Image-space Constraints for Controlling Camera Interpolation

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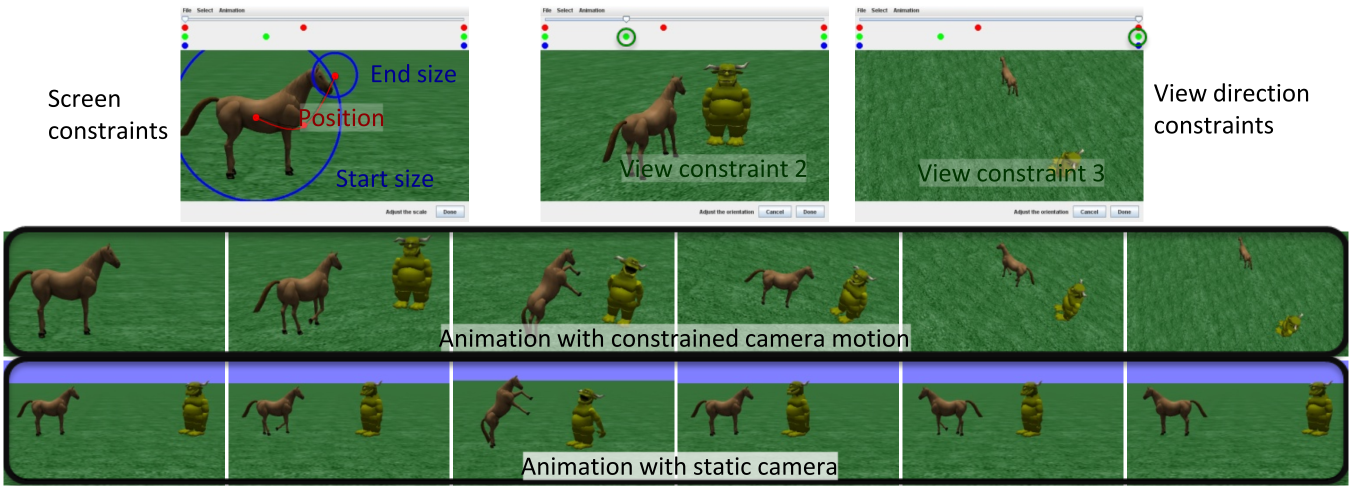

Figure 1: ***Specifying a camera motion using in-screen constraints. Top row:*** *(Left) The user specifies the path the horse should take using the spline curve (red dots). They use the blue circles to specify that the horse starts out big and gets small. (Middle, Right) The user also specifies the desired viewing direction at two other points in time.* ***Middle row:*** *The original animation viewed with a camera motion that meets the user's constraints.* ***Bottom row:*** *The original animation sequence viewed with a static camera.*

1 Introduction

Camera keyframing is an integral part of the animation making process. The animator places the camera in a sequence of "key" positions, and the computer produces a set of intermediate camera locations that interpolates between these keyframes. Camera keyframing traditionally treats the camera as just another 3D object in the scene, with intermediate frames produced by interpolating the position and focal point of the camera in space. Unlike a 3D object, however, the camera's role is to *project* the 3D scene into 2D. The animator indirectly controls the projection — how objects in the scene are placed in the 2D image — by adjusting the camera parameters for each keyframe. Automatic 3D camera interpolation adds yet another layer of indirection. The net effect is that the animator must solve a complicated inverse problem in order to move objects across the 2D scene in the desired manner.

Image-space constraints [Gleicher and Witkin 1992] were introduced as a solution to the inverse problem. The animator specifies the desired image-space constraints (this object should be here) and the system solves the inverse problem to determine the correct camera path. Unfortunately, except for a few types of animations (flying around an object, panning across a scene), this approach is unstable and difficult to control [Barrett and Grimm 2006]. There are several reasons for this, but one of the primary problems is that there are multiple ways to move the camera in order to account for changes to the image-space constraints. If the image-space constraints are relatively simple (translation across the image) the system behaves well, but for more complicated constraints, such as a rotation plus a translation, the resulting camera paths are jerky, or may pass through un-intuitive camera positions.

2 Our Approach

We expand on the spirit of Gleicher and Witkin's work to provide a more usable interface, a direct solve in the case of a single object, and a robust solver when the user wishes to control multiple objects. Our interface has the notion of a keyframe, but instead of specifying an entire set of camera parameters, the animator specifies one (or more) image-space constraints — the object must be here, it must be this size, and this is the view direction. To determine where the camera is for any intermediate frame, the system interpolates these constraints then solves for a camera that meets them, while producing a smooth camera path. The interpolations can be visualized, and edited, in the image plane in order to control what happens *between* the keyframes as well.

Traditional camera interpolation works well for a certain class of animations, such as following an object or panning over a scene. Our interface can, of course, be used to make these traditional camera motions, but its real strength is that it makes it easier to specify camera motions where the traditional camera actions (look at that object, pan across the scene, etc.) do not apply.

References

BARRETT, L., AND GRIMM, C. 2006. Smooth key-framing using the image plane. Tech. Rep. 28, Washington university in St. Louis.

GLEICHER, M., AND WITKIN, A. 1992. Through-the-lens camera control. In *Siggraph*, E. E. Catmull, Ed., vol. 26, 331–340. ISBN 0-201-51585-7. Held in Chicago, Illinois.