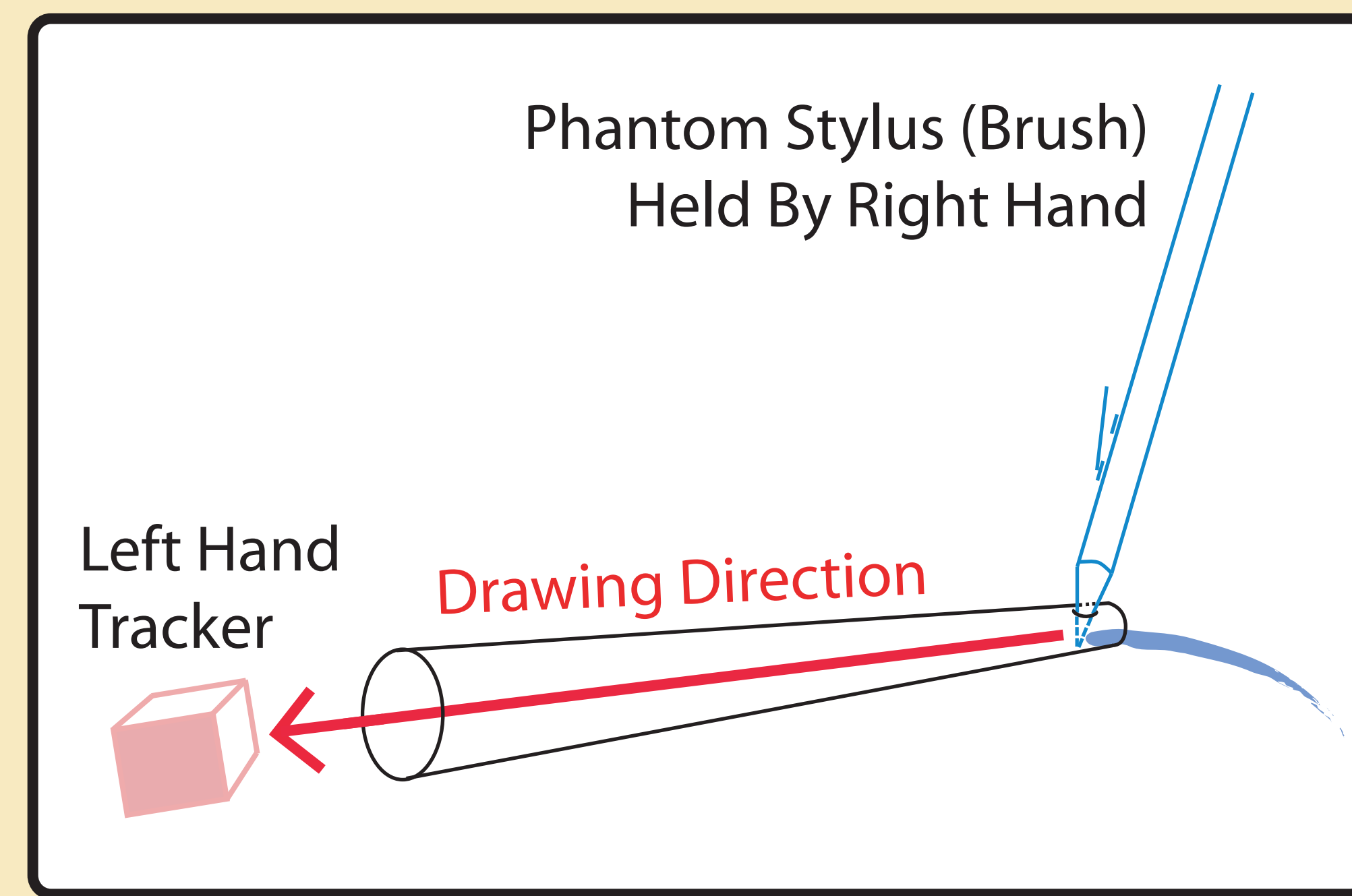
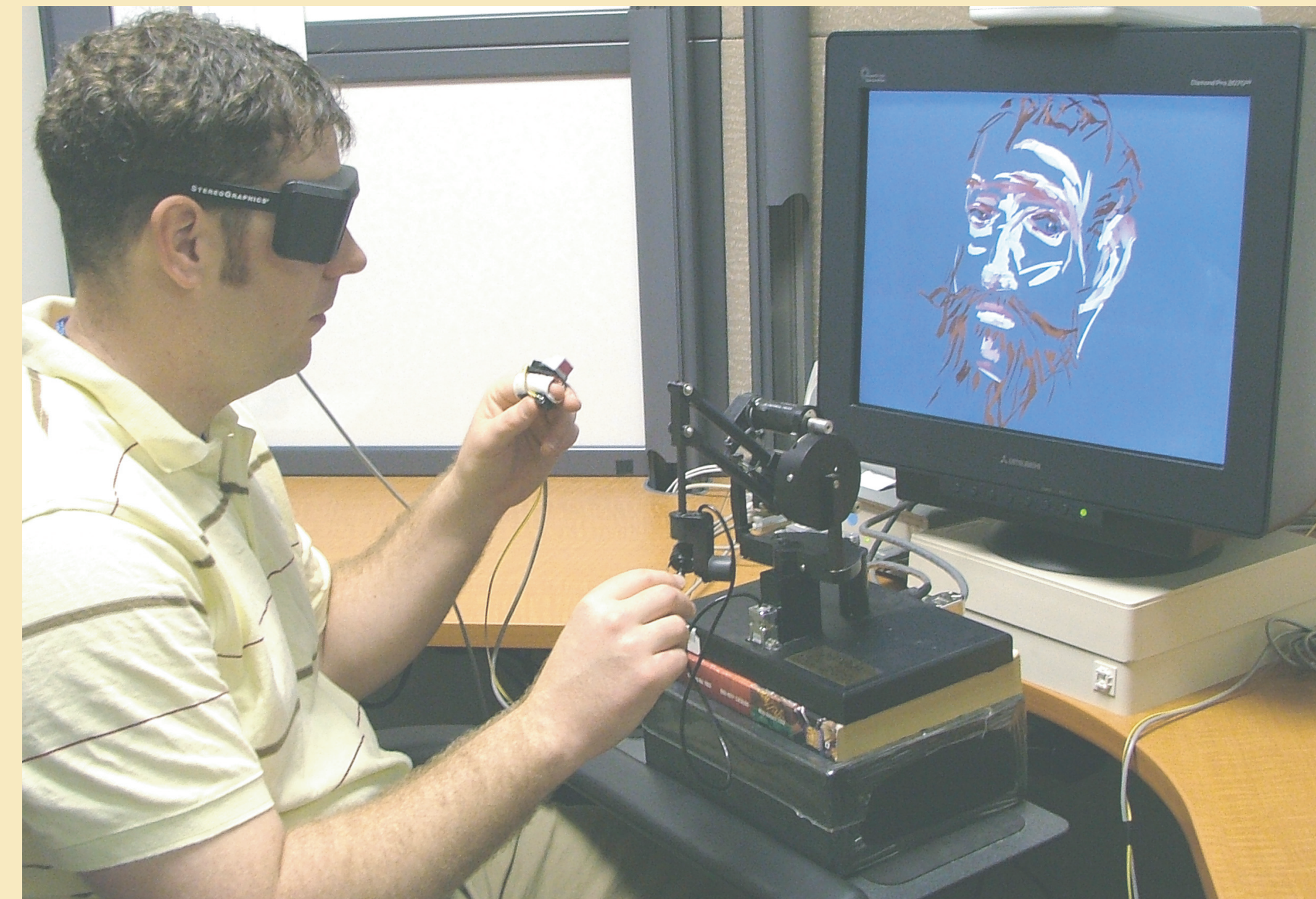
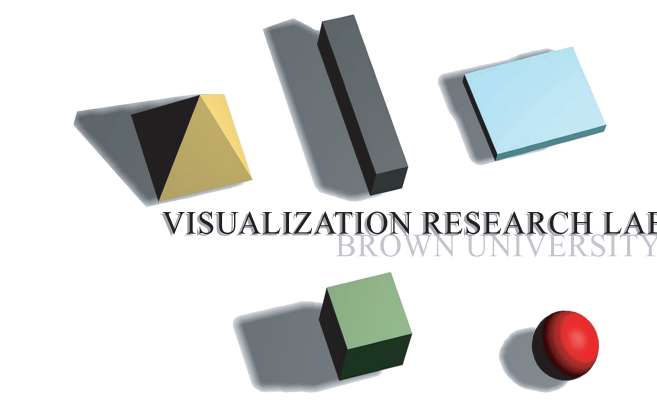


# A Haptic Interface for Creating Smooth 3D Curves with Varying Line Weight

Daniel F. Keefe and David H. Laidlaw



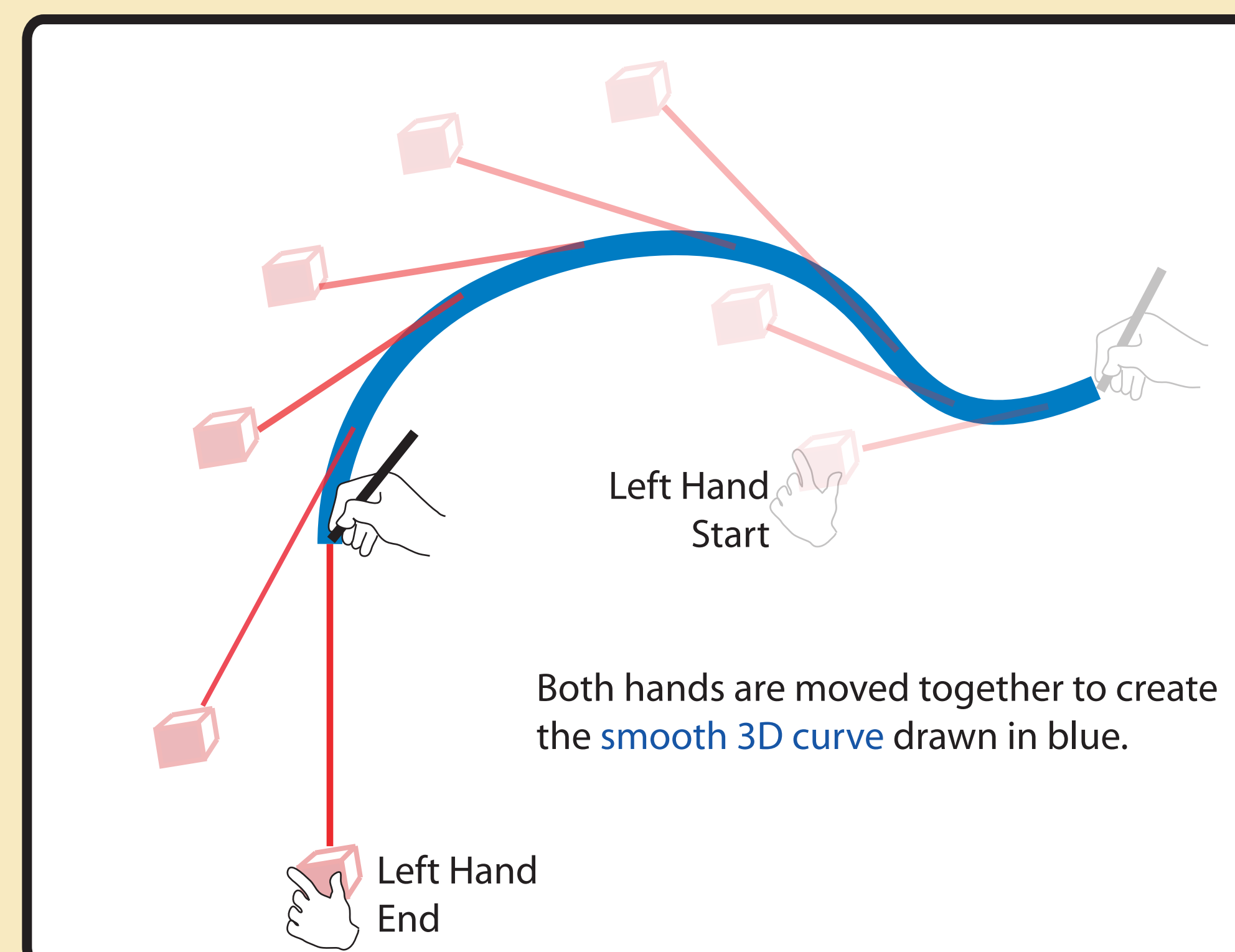
## Interface Goals

- To help artists create complex 3D curves that are smooth, i.e. have less jitter and bumpiness than what we often see when inputting a curve by drawing a path directly in the air with a 3D tracker.
- To provide artists with a natural way to vary line weight of a mark while creating it.

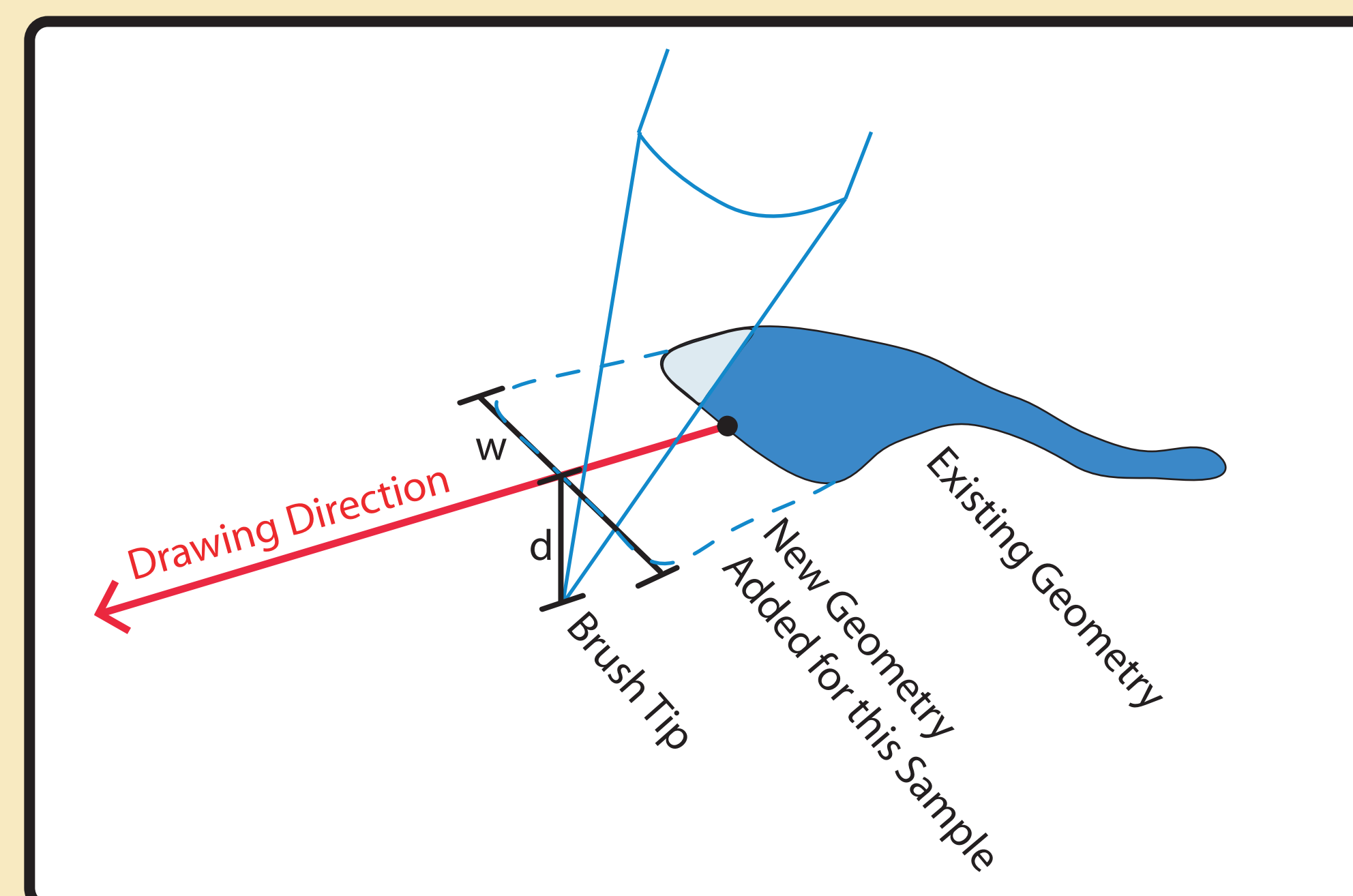
## Two-Handed, Haptic Free-Form Modeling

Our system uses a fishtank (desktop-based) virtual reality setup with two magnetic trackers, one tracking the artist's head and one tracking his left hand. The stylus of a SensAble Phantom force feedback device is held in his right hand. Our modeling medium is something like virtual wire sculpture: 3D models are made up of thin ribbon-like 3D curves that are typically viewed in stereo in virtual reality. [2,3] Our two-handed approach to drawing is inspired by digital versions of tape drawing, a drawing technique used by car designers. [1]

As seen in the figure above, the **drawing direction** vector points from the last point added to the curve to the position of the left hand. The brush held in the right hand is constrained by haptic forces to stay on this line. You can think of the forces as modeling a thin paper tube that the brush tip is stuck inside. As the artist pushes against the force (against the side walls of this imaginary paper tube) the line weight is adjusted in proportion to the pressure applied.

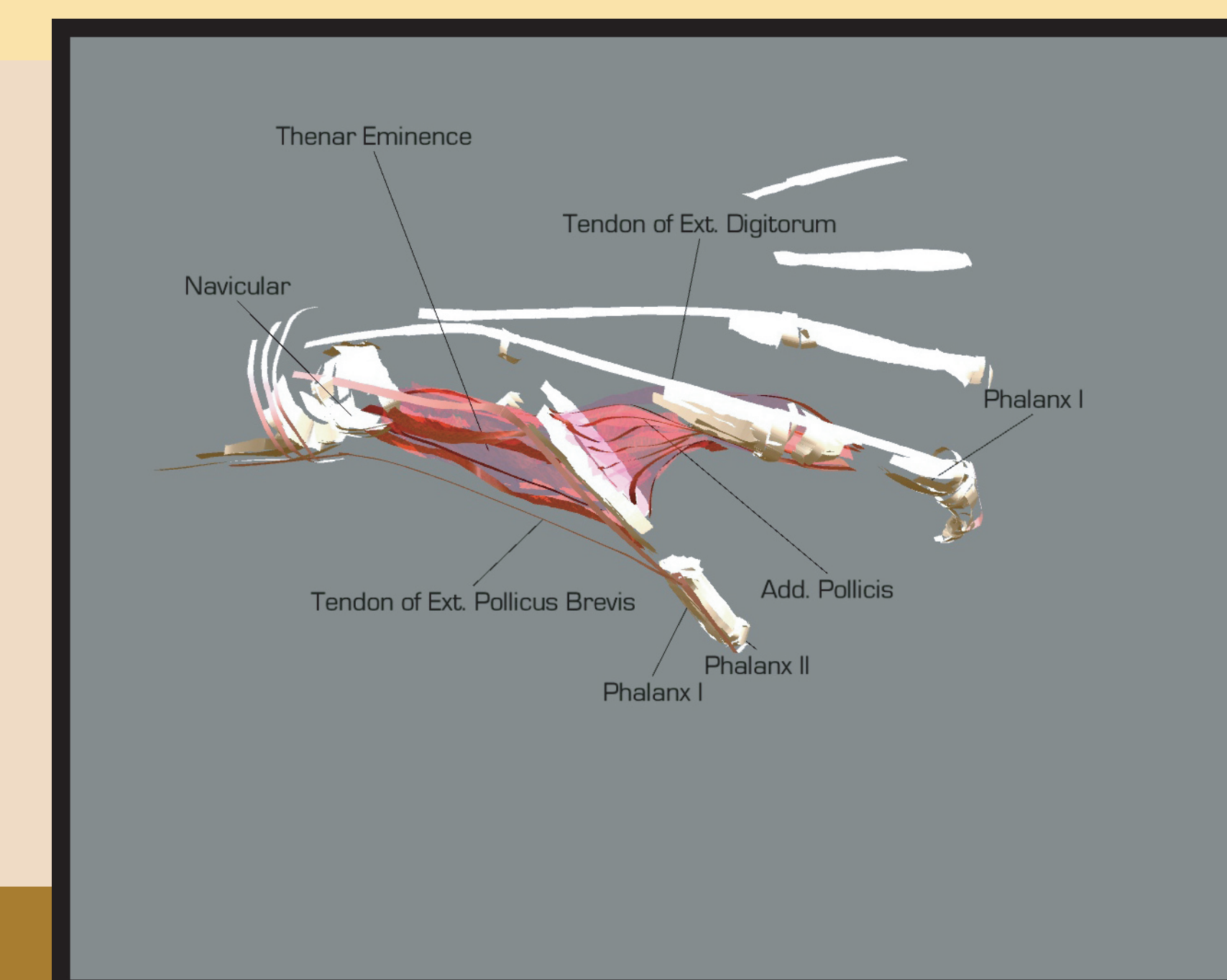
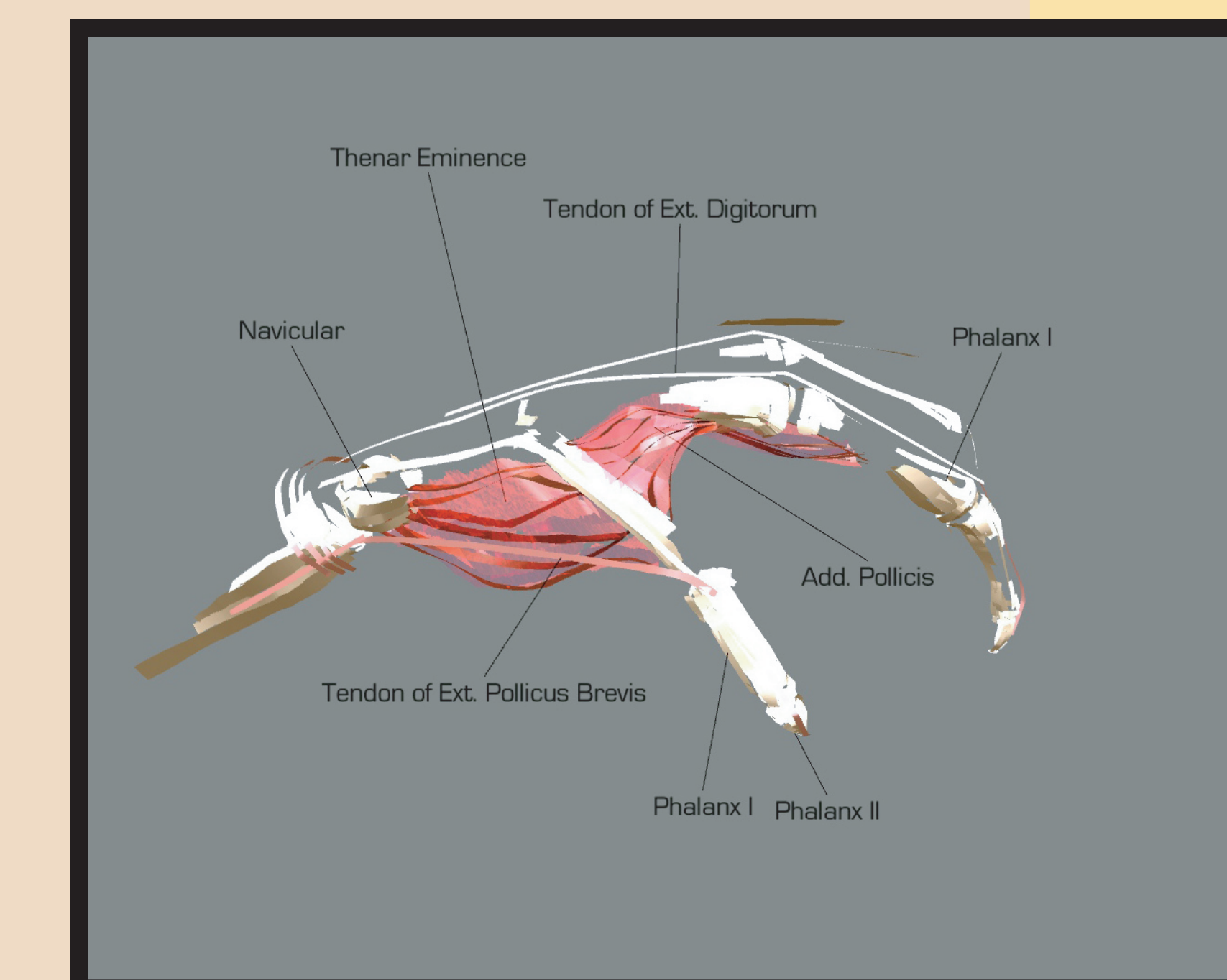


To draw a curve, both hands must move together. The drawing direction vector is constantly updated as the left hand moves around. This vector specifies the tangent for the curve as it is drawn. Typically, large movements of the left hand correspond to small adjustments in this tangent, thereby naturally producing a smooth 3D curve.

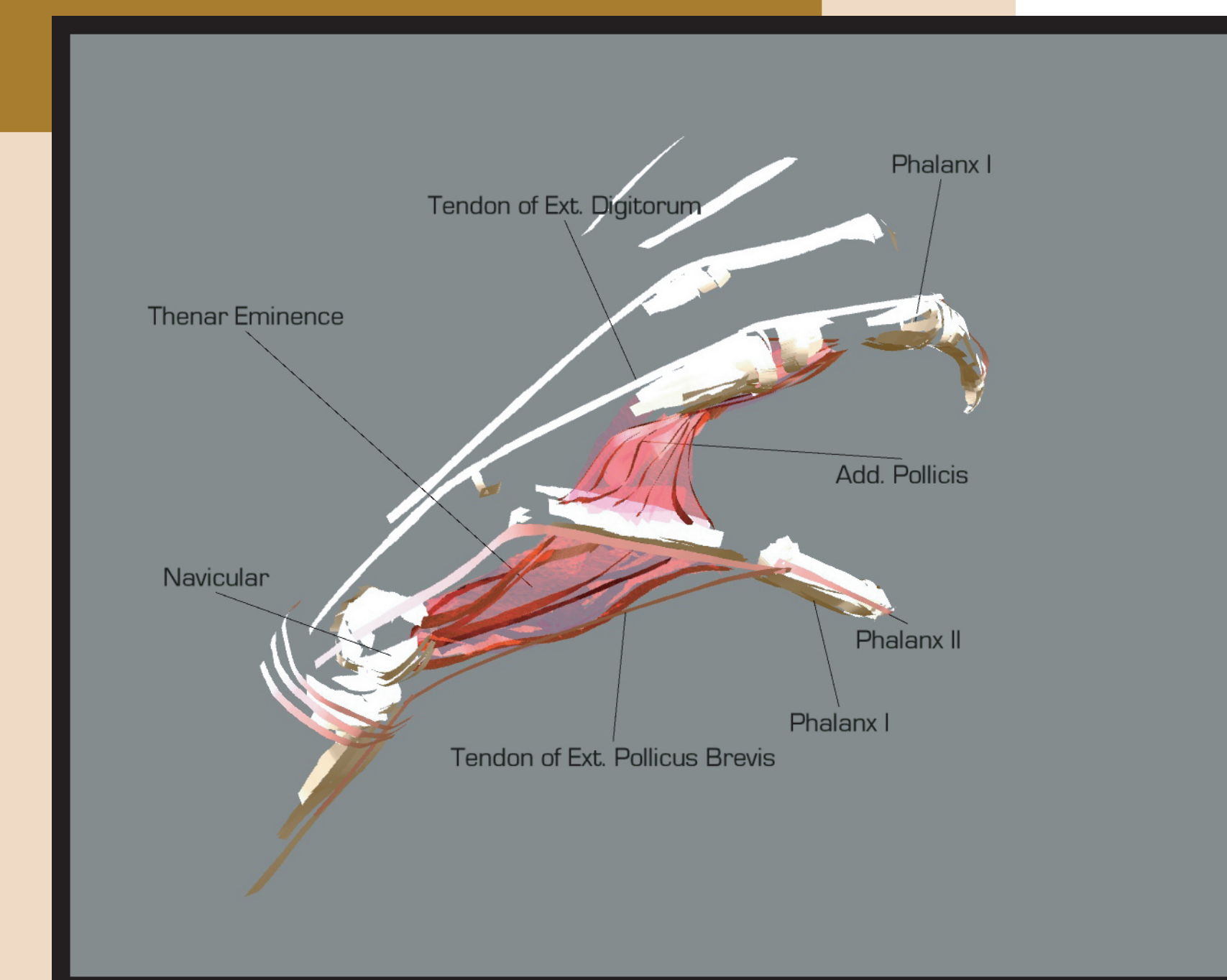
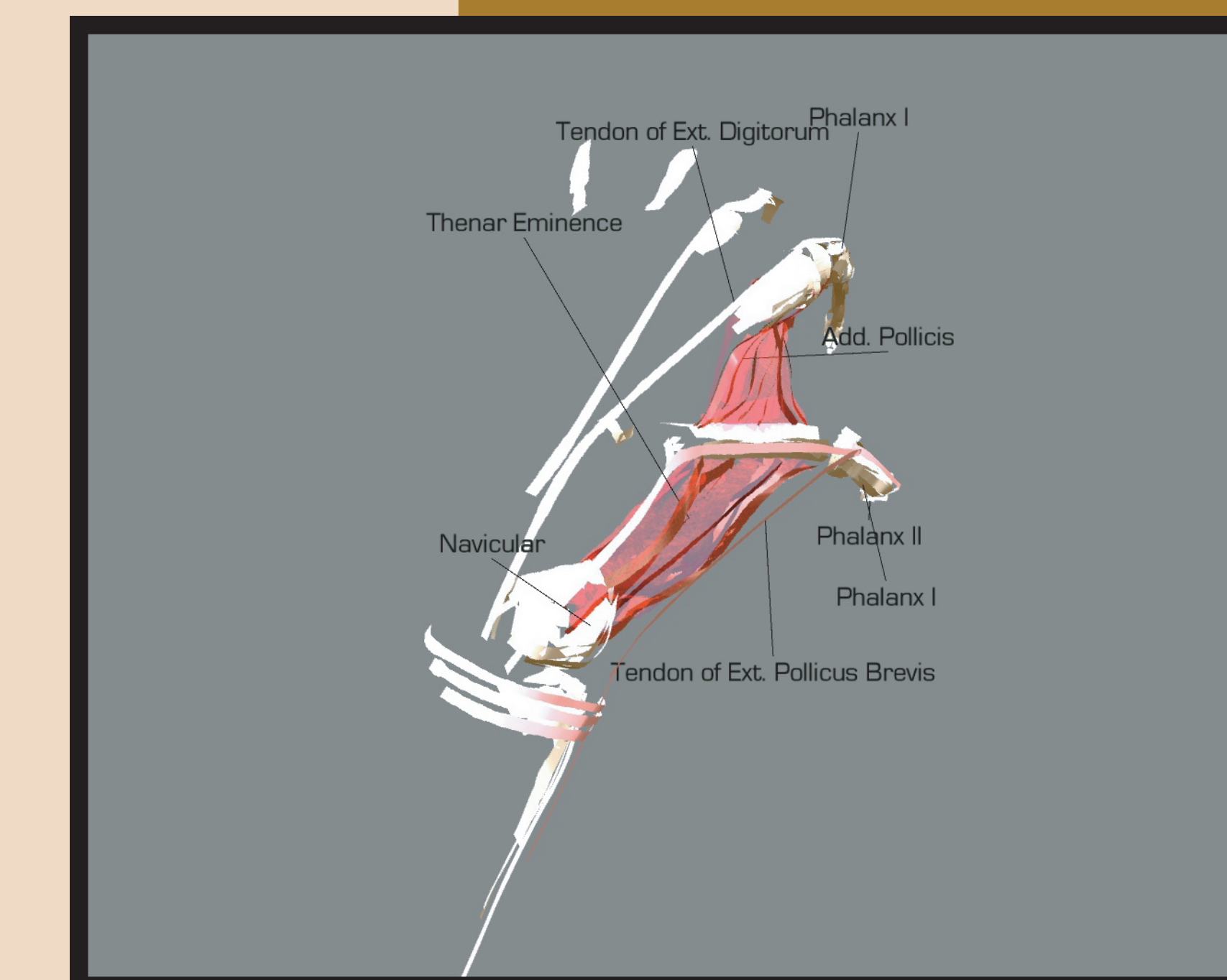


The line weight, or thickness of the mark ( $w$ ) for each new sample is proportional to the distance ( $d$ ) from the brush tip to the closest point on the drawing direction line segment. When no pressure is applied by the artist,  $d$  is zero. As pressure is applied, the tip is pushed away from the drawing direction line, and the line weight is increased.

## Artistic Anatomical Illustration



## Scientific Illustration



## Motivation

The project is motivated by the desire to tackle more challenging subjects with free-form modeling approaches. **We focus on anatomical subjects because:**

- Their complex, organic shapes are difficult and time consuming to create in traditional modeling systems.
- Clarity of form is extremely important - a sloppy model is unacceptable for most anatomical illustrations, especially when they target scientific or medical audiences.

[1] Grossman, T., Balakrishnan, R., Kurtenbach, G., Fitzmaurice, G., Khan, A., and Buxton, B. 2002. Creating Principal 3D Curves with Digital Tape Drawing. In Proceedings of Computer-Human Interaction Conference, 121-128.  
 [2] Keefe, D., Acevedo, D., Moscovich, T., Laidlaw, D., and LaViola, J. 2001. CavePainting: A Fully Immersive 3D Artistic Medium and Interactive Experience. In Proceedings of ACM Symposium on Interactive 3D Graphics 2001, 85-93.  
 [3] Keefe, D., Karelitz, D., Vote, E., and Laidlaw D. 2005. Artistic Collaboration in Designing VR Visualizations. IEEE Computer Graphics and Applications (March/April).