Space Maze: Experience-Driven Game Camera Control

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ABSTRACT

Virtual camera control is a key factor in game experience because the camera dictates how players see the game world. As the complexity and unpredictability of games increases, automatic camera control becomes a fundamental requirement. In this paper, we present a game technology demonstrator that showcases automatic camera control capable of creating dissimilar experiences within a 3D prey/predator game. An adaptation algorithm informed by predictors of subjective experiences adjusts the behavior of the camera to influence the experience of the player throughout the game.

1. ADAPTIVE CAMERA CONTROL

Camera control is an important component of player experience [4]: the camera viewpoint defines the amount of information shown to the player and thus has a direct impact on the perceived challenge [5] as well as other aspects of the experience, such as player frustration [6].

While most research on automatic camera control techniques has centered around the efficient placement of the camera, determination of the viewpoint and the ease of use (e.g. [3]), a number of studies have investigated the connections between camera control and player experience. Burelli and Yannakakis [2] studied automatic camera control in relation to playing and gaze behavior, building computational models of camera view preferences based on the players' behavior. Yannakakis et al. [6] investigated a larger variety of experiences focusing on the relation between camera and several affective states, such as *frustration* and *excitement*. Computational models mapping the player's physiological state and the game's camera profile to subjective self-reports of experience were built facilitating an objective estimator of the player's affective state in relation to camera behavior. Similar models — substituting physiological information with gameplay data — were used to implement a demonstrator of affective camera control[1] in which the camera controller relied on the prediction of the models driving the experience towards the target affective states. The demonstrator presented in this paper[2] utilizes similar models but introduces camera adaptation as an active game mechanic rather than a subtle change in the background. We expect that as a consequence, the effect of camera adaptation will be clearly manifested in the players' behavior providing a validation for experience-driven camera control. In the following sections the game mechanics, model construction and adaptation scheme are described in detail.

2. THE GAME

The demonstrator is a three-dimensional prey/predator game named Space Maze. The player (prey) controls a rolling ball, which moves inside a maze. Floating disk-shaped enemies (predators) patrol the maze where several diamond-shaped pellets are placed. The goal of the player at each level of the game is to collect all the pellets and reach the exit in a predefined time window of 90 seconds while avoiding being touched by the enemies. The 90-second play-time window is designer-driven and attempts to maintain a good balance between sufficient gameplay and the player's cognitive load, which can facilitate future evaluations of players' experience. If two lives have been lost or the player has run out of time to explore the maze, the game ends.

The main feature of the game is its adaptive camera. The camera profile, which determines aspects of the camera movement, such as frame coherence, is updated during gameplay according to the current model of experience (see Section 3). Each of the pellets in the maze is associated with a different player experience state (e.g. frustration, challenge). Each time the player picks a pellet, the camera adapts in order to sway the player's experience towards the target state associated with the respective pellet. Figure 1 shows the game played by the same player during the three different experience adaptations implemented in the demonstrator, namely *frustration*, *fun* and *challenge*. Note that camera adaptation depends on the in-game behavior generating different camera profiles based on how the game is played. The player explores the maze attempting to collect all the pellets under the changing camera behaviors, which are aimed to elicit dissimilar experiences tailored to her particular playing style and performance.

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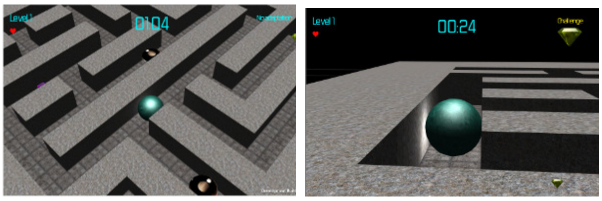
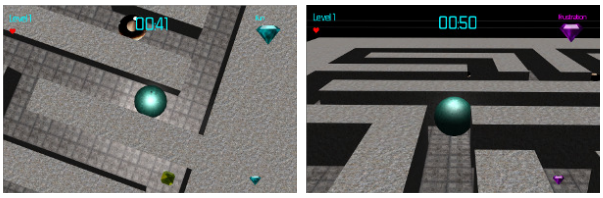
[1] `http://www.aigameresearch.org/demo-item/maze-ball/`

[2] Play at: `http://www.hectorpmartinez.com/SpaceMaze/demo.html`



(a) No adaptation (b) Challenge



(c) Fun (d) Frustration

Figure 1: Space Maze screenshots under different camera adaptations.

2.1 Constraint-Based Camera Controller

The camera in the game is automatically controlled by a system based on a weighted Constraint Satisfaction Problem solver framework for satisfying view constraints (e.g. size of a particular object in the screen) at each frame [1]. To geometrically solve a particular set of given constraints, the constraint solver searches through the six-dimensional space for potential solutions defined by the position $\{x, y, z\}$ and rotation $\{pitch, roll, yaw\}$ of the camera. Three constrains are used in this game: *distance*, *height*, and *frame coherence*. The distance variable's values are constrained to maintain a relative distance relationship with the player's avatar. Height values are constrained to maintain a fixed height relative to the player's avatar. Frame coherence values are constrained to maintain smooth motion across frames and avoid erratic camera movements. The three parameters constitute the *camera profile*.

Camera profiles with low height values lead to a smaller part of the maze being visible at any time during the game. Similarly, low distance values restrict the visibility of grid cells behind the player and further out in front of the player. Coherence values determine how fast the camera sweeps across when the player changes direction or speed. This affects the visibility of the maze during the interval between the successive camera transitions, which has shown to positively correlate with perceived challenge [5].

3. EXPERIENCE MODELS AND ADAPTATION

The predictors of players' subjective experience are constructed as multi-layer perceptrons (MLP) trained to map a set of gameplay features, such as the average distance to the closest pellet, to post-experience self-reports. The data used to train the models were collected from 36 participants playing several variants of *Maze-Ball* (MB) [5]. In this game, the player also has to find and gather pellets in a maze while avoiding enemies; these similarities with Space Maze allow us to calculate similar gameplay features profiteering from already constructed models. In addition, different MB variants feature dissimilar camera profiles, creating a relation between the players' self-reported preferences and particular camera profiles.

The inputs to the MLPs include the three camera profile parameters and a subset of statistical gameplay features selected automatically via *sequential forward feature selection*. An MLP is trained for each subjective experience (*fun*, *frustration* and *challenge*) and for different time intervals (15, 30, 45, 60 and 75 seconds, respectively, always starting from the beginning of the game) using *neuro-evolution preference learning* [6].

Camera adaptation is achieved by adapting the camera profile parameters every 15 seconds. At these time steps, the statistical gameplay features are calculated based on the current progress of the game and fed into the corresponding model (determined by the elapsed time and the last collected pellet). An exhaustive search of possible values for the three parameters of the camera is performed and the triplet that yields the highest model's output is chosen as the new camera profile. Note that this does not produce an abrupt change as the camera controller tunes the camera position and rotation smoothly across frames until the new constrains are satisfied.

The reader is advised to refer to [6] for more details on the modeling methodology, Maze-Ball and the dataset used.

4. FUTURE WORK

The next steps for this project involve the utilization of this prototype to evaluate the effects of affective camera control on players' experience. In addition, further gameplay and physiological data will be collected in order to enhance the adaptation with more accurate multi-modal predictors of experience.

Acknowledgements

The authors would like to thank all the participants of the experiments. Special thanks go to Martin Schwartz for the implementation of the camera controller. This research was supported, in part, by the ILearnRW (project no: 318803) and the C2Learn (project no. 318480) FP7 ICT EU projects.

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