

Motivated Reinforcement Learning

Curious Characters for Multiuser Games

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Preface

The past few years have seen steady improvements in computer technology for graphics, sound, networking and processing power. Using these technologies, online virtual worlds like *Second Life*, *There*, and *Active Worlds* are emerging as platforms for multiuser computer games, social interaction, education, design, health, defence and commerce. Computer-controlled, non-player characters facilitate games and activities in these worlds and may interact with hundreds of thousands of human-controlled characters. However, artificial intelligence technology to control non-player characters has, so far, lagged behind advances in other virtual world technologies. There is now a need for more believable and intelligent non-player characters to support and enhance virtual world applications.

This book presents a new artificial intelligence technique – motivated reinforcement learning – for the development of non-player characters in multiuser games. Both theoretical and practical issues are addressed for developing adaptive, dynamic non-player characters. Focus applications include multiuser, role-playing and simulation games.

Humans and animals have the ability to focus and adapt their behaviour. Motivations, such as hunger, curiosity or peer pressure, inspire natural systems to exhibit behaviour that forms distinct cycles, is adaptive and is oriented towards different tasks at different times. These behavioural traits are also an advantage for artificial agents in complex or dynamic environments, where only a small amount of available information may be relevant at a particular time, and relevant information changes over time. Motivated reinforcement learning combines computational models of motivation with advanced machine learning algorithms – to empower non-player characters to self-identify new tasks on which to focus their attention and learn about. The result is an agent model for non-player characters that continuously generate new behaviours as a response to their experiences in their environment. Motivated reinforcement learning can achieve advantages over existing character control algorithms by enabling the development of non-player characters that can generate dynamic behaviour and adapt in time with an unpredictable, changing game environment.

Motivated reinforcement learning transforms the capability of non-player characters because it provides non-player characters with a mechanism for open-ended, online adaptation of their own behaviour. The aim of this book is to provide game programmers, and those with an interest in artificial intelligence, with the knowledge required to develop adaptable, intelligent agents that can take on a life of their own in complex, dynamic environments.

Motivated learning is an exciting, emerging research topic in the field of artificial intelligence. The development of motivated machines is at the cutting edge of artificial intelligence and cognitive modelling research and contributes to the development of machines that are able to learn new skills and achieve goals that were not predefined by human engineers. This opens the way both for new types of artificial agents, and new types of computer games. This book provides an in-depth look at new algorithms for motivated reinforcement learning and offers insights into the strengths, limitations and future development of motivated agents for gaming applications.

Part I – Non-Player Characters and Reinforcement Learning

Chapter 1 – Non-Player Characters in Multiuser Games

Chapter 2 – Motivation in Natural and Artificial Agents

Chapter 3 – Towards Motivated Reinforcement Learning

Chapter 4 – Comparing the Behaviour of Learning Agents

The first part of this book synthesises the basic concepts of non-player characters, motivation, and reinforcement learning. To highlight the need for new kinds of intelligent agents for computer games, Chap. 1 examines current multiuser games, the roles of non-player characters and existing approaches to artificial intelligence used in games. As inspiration for the development of motivated agent models, Chap. 2 examines theories of motivation proposed by psychologists and models of motivation used in artificial agents. Chapter 3 introduces the computational theory and notation for reinforcement learning and the ways in which computational models of motivation fit within this framework. Chapter 4 examines how the behaviour of learning agents and non-player characters can be compared and evaluated.

Part II – Developing Curious Characters Using Motivated Reinforcement Learning

Chapter 5 – Curiosity, Motivation and Attention Focus

Chapter 6 – Motivated Reinforcement Learning Agents

Part II of this book presents a framework for the development of non-player characters as motivated reinforcement learning agents. Chapter 5 presents models of motivation for this framework, while Chap. 6 describes how these models can be incorporated with different reinforcement learning algorithms.

In Chap. 5, motivation is modelled as a process that starts with observations and events as potential learning tasks, selects tasks to learn, applies psychologically inspired, experience-based reward signals, and then arbitrates over reward signals for different tasks to compute a motivation signal. The motivation signal directs the reinforcement learning algorithm as a replacement for a task-specific reward signal. This chapter concludes by describing two models of curiosity using interest and competence to compute a motivation signal for non-player characters.

In Chap. 6, three motivated reinforcement learning algorithms are presented that combine the two computational models of motivation with flat reinforcement learning, multioption reinforcement learning and hierarchical reinforcement learning. These algorithms enable non-player characters to learn behaviours with different levels of recall and ability to reuse learned behaviours.

Part III – Curious Characters in Games

Chapter 7 – Curious Characters for Multiuser Games

*Chapter 8 – Curious Characters for Games in Complex, Dynamic
Environments*

Chapter 9 – Curious Characters for Games in Second Life

In Part III, the theory from previous chapters is applied in a range of practical game scenarios. Chapter 7 demonstrates six different types of curious characters in small-scale, isolated game scenarios. Case studies and empirical results are examined to provide insight into the type of behaviour achieved by characters using motivated reinforcement learning. Chapter 8 moves curious characters into three more complex, dynamic environments and examines the changes in their behaviour.

Chapter 9 presents a demonstration of motivated reinforcement learning for controlling characters in a simulation game, in which player characters can make open-ended modifications to the game world while the game is in progress. This case study provides an evaluation of the adaptive, multitask learning performance of motivated reinforcement learning with respect to a specific application. The game is implemented in the *Second Life* virtual environment. This case study shows how a single agent model can be used to develop different characters by exploiting the ability of motivated

reinforcement learning agents to develop different behaviours based on their experiences in their environment.

Part IV – Future

Chapter 10 – Towards the Future

In Chap. 10, the strengths and limitations of motivated reinforcement learning are considered and used as a basis for discussion of the future directions for motivated agents and multiuser computer games. Advances in computational models of motivation, motivated learning models and their application to multiuser games are considered.

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