COPPE
UFRJ

Instituto Alberto Luiz Coimbra de
Pós-Graduação e Pesquisa de Engenharia

MODELAGEM DE JOGADORES COM PROVENIÊNCIA

Leniel Maccaferri

Dissertação de Mestrado apresentada ao Programa de Pós-graduação em Engenharia de Sistemas e Computação, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Mestre em Engenharia de Sistemas e Computação.

Orientador: Geraldo Xexéo

Rio de Janeiro
Março de 2019

MODELAGEM DE JOGADORES COM PROVENIÊNCIA

Leniel Maccaferri

DISSERTAÇÃO SUBMETIDA AO CORPO DOCENTE DO INSTITUTO ALBERTO LUIZ COIMBRA DE PÓS-GRADUAÇÃO E PESQUISA DE ENGENHARIA (COPPE) DA UNIVERSIDADE FEDERAL DO RIO DE JANEIRO COMO PARTE DOS REQUISITOS NECESSÁRIOS PARA A OBTENÇÃO DO GRAU DE MESTRE EM CIÊNCIAS EM ENGENHARIA DE SISTEMAS E COMPUTAÇÃO.

Examinada por:

_____
Prof. Nome do Primeiro Examinador Sobrenome, D.Sc.

_____
Prof. Nome do Segundo Examinador Sobrenome, Ph.D.

_____
Prof. Nome do Terceiro Examinador Sobrenome, D.Sc.

RIO DE JANEIRO, RJ – BRASIL
MARÇO DE 2019

To Jesus for allowing me this
M.Sc. degree.

Acknowledgments

I'd like to thank everyone who helped me during this endeavor.

Resumo da Dissertação apresentada à COPPE/UFRJ como parte dos requisitos necessários para a obtenção do grau de Mestre em Ciências (M.Sc.)

MODELAGEM DE JOGADORES COM PROVENIÊNCIA

Leniel Maccaferri

Março/2019

Orientador: Geraldo Xexéo

Programa: Engenharia de Sistemas e Computação

This thesis presents an overview about Player Modeling

Abstract of Dissertation presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Master of Science (M.Sc.)

PLAYER MODELING WITH PROVENANCE

Leniel Maccaferri

March/2019

Advisor: Geraldo Xexéo

Department: Systems Engineering and Computer Science

This thesis presents an overview about Player Modeling and shows how Provenance can help while building such models.

Player Modeling is inherently associated with games in general. In this context, some questions come to the mind when modeling a player - the foremost question is: what is a player model? A second possible question can be: what kind of input is used to model a player?... going on: what processes are involved while building a player model? A possible question to close the loop: what is the purpose\outcome of building player models after all?

This work was conceived because the author has a true appreciation for electronic games and specifically in how mapping\modeling player motivations, preferences and actions can change the outcome for both players and game creators\developers.

We live in the big data boom era and as such we have plenty of raw data to explore. Game session logs can be explored in many different ways. This data hides gems that can improve player entertainment while maximizing game creators budget.

All in all what the player wants is a engaging game with balanced characteristics, that is, not too easy and not too hard; not too short and not too long, etc. At the same time, game developers want to create those engaging games of course. To be able to create such games, the use of player models can be of high value and that's what this thesis discuss in a more deep level.

Contents

List of Figures

List of Tables

List of Abbreviations

AI   Artificial Intelligence, p. 1

HCI   Human Computer Interaction, p. 6

NPC   Non-Player Character, p. 2

Chapter 1

Introduction

Player Modeling is currently a very relevant topic in game Artificial Intelligence (AI) research.

The term "player model" is nebulous, and a broad spectrum of possible definitions have been used in various publications [1]. While many people have described player modeling and discussed its importance, the definition and usage of the idea has grown over time, with no single clear definition or scope.

The practice of trying to understand players through analyzing their interactions with the games they play is becoming more and more common and important. Under the labels "player modeling", "game data mining" and "game analytics", researchers from various fields (game studies, game design, computational intelligence and statistical machine learning) are bringing learning algorithms and statistical techniques to bear on the logs of (usually multiple, sometimes huge numbers of) players playing games.

The most important goal for almost every existing game is entertainment [2] and this is achieved with a combination of items like graphics, story (in some game genres) and AI. Entertainment is a subjective concept and, in order to know how much a game entertains a player, some general metrics are evaluated. One of the most important metrics is immersion, which is generally related to how absorbing and engaging a game is. Two common approaches to achieve immersion are the use of stunning graphics and the development of a good AI system. While graphics are responsible for initially "seducing" the players, AI is responsible for keeping them interested and engaged in the game. The aesthetic elements were the industry's main concern for a long time since they are more attractive. It's easier to convince a customer to buy a game because it "looks good" than because it has a complex AI that is much harder to be presented in marketing events. However this scenario is starting to change. Game AI is receiving increasing attention since it helps keeping the player engaged to the game.

The successful design of player experience can make the difference between a
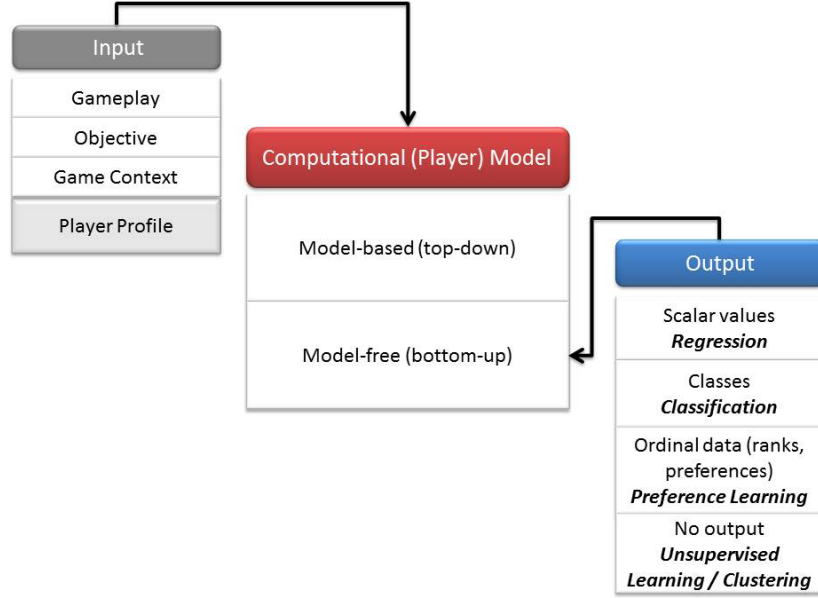
Figure 1.1: Player Model components

game that engages players for extended periods of time and a game that contains content — whether that is mechanics, levels, maps or narrative plots — that fail to elicit appropriate experience patterns and rich affective experiences to its users [3].

The primary goal of player modeling and player experience research is to understand how the interaction with a game is experienced by individual players. Thus, while games can be utilized as an arena for eliciting, evaluating, expressing and even synthesizing experience, one of the main aims of the study of players in games is the understanding of players' cognitive, affective and behavioral patterns. Indeed, by the nature of what constitutes a game, one cannot dissociate games from player experience [4].

In summary, player modeling is the study of computational means for the modeling of player cognitive, behavioral, and affective states which are based on data (or theories) derived from the interaction of a human player with a game [5].

1.1 Player Modeling

Player models are built on dynamic information obtained during game-player interaction\sessions, but they could also rely on static player profiling information [4]. The core components of a player model are depicted in Figure 1.1. It includes the computational model itself and methods to derive it as well as the model's input and output.

It's trivial to detect behavioral, emotional or cognitive aspects of either a human player or a non-player character (NPC). In principle, there is no need to model an

NPC, for two reasons:

1. an NPC is coded, therefore a perfect model for it exists in the game's code, and is known by the game's developers; and

2. one can hardly say that an NPC possesses actual emotions or cognition.

By clustering the available approaches for player modeling, we are faced with either model-based or model-free approaches as well as potential hybrids between them [4].

1.1.1   Top-down (model-based)

A top-down approach is based and built on a theoretical framework such as the usability theory [6]. Researchers follow the modus operandi of the humanities and social sciences, which hypothesize models to explain phenomena, usually followed by an empirical phase[1] in which they experimentally determine to what extent the hypothesized models fit.

Moreover, there are theories that are driven by game design, such as Malone's design components for 'fun' games [8] and Koster's theory of fun [9].

Several top-down difficulty and challenge measures have been proposed for different game genres as components of a player model. In all of these studies, difficulty adjustment is performed based on a player model that implies a direct link between challenge and 'fun' [4].

1.1.2   Bottom-up (model-free)

A model-free approach refer to the construction of an unknown mapping or model between player input and a player state representation. Researchers follow the modus operandi of the exact sciences, in which observations are collected and analyzed to generate models without a strong initial assumption on what the model looks like or even what it captures. Player data and annotated player states are collected and used to derive the model. In a later stage, classification, regression and preference learning techniques adopted from machine learning or statistical approaches are commonly used for the construction of a computational model [4]. In model-free approaches we meet attempts to model and predict player actions and intentions. Data mining efforts are put into use to identify different behavioral playing patterns within a game.

---

[1]Empirical means based on, concerned with, or verifiable by observation or experience rather than theory or pure logic. A naive observer might indeed conjecture that science owes its special status because it pays close attention to observed phenomena (the empirical data) and draws whatever conclusions these phenomena inductively warrant (empirical confirmation) [7].

1.1.3 Hybrids

The space between a model-based and a model-free approach can be viewed as a continuum along which any player modeling approach might be placed. While a completely model-based approach relies solely on a theoretical framework that maps a player's responses to game stimuli, a completely model-free approach assumes there is an unknown function between modalities of user input and player states that a machine learning algorithm (or a statistical model) may discover, but does not assume anything about the structure of this function. Relative to these extremes, the vast majority of the existing works on player modeling may be viewed as hybrids between the two ends of the spectrum, containing elements of both approaches [4].

Chapter 2

Games

In this work player modeling is applied to electronic games. What follows is a brief background information about what constitutes a game.

2.1   What is a Game?

The existence of a discussion about what a game is, or whether some activity is actually a game may surprise those who stumble upon it for the first time. However, while studying games, it is important to understand what we are analyzing or what we are creating. For this, it is better that the concept of what defines a "game" is plain clear and that we know how far we are moving away from an "ideal game" when we are creating a new game [10].

Based on various definitions of games found in the literature and repeated in several introductory articles and also in the observation and detailed analysis of what happens when we play, the following definition of what a game is, can serve as a beacon for our study:

> Games are social and cultural voluntary activities, meaningful, strongly absorbing, non-productive, that use an abstract world with real-world negotiated effects, and whose development and final outcome is uncertain, where one or more players or teams of players, interactively and quantitatively modify the state of an artificial system, possibly in pursuit of conflicting goals, by means of decisions and actions, some with the capacity to disrupt the opponent, being the whole process regulated, oriented and limited by accepted rules, and thereby obtaining a psychological reward, usually in the form of entertainment, amusement, or a sense of victory over an adversary or challenge.

The reason for having a definition of what a game is is not to create a barrier between games and not games. What we want is to delimit in a fluid way what we

consider a game. We may think that this definition is a big "or" of requisites. Thus, something totally ceases to be a game only when all conditions are broken [10].

2.2   Game Potential

The high potential that games have in affecting players is mainly due to their ability of placing the player in a continuous mode of interaction, which develops complex cognitive, affective and behavioral responses [4].

Every game features at least one user (i.e., the player), who controls an avatar or a group of miniature entities in a virtual\simulated environment [11]. Control may vary from the relatively simple (e.g., limited to movement in an orthogonal grid) to the highly complex (e.g., having to decide several times per second between hundreds of different possibilities in a highly complex 3D world).

The interaction between the player and the game context is of prime importance to modern game development, as it breeds unique stimuli which yield emotional manifestations to the player.

The study of the player in games may not only contribute to the design of improved forms of Human Computer Interactions (HCI), but also advance our knowledge about human experiences.

2.3   Game Industry

According to the Global Games Market Report [12] the gaming market has now 2.2 billion gamers across the globe with an expectation of generating $116 billion in game revenues in 2017 [13].

It is a competitive market especially in terms of gameplay, which is something largely determined by the quality of a game's AI. A game with a large variety of unique agent behaviors has a competitive advantage to a game with a few hand coded expert systems. In addition to being a preferred investment to developers it's also a viable option on current hardware. Due to hardware advancements, processor cycles are easier to come by and memory is cheap.

Bibliography

[1] SMITH, A. M., LEWIS, C., HULLETT, K., et al. "An Inclusive Taxonomy of Player Modeling", p. 19.

[2] NAREYEK, A. "AI in Computer Games", *ACM Queue*, v. 1, pp. 58–65, fev. 2004. doi: 10.1145/971564.971593.

[3] YANNAKAKIS, G. N., KARPOUZIS, K., PAIVA, A., et al. "Emotion in Games". In: D'Mello, S., Graesser, A., Schuller, B., et al. (Eds.), *Affective Computing and Intelligent Interaction*, v. 6975, Springer Berlin Heidelberg, pp. 497–497, Berlin, Heidelberg, 2011. ISBN: 978-3-642-24570-1 978-3-642-24571-8. doi: 10.1007/978-3-642-24571-8_62. Available at: <http://link.springer.com/10.1007/978-3-642-24571-8_62>. Accessed on: 7 June 2017.

[4] YANNAKAKIS, G. N., SPRONCK, P., LOIACONO, D., et al. *Player Modeling*. Technical report, Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik GmbH, Wadern/Saarbruecken, Germany, 2013.

[5] YANNAKAKIS, G. N. "Game AI Revisited". In: *Proceedings of the 9th Conference on Computing Frontiers*, CF '12, pp. 285–292, New York, NY, USA, 2012. ACM. ISBN: 978-1-4503-1215-8. doi: 10.1145/2212908.2212954. Available at: <http://doi.acm.org/10.1145/2212908.2212954>. Accessed on: 21 March 2018.

[6] "Game Usability - Jnd.Org". Available at: <https://www.jnd.org/dn.mss/game_usability.html>. Accessed on: 23 March 2018.

[7] STREVENS, M. "What Is Empirical Testing?" p. 33.

[8] MALONE, T. W. "What Makes Things Fun to Learn? Heuristics for Designing Instructional Computer Games". In: *Proceedings of the 3rd ACM SIGSMALL Symposium and the First SIGPC Symposium on Small Systems*, SIGSMALL '80, pp. 162–169, New York, NY, USA, 1980. ACM. ISBN: 978-0-89791-024-8. doi: 10.1145/800088.802839. Available at:

<http://doi.acm.org/10.1145/800088.802839>. Accessed on: 23 March 2018.

[9] "A Theory of Fun for Game Design". Available at: <https://www.theoryoffun.com/>. Accessed on: 23 March 2018.

[10] XEXÉO, G. "O que são Jogos?" Available at: <http://ludes.cos.ufrj.br/wp-content/uploads/2016/07/LJP1C01-O-que-sao-jogos-v2.pdf>, 2013. Accessed on: 23 March 2018.

[11] CALLEJA, G. *In-Game: From Immersion to Incorporation.* Cambridge, Mass, MIT Press, 2011. ISBN: 978-0-262-01546-2.

[12] "New Gaming Boom: Newzoo Ups Its 2017 Global Games Market Estimate to \$116.0Bn Growing to \$143.5Bn in 2020". Available at: <https://newzoo.com/insights/articles/new-gaming-boom-newzoo-ups-its-2017-global-games-market-estimate-to-116-0bn-growing-to-143-5bn-in-2020/>. Accessed on: 23 March 2018.

[13] "The Global Games Market 2017 — Per Region & Segment". Available at: <https://newzoo.com/insights/articles/the-global-games-market-will-reach-108-9-billion-in-2017-with-mobile-taking-42/>. Accessed on: 23 March 2018.

Appendix A

Demos