# Contour Shape Analysis using a Crystalline Flow

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**Abstract**

Evolution based scale-space methods play an important role to characterize a contour figure.Especially, a curvature flow is widely used to obtain the scale-space. In a curvature flow, a contour evolves in the normal direction with the speed $V$ that is determined by the curvature $\kappa$. As a contour evolves, small geometric features in the contour are smoothed out, and large features come to appear. There are classical and thoroughly elaborated theories on the contour evolution. For example, it is proved that, letting $V = \kappa$, any contour converges to a circle at finite time, and that no new curvature inflection point is generated as the contour evolves. These aspects permit us to define the scale using the time in the evolving process.

The scale-space methods have been mainly treated a smooth curve. In a case of $V = \kappa$, for example, it is known that any evolving contour is analytic at $t > 0$. In a digital image, however, contours that we encounter cannot be considered smooth: they are discrete. Most of all methods for obtaining a curvature flow, e.g. a level set methodor other smoothing methods,represents an smooth contour with a series of sampled points in it. Because the arc length of the evolving contour keeps changing through the evolving process, it is not easy to track a point through the process so as to represent characteristics in the scale-space.

In this presentation, in order to characterize a contour shape, we introduce a crystalline flow, which is an essentially discrete version of a classical curvature flow. A crystalline flow is a family of evolving polygons. An initial contour must be a polygon that is called an admissible crystal, and the evolving contour remains an admissible crystal through the evolution. In the crystalline flow, each facet evolves in the normal direction with the speed $V$ that is determined by the *nonlocal curvature* $\Lambda$. The quantity of the nonlocal curvature is calculated using the length of each facet. It is proved that letting $V = \Lambda$, for example, the number of facets in the polygon decreases as $t$ increases, and the polygon becomes convex at finite time. We can track each facet straightforwardly through the evolving process, because the contour remain polygonal.

We propose a method for extracting dominant corners. In the classical framework, a corner is defined as a point that has a maximal curvature.In the presented framework of the crystalline flow, on the other hand, a corner is defined as a facet that has non-zero nonlocal curvature. As the time $t$ increases, the number of corner facets decreases, in the evolving process.

Tracking each facet, we determine the lifetime of it in the evolving process, and extract dominant corners. Some experimental results show that the presented method extracts dominant facets well.