Artificial Intelligence for Computer Games

John David Funge

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An Introduction

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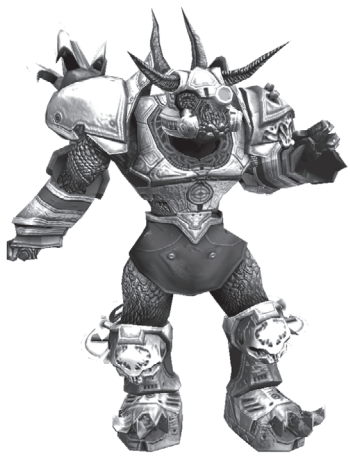

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Dedicated to David and Patricia.

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Preface

This is the second book I have written about Artificial Intelligence (AI) and computer games. My first book was closely based on my PhD thesis and although it was therefore quite specialized it was well received. I was pleased by the compliments I received from some well-known game developers who told me they had enjoyed reading it and found it helpful. This new book is more accessible than the last one and should appeal to an even wider audience. I believe it should be useful to anyone looking to become a game AI programmer, as well as those already working in the field.

I also hope that this book will spark new interest among academics in AI research for computer games. There is a tendency to assume that games are just another application area for AI and as such they deserve no special attention. While it is true that many general purpose AI algorithms are applicable to games, there is also a wealth of opportunity for more specialized study.

There are already several interesting books available that are either solely or partially dedicated to AI and games. Those other books tend to take the form of compendiums of articles by different authors about a wide range of AI-related topics. Instead of trying to compete, in this book I take a complementary approach that presents a more unified overview of AI in games. In particular, the unifying theme of this book is of a Non-Player Character (NPC) and the capabilities that can be built into it.

There are also an enormous number of books on the subject of AI in general. The wonderful thing about the existence of all these books is that

it provides such a firm foundation to build upon. There is no need for subsequent books on AI (like this one) to rehash all the same ideas and algorithms. Instead, this book is free to concentrate solely on the application of AI to games and to give references for introductory material that is readily available elsewhere. At the other end of the spectrum, this book also provides a jumping-off point to many advanced topics in AI that are relevant to games.

In this day and age there are also many game- and AI-related resources online that provide lots of detailed information about algorithms and techniques. This book does, of course, contain a comprehensive bibliography that includes some web sites, but a traditional bibliography is limited and soon becomes out of date. There is therefore a companion web site for this book at www.ai4games.org that you will be referred to throughout the text for additional resources and information.

Since my first book, I have been working in the games industry developing AI technology. The experience has given me a much clearer understanding of game AI, and a perspective that I think many academics lack. For example, many academics will make efficiency arguments for why their AI is good for games. But AI programming is not usually such a significant part of the cost of a game that, from a business point of view, it would justify the risk of using a new technique. What the business people in the games industry do care about, however, is new effects that can help differentiate their game from the competition.

Typically new effects have come from the graphics industry, for example, the move to three-dimensions, texture maps, and lately, real-time procedural shading languages. That is why new games are constantly pushing the envelope for graphics while they often languish in the past with their AI. Until AI has some new exciting effects to offer the mainstream game player, this will continue to be the case.

Sooner or later graphics is going to run out of steam as a driving force behind games. Already the law of diminishing returns makes it hard for the casual gamer to tell the difference between this year and last year's graphics. AI has the potential to become the new driving force behind computer game innovation. With the right technology, whole exciting new game genres could be developed. I hope this book will help you think about new AI effects for your games that will generate enthusiasm for AI among game designers and players.

Acknowledgments

I am currently working at a startup which I cofounded that develops AI technology for the entertainment industry. It is one of my hopes that this book, by promoting a common framework and terminology, will make it easier for game developers to interact with AI middleware companies. At the time of writing, we are still being secretive about the technology we have developed so I have been careful not to include any confidential information in the writing of this book. Nevertheless many of my ideas about the general topic of game AI have been shaped and heavily influenced by my experiences at work and by the people with whom I work. I am therefore indebted to many of my current and former colleagues: Brian Cabral, Wolff Dobson, Nigel Duffy, Michael McNally, Ron Musick, Stuart Reynolds, Xiaoyuan Tu (cofounder), Ian Wright, and Wei Yen (CEO and cofounder).

Wei Yen is a remarkable person to whom I am grateful for giving me the opportunity to work for him in such an educational and interesting environment. Ian, Michael, and Wolff have all developed successful commercial games and their experience has been invaluable to me in understanding how AI is applied in the real world of game programming. Ian also proofread the book and provided numerous suggestions on style and content throughout the writing process that have significantly improved the book. Michael has taught me a great deal about programming and about good ways to organize a game's architecture. Ian and Brian have also improved my knowledge of programming. Nigel and Ron have taught me an enormous amount about AI, and Stuart has taught me a lot about reinforcement learning in particular. Xiaoyuan has been at the heart of developing our core technology and has helped me develop a deeper understanding of AI. Dale Schuurmans and Stuart Russell also deserve special mention for it was they who helped provide me with a more modern perspective on AI. Thanks also to Benjamin Funge who helped out with some proofreading.

I have also benefited from numerous conversations with people in the games industry over the years, too many to list, but I am thankful to them too. While much of the credit for the ideas in this book therefore lies with other people, the responsibility for any errors or omissions is obviously my own.

Xiaoyuan is my colleague and also my wife. At home, I am grateful for her love, kindness, and support. On the subject of home, I would also like to express my appreciation to Pung Pung and Willow for their companionship.

Finally, I would like to thank Alice Peters and all the staff at A K Peters for their support, understanding, and encouragement throughout the writing of this book. Special thanks to Jonathan Peters and the people at Garage Games for contributing their time and artwork to produce such a wonderful front cover.

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Chapter 1

Introduction

Computer games, or perhaps more accurately, video games, began with the invention of "Tennis for Two" in 1958. It was not until the 1970s that Atari introduced a wider audience to computer games with the successful console game Pong. Since then computer games have become a multibillion-dollar industry with countless titles published every year. Despite the large number of individual game titles, there is a relatively small set of different game genres. The exact list of genres is debatable, and just like with movies, people argue about which genre(s) a particular game belongs to. This book's companion web site (www.ai4games.org) has links to sites that provide a comprehensive list of genres and example games from each. There are also additional links to interesting information on the history and status of computer games.

1.1 Computer Game Characters

Lara Croft, Mario, and Pac-Man are all well-known computer game characters. Each of them is an example of a *player character*. A player character is a character whose behavior is controlled by a human player through some input device like a joystick. For example, the player presses the A button and the character jumps, presses the B button and it punches, pushes up on the thumb pad and it walks forward, and so on. Player characters often play the hero in a game and *Non-Player Characters* (NPCs) play the other roles such as villains, side-kicks, and cannon-fodder. Wario (Mario's

evil brother), Blinky, Pinky, Inky, and Clyde (the four ghosts in Pac-Man) are some rare examples of characters who originally became famous as NPCs.

The distinction between player characters and NPCs is not always straightforward. For example, some games allow the player to control different characters at different times. In such cases, which characters are player characters and which are NPCs is constantly changing. In games where the player controls a party of characters (a team or squad) the switch between player character and NPC can be so fluid that the distinction becomes blurred. That is, the NPCs behave autonomously until the player intercedes to give them a direct order. They then carry out the order, after which they revert to behaving autonomously.

Within a game, NPCs also take on the role of camera person, lighting technician, commentator, and even director. Of course, there is (usually) no little person rendered into the scene who is holding a camera, moving lights around, providing commentary, or directing the other NPCs. There is, however, a piece of code that is controlling the camera, lighting, commentary, direction, etc. It is convenient to think of these pieces of code as NPCs as they share many properties with their on-screen counterparts. Most of techniques in this book therefore apply equally well to NPCs behind the camera as to those in front.

1.2 Behavior

Every character in a game has at least one *controller* associated with it and controllers can be shared between different characters. A controller acts as the character's brain, its inputs are information about the state of the game world, and the outputs are the action choices that affect the game world and produce the associated NPC's behavior.[1]

In other publications, the term "controller" is sometimes used to refer to the player's input device. In this book, "controller" is used exclusively in the sense of the character's brain. The term "joystick" is used for the player's input device.

[1] When it is obvious from the context, the term "NPC's associated controller" is often just replaced with "NPC". For example, "the NPC chooses to jump" is understood to mean "the NPC's associated controller chooses to jump".