

Physically Based Camera Systems: The Human Element in CG Camerawork

- I. Introduction & Problem Statement
 1. The camera work of any time-based work, whether it be a film, CG short, or television show, is vital because not only is it the viewer's portal into the world, but also because it is an integral part of conveying the mood of a particular piece.
 - A. CG camerawork historically has been very static, or at the very least, very planned.
 - a. Is this an aesthetic choice, or is there a limiting factor?
 - b. This lack of motion could stem from the roots in 2D animation, where it was very difficult to move the camera [ref?]
 - c. Are the current tools used in layout design insufficient to achieve "film-like" camera motion?
 - B. When a camera is used in film production, it is usually never still. [ref]
 - a. There are small movements associated with the camera operator walking, even just holding the camera.
 - b. Even camera rigs such as cranes and tracks have small movements.
 - c. There are also small imperfections when focusing and zooming the camera.
 - C. CG films also have the problem of a "mass-less" camera. [ref]
 - a. If a camera has no mass, there is no follow-through when it moves.
 - b. Real cameras do have mass.
 - a. A heavy camera held by a person will be harder to stop than a light camera
 2. Two questions can be asked when thinking of physically based cameras in CG.
 - A. Can the controls and interface to the current camera control systems be improved to be more like those of a traditional camera operator?
 - B. Does adding a more realistic camera system to CG improve the experience, or detract from it?
- II. Prior Work
 1. CG Camera work
 - A. Historical work
 - a. Relatively small amount of papers done on the subject of camera movement, especially about physically based movement or matching a cinematic feel.
 - a. Turner et.al. describe an interactive approach to a physically based camera system.
 - i. Driven by dynamics (torque, forces, friction)

- ii. Driven by external controls, not keyframed
 - b. Li-wei et.al. describes a virtual cinematographer system
 - i. Real time, actor driven scripting system
 - c. Kolb et.al. describe a realistic camera lens system
 - b. Historical papers deal with basic scripting
 - a. Gleicher et.al. Through the lens camera controls.
 - b. Drucker et.al. CINEMA. Camera scripting
 - c. Potmesil et.al. Depth of field.
 - c. Studios use camera rigs that emulate traditional camera setups.
 - a. Emulate movements, without any of the ‘imperfections’ of physical camera movement.
- B. Current CG Camerawork
- a. Cars (2006) – Uses techniques to create more realistic camera movements.
 - a. Camera bounce, imperfect movements, handheld type movements.
 - b. Monster House (2006) – Very nice camera moves, but camera lacks feeling of weight
 - a. When filming, the directors used a physical camera to control the CG camerawork
 - b. When coming to rest, cameras have either full deceleration, or come to a complete stop without following through.

2. Film camera work

A. Intro

- a. Camera moves in film can be evaluated to their basic forms to see

B. Traditional Camera Movements

- a. Camera movements in film can be broken down into several attributes.
 - a. The camera *pivots* on a point
 - b. The camera *moves* along with its pivot
 - c. How stiff the pivot is
 - d. Its weight – all cameras have this
- b. Pan.
 - a. *Pivots* on a fixed point.
 - b. Horizontal axis of camera movement.
 - c. Commonly used when following an object or re-framing a shot.
 - d.
- c. Tilt.
 - a. *Pivots* on a fixed point
 - b. Vertical axis of camera movement
 - c. Used to follow object in motion, show height

- d.
- d. Dolly.
 - a. *Moves* horizontally through space on a fixed pivot.
 - b. Used in the same manner as the pan.
- e. Handheld.
 - a. Movement is not constrained to any particular direction
 - b. Ability to *move* with pivot as well as *pivot* on it
 - c. Pivot is very loose
- f. Steadicam.
 - a. Movement is not constrained to any particular direction
 - b. Pivot stiffness is between dolly and handcam
- g. Crane/ Boom.
 - a. Camera is attached to a Crane/Boom/Jib
 - b. Much of the motion is in the vertical direction, but also has a horizontal component
- h. Zoom.
 - a. Camera is not in motion
 - b. Focal length is changed
- i. Rack Focus.
 - a. Camera is not in motion
 - b. Focus is changed from object to object
- j. CG only
 - a. Several kinds of properties CG cameras have that does not apply to physical cameras
 - i. CG cameras have the ability to have no mass/weight
 - ii. CG cameras have the ability to not take up physical space. i.e. they can pass through other objects
 - b. Camera can be constrained to whatever the director prefers i.e. no true pivot point
 - c. Movements can be very ‘unnatural’, they do not need to obey physical rules

3. Real-time Physics

4. Real-time Depth of Field

III. Goals & Objectives

1. The goal of this project is to create an application or plug-in that allows the movement and previewing of focus of a three dimensional camera though the use of a gyroscopic controller. This application will export the data back into an animation package.
2. Several objectives will be achieved by conducting research into physically based camera systems
 - A. Maya API and camera system will be extended with specialty cameras.

- a. Track, Crane, etc.
 - B. Real time physics will have to be implemented.
 - C. Bluetooth drivers for the gyroscopic control will be extended from their current implementation.
 - D. Real time depth of field will be implemented to achieve the realistic camera de-focusing effect.
- IV. Methodology
 - 1. Maya Export Scripts
 - 2. Nintendo Wii Gyroscopic controller
 - 3. Real-time physics
 - 4. Real-time Depth of field
 - 5. Maya Import Scripts
- V. Expected Results
 - 1. The ability for someone to control the CG camera as one would a real camera
 - A. More realistic movement, movement of camera corresponds to operators hand movements
 - B. Camera mass determines physical properties of the camera
 - C. Real time depth of field that previews the focus of the camera
 - D. Zooming in and out using gyroscopic controls
 - E. Allow the camera operator to more effectively convey mood with the camera
 - 2. The addition of more realistic camera motion in a CG piece will connect the audience more to the piece.
 - A. More film like and less like a two dimensional piece
- VI. Future Work
 - 1. Importing into other software packages
 - A. Complete integration into the previewing window
 - 2. Aperture opening effects using HDR
- VII. References
 - 1. He, L., Cohen, M. F., and Salesin, D. H. 1996. The virtual cinematographer: a paradigm for automatic real-time camera control and directing. In *Proceedings of the 23rd Annual Conference on Computer Graphics and interactive Techniques SIGGRAPH '96*. ACM Press, New York, NY, 217-224.
 - 2. Drucker, S. M., Galyean, T. A., and Zeltzer, D. 1992. CINEMA: a system for procedural camera movements. In *Proceedings of the 1992 Symposium on interactive 3D Graphics* (Cambridge, Massachusetts, United States). SI3D '92. ACM Press, New York, NY, 67-70.
 - 3. Kolb, C., Mitchell, D., and Hanrahan, P. 1995. A realistic camera model for computer graphics. In *Proceedings of the 22nd Annual Conference on Computer Graphics and interactive Techniques* S. G. Mair and R. Cook, Eds. SIGGRAPH '95. ACM Press, New York, NY, 317-324.
 - 4. Gleicher, M. and Witkin, A. 1992. Through-the-lens camera control. In *Proceedings of the 19th Annual Conference on Computer Graphics and interactive Techniques* J. J. Thomas, Ed. SIGGRAPH '92. ACM Press,

New York, NY, 331-340.

5. Turner, R., Balaguer, F., Gobbetti, E., and Thalmann, D. 1991. Physically-based interactive camera motion control using 3D input devices. In *Scientific Visualization of Physical Phenomena*, N. M. Patrikalakis, Ed. Springer-Verlag New York, New York, NY, 135-145.