Hybrid Multiobjective Optimization Genetic Algorithms for Graph Drawing

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ABSTRACT

In this paper we introduce an application of multiobjective optimization with genetic algorithms to the problem of graph drawing and explore the potential contribution of the genetic algorithms for this particular problem.

Categories and Subject Descriptors

I.2.8 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search

General Terms

Algorithms, Experimentation

Keywords

multiobjective optimization, graph drawing

1. ALGORITHMS AND RESULTS

The problem we focus on for this study is building consistent graph layouts for weighted graphs, in particular following a specified geometric shape. In this paper we explore the potential use of multiobjective genetic algorithms to this problem and various implementation aspects related to it. Starting with a specific layout, we are interested in reconstructing it from the weights in the graph with no other topological information. For the purpose of this paper we chose a set of initial layouts representing the Platonic solids.

To solve this problem we propose a combination of a multi-objective genetic algorithm (GA) and force–based heuristics [1], [2]. The multi-objective GA aims to minimize the total error in the graph in terms of consistency between the weights and the vertex distances, and at the same time maximize some geometric property of the layout. The geometric criteria consist in maximizing the surface, the volume, the uniformity of the angles around each vertex, and minimizing the overlap of edges and polygons. We normalize each of these measures to obtain values within the same order of magnitude and employ a linear aggregate function with equal coefficients for each of the measures used in each case.

We performed two sets of experiments, with and without the GAs. The first one consists in 2000 iterations of the force-based methods alone. The second set consists in 2000 iterations of the GAs with an aggregate fitness combining in equal measures one of the geometric constraints and the total error, followed by 2000 iterations of the force-based tension vector algorithm. The population size was of 50 or 100, depending on the size of the graph. We used a real-encoded representation of the chromosome with the uniform crossover and a hybrid mutation inspired from the force-based heuristics.

The GAs were capable of finding an almost perfect layout for all of the Platonic solids except for the dodecahedron. Figure 1 show a comparison of the solution found by the force-based heuristics alone with the GAs for the latter. It shows that the best layout found by the GAs is still recognizable.

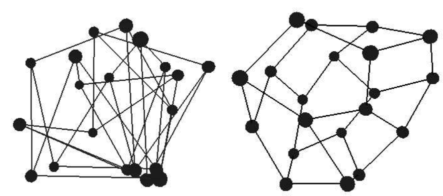

Figure 1: Dodecahedron, force-based (left) versus GA - surface maximizer (right)

In terms of consistency of the weights in the graphs with the distances between the vertices in the resulting layouts, both the hybrid GAs and the force-based heuristics were able to produce solutions with less than 1% error. In general, the surface maximizer seems to provide the best geometric results. The percentage of nearly optimal solutions vary from 70% for the octahedron to about 10% for the icosahedron, while the force-based algorithms couldn't produce solutions even close to optimal.

In conclusion, even though the force-based algorithms are faster and more efficient in terms of consistency of weights and distances in the graph, the GAs are a better approach when looking for geometric shapes that are visually pleasing or that present interesting geometric properties.

2. REFERENCES

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