Graph Drawing Contest Report

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Abstract. This report describes the 17th Annual Graph Drawing Contest, held in conjunction with the 2010 Graph Drawing Symposium in Konstanz, Germany. 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 challenge and the online challenge. The offline challenge had three categories: two dealt with edge routing and one was a mystery graph. The data sets for the offline challenge were published months in advance, and contestants could solve and submit their results before the conference started. For the two edge routing categories, the supplied data sets had nodes with fixed positions and nonzero dimensions. The task was to produce an aesthetic routing of the edges using bends or splines. For the mystery graph data set, the task was to determine the meaning of the graph and to produce a suitable drawing.

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

Overall, we received 25 submissions: 9 submissions in the offline challenge and 16 submissions in the online challenge.

2 Edge Routing - Circuit Diagram

The first data set for the edge routing challenge was a circuit diagram of the Apple II+ Video Signal Generator [1]. It consists of 48 nodes and 84 edges. The sizes and positions of the nodes were approximately the same as in the original

Fig. 1. First place, Circuit Diagram

drawing, except that the original drawing had some node duplicates that were removed from the challenge data set.

The winning submission, from Quan Nguyen from the University of Sydney (Figure 1), used an orthogonal routing style, which is very common for circuit diagrams. The layout was produced using yEd [5] by parametrizing the automated layout with a very large crossing penalty. The layout was then tuned by a few manual adjustments for multiedges.

3 Edge Routing - Author Collaboration Graph

The second data set for the edge routing challenge was the author collaboration graph of the graph drawing community. The 362 nodes represent the authors of select papers published in the graph drawing community. When several people coauthored a paper, edges were created between each pair of authors of that paper, yielding 942 edges. Papers with only a single author do not contribute to the set of edges and were removed from the data. The data was obtained from GDEA [2] for the years 2004 – 2010. The graph contains one big connected component, representing the core graph drawing researchers who have collaborated significantly over the years, and several smaller components from authors from other research communities that probably only occasionally contribute to the graph drawing literature.

The submitted work of Quan Nguyen and Seok-Hee Hong from University Sydney must be honorably mentioned. They analyzed the graph semantically using centrality and k-core techniques to produce confluent drawings. They were

Fig. 2. First place, Author Collaboration Graph, (a) overview and (b) detail

able to detect strongly connected researchers as well as highly connected research groups and could even reverse engineer the related papers from the given data (which contains only information about the authors, not about the papers directly).

However, the winning and most visually pleasing layout (Figure 2) was submitted by Sergey Pupyrev from Ural State University using an edge bundling technique similar to [3]. This layout avoids overlaps between nodes and edges completely and reduces the number of edge crossings.

4 Mystery Graph

The mystery graph was a small bipartite graph with 49 edges. One node set was labeled A to G, and the other node set was labeled 0000 to 1001. Besides delivering an aesthetic drawing, the task was to determine the meaning of the data. Not all submissions found the correct answer that it represents the mapping of the 10 digits, labeled in binary form, to a seven-segment display.

The winning submission came from Michael Baur, Martin Siebenhaller, Roland Wiese and Thomas Wurst from yWorks. Since a straight-forward layout was very unclear due to the relatively large number of edges, they used a dependency analysis to obtain a simpler display. The representation of some digits include other digits. For example, the segments for digit 7 contain all segments of digit 1, and digit 8 requires all seven segments hence contains all other digits. Figure 3a shows these dependencies. To minimize the edge paths by taking advantage of these dependencies, edges were routed to (one of) the nodes of their contained digits whenever possible. The final layout (Figure 3b) was obtained through yFiles [5] by using the orthogonal layout algorithm for the digit nodes while the segment nodes were placed manually, and an orthogonal edge router to combine routes to bundles.

Fig. 3. First place, Mystery Graph

5 Online Challenge

The online challenge, which took place during the conference, dealt with minimizing the longest edge in a planar orthogonal 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 participate in one of two categories: *automated* and *manual*. In the automated category, contestants received graphs ranging in size from 69 nodes / 101 edges to 3070 nodes / 4604 edges and were allowed to use their own sophisticated software tools with specialized algorithms. Only one team (Petra Mutzel and Hoi-Ming Wong from TU Dortmund) submitted results in this category and hence was the winner. They submitted only results for the four smallest graphs, which were computed with the tool *Gryphon*, a graph editor based on the OGDF [4] graph drawing library. They applied standard orthogonal graph drawing algorithms for minimizing the number of bends in the drawing, followed by advanced flow-based orthogonal compaction techniques. Notice that the overall optimization goal of this approach is not minimizing the length of the

Fig. 4. Challenge graph with 120 nodes / 146 edges. (a) The initial layout. (b) The best (and optimal) manually obtained result by team Löffler/Nöllenburg, with longest edge length 1.

Fig. 5. The best automated result of the same graph as in Fig. 4 by team Mutzel/Wong, with longest edge length 16

longest edge; however, this approach usually leads to short edges. In addition, their bend minimization procedure used a special option which forces two 180 degree angles on nodes of degree two if this does not increase the number of

bends. Though this leads to aesthetically pleasing drawings in many cases, it appears to be a bit counter-productive for this contest, since inserting clever “bends” at degree-2 nodes seems to be a basic requirement for achieving short edges (compare manual results in figure 4 with figure 5).

The 15 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 4 nodes / 6 edges to 190 nodes / 284 edges. Two of the larger input graphs were also in the automated category, and the best manual teams scored similar and better than the automated submissions. To determine the winner among the manual teams, the scores of each graph, determined by dividing the longest edge length of the best submission by the longest edge length of the current submission, were summed up. With a score of 4.78, the winner was the team of Maarten Löffler from UC Irvine and Martin Nöllenburg from Karlsruher Institut für Technologie who found the optimal results for four of the six contest graphs.

Figure 4 shows the initial layout and the best manually obtained result of one contest graph with 120 nodes and 146 edges. Figure 5 shows the best automated result of the same graph, since it was used in both the manual and the automated category. For the largest graph in the manual category, we know of a solution with the longest edge having length 13 (Figure 6a), but the best solution found by the manual teams was only 19 (Figure 6b).

Fig. 6. Challenge graph with 190 nodes / 284 edges. (a) A solution with longest edge length 13. (b) The best result, found during the contest, with longest edge length 19.

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References

1. Gayler, W.: The Apple II Circuit Description. Sams Technical Publishing (1983)
2. GDEA. Graph drawing e-print archive, <http://gdea.informatik.uni-koeln.de/>
3. Nachmanson, L., Pupyrev, S., Kaufmann, M.: Improving layered graph layout with edge bundling. In: GD 2010 (this proceeding), Springer, Heidelberg (2010)
4. OGDf. The open graph drawing framework, <http://www.ogdf.net>
5. yWorks, <http://www.yworks.com>