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# Adapting Virtual Camera Behaviour

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## ABSTRACT

In a three-dimensional virtual environment aspects such as narrative and interaction completely depend on the camera since the camera defines the player's point of view. Most research works in automatic camera control aim to take the control of this aspect from the player to automatically generate cinematographic game experiences reducing, however, the player's feeling of agency. We propose a methodology to integrate the player in the camera control loop that allows to design and generate personalised cinematographic experiences. Furthermore, we present an evaluation of the aforementioned methodology showing that the generated camera movements are positively perceived by novice and intermediate players.

## 1. INTRODUCTION

Automatic camera control aims to define an abstraction layer that permits the control of the camera using high-level and environment-independent requirements, such as the visibility of a particular object or the size of that object on the screen. The definition of the requirements is commonly delegated to a human designer which hand-crafts manually the cinematographic experience.

However, a limit of this approach is that it excludes the player from the control loop. Tomlinson et al., in their paper on expressive autonomous cinematography [5], quote a statement by Steven Drucker at SIGGRAPH '99: "It was great! I didn't notice it!". Drucker was commenting Tomlinson's work presented at SIGGRAPH that year and, in his comment, he clearly associates the quality of a camera control system with the lack of intrusiveness; however, the way we can achieve such a result or how it is possible to take the control of the camera from the player but still moving the camera the way the user would have wanted (or as close as possible) are open research questions.

We believe that, to bridge the gap between automatic and manual camera control, the camera objective should be affected by the player. To achieve this goal, we propose a

new approach to automatic camera control that indirectly includes the player in the camera control loop. In our view, the camera control system should be able to learn camera preferences from the user and adapt the camera profile to improve the player experience.

Bares et al. [1, 2] have investigated the personalisation of the cinematographic experience through task and user modelling; this research work extends this idea, by investigating player preferences concerning virtual camera placement and animation, in relationship to player behaviour and game mechanics. Player behaviour describes the way the player performs in the game — e.g. how many jumps she performs, while camera behaviour describes how a player moves the camera and what she would like to frame with it.

This article presents a general methodology to build personalised models of camera behaviour and generated adaptive virtual camera experiences. Furthermore, it presents a user evaluation of the proposed methodology on a 3D action-platform game. The results of the evaluation show that the camera behaviours designed following the proposed approach are perceived by a large part of the test participants as an improvement in their gaming experience.

## 2. CAMERA BEHAVIOUR MODELLING

Following the approach presented in [4], we model camera behaviour using a combination of gaze and camera position at each frame. Combining gaze data with camera data allows a finer analysis of the player's visual behaviour permitting, not only to understand what objects are visualised by the player, but also which ones are actually observed. This information permits to filter exactly which object is relevant for the player among the ones visualised by the player through her control of the virtual camera. A cluster analysis of the gaze data collected is run to investigate the existence of different virtual camera motion patterns among different players and different areas of the game.

Moreover, as described previously in [3], the relationship between player behaviour and camera behaviour can be modelled using machine learning. Artificial Neural Networks (ANNs) can be employed to build predictive models of the virtual camera behaviour on player behaviour in earlier stages of the game.

## 3. ADAPTATION

As displayed in the protocol in Fig. 1, these models can be used, in a second phase, to drive an automatic camera controller and provide a personalised camera behaviour on the same game.

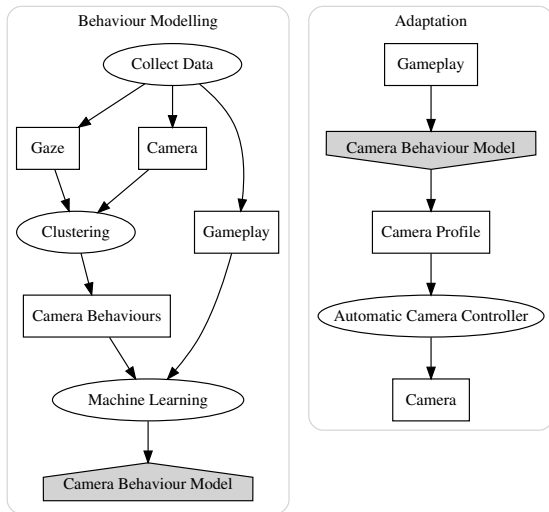


Figure 1: Camera behaviour modelling and adaptation phases of the adaptive camera control methodology

The camera behaviour model built this way is able to predict the camera behaviour given information about the way the player played up to a certain point of the game. Once the upcoming camera behaviour is detected, a camera profile — i.e. a set of frame and motion constraints — should be generated to instruct the automatic camera controller.

The translation process between gaze based camera behaviours and camera profiles is hardly generalisable over different games as the number and the quality of the objects present on screen varies considerably. In most action games — e.g. *Tomb Raider* (Eidos Interactive, 1996) or *Super Mario 64* (Nintendo, 1996) — the camera can be instructed to follow the main avatar and maintain the visibility of the objects which have received visual attention in the camera behaviour. The weights of the frame constraints imposed on each object can be related to the amount of time spent observing the objects of the same kind as this information is related to the amount of attention that an object receives. Such an approach can be applied to virtually any game which features an avatar, the constraints imposed on the avatar and on the other objects included in the behaviour can be changed to alter the overall composition.

## 4. EVALUATION

Our experimental hypothesis is that the camera behaviour models built on the combination of gameplay, gaze and camera information can be successfully used to adapt the camera behaviour to the player’s preferences. To test this hypothesis, we have conducted a within-subject evaluation in which each subject plays the same level with two camera control schemes (conditions): (a) the camera is controlled automatically with a static profile or (b) the camera is controlled by the player model influenced by the player behaviour. At the end of the second experiment each subject expresses her or his preferences between the two camera control schemes.

The game employed is a custom version of *Lerpz Escape*, a tutorial game by Unity Technologies<sup>1</sup>. It features an alien-

like avatar trapped in a futuristic 3D environment made of floating platforms. Each platform can be connected to another platform through a bridge or be disconnected, in which case, the avatar is required to jump to move from one platform to the other.

The adaptation mechanism is triggered at the instant in which the player moves from one platform to the next one. At the instant, the game takes the gameplay data collected up until that moment and feeds it to the camera behaviour prediction model. The output of the model indicates which camera behaviour should be selected from that moment until the player enters another area. The models used in this evaluation are the results of one of the author’s previous works on camera behaviour modelling [3] and have been built on the same game.

Twentyeight subjects participated, among which 21 were males; the age of the participants ranged between 18 and 40 years (mean=27.04, std=4.63). The preferences reported by the participants do not indicate a strong preference towards adaptive camera control which is, in general, not perceived as an enhancement to the game. The test reveals only a very mild correlation ( $r_o = 0.14$ ), with no statistical significance ( $p\text{-value} = 0.51$ ) between preference and camera control paradigm. However, when sorting the subjects by their playing skill level, it appears that the two groups of players with lower in-game performance — i.e. novices and average — significantly prefer adaptive camera control over simple automatic camera control with correlation coefficients higher than 0.6. The opposite effect is present for the expert players, for which the correlation between preference and camera control paradigm is significantly negative ( $r_o = -0.55$ ) indicating that the expert players preferred the level without adaptation.

## 5. CONCLUSIONS

The article presented a methodology for designing and generating personalised cinematographic experiences in games. Moreover, it presented a case study that evaluated the applicability of such a methodology. While the results show no clear preference for the levels featuring adaptivity across the whole test sample, the adaptation mechanism showed to be able to provide a satisfactory experience for most of the non-expert participants.

## 6. REFERENCES

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<sup>1</sup><http://www.unity3d.com>