Decision Making in Computer Games

Christoffer Holmgård
Center for Computer Games Research
IT University of Copenhagen
DK-2300 Copenhagen S, Denmark
holmgard@itu.dk

ABSTRACT

The purpose of this paper is to introduce a research agenda for measuring and modeling human decision making styles in computer games within the field of Game Artificial Intelligence (Game AI). It is proposed that the combination of psychological decision theory and BDI agents could provide a valuable frame for both modeling and simulating human decision making styles in computer games. An approach for a study investigating this proposition is presented.

1. INTRODUCTION

Historically, the term Game AI has, first from an industry perspective and later from an academic perspective, primarily related to the devising of methods for controlling non-player characters (NPCs) in games. Recently, the term has been re-focused to also include player modeling, player experience modeling, and procedural content generation. This development has brought Game AI closer to other disciplines concerned with the actions or experience of the player, for instance the social sciences concerned with motivation, cognition and behavior. It has also caused a change in the relation to the discipline of game design making interaction go beyond the design of character/controller behavior. As a side effect, academic interest in Game AI's ability to generate interesting methods for NPC control has rekindled, focusing on increasing NPC believability through adapting the controller and the context in which it is embedded. This strand of Game AI research is still in its infancy, as Yannakakis [20] puts it:

> So far, the question of whether empirical research efforts should be put more on the agent or its environment (or both) in order for the agent to appear more believable, human-like, or intelligent remains largely unanswered.

The agenda for the research presented here ties into this problem: Its purpose is to investigate the opportunity for using methods and results from player (experience) modeling to drive the creation of believable NPC controllers by leveraging *decision theory*.

Using theory from the social sciences to drive player classification is nothing new. Other studies have e.g. used personality theory [21] or persona theory [3, 18] to fuse theory driven concepts with data mining of game metrics. The novel aspect of the research proposed here is to use the concepts and terminology of decision theory and the concept of decision making styles to produce a different analytical perspective on players' responses to and behavior in computer games. The overall purpose of this is two-fold: To understand player behavior and reasoning from a new perspective and to be able to simulate players in games in ways that are believable [16].

2. DECISION THEORY

Decision theory as a field was founded by Tversky & Kahneman [17] and quickly spawned the subfield of *prospect theory* [10]. The work presented a theoretical and empirical critique of expected utility theory which adhered to the idea of humans as perfectly rational decision makers. The authors documented a vast number of identifiable heuristic processes that guide, shorten or bypass conscious analytical decision making. They further documented that humans sometimes apply heuristics to the extent that they become biases; systematically skewed evaluations in spite of evidence that, subjected to detailed analysis, would have yielded different conclusions. Their seminal work spawned many strains of research, two of which are particularly noteworthy to the study of modeling humans in computer games and are presented below in detail: (1) emotions as decision making heuristics and (2) the idea of humans exhibiting individual decision making styles.

2.1 Somatic Markers

One notable addition to the field of decision research was the neuropsychological work of Damasio et al. that resulted in the *somatic marker hypothesis* (SMH) [6]. The SMH views decision making as a partially conscious cognitive process supported by corporeally distributed heuristics experienced by the subject as "feelings" [5]. The work has demonstrated an integration between two separate, but functionally interacting neurological systems in the human brain: A fast emotional system that labels expected outcomes quickly, parallelly and mostly unconsciously and a slower, but more detailed, conscious system that integrates and sometimes inhibits the output of the fast system. Normal individuals exhibit traceable physiological signals when deciding under uncertainty and these signals match the experience of emotionally deciding based on feeling what the preferred decision is rather than solely analytically knowing [1].

2.2 Decision Making Styles

A second part of decision research of relevance to this work is the finding that people tend to exhibit typical patterns or tendencies in decision making. Individuals seem to hold a disposition or trait toward one or more types of decision making strategies that have an impact on their performance on specific tasks. From the prospect theory perspective, we may say that they are systematically expressing general biases in their heuristic evaluations through specific decisions [8]. The concept has, among other things, been operationalized into a psychological instrument that has starting to see some use and attain evidence for reliability and validity [11, 14, 15].

2.3 Two Systems of Decision Making

The ideas of somatic markers of decisions and decision making styles map very well onto modern decision theory that understands decisions as outcomes of the interaction of two systems:

System 1: A quickly classifying, motivating, impulsive, and highly parallel emotional process. Capable of rapidly making decisions, but prone to bias and misclassification.

System 2: A slower, laborious, attention demanding, memory limited, sequential process that delivers precise responses and inhibits motivations and biased outputs from system 1.

Their interaction produces results that are systematically shaped by the biases of system 1 and the performance capabilities of system 2, both properties that are somewhat stable within the individual [9]. These stable tendencies, or decision making styles, should be expressed through actions in game-play in the same way that they are expressed across other activities in everyday life.

If we can model the heuristic tendency of the player's system 1, and combine this with knowledge about a) the capacity/performance of the player's system 2 and b) knowledge about possible optimal solutions for achieving the player's current goal in the game, we may be able to predict the player's decisions with some accuracy. We should also be able to support this analysis using methods from affective computing [13], since we know that decision making elicits measurable physiological responses in normal humans.

Drawing on these ideas the key research questions of the proposed research are:

1. Do players of computer games exhibit decision making styles through their in-game actions?
2. Can these expressions of style be captured, classified, and simulated using methods from Game AI, such as objective and game-play-based player experience modeling, data mining, and agent based NPC AI, as outlined by Yannakakis [20]?

3. DECISION MAKING IN GAMES

In order to answer the research questions stated above, we must consider how to operationalize players' decision making. One approach could be to record and examine every instance of input to the game that the player delivers — i.e. raw play data. However, forthcoming research by Canossa and Cheong [2] indicates that it is naive to consider all inputs to the game as expressions of intended, willful or even goal-directed behavior. They classify actions, and thereby inputs, as being the consequence of either intentional, trained or chaotic behavior, which we for this purpose may translate roughly into planned, reactive or random behavior, respectively. Any model we choose to use for the human player's decision making should be capable of treating these facets of the in-game actions. As the research question above also includes the need to not only capture and classify, but also simulate the human player's decision making, an agent-based approach might be in order for the modeling task. One specific kind of agent that would seem appropriate is the *Belief, Desire, Intention* (BDI) *agent* [19].

4. BDI AGENTS

The use of BDI agents has a rather long history in simulations, but they have less commonly been found in computer games, the most notable examples being the *Black & White* series of god-games (Lionhead Studios 2001, 2005) [12]. The paradigm is fundamentally a reasoning and planning approach that uses three high level concepts, *beliefs, desires*, and *intentions*, that together constitute an agent model.

Beliefs describe the agents current representation its own state and the state of its surrounding environment.

Desires describe all the current goals that the agent would like to achieve at a given time.

Intention(s) describes the active goals(s) that the agent is pursuing at any given time.

In addition to this, a typical approach is for the agent to have a plan library, from which it selects courses of action to form intentions [12].

Two main aspects of the BDI paradigm make it especially useful for modeling human decision making: The psychologistic nature of the model maps well to a human introspective understanding of thought processes. Norling and Sonenberg [12] mention that the framework does not match the actual way that human reasoning occurs, but by small appropriations, the BDI paradigm can fit the typical model of human reasoning from cognitive psychology rather well: If beliefs are understood as a common headline for perception and evaluation of the state of an agent's internals as well as its environment it need not be a completely conscious representation. We can take the beliefs as being the total sum of the agent's available information, including declarative, non-declarative, procedural, and emotional knowledge. By the same reasoning, desires can be understood as motivations widely, incorporating both conscious wishes as well as unconscious drives, instincts and behavioral tendencies all the way down to the conditioned level. Finally, intentions can be understood as the selection basis for the current plan under execution, regardless of whether this plan was motivated by conscious (system 2) determination or by partially or wholly heuristically selected impulses (system 1). That means that the moment an intention is formed and followed in the BDI framework, it can be understood as a decision.

One critique of the BDI model is that its sequential processing going from beliefs, to desires, to intentions, does not fit the feedback loops inherent to human cognition, such as e.g. the fact that motivation often has a strong influence on perception and attention[1] [7], but e.g. the work of Norling and Sonenberg [12] on Quake II bots, shows that the model is useful for transforming human expert knowledge into in-game agent behavior.

4.1 Domain Dependence

The work of Norling and Sonenberg [12] on Quake II bots, has shown that the BDI model is useful as a framework for transforming human expert knowledge into in-game agent behavior. Whether the BDI paradigm also provides a useful analytical framework remains to be seen and is one of the goals of the research proposed here. One first step in answering this question could be to find a viable way of identifying the BDI paradigm's constituent elements from the human perspective in games: what is perceived and processed of the game world (beliefs), what are possible situations the player might want to bring about and with what motivations (desires), and which of these would it seem plausible that the player could be pursuing at any given time step that we choose to analyze (intentions).

The answers to these questions depend on the qualities of the game in question. Solutions for an analytical game such as *Civilization V* (Firaxis, 2010) would be vastly different than for an almost completely procedural-skill based game like *Super Hexagon* (Terry Cavanagh, 2012). *Civilization V* is characterized by (potentially) unlimited time for analysis and deliberation, but features an enormous amount of variables that could all be taken into consideration[2]. *Super Hexagon*, on the other hand, has only few parameters that the player needs to consider in the game, but responses must be immediate and flawless to avoid failure.

5. PLANNED APPROACH

While the high level paradigm for describing a human player from the BDI perspective stays the same, the low level implementation of the BDI paradigm is almost entirely domain dependent.

In order to handle this problem, I intend to look at naturalistic game-play data to the extent that corpora are available, while also developing specialized games for studying decision making. The research phase featuring specialized games will start with a number of experimental trials in controlled laboratory setups and slowly move on to crowdsourced experiments facilitated via the Internet. The laboratory trials will feature small game prototypes with very clear decision making problems, using physiological measurements to enrich game-play information with indications of emotional responses, building from existing, established game-like experimental paradigms for measuring markers of decision making [1, 4].

I believe that these experiments will provide the foundation for identifying different types of decision making styles in the games, and I will seek to use the physiological data to relate emotional responses to specific decision making tendencies. Informed by these initial experiments, I plan to move on to create a larger (but still limited) game for data collection. Ideally this game will be released publicly. The idea will be to design the game to equally benefit as many different decision making styles as possible and continuously log play data from all consenting players to crowd-source a corpus of game play material. This corpus will then be used to affirm or disaffirm the previously established decision making styles from the lab and/or discover new ones.

Finally, the crowdsourced data should provide the basis for constructing BDI agents for playing the same game, but in different play styles. As such the envisioned contribution of the thesis is a series of multi-modal experimental studies of human decision making in computer games.

[1] For the model to take that into account it would arguably need some way of handling feedback from desires to beliefs in the same time step.

[2] This does not mean that a *Civilization V* player does not plausibly draw on emotionally founded heuristics. If she has any experience with the game, the emotional heuristics would most probably allow her to take more variables into account than a novice player.

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