Difficulty Scaling through Incongruity

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Abstract

In this paper we discuss our work on using the incongruity measure from psychological literature to scale the difficulty level of a game online to the capabilities of the human player. Our approach has been implemented in a small game called *Glove*.

Introduction

The entertainment value of modern day computer games is a topic of much interest. Iida, Takeshita, & Yoshimura (2002) created an entertainment measure for board games, but their measure uses concepts that have no equivalent in modern computer games. Yannakakis & Hallam (2005) attempted a similar approach for predator-prey computer games using ad-hoc calculations, with limited success. As a measure of interest (and thus entertainment) psychological literature introduced the concept of 'incongruity' (Rauterberg 1995). Incongruity is the difference between the complexity of an environment and the complexity of the mental model a human has of the environment. Research has shown that human interest in an environment is highest when the incongruity is neither too high nor too low. For software environments, indications for the complexity of the mental model can be derived from the human's interactions with the environment (Rauterberg 1995). Since the actual complexity of a game can be defined as its difficulty level, it seems possible to calculate incongruity, and thus entertainment value, during a gaming session. In our research, we developed a small computer game, named *Glove*, that uses the concept of incongruity to scale the difficulty level of the game online to the capabilities of the human player.

We first discuss incongruity as a measure for the player interest in a game. We then explain how we used incongruity in *Glove* to adapt game difficulty to the player's skill. Finally, we discuss future work.

Incongruity for Game Complexity

When people encounter an environmental context, they need to process information about that context. They do this by using an internal mental model of the context. This internal model, also called the 'system,' can be said to have levels of mental complexity in several dimensions. E.g., if the context is a game, then the system is the mental model that the player has of the game. This model may have, for instance, a tactical complexity, which describes how well the player is able to deal with game tactics, and an interface complexity, which describes how well the player is physically able to control the game.

Incongruity is defined as the difference between the environmental (context) complexity and the mental (system) complexity. There is positive incongruity when the environmental complexity is higher than the mental complexity and negative incongruity whenever it is lower. For instance, in the case of a game, a negative incongruity in tactical complexity would indicate that the human player's tactical understanding of the game is such that he is able to defeat the game easily. Figure 1 schematically visualises the concept of incongruity.

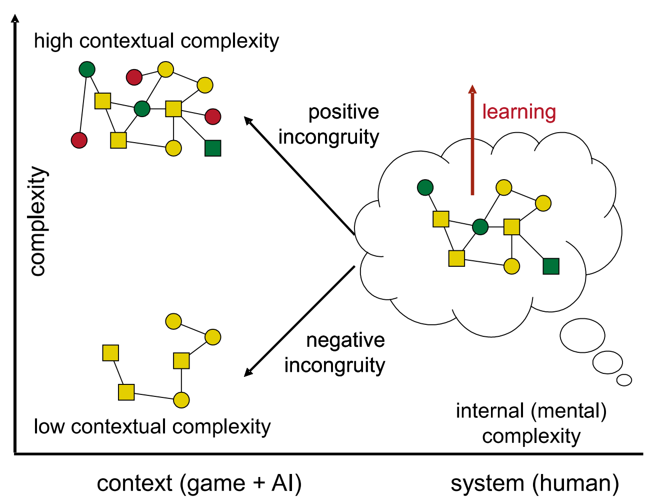

Figure 1: Incongruity.

In the case of positive incongruity humans have a tendency to optimise their mental complexity to the level of environmental complexity through seeking and exploration in order to match mental complexity to the environmental complexity. I.e., they learn. However, when they encounter positive incongruity that is above a personal threshold or comfort level they tend to display avoidance behaviour. In situations of large negative incongruity humans start to look for new stimulation. (Rauterberg 1995). In the case of game playing, this means that when incongruity is large and positive, the player gets frustrated with the game and refuses to play. In contrast, when incongruity is large and negative, the player is bored.

For games, there is usually no direct way to measure mental complexity. The only possibility is to measure the complexity of the player's behaviour in a game and infer the mental complexity from that. Rauterberg (1993) states that low mental complexity will lead to the player's behaviour being largely determined by heuristics, while expert players, with high mental complexity, use other, more straightforward methods.

Glove

The game *Glove*, displayed in Figure 2, is a simple, turn-based, side-scrolling arcade game, in which the player controls one character, which must be moved from the left side to the right side of the playing area. The player has just enough health to reach that goal. The player encounters enemies of three different tactical types, which may damage him, which costs health. However, defeating enemies gains the player health. Therefore, if the player encounters enemies which he finds easy to defeat, he will easily reach the goal. However, if the enemies are too difficult for him, the goal cannot be reached. A good balance of enemies will allow the player to reach the goal, but just barely.

Glove is an attempt to cause situations of perpetual positive incongruence within personal preferences of the player. We assume that the player finds a well-balanced game most interesting to play. By adapting the context complexity to the inferred mental complexity of the player, so that incongruity is at a constant, balanced level, the player should continually experience interest. This is also known as "flow" (Csikszentmihalyi & Csikszentmihalyi 1988).

During gameplay the amount of damage that each of the enemies inflicts on the player is measured. This defines the complexity of each enemy type, difficult enemies having a higher damage amount. The environmental complexity is defined as the total of the complexities of the different enemies. By increasing the amount of difficult enemies the environmental complexity rises. By decreasing the amount of enemies in general and the amount of difficult enemies specifically the environmental complexity drops.

The mental complexity of the player is represented by the ease of working through an area of the game. A constant score is kept of the progress of the player and the amount of damage he has sustained. If the amount of progress is larger than the amount of damaged sustained then the player has a larger mental complexity than the game.

Incongruity is at a balanced level if the player maintains at all times just enough health to reach the game's goal, but not more.

Glove has three settings for incongruity: a hard one that makes the player lose after having progressed through about three-quarters of the game world, an easy one that lets the player reach the goal with plenty health to spare, and a balanced one as described above. Our assumption is that with the first two settings the player will get frustrated or bored, respectively, but that with the balanced setting the player is encouraged to learn, and will constantly increase his mental complexity.

Figure 2: Glove.

Future Work

In future work, we will research whether our assumptions on the effect of adapting to incongruity is as we assumed. If that is the case, then we will implement these concepts in other, more complex games.

Acknowledgements

This research is supported by a grant from the Dutch Organisation for Scientific Research (NWO grant 612.066.406).

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