# Interface Techniques for 3D Control of Spatial Keyframing

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## 1 Spatial Keyframing in 3D

Spatial Keyframing offers a compelling approach for interactive control of 3D characters, as user motion directly controls the timing of an animated interpolation among a set of target poses [Igarashi et al. 2005]. In the original system, the user sets up a collection of target icons with associated character poses in a two dimensional control space that is overlaid with an interactive rendering of the 3D character. Mouse pointer location in this control space defines a multi–target pose interpolation, allowing navigation to become a form of interactive character animation. We are investigating techniques for using 3D control spaces (Figure 1), as the extra dimension provides more freedom in terms of specifying motions among the target poses, similar to how 2D control provides more potential motions than a one–dimensional slider that transitions through a fixed sequence of poses. This presents control difficulties, however, as mouse motion and traditional displays are inherently two–dimensional, which makes setup, control, and visualization more difficult. We are developing techniques that assist users with positioning new pose targets and choosing control space views that maximize the number of reachable targets. In addition, the 3D control space allows us to use novel interfaces to capture expressive 3D hand motion without the constraints associated with mouse navigation. We are taking this approach to create a virtual puppeteering system, in which users navigate a true 3D control space to control a 3D volumetric rendering of an interactive character.

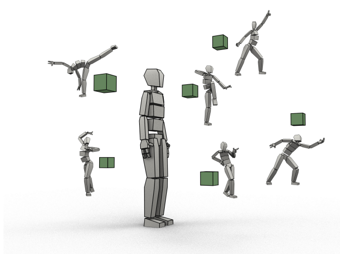

Figure 1: In 3D spatial keyframing, target poses have icons located in a 3D control space that can be overlaid with the character. Cursor position in the control space defines a pose by multi–target interpolation, and cursor navigation defines an interactive animation.

## 2 Setup and Navigation Assistance

When using 2D devices such as a mouse and display screen for control of 3D spatial keyframing, difficulties arise in both creating the layout of targets and in navigating the target layout during interactive animation. As the number of targets increases, choosing a good location for new targets becomes difficult. Our system uses a stochastic global optimization algorithm to suggest a location by finding the point in control space whose interpolated pose best matches the new pose created by the user. To assist users with navigating the control space, we provide a tool that moves control space targets as a group to provide a control space view that maximizes screen space coverage to avoid target overlaps. The character view is preserved, and we determine the new layout by aligning the two largest axes of a PCA decomposition of the targets' locations with the screen space axes.

## 3 True 3D Control and Visualization

We have designed our 3D interface as a virtual puppeteering system, in which we optically track hand motion[1] above a 3D volumetric character display[2] [Grossman et al. 2004]. We map the 3D control space to the region surrounding the display globe (Figure 2), and users learn to control a pose layout as an animation rig, similar to how puppeteers design mechanical control rigs and refine their puppeteering skills with that rig through practice. We believe the 3D display provides a compelling interactive experience and are looking to combine multiple interacting characters controlled by multiple users. In addition, it reduces the depth ambiguity responsible in part for the difficulty in creating 3D character poses on 2D displays. This approach, however, does not allow us to have physical target proxies in place, as this would interfere with hand motion. Ongoing work includes incorporating a representation of the control space into the volumetric rendering. We believe this will help users learn the pose layout, after which they could use the system without the display of the targets in place. To create character poses and set up the control space layout, we have incorporated the system into Autodesk's 3ds Max software. Users currently create poses and target layouts in this system; we are also developing direct manipulation tools that use optically–tracked hand position, orientation, and pose to incorporate this capability into the 3D interface.

Figure 2: We track hand position to control a virtual control space above a volumetric character display, much as a puppeteer would control a puppet rig with a suspended character.

## References

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[1]Vicon: http://www.vicon.com

[2]Actuality Systems: http://www.actuality-systems.com