Graph Drawing Contest Report

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Abstract

This report describes the 31st Annual Graph Drawing Contest, held in conjunction with the 32nd International Symposium on Graph Drawing and Network Visualization (GD'24) at TU Wien, Vienna, Austria. The mission of the Graph Drawing Contest is to monitor and challenge the current state of the art in graph-drawing technology. This year's edition featured two categories, a creative track in which participants visualized a dataset based on the Olympic medal track-record of countries and a live challenge held at the conference where participants had to draw a graph on a given point-set with as few crossings as possible.

2012 ACM Subject Classification Human-centered computing → Graph drawings; Human-centered computing → Visualization systems and tools; Human-centered computing → Visual analytics

Keywords and phrases Information Visualization, Graph Drawing Contest

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1 Introduction

Following the tradition of the past years, the Graph Drawing Contest was divided into two parts: the *creative topic* and the *live challenge*.

As in the 2023 edition, the creative contest focused on only one dataset this year. In this year the topic was *Medals Won by Countries at the Olympic Games*: The data consisted of countries and their gold, silver, and bronze medals won per category of sports. Additionally, the contestant had access to a wide set of metadata which we describe below. The data set was published about half a year in advance, and contestants submitted their visualizations before the conference started.

The live 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 one hour to submit their highest scoring drawings. As is tradition, this year's topic was repeated from the last year: given an undirected simple graph and a point set, find straight-line drawing of the graph with the vertices drawn on top of the points such that the number of crossing edges is minimized.

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Overall, we received 33 submissions: 9 submissions for the creative topics and 24 submissions for the live challenge (17 manual and 7 automatic).

2 Creative Topic

The dataset for the Creative Topic represents countries participating and their medals won at the modern Olympic games since 1896 and until 2020. In the final dataset each country formed a vertex and was connected via an edge to a category of sports if it ever won any medal in a discipline contained in that category. The categories we chose were:

- Athletics
- Boating
- Equestrian
- Fighting
- Gymnastics
- Racquet
- Shooting
- Swimming
- Teams
- Other

Similar to the directly preceding contests we decided to keep a large set of metadata attached to each edge. In contrast though, we explicitly asked contestants to formulate a question or hypothesis about the data and try to answer or explore it with their visualization.

Vertices came with an `id` and `name`. The ones representing countries additionally contained a feel `noc` with the international abbreviation of that country. Every edge had a large record connected to it containing the following information for each medal won by the country in this category:

```
{
    "athlete": {
        "name": "<NAME OF ATHELETE>",
        "sex": "<MALE OR FEMALE>",
        "born": "<DATE OF BIRTH yyyy-mm-dd>",
        "height": "<HEIGHT IN cm OR na IF NOT AVAILABLE>",
        "weight": "<WEIGHT IN kg OR na IF NOT AVAILABLE>"
    },
    "sport": "<OLYMPIC SPORT>",
    "event": "<NAME OF EVENT>",
    "year": "<YEAR OF THE RESULT>",
    "city": "<CITY>",
    "medal": "<MEDAL TYPE>"
}
```

The total graph had 163 vertices and 700 edges.

The raw data forming the basis of the dataset was taken from a Kaggle repository.[1] Using Python scripts we formed the categories mentioned above and extracted the final dataset.

[1] `https://www.kaggle.com/datasets/josephcheng123456/olympic-historical-dataset-from-olympediaorg/data`

The general goal of the creative topic was to visualize the dataset with complete artistic freedom, and with the aim of answering a question or hypothesis about the data which the contestants were free to form themselves. For inspiration we provided examples on the contest website:

Temporal. How has the graph structure evolved over time with each Olympic event? Are there any noticeable changes in the graph's topology across different Olympic years?

Comparative. How do the subgraphs of male and female athletes differ in terms of structure and connectivity?

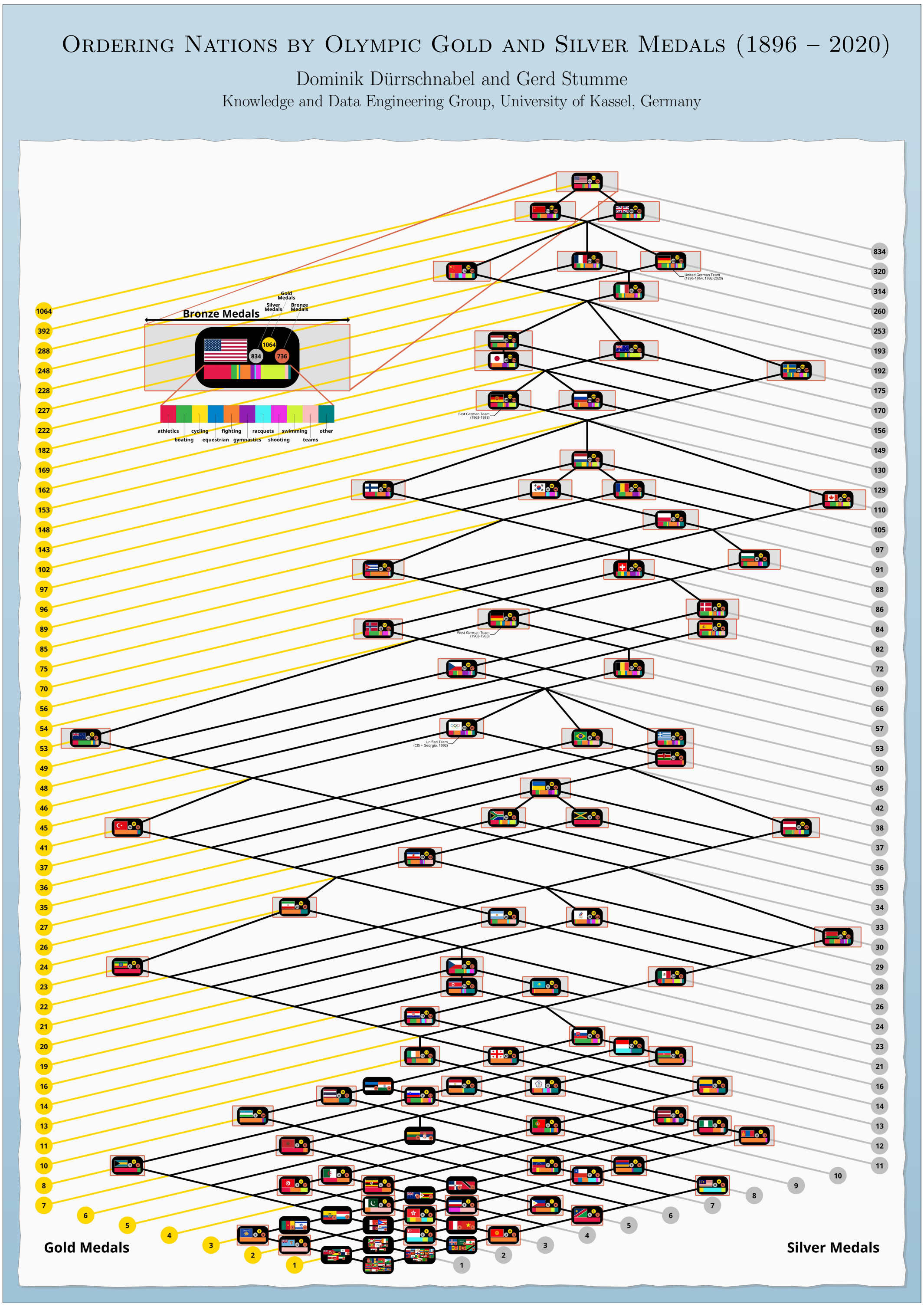
Clustering. Can clusters or communities of countries with similar Olympic success profiles be identified within the graph? Are there distinct communities within the graph based on geographical or cultural similarities? For instance, are countries that excel in swimming close to the sea?

We received 9 submissions for the creative challenge. Submissions were evaluated according to four criteria:

1. readability and clarity of the visualization,
2. aesthetic quality,
3. novelty of the visualization concept, and
4. design quality.

We noticed overall that it is a complex combination of several aspects that make a submission stand out. These aspects include but are not limited to the understanding of the structure of the data, investigation of the additional data sources, applying intuitive and powerful data visual metaphors, careful design choices, combining automatically created visualizations with post-processing by hand, as well as keeping the visualization, especially the text labels, readable. We selected the top six submissions before the conference, which were printed on large poster boards and presented at the Graph Drawing Symposium. We also made all the submissions available on the contest website in the form of a virtual poster exhibition. During the conference, we presented the top six submissions and announced the winners. For a complete list of submissions, refer to `https://www.graphdrawing.org/gdcontest/2024/results/`.

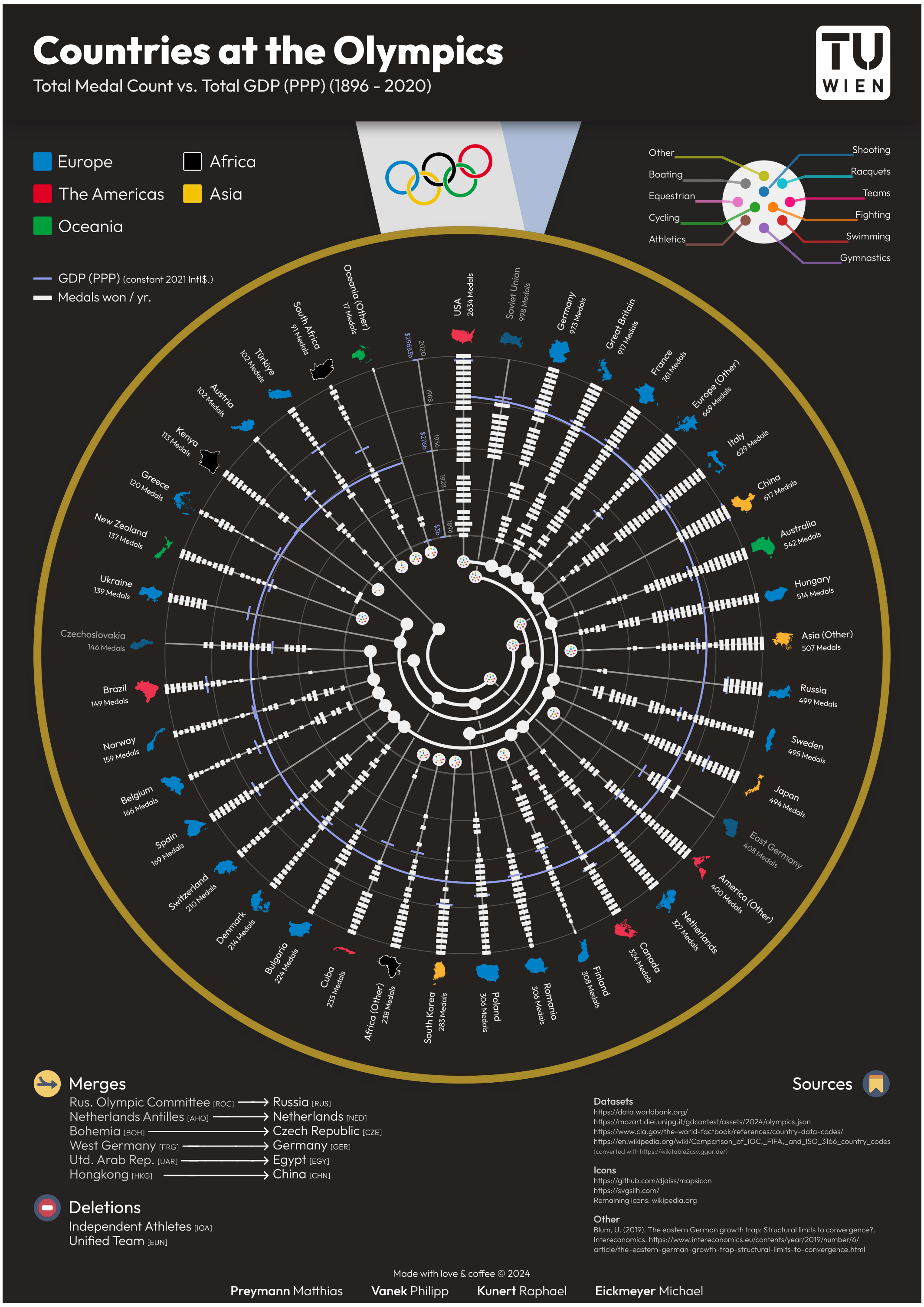
3rd Place: Dominik Dürrschnabel and Gerd Stumme (University of Kassel)



This submission stood out for its unique interpretation of the data: With no universal metric available to rank nations, based on the medals they won, this submission suggests to use a partial ordering of the nations. The result is a drawing that has many properties of a classic Hasse diagram. The contest committee appreciates that even with the abundance of meta data to visualize, this submissions' focal point is a drawing with nodes and links.

> “Our submission uses order as the guiding principle to rank nations based on their gold and silver medal counts, ensuring a two-dimensional layout. Each nation is represented by a pill-shaped dot containing its flag, medal tally, and a scarf plot showing the distribution of medals across sports. Bronze medals are indicated by the width of a box surrounding each nation's pill. This approach is an application of formal concept analysis, which is applied to compute the ranking.”
> *D. Dürrschnabel and G. Stumme*

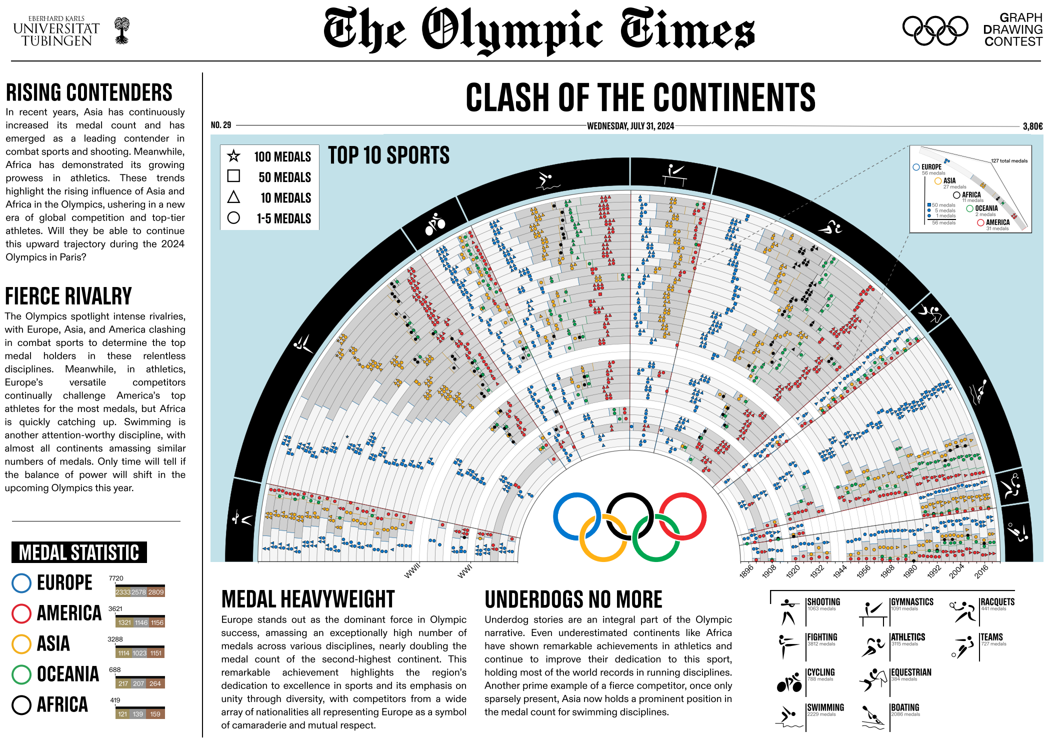
2nd Place: Matthias Preymann, Philipp Vanek, Michael Eickmeyer, and Raphael Kunert (TU Wien)



The committee found that this submission was of excellent visual quality and appreciated the idea of contrasting GDP and medals at Olympia. The radial style makes the drawing intuitive and well legible without sacrificing space. The small hypergraph visualization in the center is nice and the committee found it well executed, but would have liked it to be integrated better and maybe more prominently into the visualization. The committee also found that the GDP data could have been better focused or put in a more interesting relation as the medal count is given per year, but the GDP isn't.

> “Our poster is shaped by our main design decision to use a radial figure which emulates a medal. The large amount of data prompted combining countries and regions, which was further guided by taking various geopolitical events into account. By overlaying the medal count timeline with a GDP regression spiral, clear trends can be observed. Finally, to incorporate the full bipartite nature of the input graph, a very compact country-category mapping is included in the center.”
> *M. Preymann, P. Vanek, M. Eickmeyer, and R. Kunert*

1st Place: Hoang An Nguyen, Nico Martin, Jannik Brandstetter, and Micha Fauth (University of Tübingen)



The committee valued the graphical choices of this submission. The presentation and execution of the idea of a newspaper article as a drawing point works well and the small articles are interesting to read. The visualization itself is well executed. It is arguably more reduced than the preceding contenders, but it accomplishes it goals cleanly and with good ideas to overcome the challenge of presenting a very dense dataset. The committee thinks that the glyphs used for the amounts of medals won could have been improved by more coarse categories, removing them for too small amounts, or actually using none at all as the diagrams are for the most part sufficient in communicating the amounts.

> “The goal of our visualization is to offer users an intuitive and visually engaging way to understand the data without sacrificing key information. At first glance, it provides a high-level overview of the “Clash of the Continents,” highlighting which ones excel in specific sports categories. As viewers explore further, the visualization reveals more granular details, such as absolute figures, providing clear reference points for better understanding and comparing performances across countries. Maintaining a cohesive design was also essential, leading us to choose a newspaper theme to emphasize the timeliness and relevance of the topic, particularly in light of the upcoming Paris Olympics 2024, further enhancing reader engagement.”
>
> *H. An Nguyen, N. Martin, J. Brandstetter, and M. Fauth*

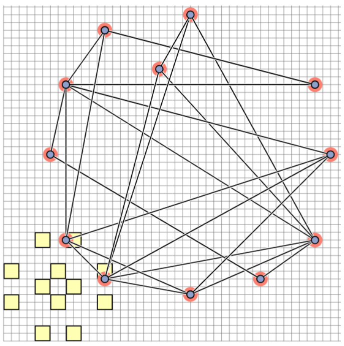
3 Live Challenge

The live challenge took place during the conference and lasted exactly one hour. During this hour, local participants of the conference could take part in the manual category (in which they could attempt to draw the graphs using a supplied tool: `http://graphdrawing.org/gdcontest/tool/`), or in the automatic category (in which they could use their own software to draw the graphs). As in the last year, we allowed everybody in both categories to participate remotely. To coordinate the contest, give a brief introduction, answer questions, and give participants the possibility to form teams, we were kindly provided with both a room in the conference building, and a Zoom stream for the conference. A small bug emerged during the contest related to the submission system. The contest committee determined that the manual category could best be evaluated by each team sending a screenshot. The automatic category turned out to be not affected afterall. The error has by now been found and corrected.

The challenge focused on placing the vertices of an undirected simple graph on a given point set with the goal to minimize the edge crossings in the resulting straight-line drawing. We allowed for points of the point set to be collinear and for vertices to lie on top of edges. For each proper crossings we added one to the quality measure and for each vertex-edge overlap we added n to the quality measure where n was the number of vertices. Embedding vertices at fixed or constraint locations is a researched topic in information visualization and graph drawing often with a focus on achieving plane drawings. With this challenge we hope to point to the possibility in this topic to also look at classic quality measures, such as edge crossings.

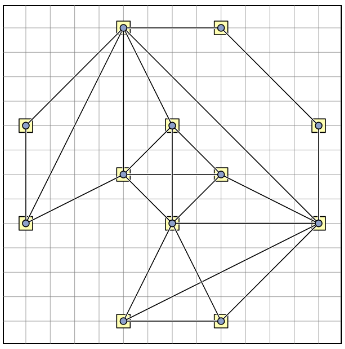
3.1 The Graphs

In the manual category, participants were presented with seven graphs. These were arranged from small to large with the exception of the last graph and chosen to contain different types of graph structures. In the automatic category, participants had to draw the same seven graphs as in the manual category, and in addition another eight larger graphs. Again, the graphs were constructed to have different structures.

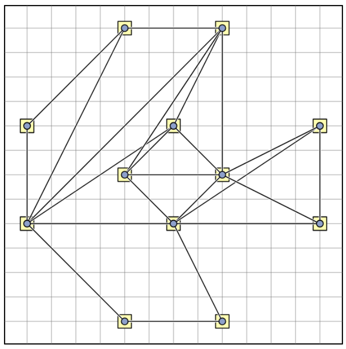


Provided drawing

invalid drawing



Best manual solution
ThePointless
2 crossings



Best automatic solution
Graph Gladiators
2 crossings

For illustration, we include below the third graph, where the contestants were given a planar graph plus one edge on a symmetric pointset. The best manual and automatic solutions managed to find drawings with 2 crossings. While the best manual and automatic solutions reached the same number of crossings, the manual ones show on average a better and clearer embedding of the graph on the pointset. For example in the drawings we show below, the automatic solution has a worse angular resolution around the vertices than the manual one.

This example fits into similar observations throughout the past years. The committee sees repeatedly that manual (human) drawings of graphs display a deeper understanding of the underlying graph structure than automatic and therefore gain in readability. Moreover, on all but three of the smaller graphs the humans were able to find a solution with the same number of crossings (presumably the best possible) as the automatic solutions.

For the complete set of graphs and submissions, refer to the contest website at `https://www.graphdrawing.org/gdcontest/2024/results/`. The graphs are still available for exploration and solving Graph Drawing Contest Submission System: `https://www.graphdrawing.org/gdcontest/tool/`.

3.2 Results: Manual Category

Below we present the full list of scores for all teams. The numbers listed are the edge-length ratios of the drawings; the horizontal bars visualize the corresponding scores.

graph	1	2	3	4	5	6	7
Brokkoli	11	–	20	37	–	54	232
CrossingreDUCKtion	11	0	4	23	–	68	48
Alse	15	40	5	40	12	49	–
overenthusiastic sKITtles	11	0	4	22	12		36
NoFloodOfCrossingsPlease!	11	2	4	11	12	45	35
ChadPGP	11	0	6	31	–	56	175
CroTheSKh	11	0	5	290	12	63	49
Es gibt kein schlechtes Wetter	11	0	2	26	12	52	92
94_crossings	11	0	2	14	12	34	24
The Gronemanns	11	0	3	14	12	39	26
ThePointless	11	0	2	30	143	70	82
Localhost	15	0	4	17	12	57	31
OhneMaus	11	0	4	28	12	39	47
FPTourists	11	0	2	27	12	46	21
Power Graph Girls	11	0	8	35	12	56	26
We Made The Rules	11	0	3	27	12	45	34
Cross-Busters	11	–	7	42	–	51	100

Third place: **FPTourists**, consisting of Mathis Rocton and Vaishali Surianarayanan.

> “In this contest, we aimed to minimize edge crossings by manually rearranging the vertices of a given graph. We started by analyzing the graph's structure, identifying dense and sparse regions, and distinguishing low-degree from high-degree vertices to extract as much visual structure as possible. This gave us an intuitive understanding of the graph's shape – like connected components and symmetries – before considering the specific point set.
> From there, we worked on finding an embedding with fewer crossings and used local optimization, swapping small sets of vertices to further reduce crossings. While we didn't actually use fixed-parameter techniques, our team, humorously called the “FPTourists,” did a pretty good job of improving the graph's visual clarity!”
> *M. Rocton and V. Surianarayanan*

Second place: **The Gronemanns**, consisting of Fouli Argyriou, Mirko Wagner, and Henry Förster

> “In this year's contest, we applied a three-phase approach. The first phase, called the "Pressure phase," focused on quickly submitting solutions to assert pressure on other contestants by achieving a high score on the leader board. The second phase, known as "Drag around until no edge is colored orange," used greedy heuristics to reduce edge-vertex overlaps, which incurred penalties, though this year's instances made it easier to find solutions without overlaps. In the third phase, a vertex swap heuristic and a pattern recognition approach were employed to refine the layout. The vertex swaps iteratively improved the solution, while pattern recognition suggested macro adjustments, yielding near-optimal solutions even for the most difficult challenges.”
> *F. Argyriou, M. Wagner, and H. Förster*

Winner: **94_crossings**, consisting of Tim Hegemann and Johannes Zink.

> “We asked ChatGPT to write us a victory speech. Here is what we got: GD'24, day two, Vienna 17:45. With just the two of us, Team 94_crossings assembles once more for another exciting challenge. 17:50. Armed with geometry, strategy, and a shared birth year (but let's keep that a secret!), we dive into the vibrant contest. 18:00. Navigating through vertices and the intricate dance of crossing minimization, we remain focused on our ambition. Ending with 97 crossings – slightly above our namesake goal – the outcome is clear: another victory in a field brimming with exceptional teams. Here's to close contests and the spirit of collaboration in beautiful Vienna!”
> *T. Hegemann and J. Zink*

3.3 Results: Automatic Category

In the following we present the full list of scores for all teams that participated in the automatic category. The numbers listed are the number of crossings of the drawings; the horizontal bars visualize the corresponding scores. Given that node-edge overlaps added the number of vertices to the number of crossings relatively high numbers of crossings were present in the results.

Third place: **Baseline**, consisting of Maximilian Pfister.

> “As the title already suggests, the approach is as straightforward as you can think of: An initial (random) assignment of the vertices to the points is generated, which is consequently improved by either using a (i) "swap-operation", where the position of two vertices is exchanged, or a (ii) "replace-operation", where a vertex is moved to an unused point. Random restarts were deployed to escape local minima and new assignments were accepted in a greedy fashion, i.e., whenever they did not increase the number of crossings. The decent performance of the algorithm can be attributed to the efficient update of the number of crossings (enabled by the small local changes) which allowed to perform many iterations in a short number of time.”
> *M. Pfister*

Table 1 Results of the automatic live challenge.

Graph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Geometry	11	0	10	28	143	41	—	—	324248	—	—	—	—	—	—
Rustlings	11	0	2	9	19	37	21	2.1*E7*	2091036	1412682	26382	2.1*E7*	2820156	1.1*E7*	306049
Graph Gladiators	11	0	2	8	12	24	15	183516	307724	25309	5450	2113030	598224	831078	12619
Baseline	11	0	2	9	12	27	18	63786	334434	14886	18092	3420933	709006	1663029	13246
Irp	11	0	—	10	74	27	16	2.1*E7*	851337	119752	22559	1.75*E7*	—	—	—
OptimizationGroup2	11	0	2	46	1353	51	80	2.1*E7*	1291315	1369448	424034	2.1*E7*	3065353	1.1*E7*	2822936
OMEGA	11	0	2	8	12	24	15	4468	309244	3961	4	65486	3242986	65947	3583

Second place: **Graph Gladiators**, consisting of Philipp Kindermann, Alexander Kutscheid, and Jan-Niclas Loosen.

> “We started with an ILP formulation to solve the problem exactly, which as expected turned out to be too slow, even for the larger manual graphs; but we could solve the problem for convex point sets and double chains quickly with a specialized ILP. For the larger instances, we first created random and force-directed layouts (Tutte, Eades and FruchtermannReingold) and matched the vertices to the closest points. It turned out that FruchtermannReingold works the best, and computing a greedy matching is more effective than finding the optimum one. We then used a simulated annealing approach to move either a single vertex or a vertex plus its closest neighbors to different points. We selected the vertices to move randomly weighted by the number of edge crossings it is involved in. The main difficulty for us was to update the vertex weights and the number of crossings during the movements without recomputing them from scratch.”
> *P. Kindermann, A. Kutscheid, and J.-N. Loosen*

Winner: **OMeGA**, consisting of Julien Bianchetti, Pauline Blavy, Guilhem Gerouille, Laurent Moalic, and Dominique Schmitt.

> “The algorithm we used this year is the one we implemented for last year’s challenge, with some improvements. We generate a first embedding of the graph with the FMME algorithm from the OGDF library. Every node of the embedding is then assigned to its closest available point. Different assignments are tested, and the one providing the best score is kept. Using a simulated annealing approach, the nodes are then randomly moved to other locations. The move is always accepted if it improves the current solution. If the solution is degraded, the move is accepted with a certain probability depending on the temperature reached by the simulated annealing. The initial value of the temperature and its variations are automatically computed to be best adapted to the graph being processed. We ran our program on a 10-core CPU, simultaneously on the 15 given graphs. It crashed on graphs 3 and 13. We solved graph 3 manually and submitted graph 13 in its original version (without improvement).”
> *J. Bianchetti, P. Blavy, G. Gerouille, L. Moalic, and D. Schmitt*

4 Conclusion

The 2024 edition of the Graph Drawing Contest was again a success in participation and result. The high numbers from the 2023 edition could almost be replicated, which the committee, given that in the 2023 iteration several participants of the yWorks company were present due to an overlap in events in Sicily, values as a success. The participation in the automatic category especially was stronger the last two iterations than the iterations before. The committee nonetheless believes that some changes should be made to the format to make it even more attractive for participants from the Graph Drawing community. The manual live challenge is in a good spot the committee believes, the participation numbers are high and from talking at the conference the committee gathers that the participants enjoy the format. Finally, the creative contest has seen an increase in submissions and, arguably, overall quality in the last years. The turn to only one category made the contest more focused and targeted, the committee believes.