Phase transition properties of clustered travelling salesman problem instances generated with evolutionary computation

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Summary

We study the effect of certain clustering properties of symmetric TSP problems on a 2-dimensional lattice. An evolutionary algorithm is developed to create problem instances that adhere to predefined properties. We look at the difficulty of solving these problem instances with Chained Lin-Kernighan.

Generating 2D maps

» Uniform randomly: creates centers randomly and places nodes randomly in a rectangle around this center.

» Evolutionary algorithm: moves points around the 2D lattice while trying to satisfy two constraints:
1. the maximum distance between nodes
2. the minimum distance between nodes.

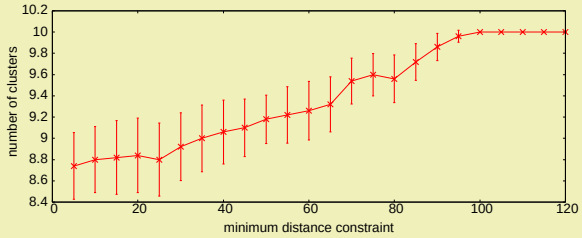
Tools

» GDBSCAN: a clustering method which does not assume the shape of clusters and which works without a predefined number of clusters.

» Chained Lin-Kernighan: solves TSP problems, where the main operator of LK is to flip a segment in a tour. This version executes the LK repeatedly where the initial tour is the result of the previous run with a small perturbation.

Robust parameter settings

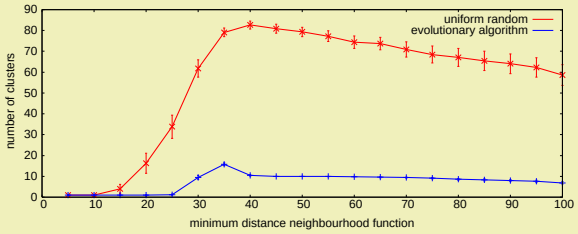
» 50 maps per setting, 95% confidence intervals.



» Using a minimum distance of 100 provides maps with 10 clusters, with a sufficient confidence.

Comparison

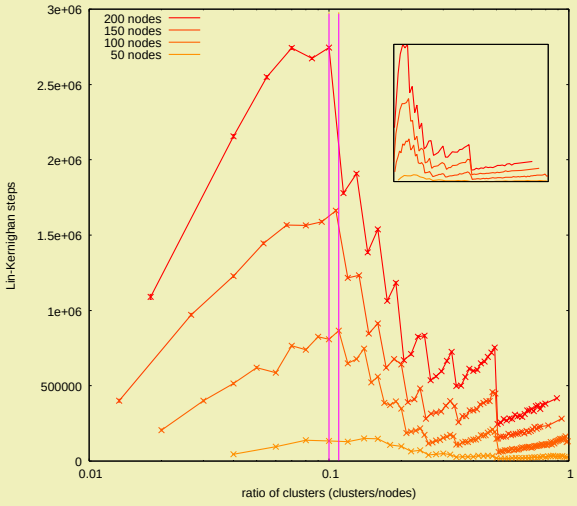
» Observing the sensitivity of the clustering method to the two problem generators.



» For uniform random, only one setting of the neighbourhood function provides the correct number of clusters. The evolutionary algorithm provides maps where the clustering is reliable.

Phase transition

» For problems of size n = {50,100,150,200}, we run Chained Lin-Kernighan on problems with different numbers of clusters (50 instances/setting).



» We observe a phase transition between the purple lines when the ratio of clusters to nodes lies between 10% and 11%.

» When the nodes are evenly distributed over the clusters, we notice peaks in the difficulty of solving these problem instances.

Conclusions

» We propose an evolutionary algorithm that can reliably provide maps with sets of clustered nodes.

» Using Chained Lin-Kernighan we show the presence of a phase transition when solving symmetric TSP problems that contain clusters.