Label placement

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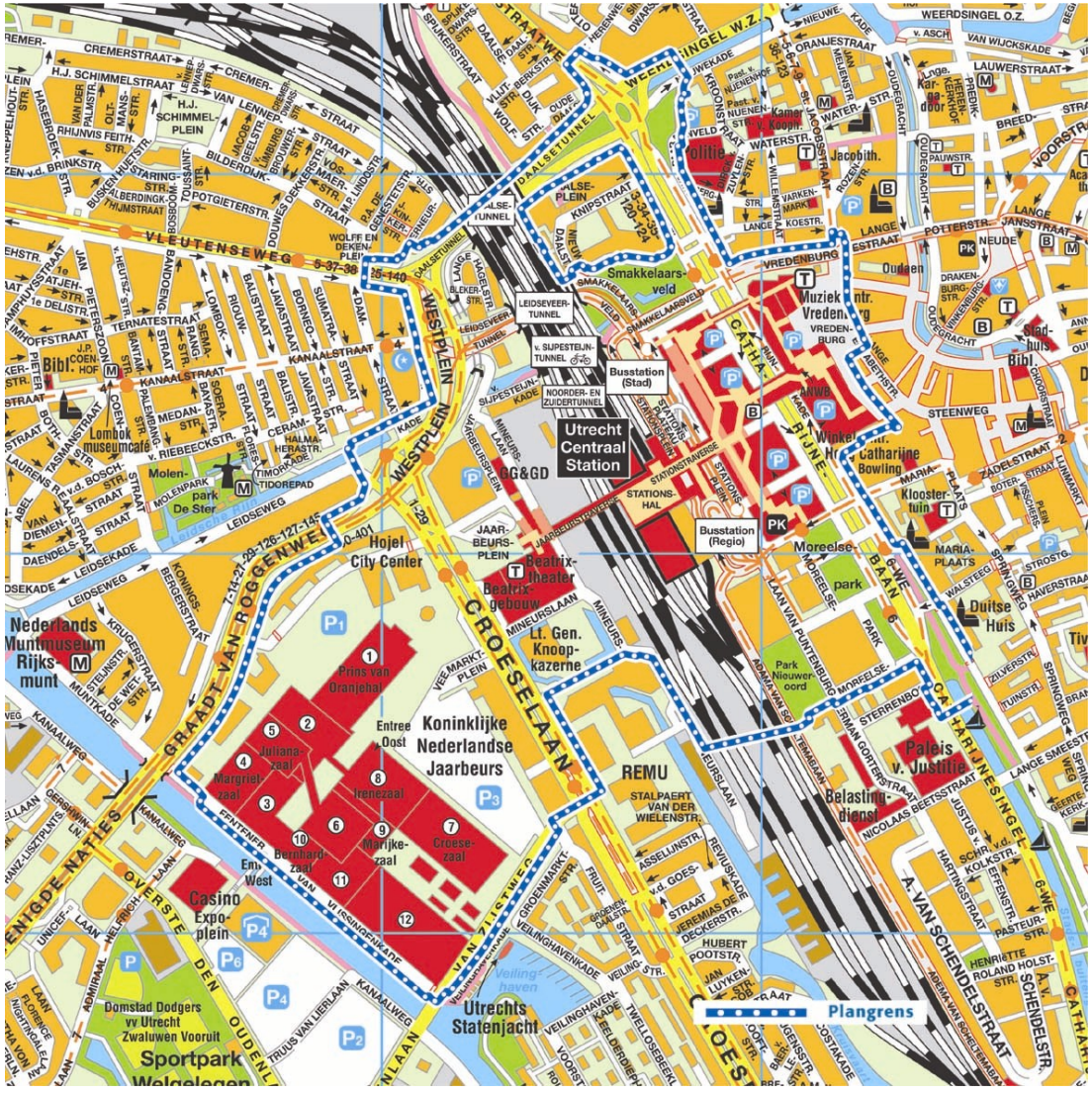
The city of Utrecht



A random generated country

What is label placement?

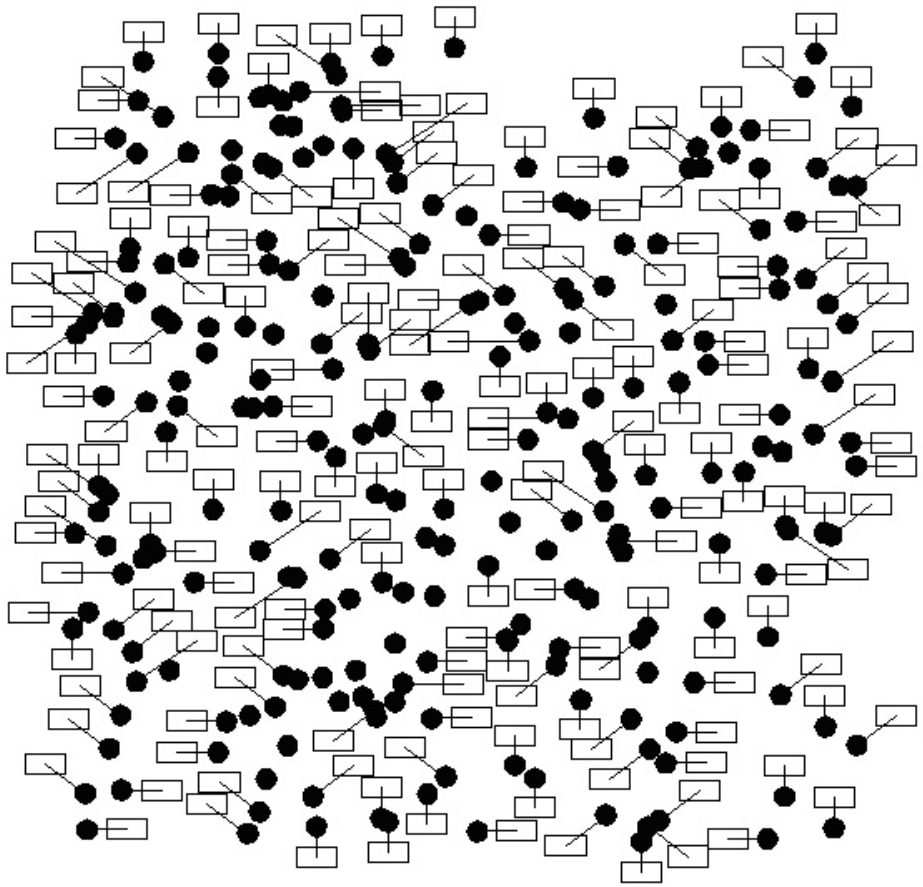
Label placement in general

- Given features on a map and the labels that belong to these features, place the labels near the features without labels overlapping other labels or overlapping features on the map
- Even nowadays label placement is often done by hand
- An expert will place about 20 to 30 labels on a map per hour [2]

Point labeling

1 / 3 categories

- Point labeling



Line labeling

2 / 3 categories

- Point labeling
- Line labeling

Area labeling

3 /3 categories

- Point labeling
- Line labeling
- Area labeling

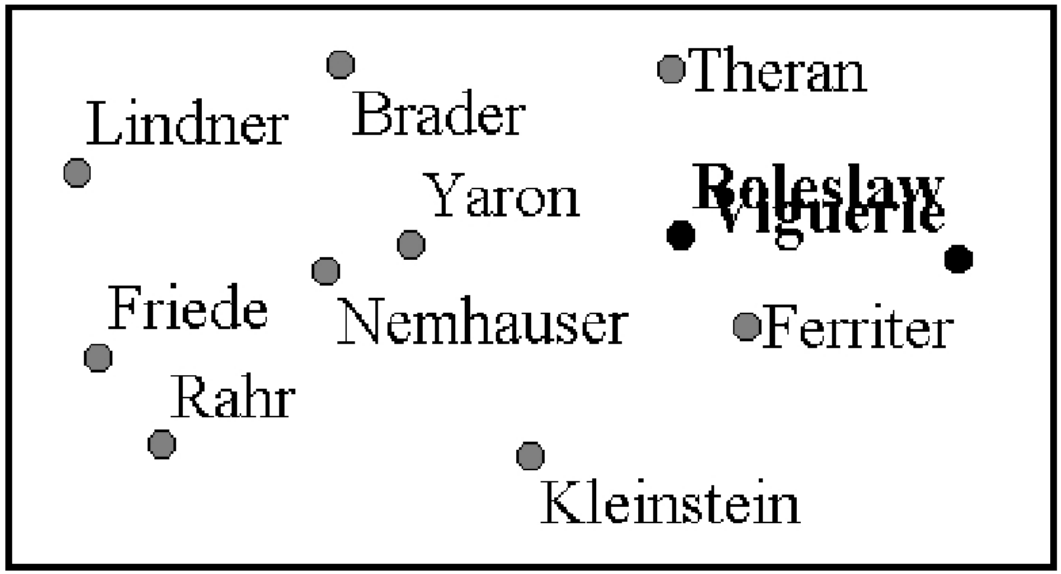
Overal label placement rules

Label placement rules defined by Imhof and Yoeli

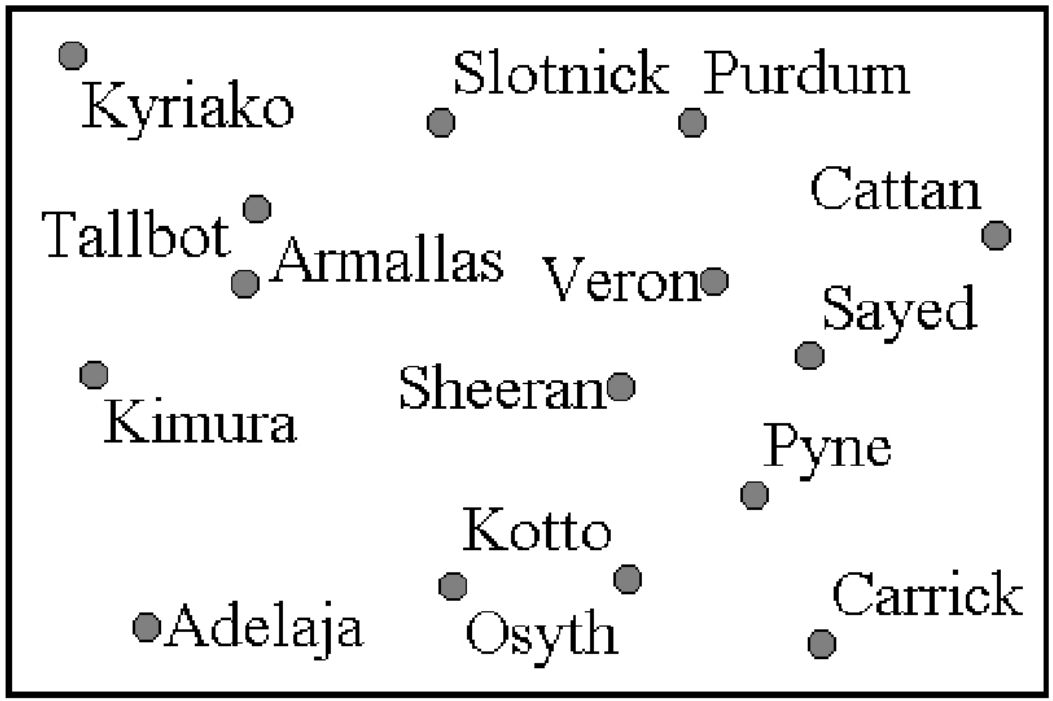
There are three important basic rules about label placement:

- Readability: labels must have legible sizes
- Unambiguity: each label must be easily identified with exactly one graphical feature
- Avoidance of overlaps: labels should not overlap with other labels or other graphical features

Overlap


Lindner
Brader
Theran
Yaron
Roleslaw
Friede
Nemhauser
Ferriter
Rahr
Kleinstein

Ambiguity


Kyriako
Slotnick
Purdum
Cattan
Tallbot
Armallas
Veron
Sayed
Kimura
Sheeran
Pyne
Kotto
Carrick
Adelaja
Osyth

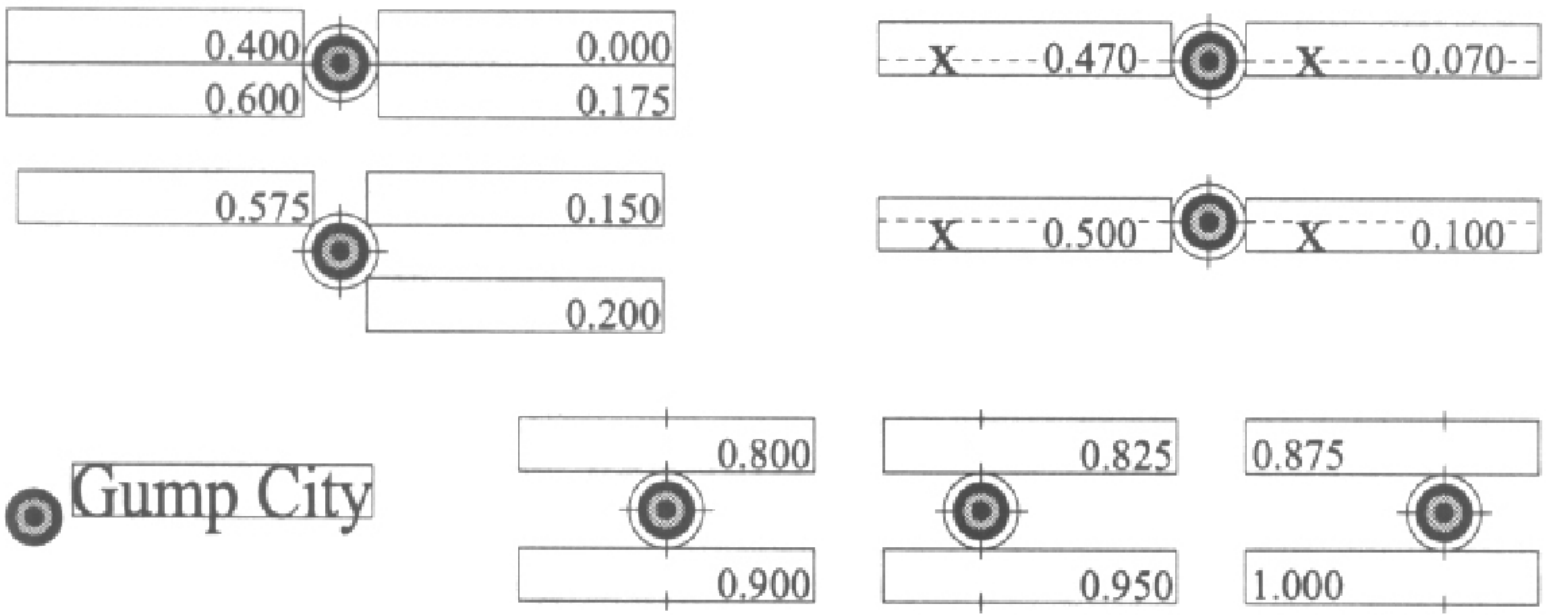
Point label placement rules

Some of Imhof's guidelines [5]

- Label positions to the right are preferred to those on the left
- Labels above a point are preferred to those below
- The further a label is placed from it's point, the less favoured it is

Point label placement rules

The smaller the value of a label position the more favoured it is:

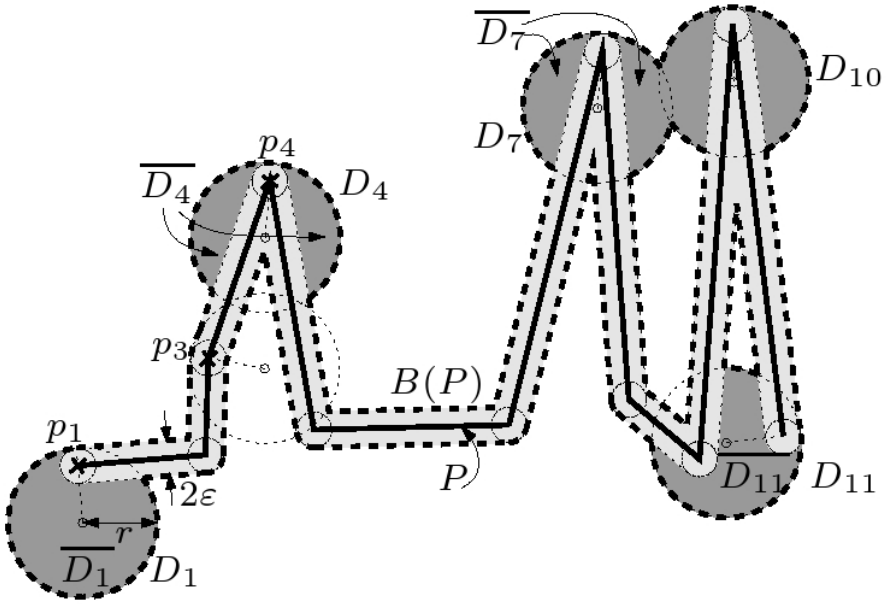


Line label placement rules [1]

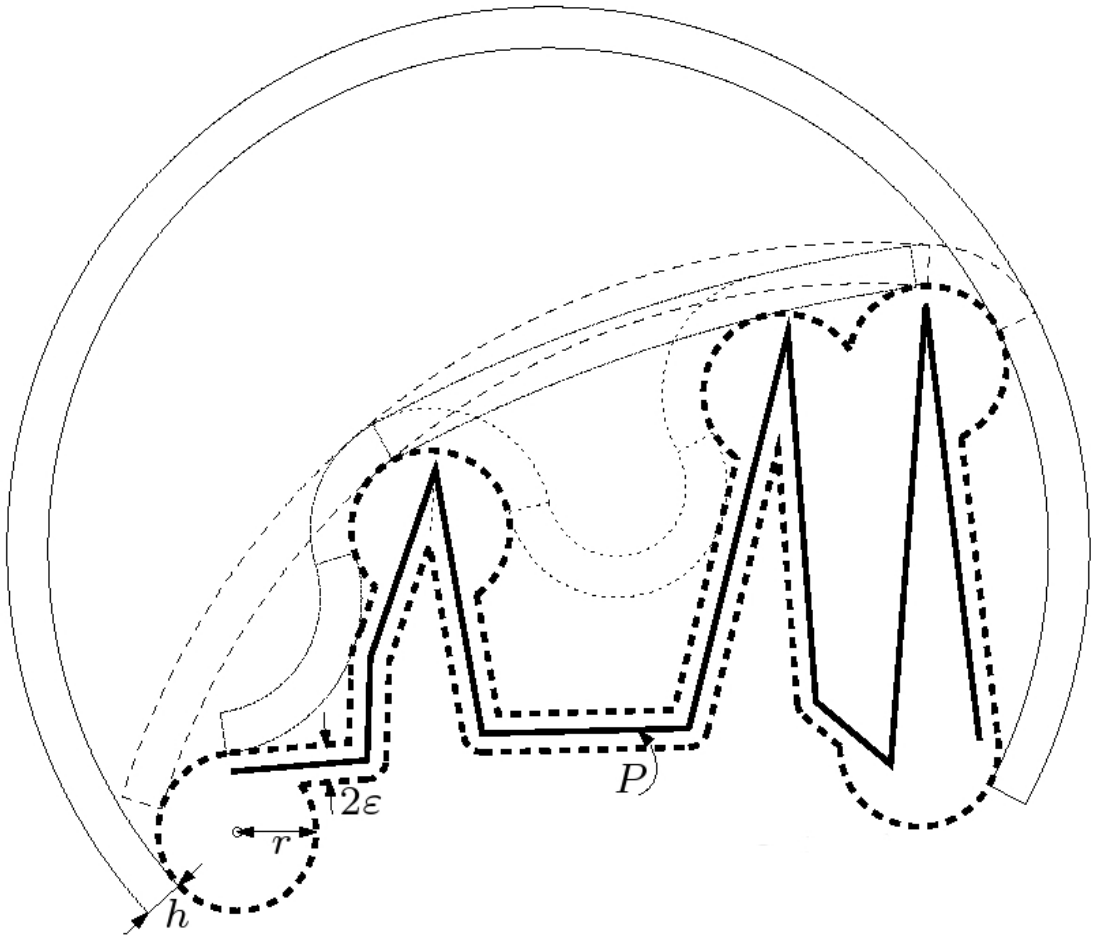
Hard constraints on line label placement

- A label must be placed at least at some distance ϵ from the polyline
- The curvature of the curve along which the label is placed is bounded from above by the curvature of a circle with radius r
- The label must neither intersect itself nor the polyline

Line label placement rules (curvatures)



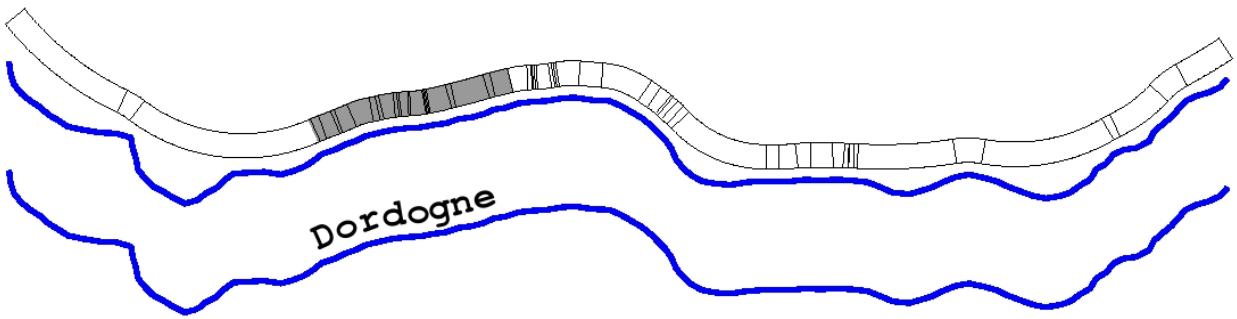
Line label placement rules (curvatures)



Line label placement rules

Soft constraints on line label placement

- A label should be close to the polyline it belongs to
- A label should have few inflection points
- A label should be placed as straight as possible
- A label should be placed as horizontally as possible



Area label placement rules

Some guidelines

- A label must not cross the borders of the area it belongs to
- It must be clear what the total area is
- A label must not conflict with any other label or area feature

NP-complete

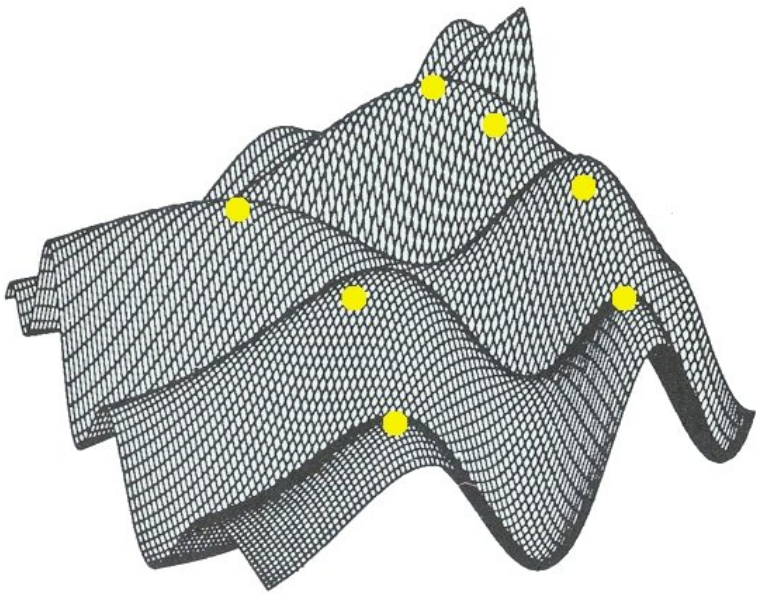
Point labeling is NP-complete

- Point labeling is the most difficult of the three label placement problems
- Problem: decide if a label placement is possible with no overlap
- When more constraints added the problem becomes even harder
- Formal proof can be found in 'The computational complexity of cartographic label placement' [6]

Approximation algorithms

Often used in approximation algorithms

- Imhof's point values
- Search space
- Objective function (overlaps, unlabeled points, a priori preferences)



Approximation algorithms

Computational costs vs. result

When choosing an algorithm it is important to decide on the computational cost / result problem.

Most familiar algorithms

- Random placement
- Exhaustive search algorithms
- Greedy algorithms
- Local search algorithms
- Stochastic search (Simulated annealing)
- Overlap vectors
- Mathematical programming
- Genetic algorithms

Approximation algorithms

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Exhaustive algorithms

Why should we use them?

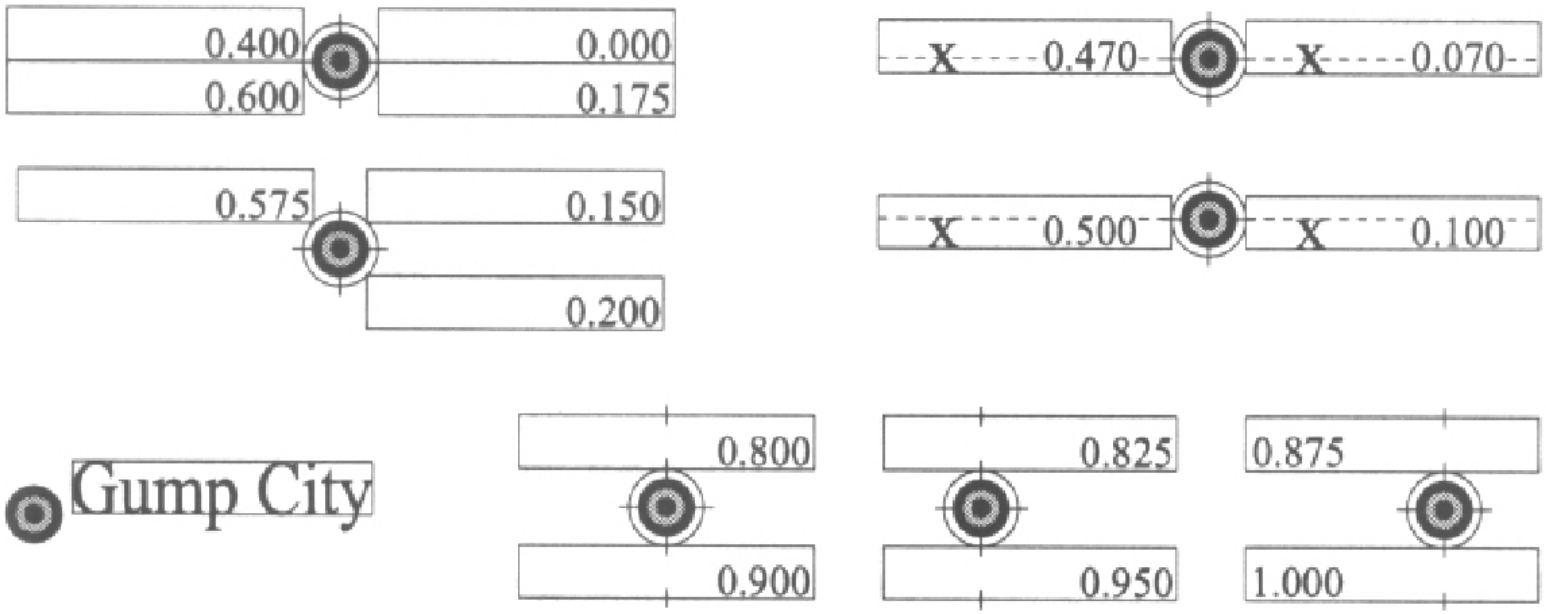
- If there is an unobstructed labeling possible, it will be found
- It can take ages, especially when there is a large search space. Unless of course, $P = NP$
- Heuristics are available to improve the performance of backtracking

Greedy algorithms

Greedy algorithm step by step

- For each point on the plane, place it's label on one of the free positions. This can be done according to Imhof's suggestions
- When there is no free position at a point:
  1. Leave the point out (only if *point selection* is allowed)
  2. Label the point even though an overlap comes into existance
  3. Ask feedback from a human expert [7]

Greedy algorithms



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Greedy algorithms

Evaluation of greedy algorithms

- When little features are present (a sparse map) these algorithm might work fine
- Greedy algorithms will outperforme exhaustive search algorithms with regards to the computational cost
- Greedy algorithms will be totally outperformed by exhaustive search algorithms with regard to the results
- These algorithms, however, can be used as a first step in other algorithms with improvement steps

Local search algorithms

Local search step by step

1. Get a (randomly generated) labeling of the features
2. Repeat until no further improvement is possible:
   1. For each feature consider moving the label to each of the alternative positions
   2. For each such repositioning calculate the change in the objective function
   3. Implement the single label repositioning that has the best improvement

Local search algorithms

Problems with the local search algorithms

- High runtimes, even when the objective function can be calculated smart
- It cannot escape from local minima

Local minimum example

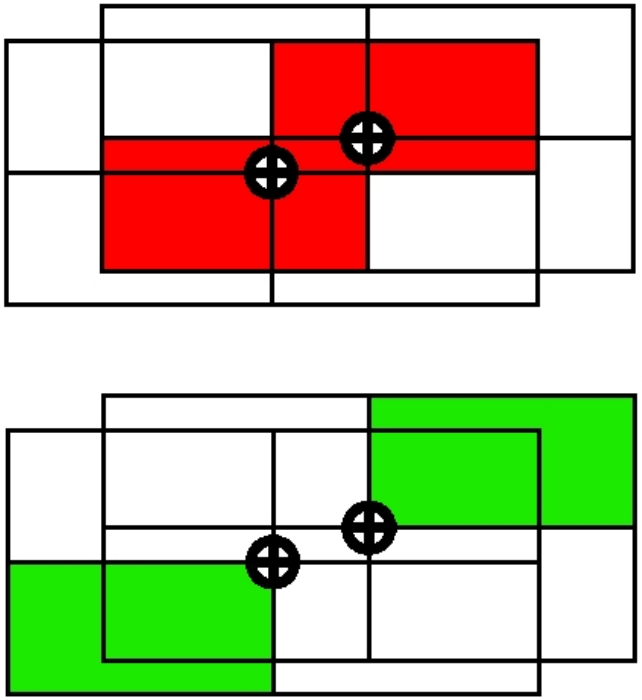

Figure: In the objective function only the label-label overlaps are counted: the global minimum is not reachable

Local minimum example

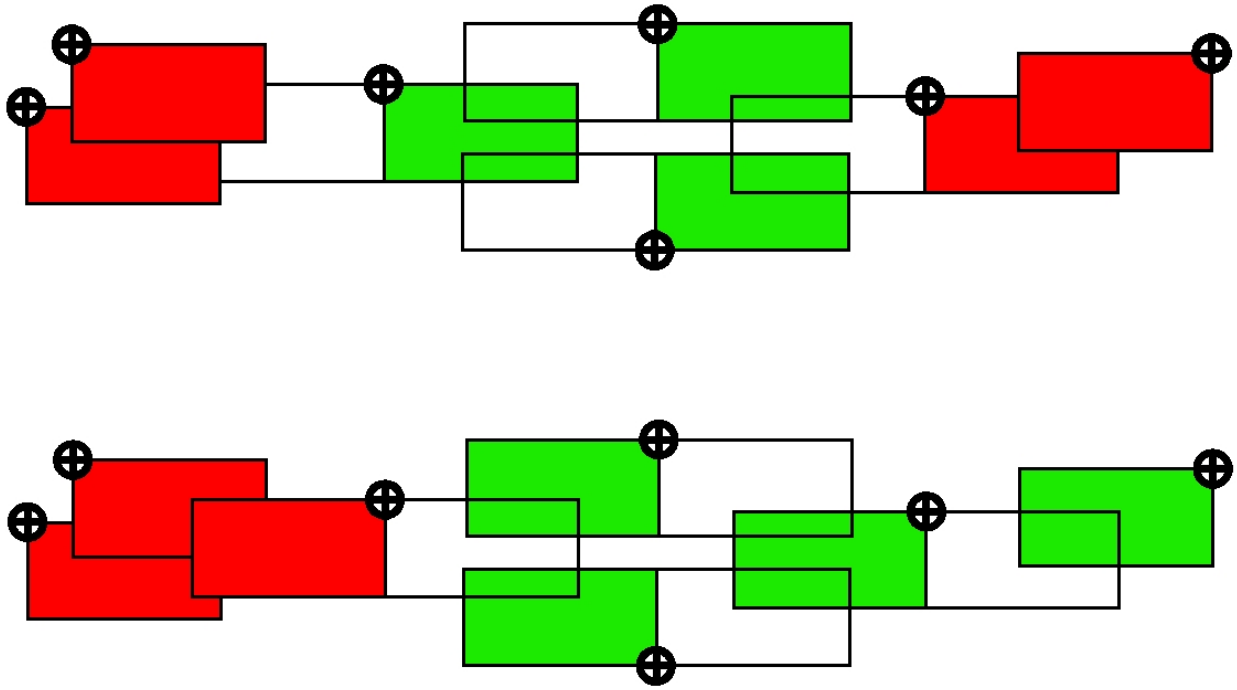

Figure: Again, the global minimum cannot be reached

Optimisations of local search algorithms

Tabu search

Tabu search is an advanced local search algorithm. This will yield in better results.

Simulated annealing

Simulated annealing is most of the time not considered to work well with problems, but in the case of the labeling problem it works pretty good.

Conclusions up until now: Random placement

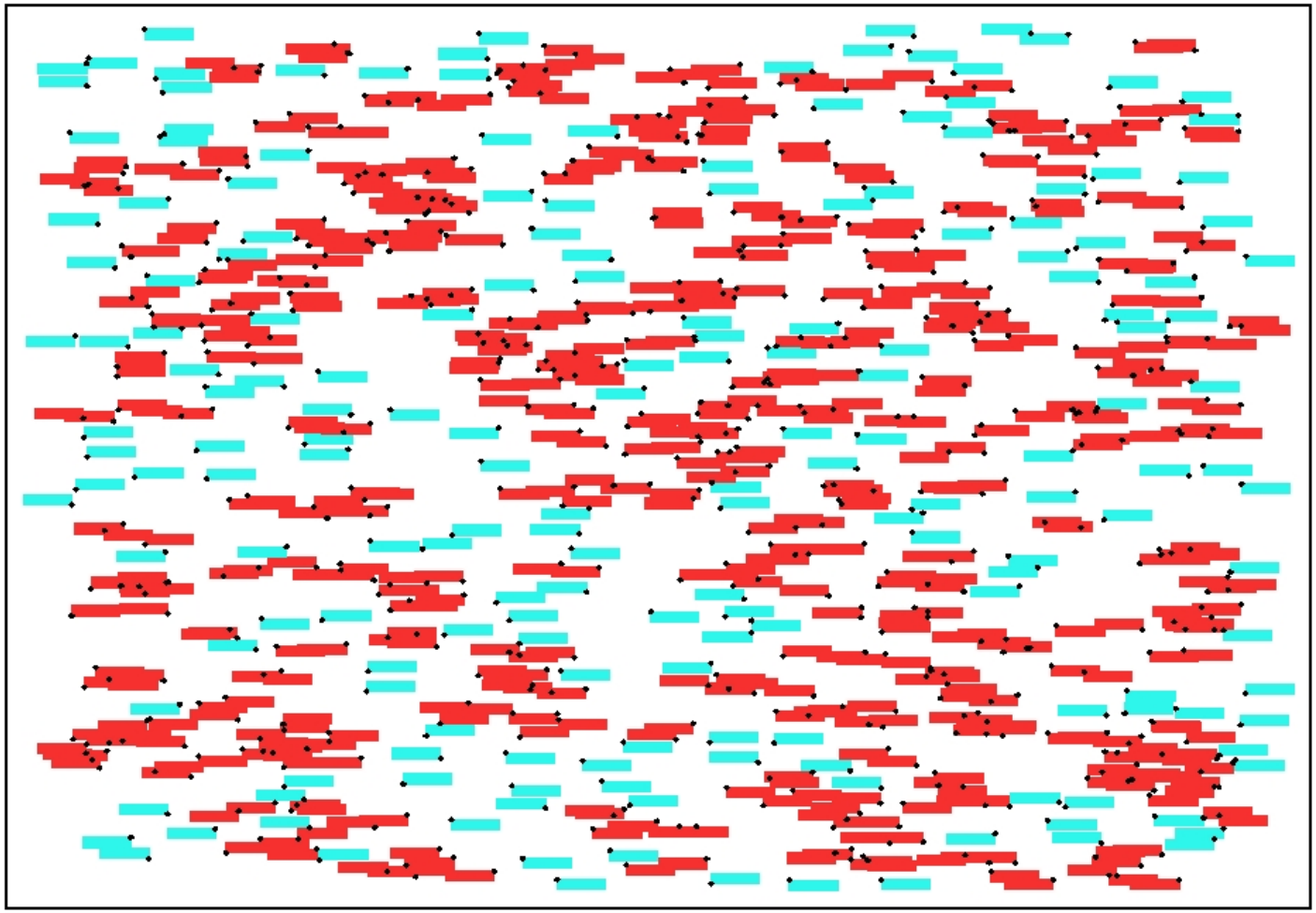

Figure: Random placement results in 564 overlapping labels

Conclusions up until now: Greedy algorithm

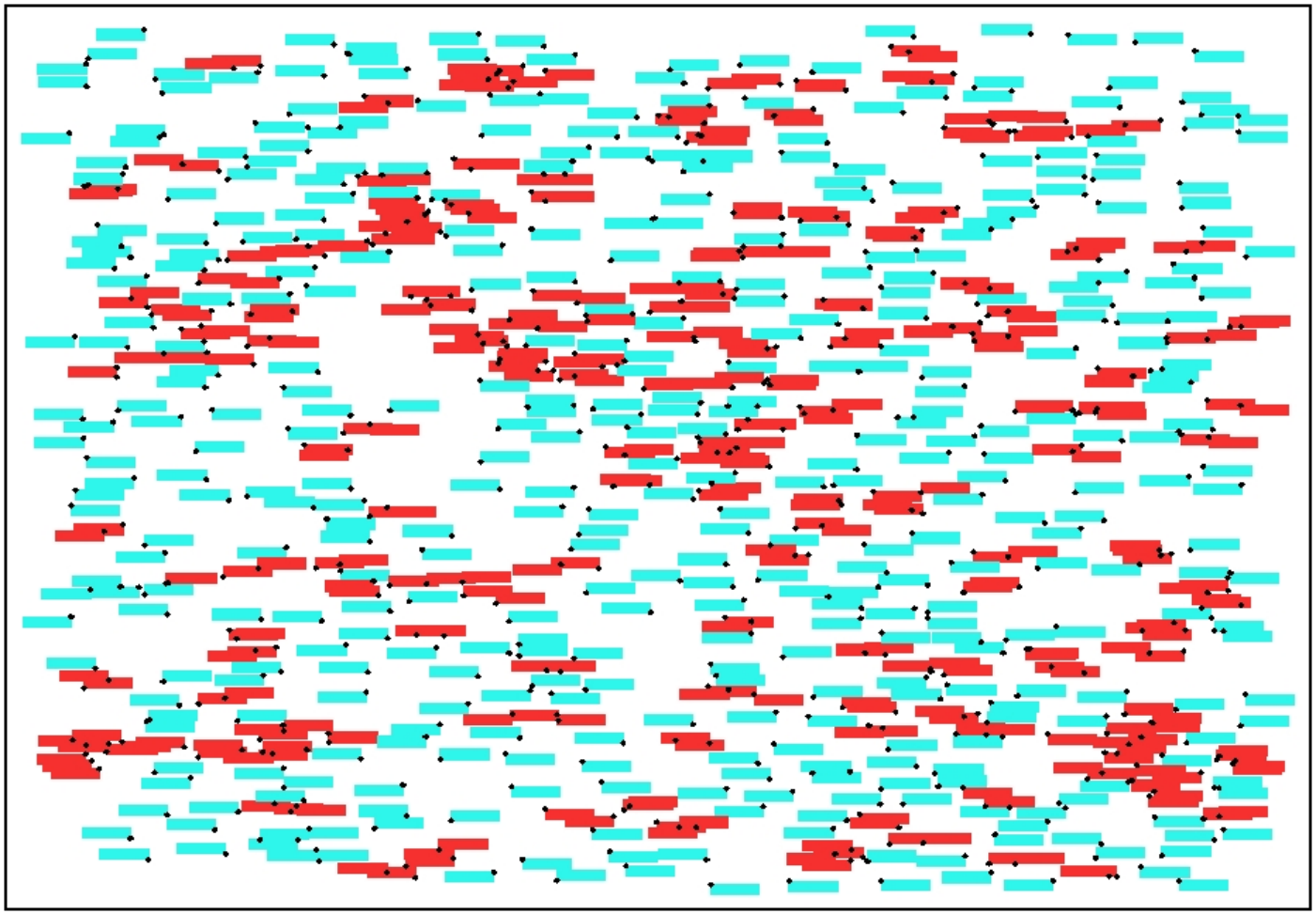

Figure: Greedy placement results in 341 overlapping labels

Conclusions up until now: Local search algorithm

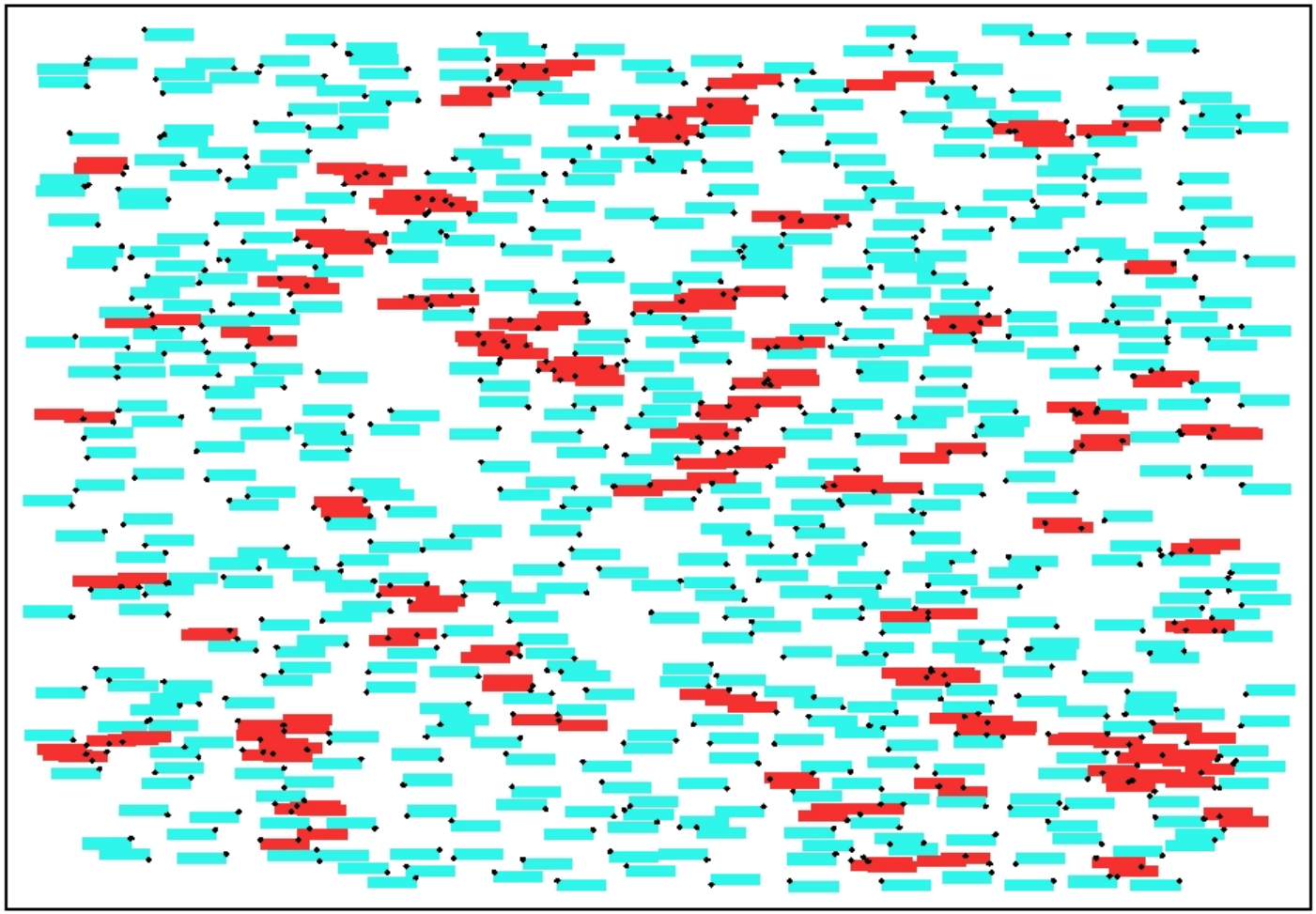

Figure: Local search results in 222 overlapping labels

Conclusions up until now

- Label placement is an NP-complete problem
- A lot of approximation algorithms are described in the literature
- The simple approximation algorithms do not work well considering either the computational costs or the quality of the result
- Other algorithms work better, like Simulated annealing or maybe even genetic algorithms

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