Fundamentals of Real-Time Camera Design

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Mark Haigh-Hutchinson

- 21 years in the games industry

- 40+ published titles

- Programmer / Designer / Project Leader

- Camera systems and player controls

  - Metroid Prime

  - Metroid Prime 2:Echoes

Agenda

Why talk about camera design?

— To raise awareness

— Avoidable camera problems persist

— Small amount of literature

— Set a high standard

Topics

- Camera System Overview
- Camera Fundamentals
- Game Genre Cameras
- Camera Design Principles
- Player Control
- Camera Design Process
- Camera Design Questions

Camera System Overview

Camera System Overview

- Controls game presentation

- Defines main interface of game

- Real-time and cinematic sequences

- Services other game systems

- Uses general and specific solutions

- Allows designers to override behaviors

Camera System Goals

Present best view of game play

Avoid player frustration

Be unobtrusive

Prevent disorientation

Allow player control as appropriate

Camera Fundamentals

Camera Fundamentals

- What do we mean by a camera?

  - Defines a view of the game world

  - Does not usually simulate real camera properties

  - Many different types of cameras

  - Cinematic or Interactive

Camera Types

Cinematic	Interactive
Pre-defined behavior Aesthetics over game play Established conventions Well-defined situations	Dynamic behavior Game play over aesthetics Conventions being defined Wide variety of situations

Camera Properties

Presentation style (Projection)

Type (First, Third person)

Behavior

- Desired position
- Motion type
- Look-At position
- Orientation method

First Person Camera

Viewed from player

Limited Field-Of-View

Positioning is difficult

Aiming is easy

Limited character view

Very immersive

Third Person Camera

External to player

Positioning easier

Aiming more difficult

Less immersive

Navigation problems

Framing problems

Camera Motion

- Desired position
- Motion types
  - Stationary
  - Slaved
  - Path constrained
  - Surface constrained
- Motion method

Camera Orientation

- Look-At position
  - Object tracking
  - Object framing
  - Path tracking
- Orientation lag
- Free-look

Game Genre Cameras
Part 1

Game Genre Cameras

- Genre-specific camera types

- Game play requirements more important

- Multiple camera types often required

- Split-screen multi-player presents additional challenges

Action-Adventure

Motion and orientation lag

Elevated position

Look-at depends on action

Generalized solution difficult

Minimize reorientation

3D Platform

Elevated position

Often pre-defined path or position

Environment view most important

User control override preferred

Flight Simulation

Requires multiple viewpoints

Roll is permissible

Look-at position ahead of craft

Replay cameras

Racing

Multiple viewpoints

Defined camera paths

Motion and orientation lag

Replay cameras

Camera Design Principles

Camera Design Principles

- Avoid player character occlusion

- Navigate environment automatically

- Allow camera manipulation

- Do not REQUIRE camera manipulation

- Minimize camera motion

- Ensure motion is smooth

Camera Design Principles

- Limit reorientation speed
- Limit use of roll
- Lead a character in motion
- Preserve player intent
- Seamless transitions

Player Control

Player Control

- Linked to camera system

- Genre & controller dependent

- Consistency of control

- Can be automated

- Abstracted to commands

- Control Reference Frame

Control Reference Frame

- Maps player controls to character motion

- Abrupt changes frustrate

- Retain after instant or rapid motion

- Game play and genre dependent

Control Reference Frame

Character-relative : Problematic in third person

Camera-relative : Player proximity issues

World-relative : Controls are consistent

Screen-relative : Motion defined by camera view

Object-relative : Inscribes a motion arc ("lock-on")

Game Genre Cameras

- Camera choice can be difficult

- Player perception linked to camera type

- Not restricted to "traditional" choices

- Experimentation is encouraged

Fighting

Must frame multiple characters

Focal point between enemies

Open environments

Cinematic approach

Role Playing Games

Elevated, distant position

Often entirely user controlled

Combat may use stationary view

Navigation difficulties

Sports

Matches TV presentation style

Multiple viewpoints

Elevated positions mostly

Replay cameras

Camera Design Process

Camera Design Process

- Important part of entire game design

- Requires dedicated staff

- Prototype and iterate early

- Derive from game play and environments

Camera Design Process

Overview

- Examine high level design goals
- Evaluate player character abilities
- Determine scope of environments
- Define base camera behavior(s)
- Determine area-specific requirements
- Technical evaluation of cameras

Camera Design Process

Per Area

— Determine specific environment needs

— Specify game play / AI / game objects

— Prototype simplest solution

— Refine once game play fixed

Camera Design Questions

Camera Design Questions

Player Abilities and Controls
- Consider all character movement properties
- Has the motion been finalized?
- Any ranged interactions?
- Do the player abilities change over time?
- Are control changes necessary?
- Simplify or restrict controls?
- Camera manipulation allowed?

Camera Design Questions

Environmental Concerns

— Sufficient space for camera motion / framing?

— Single presentation style?

— Will interpolation methods work?

— Removal or fading possible to avoid occlusion?

Camera Design Questions

Aesthetics

— Character framing?

— Aiming or ranged interactions?

— Is orientation or motion lag required?

— Does occlusion matter?

— Pre-defined or dynamic positioning?

Camera Design Questions

Technical considerations

- Object or geometry transparency?
- Rendering issues outside world
- Dynamic camera behaviors?
- Camera specific collision detection & avoidance?
- Tools to specify camera behaviors
- Camera debugging facilities?

Conclusions

Conclusions

- Camera design greatly impacts game play
- Essential part of the overall game design task
- Requires dedicated development staff
- Player control linked to camera design
- No single camera solution
- Prototype early and design away problems
- Successful camera systems are unobtrusive

Conclusions

No-one will notice if you truly succeed

Further Reading

Further Reading

Game Programming Gems Series, Volumes 1, 2, & 4

AI Game Programming Wisdom Series, Volumes 1 & 2

Real-Time Cinematography for Games - Brian Hawkins

GDC 2004 Proceedings

Full Spectrum Warrior Camera System - John Giors

Grammar of the Film Language - Daniel Arijon

Forthcoming Book

- Real-Time Cameras

- Written by Mark Haigh-Hutchinson

- Published by Morgan Kaufmann

- Series in Interactive 3D Technology

- www.mkp.com

- www.realtimecameras.com

One Last Thing...

Thanks!

GDC 2005 Selection Committee
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