techniques aimed at knowledge-based systems or learning machines, but little has been spent on designing interaction between humans and artifacts. Quite the opposite holds true for HCI research.

The essence of agent technology is mediated interaction between humans and artifacts. The broker agents mediate interaction among software agents, ranging from information brokerage to more complex negotiations such as commercial trade. The interface agents or embodied conversational agents mediate interaction among people by telling stories meaningful to the participants of the conversation.

Interaction enables intelligence. Intelligence emerges from interaction. Humans are intelligent not because their individual brain cells are clever. Instead, their intelligence comes from the interaction of billions of brain cells. Similar observation might hold in a macroscopic view. It is very hard for a human to become intelligent if she or he lives alone in a universe. Instead, her/his intelligence is formed from interaction with other people. Meanwhile, intelligence adds value to interaction. Interaction may not be interesting without intelligence. Intelligent members may allow their community to be intelligent as well, even though it is more a necessary condition than a sufficient condition.

The most important application area for the agent technology is the information space that is exponentially growing along with the advance of the information and communication technology. We look forward to truly dependable agent technology that can help us enjoy the adventures in this new universe.

Toyoaki Nishida
The University of Tokyo

Preface

Over the past two decades we have experienced a revolution in information availability and exchange. The amount of information available is growing at an exponential rate. With sensor technology for example, consider the European Space Agency's ERS-1 Space-based Synthetic Aperture Radar. This crosses the continent of Australia in few minutes, sending down imagery at a rate of 108Mb/s. There are other hyperspectral sensors with an even greater capacity for collecting information. In the communications area, the number of mobile telephone subscribers was about 50 million world-wide in 1994. This figure will approach 600 million this year. We read in the popular media that the number of internet sites goes up by thousands each day. Global shrinkage caused by the Internet is the single most important and evolutionary feature of this decade. We certainly live in an information rich environment. A quantum change is occurring in our society as far as the information is concerned.

Information agents are one of the most promising tools to conduct business in this information rich world. Information agents are the software systems that are capable of performing intelligent tasks in dynamic and unpredictable environment. It is desirable to incorporate in agents the characteristics such as autonomous, adaptive, collaborative, communicative, mobile, and reactive.

There are many real world problems in the world including decision making and classification which do not provide needed information, or the systems under consideration are not well defined. These problems are not easy to solve using conventional computing approaches but intelligent agent paradigms may play a major role in these areas.

The purpose of this book is to present the research results to the applications researcher rather than the agent purist. This book covers a

broad selection of applications that will serve to demonstrate the applications of agents in this information rich society.

We believe that this book will be of great value to the researcher and scientists/engineers alike. The research students will receive an in-depth tutorial on the topics covered.

We are grateful to the authors for their interesting chapters. We wish to thank the reviewers for their time and expertise. We are indebted to Berend Jan van der Zwaag for his help in the preparation of the manuscript. Thanks are due to the editorial staff of the Springer-Verlag for their excellent editorial assistance.

L.C. Jain
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