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BEAUTIFICATION IS HARD

By

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Abstract

We describe an elementary version of the beautification problem in one dimension and show that it is NP-complete.

1. Introduction

An important problem in the design of a computer-aided design system is that of "beautifying" the user's input. Geometric information is input through a sequence of mouse clicks which are not perfectly positioned. The result is that figures are not as "neat" or "perfect" as they may have been intended. Indeed, most designed objects have a great deal of symmetry, and different objects are usually aligned. The beautification problem is to interpret user input in a way that best approximates his "intentions".

This problem has been addressed by many researchers and a common approach taken is the design of heuristics that try to maximize the "beauty" of an illustration by maximizing one particular measure or a combination of several measures. One simple and often used heuristic is the so-called "snapping" method. For example, "snap to grid" methods place a grid in the plane, and points input by the user are interpreted as (snapped to) the closest grid point to them. This method, although simple, has many drawbacks (e.g. not preserving colinearity). A more sophisticated approach was taken by Pavlidis and Van Wyk [PV]. They considered the lengths and angles between the line segments of an illustration and tried to create drawings that contain many equal-length segments, right angles, and parallel line segments. Their heuristics were designed and tested using clustering techniques. In this note we try to address the problem from the computational complexity point of view, analyzing how hard is it to beutify a drawing according to one simple measure.

We make our problem more precise by specifying that the automatic beautifier is allowed to alter the location of a point by at most a distance ϵ. (This can be thought of as the error tolerance.) Subject to this tolerance, the problem is to maximize the "beauty" of the input drawing. Several definitions of beauty are possible, leading to a variety of objective functions. Here, we focus on the problem of inputting a set of points, and we concentrate on the one-dimensional case (which must be solved in order to solve the more interesting two-dimensional case). Our definition of beauty is the (negative of the) number of distinct lengths of intervals between consecutive points. (We negate the number since we maximize beauty, but we want to