CamOn: A Real-Time Autonomous Camera Control System

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Abstract

This demonstration presents CamOn, an autonomous camera control system for real-time 3D games. CamOn employs multiple Artificial Potential Fields (APFs), a robot motion planning technique, to control both the location and orientation of the camera. Scene geometry from the 3D environment contributes to the potential field that is used to determine position and movement of the camera. Composition constraints for the camera are modelled as potential fields for controlling the view target of the camera.

CamOn combines the compositional benefits of constraint-based camera systems, and improves on real-time motion planning of the camera. Moreover, the recasting of camera constraints into potential fields is visually more accessible to game designers and has the potential to be implemented as a plug-in to 3D level design and editing tools currently available with games.

Introduction

In interactive 3D applications, camera control is a key aspect of interaction between the user and the virtual environment. Real-time autonomous camera control has been an area of research for several years in the graphics as well as the AI community. A comprehensive survey of techniques developed so far in solving this problem is given by Christie et. al. (2006).

We describe CamOn, a system that simulates the camera as a particle moving in an Artificial Potential Fields(APFs) to perform animation and frame composition tasks. APFs is an technique commonly used in robotics for controlling navigation of robots in dynamic environments; it has been previously applied to camera control (Beckhaus, Ritter, and Strothotte 2000) to address camera path planning for automated exploration in virtual environments. Our system extends this work by integrating frame composition constraints to both camera positioning and orientation.

CamOn

CamOn is an autonomous camera control system capable of generating smooth camera animations and solving frame composition tasks. The camera is iteratively moved to converge to an optimal configuration, at each iteration it takes the current camera position, view direction, frame description and scene description as input, and returns a new camera position as output.

Frame description requires identification of the frame subjects, definition of subject importance and definition of composition rules; composition defines disposition of visual elements in an image (Arijon 1991). Inspired by the model proposed by Bares et. al. (2000) we translated three composition rules into constraints:

- Visibility (defines what fraction of the subject must be visible in the frame)
- ProjectionSize (defines the size of subject in the frame)
- View Angle (defines the angle from which the camera should shoot the subject).

Artificial Potential Fields

CamOn system employs Artificial Potential Fields(Khatib 1986) to move camera and solve frame composition tasks. We model the camera and its view target as two particles moving in the same 3D environment. Frame composition constraints are translated into APFs which. The APFs generated this way, along with APFs created from 3D scene geometry of the environment, are used to influence the movement of both the view point and the camera position particles.

Obstacle avoidance is modelled using repulsive forces and frame composition is obtained by translating frame constraints into forces affecting both the position and the look-at point of the camera. Each frame constraint produces an attracting or repulsing force for camera position and an attracting or repulsing force for camera view point. The system treats these two aspect of the camera as two different particles moving into two different potential fields.

Recasting Framing Constraints as APFs

Recasting frame constraints into APFs requires the identification of position and orientation goals for each of the frame constraint values. Ideal camera positions and orientations for each constraint are modelled as low potential zones; any other part of the solution space has a potential proportional (the exact relation can vary from constraint to constraint) to the distance from the ideal position and to the constraint satisfaction of the corresponding camera configuration. Figure 1 shows an example of the two potential fields created by a

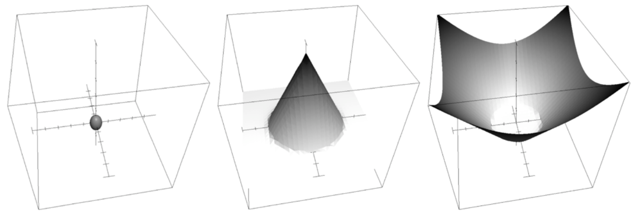

Figure 1: Example APF produced by a visibility constraint on a sphere (from left to right: sphere, position APF, orientation APF)

Visibility frame constraint on a sphere. Note that the distribution of forces (force footprint) could be custom designed for each object by a designer. This footprint also defines curves along which the camera moves when no other interfering forces are present in the 3D environment.

Implementation

CamOn is currently implemented as an Ogre3D [1] extension. The library contains functions that are used to automatically compute the motion of the camera according to the currently loaded camera profile. A camera profile is the description of camera's visual constraints on frame composition and it is defined as a set of subjects (each with an importance value) and a set of viewing constraints applied to each subject.

CamOn translates the camera profile into two potential fields, one affecting camera position and the other one camera orientation, each of these is a linear combination of scalar weighted potential fields, where each potential field corresponds to a frame constraint and each scalar value to the relative subject importance. The system animates two particles along the two potential fields until they both reach a stable configuration, camera position and camera look-at point both follow the movement of the two particles.

Demonstration Overview

The demonstrative application shows a non-interactive intro sequence showing the main character (a green ninja) and the enemies he has to avoid (4 steady robots and 2 walking robots). Users can watch the default camera animation (a predefined sequence of camera profiles), can release the camera from CamOn control, and move it manually or can interactively decide to shoot any character in the scene by selecting a specific camera profile. The camera definition file included in the demo can also be modified to test the camera animations corresponding to different constraint values and weights. Figure 2 shows sample camera shots for the given profile(Fig. 2(a)). In the first shot, shown in Figure 2(b) the robots are walking in the same direction and the camera maintains the shot to face the front of the two robots. In Figure 2(c) the robots are facing the opposite directions and the camera adapts to find a shot that maximizes constraint satisfaction.

[1] Object-oriented Graphics Rendering Engine - http://www.ogre3d.org

```
<profile name="WalkingRobotsFront">
    <subject name="WalkingRobot0"/>
    <visibility subject="WalkingRobot0" visibleFraction="1.0"/>
    <viewAngle subject="WalkingRobot0" horizontal="-30" vertical="10"/>
    <projectionSize subject="Robot0" size="0.5" />

    <subject name="WalkingRobot1"/>
    <visibility subject="WalkingRobot1" visibleFraction="1.0"/>
    <viewAngle subject="WalkingRobot1" horizontal="-30" vertical="10"/>
    <projectionSize subject="WalkingRobot1" size="0.5" />
</profile>
```

(a) Camera profile definition

(b) Robots facing same direction

(c) Robots facing opposite directions

Figure 2: Camera showing the solution of a three-quarter front shot of two robots in two different conditions

In this demonstration, the user can interact with the system in the following ways:

- Change camera profile values and switch between camera profiles in real-time.
- Interact with the camera during a non-interactive session and jump back to the non-interactive walk-through at any time and from any location in the world.

Conclusions

In this demonstration, we present CamOn - a real-time autonomous camera control system - that is based on multiple APFs. The system solves camera motion and frame composition problems by modelling frame constraints and scene geometry as multiple APFs. The demonstrative application allows the user to modify camera profiles, observe the result of changing camera parameters in real-time and interact with the camera during an animation by changing the camera location and orientation by hand. The camera system converges to the desired location and orientation from any initial location in the 3D world.

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