How is it possible that we infer shape from image information?

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Although introspectively we seem to solve shape from shading inferences effortlessly and exactly, this is an illusion. Shape from shading is a classical ill-posed problem, and we know from psychophysics that there are quantitative differences between individuals. We confront this illusion with a qualitative, or topological approach, and propose that the first step is inferring a 'scaffold', or a type of line drawing, to ground the shape inference. The line drawing is the limiting case of certain shading patches in the image. We call them 'critical contours' because they relate patterns in the image directly to the surface slant. Under this model, critical contours partition the surface into meaningful parts, and are the perceptually grounded components of the Morse-Smale complex, a formal topological invariant. Critical contours are stable over a wide class of rendering models, partition smooth surfaces into bumps and valleys, and are computable from image flows. Interpolating a full surface from this scaffold provides for individual differences.

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