Perlentaucher
Levels and their construction rationales

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This document briefly summarizes the levels of the Perlentaucher game. When using the data, please check the numbering of the levels: in the data table we start numbering with 0, in this document as in the game I start with 0.

1 General

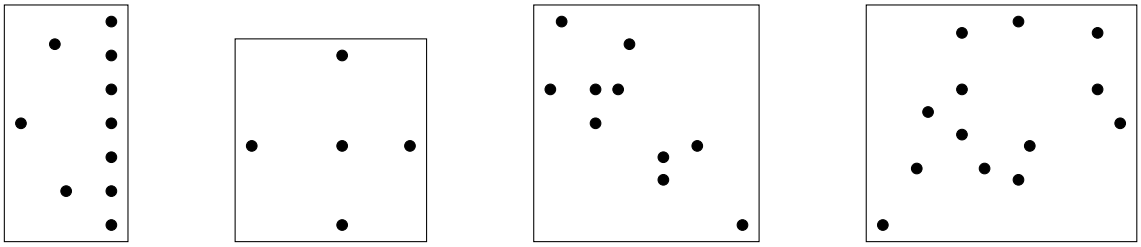
- size of field: 26×20 → max. 520 points (for Concorde: multiplication of all coordinates by 100)
- max. 5 regions

2 Levels 1–8

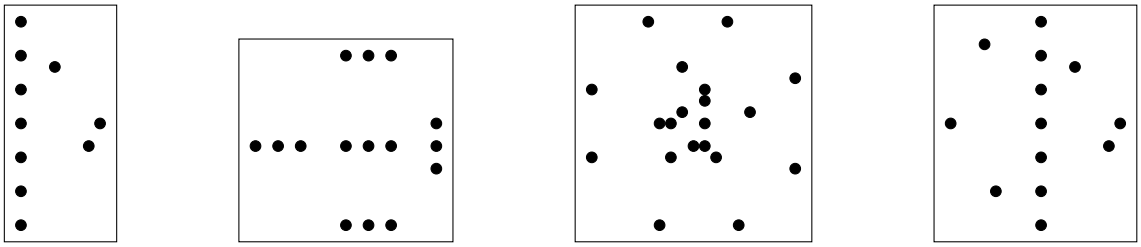
Standard TSPs without starting point

2.1 Levels

1. very simple TSP: one straight line and some points to give a triangle structure, baseline for Level 8
2. relatively simple TSP with one point in the middle, baseline for Level 6
3. randomly generated problem
4. randomly generated problem
5. "brother" of Level 1, baseline for Level 8
6. extension of Level 2: around each point in Level 2, 2 other points are arranged: in this case, clusters must be visited in different order than the order of the single points of Level 1 (which are the centers fo mass of the clusters)
7. Problem from [1] with 20 points and 12 inner points
8. combination of Levels 1 and 5, but a lot more difficult, since now the line goes straight through the problem (in the other two, the line could serve as one edge of the solution)



(a) Level 1 (b) Level 2 (c) Level 3 (d) Level 4



(e) Level 5 (f) Level 6 (g) Level 7 (h) Level 8

Figure 1: Levels 1–8: standard TSPs

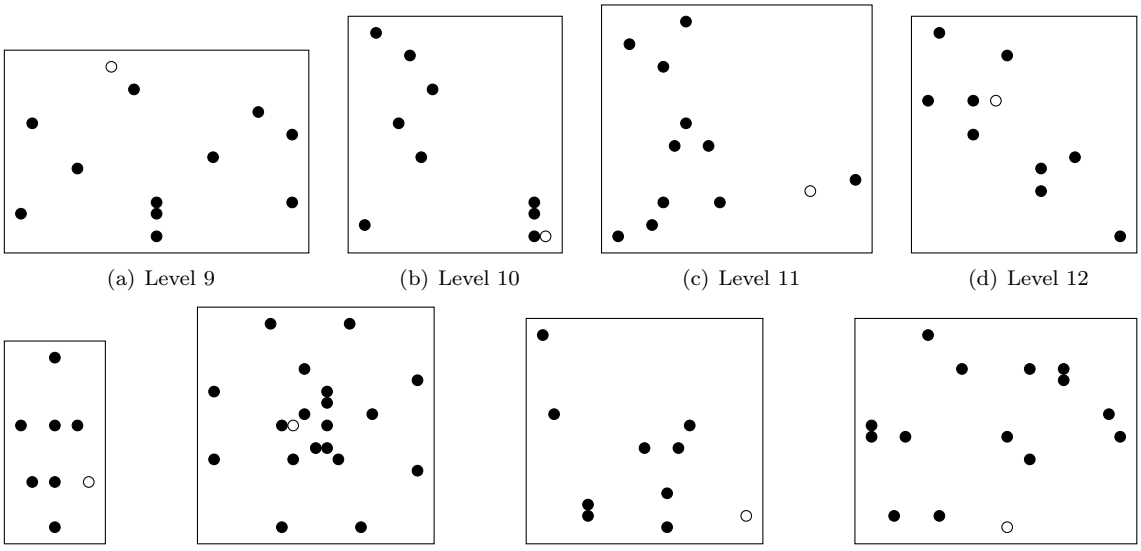
3 Levels 9–16

TSPs with given starting point

9. randomly generated problem with random starting point
10. randomly generated problem with frequently used starting point (determined in previous tests)
11. randomly generated problem with random starting point
12. same as Level 3 with rarely chosen starting point (determined in previous tests)
13. constructed problem in which cluster strategy (obviously) leads to suboptimal results
14. same asLevel 7 with rarely chosen starting point (determined in previous tests)
15. randomly generated problem with occasionally chosen point at the edge (convex hull) of the problem (determined in previous tests)
16. randomly generated problem with random starting point

4 Level 17–24

Points have different colors, so that regions can be indicated by colors



(a) Level 9 (b) Level 10 (c) Level 11 (d) Level 12

(e) Level 13 (f) Level 14 (g) Level 15 (h) Level 16

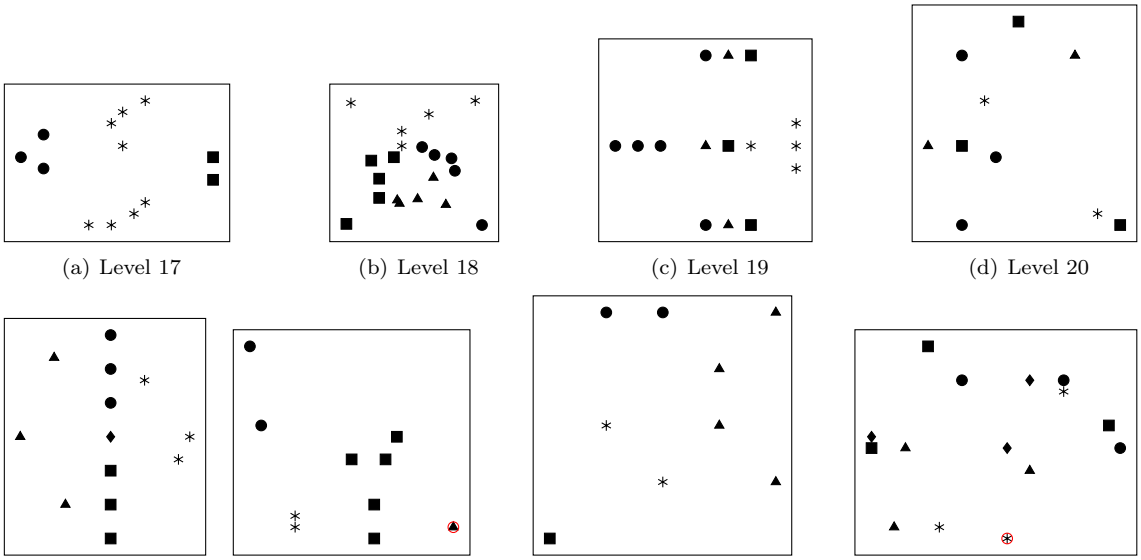
Figure 2: Levels 9–16: TSPs with start points

17. 4 clusters, colors follow clustering, but two clusters (that kind of make a nice form) are taken together and following this region information would lead to suboptimal solution
18. MacGregor-20-16: problem from [1] with 20 points, 16 inner points literature and used in previous studies; regions help to find good solutions
19. same as Level 6, but bad regions, not following clusters (which would lead to optimum)
20. randomly generated problem, regions assigned randomly
21. same as Level 8, with regions that help to find the solution
22. same as Level 14, with clusters emphasized as regions (but inadequately for shortest path); fixed starting point as in Level 15
23. problem from Wiener et al. [2], problem nn-inadequate-10; regions added here, supporting possible cluster perception, but misleading from optimum
24. same as Level 16, but random assignment of points to regions; fixed starting point as in Level 16

5 Other Remarks

5.1 Advantages of using Online Games

- (potentially) many participants



(a) Level 17 (b) Level 18 (c) Level 19 (d) Level 20

(e) Level 21 (f) Level 22 (g) Level 23 (h) Level 24

Figure 3: Levels 17–24: TSPs with given regions

- repeated attempts to same problem
- indirect "access" to player strategies by using special features/tokens (whatever they are called ...)

5.2 Disadvantages/Constraints of Online Games

- fixed order of problems (seems to be ok for TSP, since there seems to be no learning, not even for already solved problem)
- direct comparisons (e.g. with/without start point, with/without regions, rotations) are limited, because players may get bored when they have to solve the same problems all over again

References

[1] J.N. MacGregor and T. Ormerod. Human performance on the traveling salesman problem. *Perception & Psychophysics*, 58(4):527–539, 1996.

[2] J.M. Wiener, N.N. Ehbauer, and H.A. Mallot. Planning paths to multiple targets: memory involvement and planning heuristics in spatial problem solving. *Psychological Research*, 73:644–658, 2009.