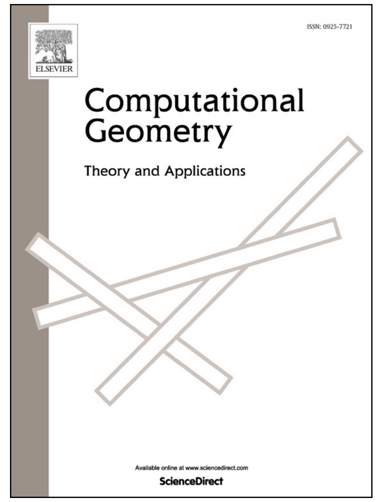
Accepted Manuscript



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PII: S0925-7721(17)30058-5
DOI: http://dx.doi.org/10.1016/j.comgeo.2017.06.006
Reference: COMGEO 1486

To appear in: *Computational Geometry: Theory and Applications*

Received date: 30 March 2015
Accepted date: 24 October 2016

Please cite this article in press as: F. Hurtado et al., Colored spanning graphs for set visualization, *Comput. Geom.* (2017), http://dx.doi.org/10.1016/j.comgeo.2017.06.006

Colored Spanning Graphs for Set Visualization*

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Abstract. We study an algorithmic problem that is motivated by ink minimization for sparse set visualizations. Our input is a set of points in the plane which are either blue, red, or purple. Blue points belong exclusively to the blue set, red points belong exclusively to the red set, and purple points belong to both sets. A *red-blue-purple spanning graph* (RBP spanning graph) is a set of edges connecting the points such that the subgraph induced by the red and purple points is connected, and the subgraph induced by the blue and purple points is connected.
We study the geometric properties of minimum RBP spanning graphs and the algorithmic problems associated with computing them. Specifically, we show that the general problem can be solved in polynomial time using matroid techniques. In addition, we discuss more efficient algorithms for the case in which points are located on a line or a circle, and also describe a fast $(\frac{1}{2}\rho + 1)$-approximation algorithm, where ρ is the Steiner ratio.

In memoriam: Ferran Hurtado (1951–2014)

This paper was initiated during a research visit hosted by Ferran and his group in Barcelona. Following tradition, hours of research were complemented by relaxing evenings with great food and wine. The authors would like to thank Ferran for being a supportive mentor, an inspiring colleague, and a great friend.

1 Introduction

Visualizing sets and their elements is a recurring theme in information visualization (see the recent state-of-the-art report by Alsallakh *et al.* [5]). Sets arise in many application areas, as varied as social network analysis (grouping individuals into communities), linguistics (related words), or geography (related places). Among the oldest representations for sets are Venn diagrams [15] and their generalization, Euler diagrams. These representations are natural and effective for a small number of elements and sets. However, for larger numbers of sets and more complicated intersection patterns more intricate solutions are necessary. The last years have seen a steady stream of developments in this direction, both for the situation where the location of set elements can be freely chosen and for the important special case that elements have to be drawn at particular fixed positions (for example, restaurant locations on a city map).

Our paper is motivated by some recent approaches that use very sparse enclosing shapes when depicting sets. LineSets [4] are the most minimal of all, reducing the geometry to a single continuous line per set which connects all elements. Both Kelp Diagrams [14] and its successor KelpFusion [22] are based on sparse spanning graphs, essentially variations of minimal spanning trees for different distance measures. These methods attempt to reduce visual clutter by reducing the amount of "ink" (see Tufte's rule [31]) necessary to connect all elements of a set. However, although the results are visually pleasing, neither method does use

* A preliminary version of this paper appeared in the proceedings of the *21st International Symposium on Graph Drawing* [19].