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The Scale Axis Transform

We introduce the scale axis transform, a new skeletal shape representation for bounded open sets $O \subset R^d$. The scale axis transform induces a family of skeletons that captures the important features of a shape in a scale-adaptive way and yields a hierarchy of successively simplified skeletons. Its definition is based on the medial axis transform and the simplification of the shape under multiplicative scaling: the s-scaled shape O_s is the union of the medial balls of O with radii scaled by a factor of s. The s-scale axis transform of O is the medial axis transform of O_s, with radii scaled back by a factor of $1/s$. We prove topological properties of the scale axis transform and we describe the evolution $s \rightarrow O_s$ by defining the multiplicative distance function to the shape and studying properties of the corresponding steepest ascent flow. All our theoretical results hold for any dimension. In addition, using a discrete approximation, we present several examples of two-dimensional scale axis transforms that illustrate the practical relevance of our new framework.