Bayesian modeling of 3D shape inference from line drawings – Seha Kim, Jacob Feldman, and Manish Singh

Human depth comparisons in line drawings reflect the underlying uncertainty of perceived 3D shape. We propose a Bayesian model that estimates the 3D shape from line drawings based on the local and non-local contour cues. This model estimates the posterior distribution over depth differences at two points on a line drawing. The likelihood is numerically computed by assuming a generative model (Figure 1), which generates random 3D surfaces and, via projection, random line drawings. The 3D surfaces are inflated from random skeletons and projected into line drawings. Given a novel line drawing, the model samples probable local surfaces based on the relations between local 3D surface patches and corresponding 2D contour segments. Then, the likelihood function of depth differences is estimated from the distribution of probable surface orientations (Figure 2). The prior is modeled as a Gaussian using known human biases in depth perception, such as slant-underestimation and closer lower-region in figure/ground organization. This model predicts the probabilities assigned to depth differences between two points on line drawings from the posterior on depth differences (Figure 3). These probabilities were consistent with human responses (Figure 4), showing that the model accounts for human interpretation of line drawings. This model encodes the uncertainty in 3D shape interpretation from line drawings, simulates the propagation of depth information from local and global contours, and provides a tool for testing the scope of cues in 3D shape inference (Figure 5).

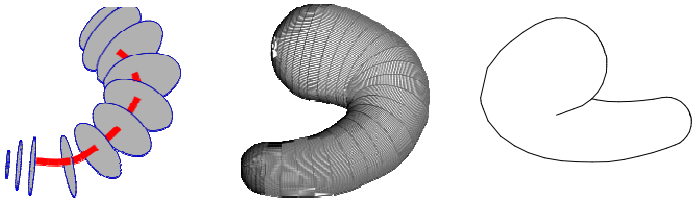

Figure 1: The generative model. From skeletons (red), surfaces are randomly inflated to have circular cross-sections (left). The inflated surfaces (center) are projected to make random line drawings (right).

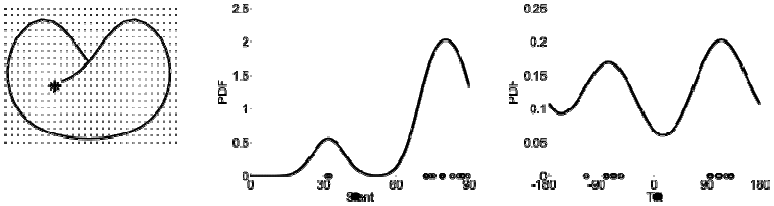

Figure 2: The distributions of surface orientations (slants and tilts) at a point (star symbol at the left image) estimated for the line drawing.

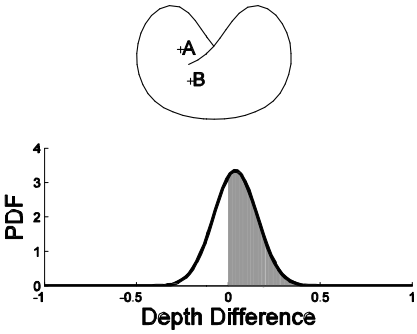

Figure 3: An example of the posterior of depth difference between A and B on the probe shown above. The integral above zero (shaded) gives the probability of judging A is to be closer than B.

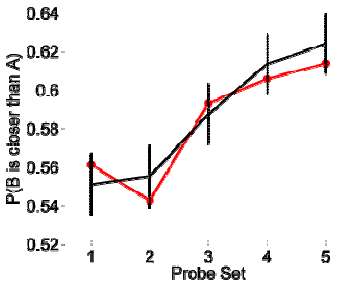

Figure 4: A comparison between model predictions for the certainty of depth difference and human responses.

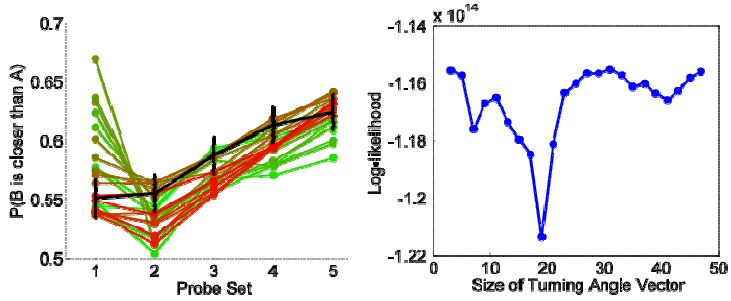

Figure 5: Model fits to data. Left: Data (black) vs. model (colored) for various levels of scale. Colored lines from green to red represent from local to global scales. Right: Model fit as a function of scale, showing dip in fit at intermediate scales.