The ITB Journal

Volume 5 | Issue 1 Article 14

2004

Camera Control through Cinematography in 3D Computer Games

James Kneafsey
School of Informatics & Engineering, Institute of Technology at Blanchardstown, Dublin 15., james.kneafsey@itb.ie

Hugh McCabe
School of Informatics & Engineering, Institute of Technology at Blanchardstown, Dublin 15., hugh.mccabe@itb.ie

Camera Control through Cinematography in 3D Computer Games

James Kneafsey & Hugh McCabe
School of Informatics & Engineering, Institute of Technology at Blanchardstown, Dublin 15
Contact email: james.kneafsey@itb.ie , hugh.mccabe@itb.ie

Abstract
Modern 3D computer games have the potential to employ principles from cinematography in rendering the action in the game. Using principles of cinematography would take advantage of techniques that have been used to render action in cinematic films for more than a century. This paper outlines our proposal to develop a camera control system that uses principles of cinematography for 3D computer games and provides a critical review of related research.

Keywords: Virtual camera, virtual environments, 3D computer games, cinematography.

1. Introduction

Interactive virtual environments present a view of a three-dimensional scene to a user by means of a virtual camera. The user interacts with the scene generally by controlling an *avatar*, i.e. a 3D representation of a character in the scene usually in human form. Throughout the interaction, the virtual camera must continually provide views of the scene that enable the user to carry out their assigned task. We propose that it should be possible for the virtual camera in 3D computer games in particular to present camera angles to the user that do not only show the user what they need to see to carry out their task but also draw the user into the story, add drama to the scene and invoke emotions in the user in the same way that cinema does. We propose that the principles of cinematography can be incorporated into a framework for controlling the virtual camera.

Cinematography is an art-form that has evolved over more than 100 years of film-making. Each revolutionary approach to camera operation which has been generally accepted by audiences, such as when D.W. Griffith first employed a moving camera, represents a new addition to the language of cinematography (Brown, 2002). Cinematography presents a number of principles that can be used to ensure that the viewer does not become disoriented and the presentation of the action is consistent throughout each scene. Particular camera treatments can make the viewer feel as though they are part of the story and help them to identify with the characters on the screen. The application of principles and techniques of cinematography to the camera can invoke emotions in the viewer in response to the action presented on the screen (Mascelli, 1965).

We propose that 3D computer games have a greater potential for the employment of cinematographic principles than other virtual environments due to the similarity in content to equivalent real-world contexts. A horror game could borrow from the techniques used in horror films. A game about gangsters could use principles employed in gangster films. Despite these similarities, a considerable difference to note between computer games and contexts in the real-world is that computer games are interactive. Whereas there is substantial determinism in how the action will play out in a film because of its adherence to a script, the same cannot be said of computer games. Autonomous intelligent entities, i.e. one or more human players and a number of *non-player characters* (NPCs) which are characters driven by software algorithms, provide the action for the game in real-time and so the level of determinism in the future state of the 3D scene at any moment is decreased significantly. This presents an additional problem not associated with the filming of action for a cinematic film: The camera control module in the game must attempt to continually predict the game's future state in order to film the relevant elements of the scene and use these predictions to present the game player with a cinematographic view of the scene.

This paper presents a critical review of related research in the area of virtual camera control and outlines our aim to implement a virtual camera control system for 3D computer games through cinematography and to implement a framework for the quantitative evaluation of our implementation and that of other research projects. The remainder of this paper is structured as follows: Section 2 discusses current approaches to camera control in 3D computer games. Section 3 outlines the principles of cinematography that are relevant to the control of the virtual camera in a 3D computer game. Section 4 presents a review of research related to camera control in virtual environments. Finally, section 5 presents some conclusions and future work.

2. Camera Control in Computer Games

There are a number of different camera views used in 3D computer games suited to the particular game genre. Some games offer more than one type of camera. A *first-person camera* (Sánchez-Crespo Dalmau, 2004) depicts the action through the avatar's eyes (figure 1). This is often the default view for games that require accuracy of movement such as shooter games, e.g. *Quake III Arena* (id Software, 1999), *Half-Life* (Valve Software, 1998). A *third-person camera* films the action from above and behind the avatar and so the avatar is displayed at the bottom of the screen. This is the default view for *Hitman 2* (Eidos Interactive, 2002) and *Tomb Raider III* (Eidos Interactive, 1998), for example.

Figure 1: Types of camera views in 3D computer games. From left to right: First-person camera in *Quake III Arena* (id Software, 1999), third-person camera in *Tomb Raider III* (Eidos Interactive, 1998).

Inertial cameras are used in a number of games to ensure that the movements of the camera are not rigidly responsive to the movements of the avatar. The cameras movements are related to the avatar's movements via a spring model (Sánchez-Crespo Dalmau, 2004) so that as the avatar moves, the camera moves smoothly as if it were attached to the avatar by a spring.

Common approaches to camera control in a 3D computer game consider only practical issues such as the placement of the camera in the 3D world, fixing camera movements to a curve to ensure smoothness of movement and, as already mentioned, using a spring model for realistic inertial movement (DeLoura, 2000). Other issues addressed include how to prevent occlusion of the view by the avatar when using a third-person camera and also how to prevent collision of the camera with the geometry of the scene (Sánchez-Crespo Dalmau, 2004). Sánchez-Crespo Dalmau (2004) also discusses setting up a number of different cameras to film action from different angles and with different movements. These cameras are set up before the interaction and a real-time algorithm then selects the best camera to film each situation during the interaction. None of these approaches attempt to apply principles from cinematography to an intelligent camera control system in a game in real-time.

3. Principles of Cinematography

Cinematography is defined as the art of making films. Through cinematography extra meaning and emotional subtext can be communicated to the viewer visually. The camera can hide elements of the scene to build suspense or focus on particular events to elucidate the plot (Brown, 2002). In this section we outline the principles of cinematography we propose to implement. More complete references on cinematography can be found in Mascelli (1965) and Brown (2002).

3.1 Types of Camera Angles

The type of camera angle used to film a particular scene determines how much the viewer will be drawn into the scene and whether they will be well oriented or not. An *objective angle* (figure 2) tends to make the viewer more detached from the scene whereas a *subjective angle* is more engaging but has the potential to disorient the viewer if maintained for a long period of time.

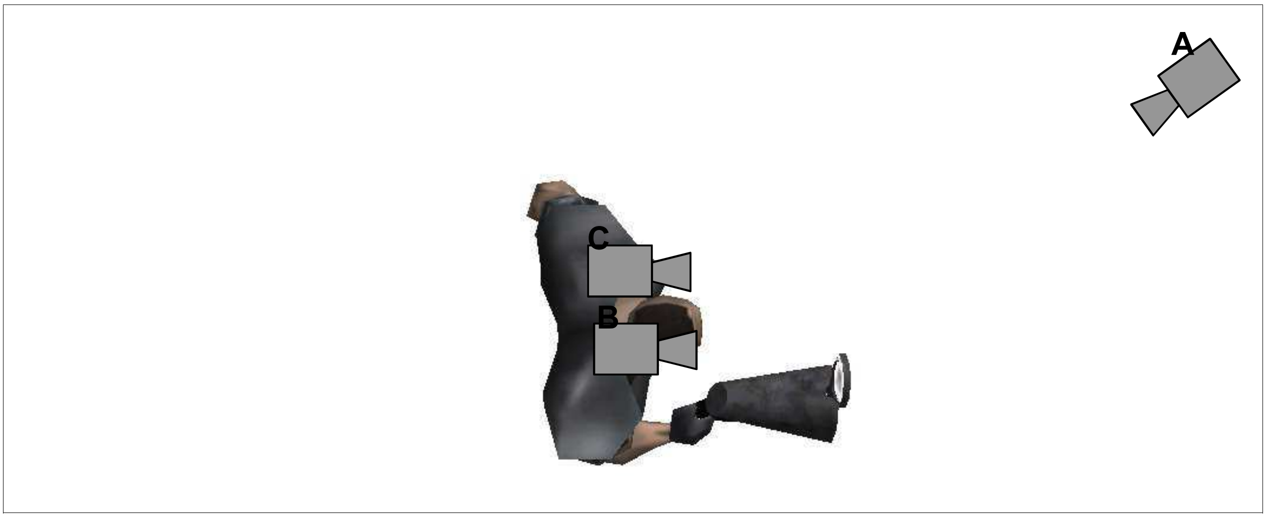

Figure 2: Types of camera angles. Camera A films the subject objectively, camera B is a subjective treatment and camera C is a point-of-view angle.

An objective angle presents the scene from the point-of-view of a neutral observer rather than that of any character in particular. A subjective angle can be used to make the viewer feel part of the scene and identify with the characters. The camera would be positioned closer to the action, for example it may move along with a speeding car. The camera may also replace one of the characters in the scene by filming what they would see. A *point-of-view angle* presents the scene from the point-of-view of one of the characters in the scene but not subjectively. It is as if the audience is cheek-to-cheek with the character. A point-of-view angle is as close to a subjective angle as the camera can get while maintaining objectivity.

3.2 Subject Size

Different subject sizes have different functions as a scene and characters are introduced and the narrative develops. A setting is often introduced with an establishing shot (a shot is a continuous unit of filmed action from the time the camera is turned on until it is turned off), usually a *long shot*. A long shot includes the entire setting, such as a room or a street, and the characters in it. Following this a *medium shot* (figure 3) may be used to introduce the principal characters. A medium shot depicts the characters from just below the waist or just above the knees up. A *close-up* may then be used to isolate one character or event in particular. There are a number of different close-ups. For example, a medium close-up depicts a character from between the waist and shoulders to just above the head and a head close up shows just the head. The scene may be re-established with a long shot to prevent the viewer from becoming disoriented due to the subjective nature of closer shots, such as the close-up and medium shot. It may also be re-established when new developments occur.

Figure 3: Examples of different subject sizes.
From left to right: Medium shot, medium close-up, head close-up.

3.3 Camera Height

The height of the camera in relation to the subjects can have a psychological effect on the viewer and influence the element of drama in the scene. A *level angle* (figure 4) is used for eye-level shots. Objective level angle shots are filmed from the eye level of a person of average height except in the case of close-ups which are filmed from the height of the subject. Point-of-view level angle close-ups are filmed from the height of the opposing character and subjective level angle close-ups are filmed from the height of the subject.

A *high angle* shot is when the camera is tilted downwards to film the subject. These shots are used to make the subject seem small or make the audience feel superior to the subject. A *low angle* shot is when the camera is tilted upwards to film the subject. This has the effect of exaggerating the speed or height of a moving subject, or giving a character prominence in the shot.

Figure 4: Examples of different camera heights. From left to right: level angle, high angle, low angle.

3.4 Screen Direction

Screen direction ensures that positions, movements and looks (a character looking at something) are consistent from shot to shot. It guarantees that the action in a scene is presented in a uniform manner so the viewer is aware of the locations of elements of the scene and so is does not become disoriented. If the subject is looking or moving in a certain direction just before a cut (the ending of a particular shot) the following shot should depict them looking or moving in the same direction unless the two shots are separated by a different scene, a time lapse or an optical effect such as a fade.

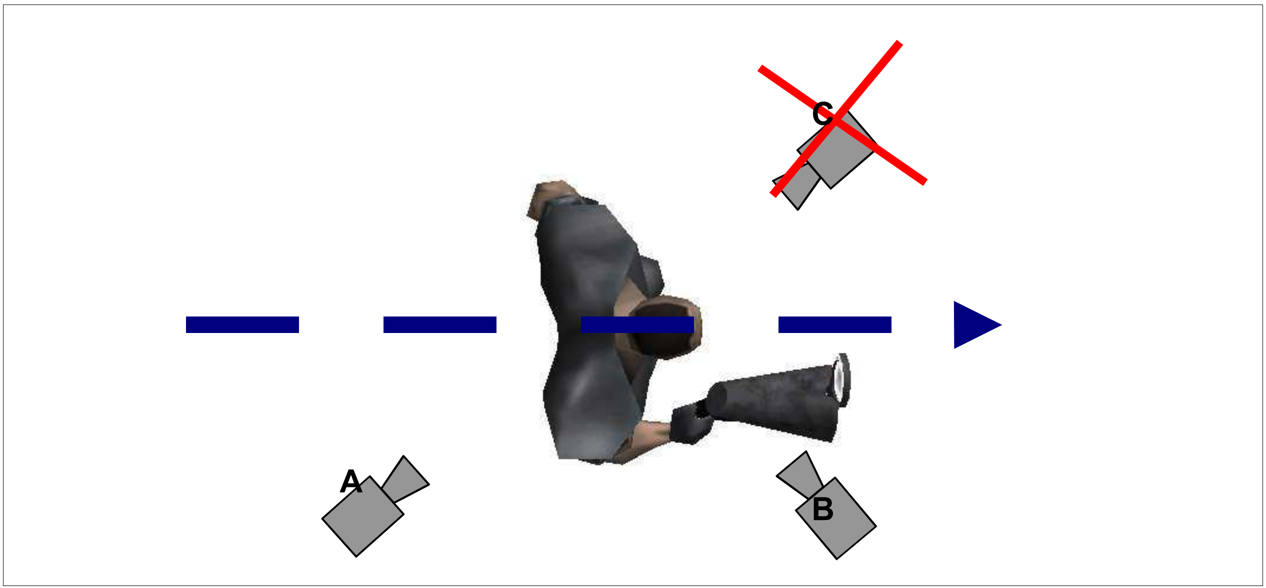

Figure 5: The action axis: If the subject is filmed with camera A, subsequent shots must keep to this side of the action axis dictated by the subject's motion. Therefore position B is valid while C is not.

Consistent screen direction is maintained by the adherence to the *action axis* (figure 5). The action axis is an imaginary line (it may be considered to be an imaginary plane in a 3D scene) established by certain factors, such as:

- A look: a character looking at something
- Movement, e.g., a car moving down a street
- A specific action, e.g., a character moving towards a door or two characters talking
- Physical geography: the layout of a room for example

When a shot ends the action axis must be noted so that screen direction will be maintained for the next shot. At the beginning of the next shot the camera must be placed on the same side of the action axis. This ensures that movement will continue in the same direction, a character will look in the same direction and characters' relative positions will be consistent with the previous shot. It is not necessary to adhere to the action axis if a time lapse has occurred or if the two shots were separated with a different scene. If the aim of a particular shot is to disorient the viewer rather than keep them oriented, inconsistent screen direction can be used by not adhering to the action axis.

3.5 Cinematography in 3D Computer Games

Examples of some of the principles of cinematography discussed above can be seen in 3D computer games.

3.5.1 Types of Camera Angles

Many 3D computer games employ first- and third-person cameras. Both of these film the scene subjectively since the camera moves along with the avatar. First-person cameras are more subjective than third-person cameras because the user sees what the avatar sees.

3.5.2 Subject Size

3D computer games employing third-person cameras depict the avatar in long shot, medium shot or close-up. Subject size is not relevant to first-person cameras as the avatar is not visible.

3.5.3 Camera Height

Recently released 3D computer games allow the user to vary the height of the camera relative to the avatar in order to vary their view.

3.5.4 Screen Direction

There are generally no cuts within the same scene in recently released 3D computer games so screen direction is not an issue. The camera continually shoots the scene in first-person or third-person mode and never cuts.

3.5.5 Action Prediction

When filming a cinematic production in the real world, the director is at liberty to position the actors and props such that the filming of the scene conveys the required meaning or emotional subtext. The director can try different arrangements of the elements in the scene and attempt to employ different principles of cinematography until they achieve the shot they want. 3D computer games afford the camera control system only one attempt to film the action since it is supplied by human players and NPCs. Nothing in the scene can be repositioned and the system must attempt to predict the future locations of characters and props in the scene at each instant of time. These factors make the filming of action in a 3D computer game more similar to that in a documentary where the director has no influence over the action than a cinematic film.

4. Related Work

Previous work in the area of virtual camera control includes *CamDroid* (Drucker & Zeltzer, 1995). This work provides a general framework on top of which camera control mechanisms can be built for a number of domains within the area of virtual environments. Constraints can be applied to the camera to achieve the required shot treatment. For example a designer may require that the camera remain a certain distance from a character or that two particular characters are kept in the shot. This is a lower level approach than ours but it highlights some of the principles upon which our research will build. Marchand & Courty (2000) discuss the positioning of the camera in a virtual environment and its reaction to changes in the environment. They address the issues of occlusion of the subject by scene geometry and the amplitude with which the camera responds to changes in order to avoid occlusion but do not consider the application of principles of cinematography to the virtual camera.

Christian et al. (1996) propose a Declarative Camera Control Language for the application of cinematographic constraints to the virtual camera. A number of *film idioms* are encoded in the camera control system; film idioms are the stereotypical ways of shooting particular scenes, for example, a scene of two people talking. User input determines the characters that are to be filmed over a period of time. The appropriate film idiom is selected and the action is filmed. The system has knowledge of factors relevant to cinematography such as subject size and shots. The system takes an animation trace from action that has already occurred so it is not suitable for use in a real-time environment. Tomlinson et al. (2000) present a camera system that attempts to reflect the calculated emotional state of the virtual actors in the scene while employing principles from cinematography. Each character in the scene has sensors, emotions, motivations, and actions. The entity controlling the camera, called the CameraCreature, also has these attributes. The CameraCreature evaluates the emotions of the actors in the scene and its own emotions to decide how to film the scene. This approach is similar to ours but it is limited in that the camera control system is purely reactive, i.e. it does not attempt to plan shots. Halper et al. (2001) present *A Camera Engine for Computer Games.* The camera control system attempts to continually predict the future state of the scene and applies constraints on the camera. A principal aim is to implement the constraints in such a way that they are not adhered to rigidly since this could produce erratic camera movements. A compromise is drawn between constraint adherence and frame coherence, i.e. continuity of movement of the camera. This work is more in line with ours in that it considers only computer games but it does not highlight the various principles of cinematography that can be used; however, it does present some methods upon which our research will build.

5. Conclusions and Future Work

We aim to implement a virtual camera control system for 3D computer games through cinematography. We plan to first implement features already present in recently released 3D computer games such as:

- Prevention of collision of the camera with scene geometry
- Prevention of occlusion of the view by the avatar or scene geometry
- Smooth camera movements

We propose to establish a number of typical scenarios in popular 3D computer game genres and apply the principles of cinematography outlined above to the virtual camera:

- The use of different types of camera angles, i.e. objective, subjective or point-of-view, depending on the context of the action
- The filming of the characters such that the appropriate subject sizes, e.g. medium shot, close-up, etc., are applied to each situation
- The filming of the characters with the appropriate camera height, i.e. level angle, high angle or low angle, for each situation depending on the dramatic or emotional subtext to be conveyed
- Adherence to the action axis when cuts are used during a scene if user orientation must be maintained

The major issue to address is the interactive nature of a computer game and its implications for the design of a system for camera control through cinematography. Another issue we propose to examine is the design of such a system such that a user will become easily accustomed to the camera work resulting from the principles employed. We will evaluate our implementation and that of other researchers by testing the systems on a number of typical scenes and compare the resulting camera work with the opinions of experts in the area. We will also evaluate our system from the point of view of playability, i.e. we will evaluate the effect of the cinematographic camera work on the user's ability to carry out the task required by the game.

References

Brown, B. (2002). Cinematography: Image Making for Cinematographers, Directors and Videographers. Oxford: Focal.

Christian, D. B., Anderson, S. E., He, L., Salesin, D. H., Weld, D. S. & Cohen, M. F. (1996). Declarative Camera Control for Automatic Cinematography. In Proceedings of the Thirteenth National Conference on Artificial Intelligence, 148-155.

Eidos Interactive. (1998). Tomb Raider III, computer game for IBM compatible PCs, released by Eidos Interactive, San Francisco, CA.

Eidos Interactive. (2002). Hitman 2, computer game for IBM compatible PCs, released by Eidos Interactive, San Francisco, CA.

Courty, N. & Marchand, E. (2001). Computer Animation: A New Application for Image-Based Visual Servoing. ICRA 2001: 223-228.

DeLoura, M. (2000). Game programming gems. Rockland, Mass.: Charles River Media.

Drucker, S., and Zelter, D. (1995). Camdroid: A system for implementing intelligent camera control. In proceedings of 1995 Symposium on Interactive 3D Graphics, 139-144.

Halper, N., Helbing, R. & Strothotte, T. (2001). A Camera Engine for Computer Games: Managing the Trade-Off Between Constraint Satisfaction and Frame Coherence. In Proceedings of Eurographics 2001, 174–183.

Halper, N. & Olivier, P. (2000). CAMPLAN: A Camera Planning Agent. In Smart Graphics, Papers from the 2000 AAAI Spring Symposium, 92-100.

id Software. (1999). Quake III Arena computer game for IBM compatible PCs, released by id Software, Mesquite, TX.

Marchand, E. & Courty N. (2000). Image-Based Virtual Camera Motion Strategies. In Graphics Interface Conference, GI2000, 69-76.

Mascelli, J. V. (1965). The Five C's of Cinematography. Los Angeles: Silman-James Press.

Sánchez-Crespo Dalmau, D. (2004). Core Techniques and Algorithms in Game Programming. Indianapolis, IN : New Riders Publishing.

Tomlinson, B., Blumberg, B. & Nain, D. (2000). Expressive Autonomous Cinematography for Interactive Virtual Environments. In Proceedings of the Fourth International Conference on Autonomous Agents, 317-324.

Valve Software. (1998). Half-Life, computer game for IBM compatible PCs, released by Valve Software, Bellevue, WA.