Significant Description of 2D Contours by Straight and Curved Segments

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Abstract

This paper introduces a new approach for the segmentation and approximation of 2D contours. Its ultimate goal is to find constant curvature segments (straight line segments and/or circular arcs) to describe the contour in a way that respects its actual shape. The approach is strictly based on discrete geometry principles, and the resulting algorithm computes two grouping processes. Preliminary results obtained with this method are compared with two recent methods from the literature. This research work is part of a more generic project for detecting and describing 3D objects in a single 2D image based on high-level structures obtained by perceptual grouping of elementary components.

Index terms

Computer vision, 2D, image curve segmentation, straight line segment, circular arc, shape representation criteria, generic object localization

1. Introduction

The design of robust and effective autonomous systems is one of the main goals of computer vision. An example of such a system is an autonomous mobile robot typically composed of three principal components: *(i)* a *visual perception* module, *(ii)* a *reasoning* module and *(iii)* an *action* module. These components should ideally be organized as a closed-loop information/control data flow allowing the robot to move in its environment and execute application-driven tasks while avoiding collisions.

Under our 3D object detection and description task, the *perception* module of the robot aims at describing its environment based on geometric features of surrounding objects. In a larger context, the feature extraction method developed must be useful both for *generic object recognition* as well as for pose determination of *specific objects*.

The extraction of the initial structural information (basic components such as straight line segments and circular arcs) from a 2D image is critical for the *perception* module since its following processing steps, which consist in the perceptual grouping of the basic components ([1] [7]) and the volumetric interpretation of these components, depend directly on this information. The volumetric information must lead to a reliable and significant description of the scene [8].

In this paper, we concentrate on the extraction of the basic components using a three-stage process: *(i)* edge detection, *(ii)* contour following, and *(iii)* description of the contour using constant curvature segments which, due to their simple semantics, form an adequate basis for the following grouping process.

Section 2 describes briefly the problem of 2D contour segmentation and approximation. Section 3 compares two existing approaches for the extraction of straight line segments and circular arcs. This is followed by a presentation of a new approach for the segmentation and approximation of 2D contours. This approach rests on several shape representation criteria which lead to more significant descriptions of the contours. The various steps of the three compared algorithms are illustrated and Section 5 discusses their performance on 2D images of medium complexity. Finally, Section 6 concludes and presents future developments.

2. Contour segmentation and approximation

The main goal of the segmentation and approximation of 2D contours is to find an optimal combination of straight line and/or curved segments that best describe the shape of the contours. Most man-made objects can be described by straight line segments and, for their more complex parts, by simple curves (circular arcs, elliptic arcs, splines). There exists two principal paradigms for the segmentation of contours: *(i)* the extraction of significant points joining the primitives (such as the CPS approach [2]), and *(ii)* the extraction of the primitives forming the contour [4] [5] [10] [11]. The crucial point addressed by these methods is to determine the points along the contour, appropriate to a description, at which it must be broken.

In general, the contours extracted from real 2D images are corrupted by noise. This complicates the unambiguous and accurate extraction of the points of interest. As the approaches belonging to the first paradigm remain sensitive