Graph Drawing Contest Report

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Abstract. This report describes the 18th Annual Graph Drawing Contest, held in conjunction with the 2011 Graph Drawing Symposium in Eindhoven, the Netherlands. The purpose of the contest is to monitor and challenge the current state of graph-drawing technology.

1 Introduction

As in recent years, this year's Graph Drawing Contest was divided into the offline contest and the online challenge. The offline contest had three categories: two dealt with angular resolution and one was a composers graph, kindly provided by Tom Sawyer Software. The data sets for the offline contest were published months in advance, and contestants could solve and submit their results before the conference started. For the two angular resolution categories, the submitted drawings were judged using visual comparison with emphasis foremost on angular resolution, particularly the worst-case deviation of the angular resolution from the perfect angular resolution value. The composers graph data set represented a very large graph, and the task was to combine graph drawing algorithms with appropriate techniques for complexity reduction (such as filtering and varying the graphical attributes) to create an illuminating visualization (one or more images, possibly with commentaries, or a movie). It was not a requirement to present the entire data set.

The online challenge took place during the conference in a format similar to a typical programming contest. Teams were presented with a collection of challenge graphs and had approximately one hour to submit their highest scoring drawings. This year's topic was the same as in the previous year, namely to minimize the length of the longest edge in a planar orthogonal grid drawing.

Overall, we received 30 submissions: 12 submissions for the offline contest and 18 submissions in the online challenge.

2 Angular Resolution

For the two categories in this topic, our primary concern was angular resolution. The *angular resolution* of any vertex in a drawing is the smallest angle formed by its

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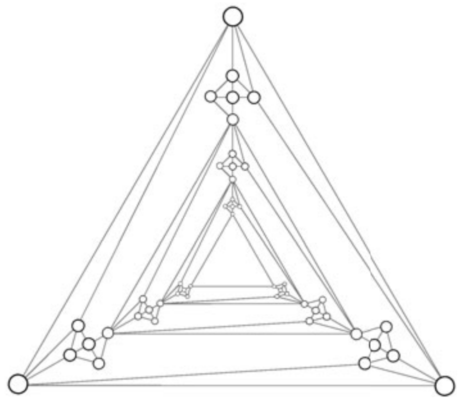


Fig. 1. First place, Angular Resolution, Category A

adjacent edges. When the edges are drawn as curved arcs it is measured with regards to the tangent at that vertex. In addition, we required that the graph should use a reasonably small grid area. The vertices did not have to be on an integer grid but the *vertex resolution*, the ratio between the distance of the closest two vertices and the farthest two vertices, should still remain relatively low. Both contest graphs were highly symmetric so any exploitation of that feature was also taken into consideration.

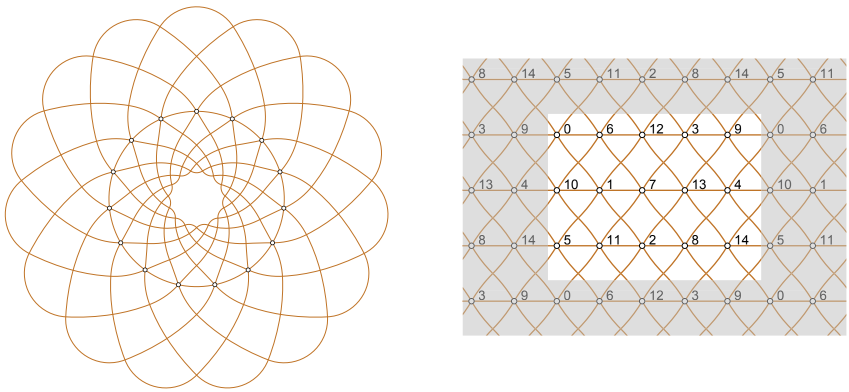
2.1 Category A: Straight-Line Planar

The first data set for the angular resolution topic was a planar graph with 48 nodes and 102 edges, and contestants had to create a drawing of the graph in the plane, without crossings, and using only straight-line edges. Whereas many bad examples of angular resolution use sequences of nested triangles, this graph contained only two nested triangles whose removal created a collection of outerplanar graphs.

We received only one valid submission in this category, and hence the winner was Hanley Weng from the University of Sydney; see Fig. 1. The layout was created by starting with a drawing produced by a variation of the spring-embedder algorithm, which was then manually modified such that the recursive symmetric structure of the graph was emphasized.

2.2 Category B: Curved Drawings

The second graph had 15 nodes and 45 edges and was not planar. The drawing, again in the plane, could have as many crossings as necessary but the angles of the crossings were also taken into consideration. In addition, the drawings could use curved arcs. There could be as many bends as needed but during judging both the number of bends and smoothness of the bends were taken into consideration and weighed against the gain in overall angular resolution.



(a) poly-arc Lombardi (b) toroidal 2-Lombardi

Fig. 2. First place, Angular Resolution, Category B

We received 5 submissions (8 drawings), from which two submissions with poly-arc Lombardi drawings [1,2] and perfect angular resolution looked quite the same (see Fig. 2(a)), but one of these submissions also contained a different visualization on the torus shown in Fig. 2(b). Though this is not really a drawing in the plane, it perfectly reflects the structure of the graph. Therefore, this pair of drawings by Maarten Löffler, David Eppstein, Michael Goodrich (UC Irvine) and Stephen Kobourov (University of Arizona) was judged to be the winning submission in this category.

3 Composers Graph

The composers graph was a large directed graph, where the nodes represented Wikipedia articles about composers, and the edges represented links between these articles. The graph had 3405 nodes and 13832 edges.

We received 5 submissions for the composers graph, including several high-quality submissions with movies, graph analysis, and specialized tools. The winning submission came from Remus Zelina, Sebastian Bota, Siebren Houtman, and Robert Ban (Meurs, Romania). The submission was comprised of an A0 poster of the graph's largest connected component (see Fig. 3) with 2743 nodes and 13769 edges, a dynamic web page that allowed one to browse and analyze the graph, as well as a movie showing the dynamic web page in action. For many of the nodes, photos of the corresponding composers were added. The underlying graph layout was mainly computed using force-directed techniques. The layout revealed several modules (shown in different colors[1]) corresponding to specific eras like Renaissance and Baroque, or genres like Russian composers and troubadours.

[1] This is only easily visible on the electronic version.

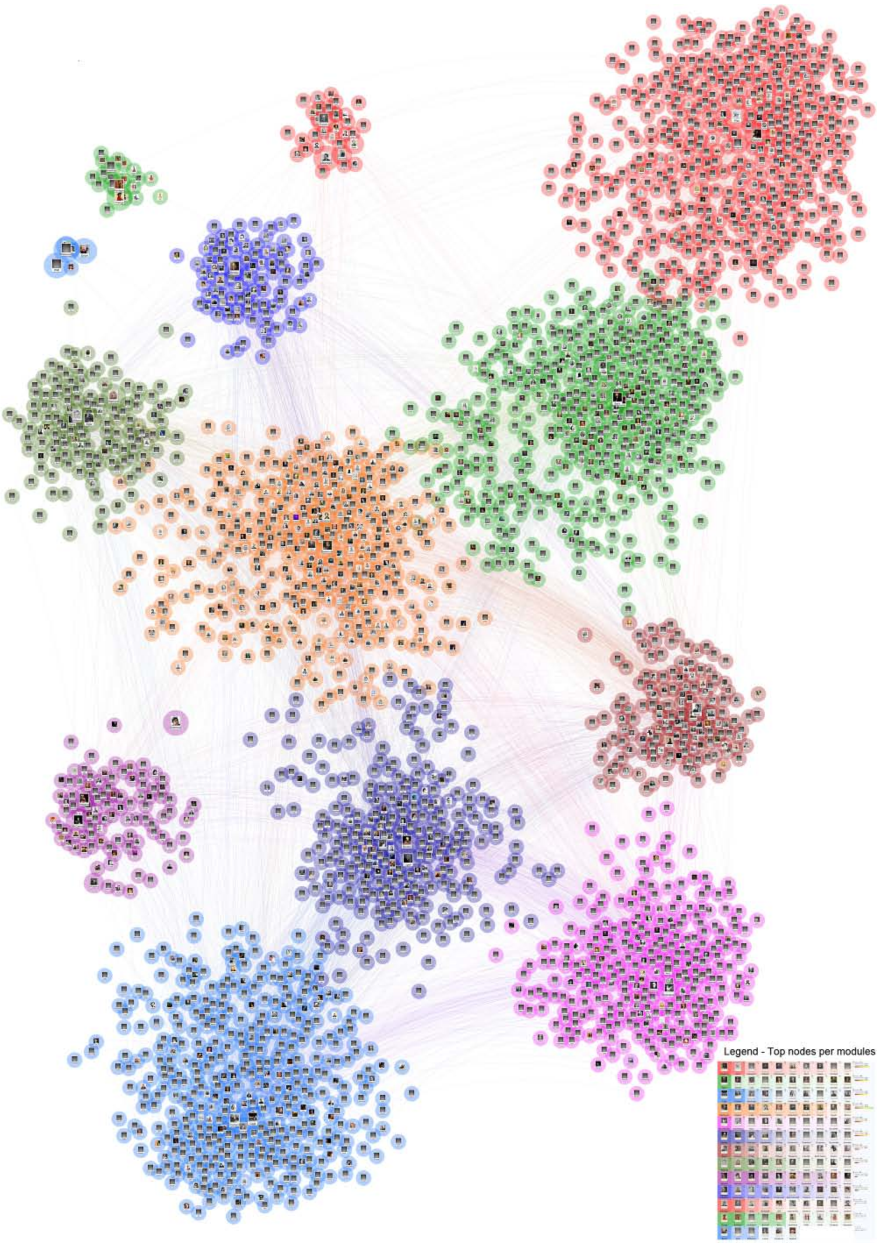


Fig. 3. First place, Composers Graph

4 Graph Drawing Challenge

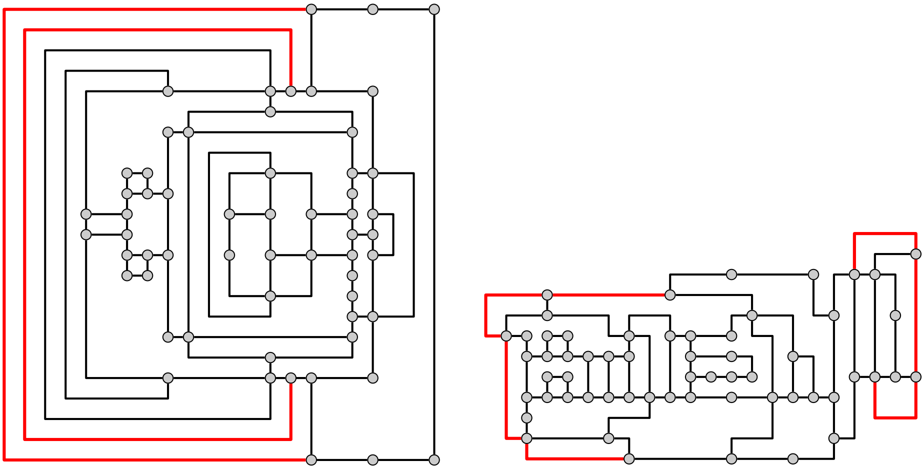
The online challenge, which took place during the conference, dealt with minimizing the longest edge in a planar orthogonal grid drawing. The longest edge can be a bottleneck for many applications; hence, minimizing its length is important. The challenge graphs were planar and had at most four incident edges per node. The task was to place nodes and edge bends on integer coordinates so that the edge routing is orthogonal and the layout contains no crossings or overlaps. At the start of the one-hour on-site competition, the contestants were given six graphs with an initial legal planar layout with very long edges. The goal was to rearrange the layout to reduce the length of the longest edge. Only the length of the longest edge was judged; other aesthetic criteria, such as the number of edge bends or the area, were ignored.

The contestants could choose to participate in one of two categories: *automatic* and *manual*. To determine the winner in each category, the scores of each graph, determined by dividing the longest edge length of the best submission in this category by the longest edge length of the current submission, were summed up. If no legal drawing of a graph was submitted (or a drawing worse than the initial solution), the score of the initial solution was used.

In the automatic category, contestants received graphs ranging in size from 59 nodes / 85 edges to 1532 nodes / 2296 edges and were allowed to use their own sophisticated software tools with specialized algorithms. Manually fine-tuning the automatically obtained solutions was allowed. Six teams were rated in this category (2 manual teams accidentally solved the automatic graphs and were rated in both categories). The two top-scoring teams used the OGDF [3] graph drawing library for obtaining an initial solution using flow-based bend minimization and compaction techniques combined with their own heuristics to optimize the solution. With a score of 5.05, the winner in the automatic category was Sergey Pupyrev from Ural State University.

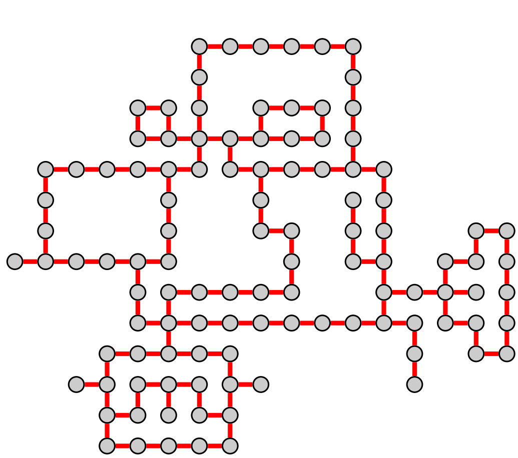
The 14 manual teams solved the problems by hand using IBM's *Simple Graph Editing Tool* provided by the committee. They received graphs ranging in size from 9 nodes / 17 edges to 150 nodes / 186 edges. Three of the larger input graphs were also in the automatic category, and the best manual teams scored similar (for two graphs) and better (for one graph) than the automatic teams. With a score of 3.82, the winner in the manual category was the team of Maarten Löffler from UC Irvine and Martin Nöllenburg from Karlsruhe Institute of Technology who found the best results for three of the six contest graphs.

Fig. 4 shows the initial layout and the best automatically obtained result of one challenge graph with 120 nodes and 146 edges. Fig. 5 shows the challenge graph used in both categories for which the manual teams found a better solution than the automatic teams (longest edge length one compared to two obtained by the automatic teams). Finally, Fig. 6 shows the only graph for which the judges know a better solution than the best solution found during the contest (6 compared to 11 found by the team of Till Bruckdorfer and Philip Effinger from Tübingen University). This graph was only used in the manual category.



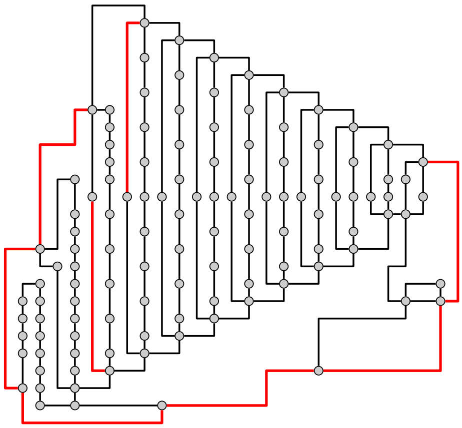
(a) initial (b) best automatic

Fig. 4. Challenge graph with 59 nodes and 85 edges: (a) initial layout (longest edge length: 52) and (b) best automatic result obtained by Sergey Pupyrev (longest edge length: 6)

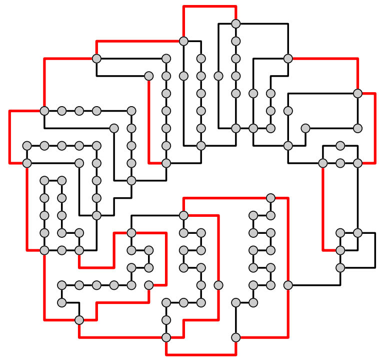


(a) best automatic (b) best manual

Fig. 5. Challenge graph with 110 nodes and 118 edges: (a) best automatic result by team Gronemann, Mallach, and Schmidt (longest edge length: 2) and (b) best manual result by team Löffler and Nöllenburg (longest edge length: 1)



(a) best found



(b) best known

Fig. 6. Challenge graph with 118 nodes and 144 edges: (a) best solution found by team Bruckdorfer and Effinger with longest edge length 11 and (b) best known result with longest edge length 6

Acknowledgments. The contest committee would like to thank the generous sponsors of the symposium and all the contestants for their participation. Further details including submitted videos and winning images can be found at the contest website, `http://www.graphdrawing.de/contest2011/results.html`.

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