# Multi-Scale Object Segmentation for Robust Recognition

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## Abstract

*Effective local segmentation of contours is an important problem which arises in occluded object recognition as well as other areas. For any recognition system to perform successfully, the segmentation procedure used must be robust in presence of noise and local distortions of shape. Furthermore, it should be based on geometric invariants so that the segmentation will not be affected by arbitrary choices.*

*This paper proposes a new multi-scale segmentation routine for planar contours (and space curves) which is based on the curvature scale space (and torsion scale space) representations. Curvature (and torsion) zero-crossing segments extracted from a continuum of scales are utilized for robust segmentation of planar contours (and space curves). Curvature (and torsion) zero-crossing points are effectively tracked across increasing scales to ensure that the same segment is extracted only once. This approach is more robust than techniques which attempt to recover features/segments from a* stable *scale and, as a result, risk over- or under-segmentation of the input contour.*

## 1 Introduction

Robust segmentation of a contour is an important problem which occurs in occluded object recognition among other areas. For such an object recognition system to perform reliably, the segmentation algorithm must be robust with respect to noise and local variations in object shape. A large amount of work has been carried out on contour segmentation. Much of the earlier work focused on polygon approximation of contour data [1]. Various criteria have been utilized to determine the number as well as the location of polygon vertices. A sequence of polygons with improving fit to the contour data can be obtained by gradually reducing the acceptable error of fit. This polygon sequence can be considered a multi-scale representation of the contour data. However, the locations of the chosen vertices tend to be arbitrary and as a result, this technique can not be considered robust with respect to noise and local shape distortions.

A newer class of algorithms segment an input contour by first smoothing it to remove some noise and then extracting the points where the absolute value of the curvature function has a local maximum. These local maxima are also referred to as *corners*. An attempt is then made to identify a *stable* scale at which the corresponding corners can be extracted [10, 11]. This group of algorithms is generally more robust than the polygon fitting algorithms described earlier. However an important problem arises since feature points are always extracted from a single scale whereas features can in general occur at multiple scales on free-form contours. As a result, the segmentation can still suffer from noise or from loss of structure due to over-smoothing.

This paper proposes a new multi-scale segmentation procedure for 2-D contours based on the curvature scale space (CSS) image, and for space curves based on the torsion scale space (TSS) image. The CSS/TSS image is an organization of curvature/torsion zero-crossing points extracted from an input contour at a continuum of scales. Section 2 presents a brief overview of the CSS technique and section 3 presents a short overview of the TSS method. Section 4 describes in detail the proposed multi-scale segmentation method for 2-D contours, and section 5 describes the adaptation of that multi-scale segmentation technique for space curves. The segmentation method described in section 4 was used in conjunction with an occluded object recognition system presented in [7]. A brief review of the system is given in section 6. Section 7 presents the results of the 2-D multi-scale segmentation technique applied to two contours as well as the results of the object recognition system based on the 2-D segmentation method. Section 8 contains the concluding remarks.