LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Lehrstuhl für Datenbanksysteme und Data Mining
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Managing Massive Multiplayer Online Games

Tutorial 20.06.2018

HMM: Evaluation / Detection

The Hidden Markov Model (HMM) $M = \{S, B, D, F\}$ with $S = \{A, B, C\}$, $B = \{\clubsuit, \heartsuit, \spadesuit\}$ is given.

$$D = \begin{pmatrix} \times & - & A & B & C \\ - & 0 & 1/3 & 1/3 & 1/3 \\ A & 1/4 & 1/4 & 1/4 & 1/4 \\ B & 1/4 & 0 & 1/4 & 1/2 \\ C & 1/4 & 1/4 & 1/2 & 0 \end{pmatrix} \quad F = \begin{pmatrix} \times & \clubsuit & \heartsuit & \spadesuit \\ A & 1/4 & 3/4 & 0 \\ B & 0 & 0 & 1 \\ C & 0 & 1/4 & 3/4 \end{pmatrix}$$

- Compute the probability of the observation $\clubsuit, \heartsuit, \spadesuit$ inductively with help of the forward-variable
- Determine with help of the Viterbi-Algorithm which sequence of states most probably produced the observation $\clubsuit, \heartsuit, \spadesuit$

HMM: Evaluation / Detection - Forward-Variable

$$\alpha_A(1) = 1/3 \cdot 1/4 = 1/12$$
$$\alpha_B(1) = 0$$
$$\alpha_C(1) = 0$$

$$\alpha_A(2) = 1/12 \cdot 1/4 \cdot 3/4 = 1/64$$
$$\alpha_B(2) = 1/12 \cdot 1/4 \cdot 0 = 0$$
$$\alpha_C(2) = 1/12 \cdot 1/4 \cdot 1/4 = 1/192$$

$$\alpha_A(3) = 1/64 \cdot 1/4 \cdot 0 + 1/192 \cdot 1/4 \cdot 0 = 0$$
$$\alpha_B(3) = 1/64 \cdot 1/4 \cdot 1 + 1/192 \cdot 1/2 \cdot 1 = 5/786$$
$$\alpha_C(3) = 1/64 \cdot 1/4 \cdot 3/4 + 1/192 \cdot 0 \cdot 3/4 = 3/1024$$

$$\Rightarrow P(\clubsuit, \heartsuit, \spadesuit) = \alpha_A(3) \cdot d_{A,-} + \alpha_B(3) \cdot d_{B,-} + \alpha_C(3) \cdot d_{C,-} = 29/12288$$

HMM: Evaluation / Detection - Viterbi

Determine with help of the Viterbi-Algorithm which sequence of states most probably produced the observation ♣, ♡, ♠

$$\delta_A(1) = d_{-,A} f_{A,\clubsuit} = 1/12 \qquad \psi_A(1) = 0$$
$$\delta_B(1) = d_{-,B} f_{B,\clubsuit} = 0 \qquad \psi_B(1) = 0$$
$$\delta_C(1) = d_{-,C} f_{C,\clubsuit} = 0 \qquad \psi_C(1) = 0$$

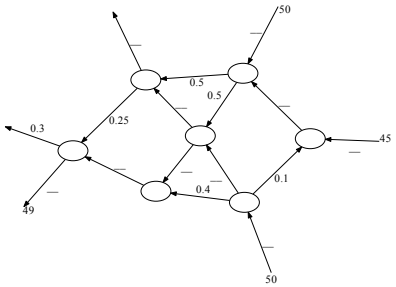
$$\delta_A(2) = \max\{\delta_A(1) \cdot d_{A,A}, \delta_B(1) \cdot d_{B,A}, \delta_C(1) \cdot d_{C,A}\} \cdot f_{A,\heartsuit} = 1/64 \qquad \psi_A(2) = A$$
$$\delta_B(2) = \max\{\delta_A(1) \cdot d_{A,B}, \delta_B(1) \cdot d_{B,B}, \delta_C(1) \cdot d_{C,B}\} \cdot f_{B,\heartsuit} = 0 \qquad \psi_B(2) = A$$
$$\delta_C(2) = \max\{\delta_A(1) \cdot d_{A,C}, \delta_B(1) \cdot d_{B,C}, \delta_C(1) \cdot d_{C,C}\} \cdot f_{C,\heartsuit} = 1/192 \qquad \psi_C(2) = A$$

$$\delta_A(3) = \max\{1/64 \cdot 1/4, 1/192 \cdot 1/4\} \cdot 0 = 0 \qquad \psi_A(3) = A$$
$$\delta_B(3) = \max\{1/64 \cdot 1/4, 1/192 \cdot 1/2\} \cdot 1 = 1/256 \qquad \psi_B(3) = A$$
$$\delta_C(3) = \max\{1/64 \cdot 1/4, 1/192 \cdot 0\} \cdot 3/4 = 3/1024 \qquad \psi_C(3) = A$$

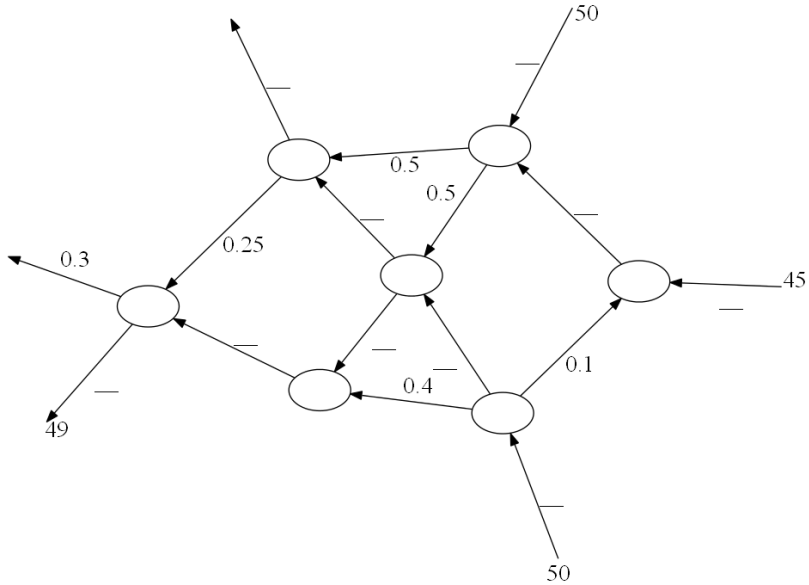
$$\delta(4) = \max\{1/256 \cdot 1/4, 3/1024 \cdot 1/4\} \approx \max\{0.0009766, 0.0007324\} \qquad \psi(4) = B$$

$$\Rightarrow \arg\max P(S_1 S_2 S_3 \mid \clubsuit, \heartsuit, \spadesuit) = AAB$$

Homogeneous Poisson Models



Labels of entering edges indicate the number of characters entering the represented area. Labels of the other edges indicate the probability that a character decides upon the corresponding way. Assume that the motion inside the road network follows a homogeneous poisson process. Calculate the missing probabilities and for every edge the expected number of characters who are located at every time on the way represented by the edge.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0.5
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0.1
0.4
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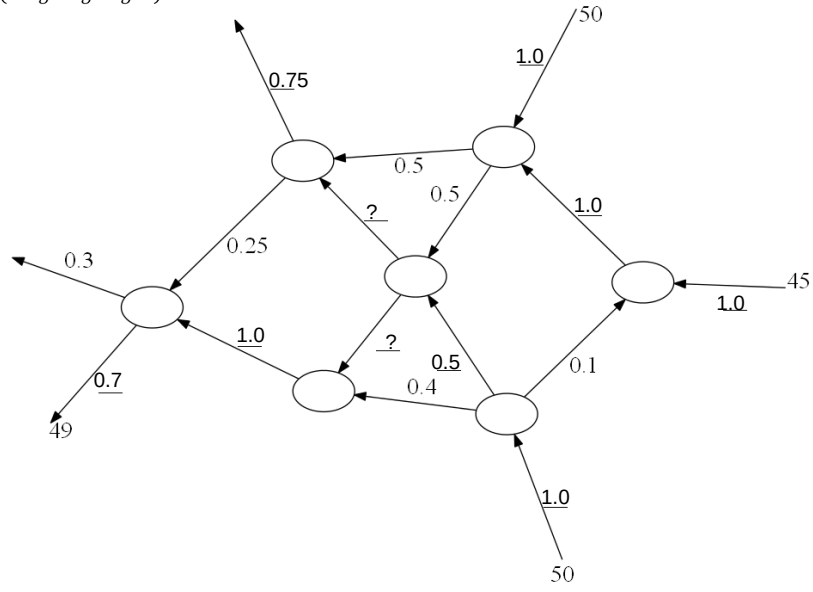
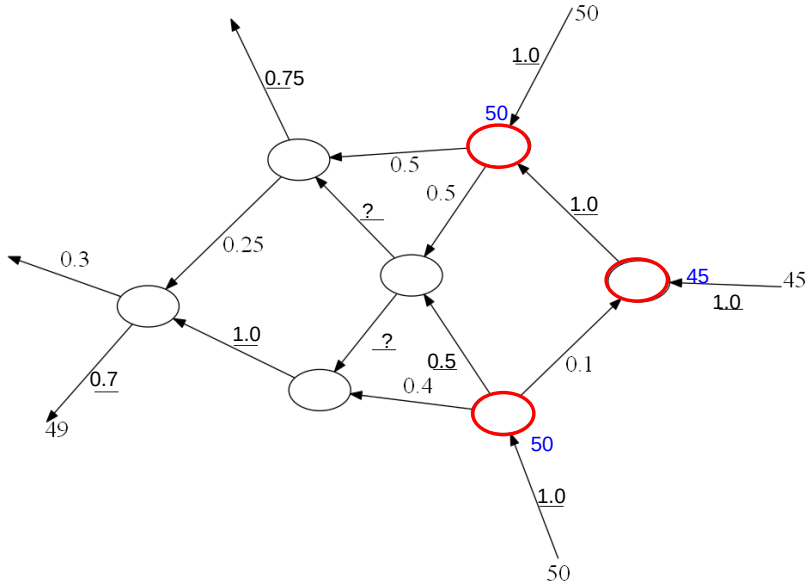
$$\sum(outgoing\ edges) = 1$$

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1.0
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0.25
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1.0
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?
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0.7
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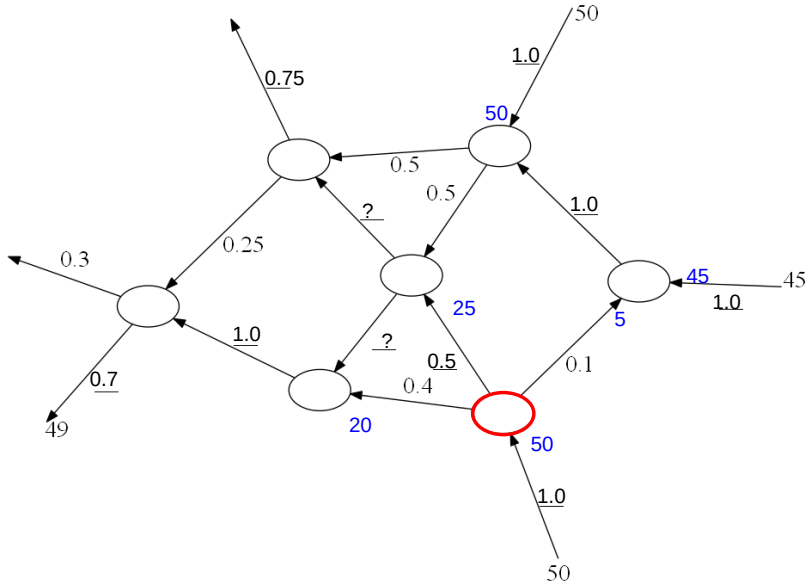
50
1.0
50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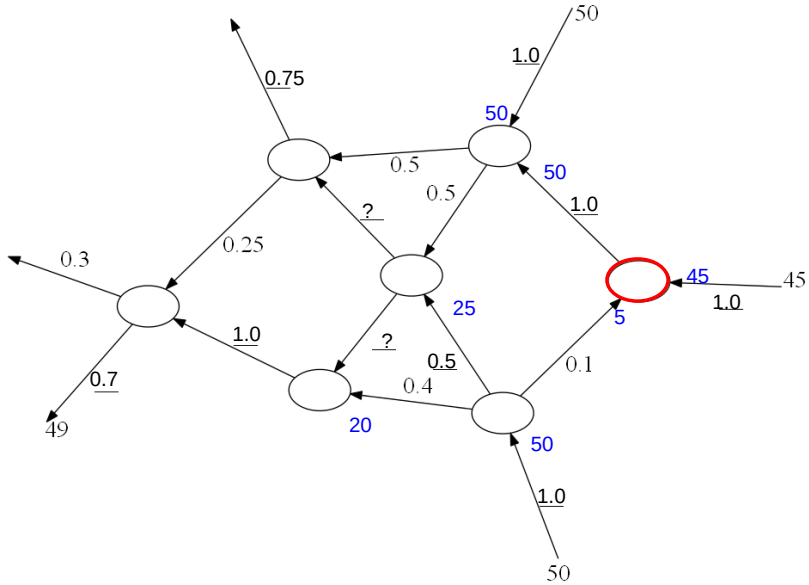
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1.0
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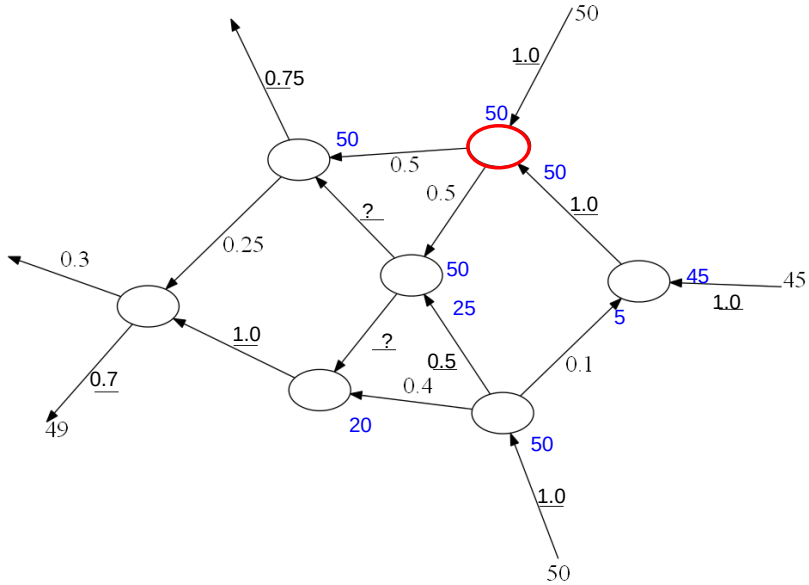
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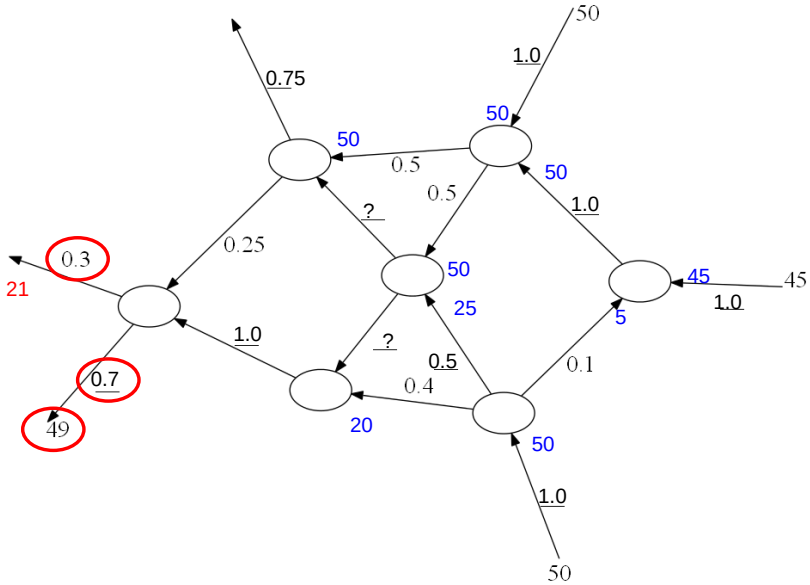
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50
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?
0.25
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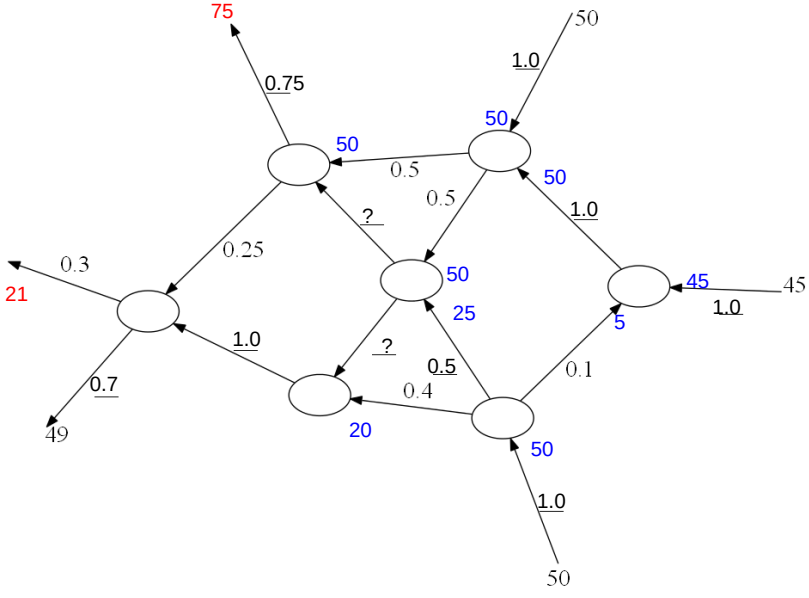
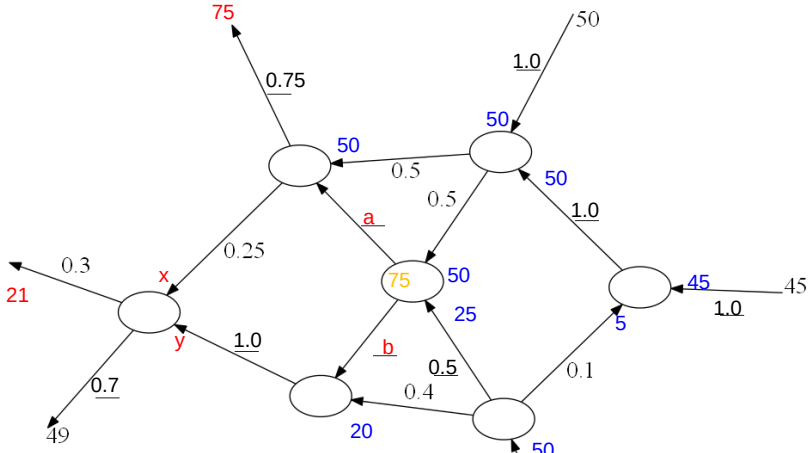
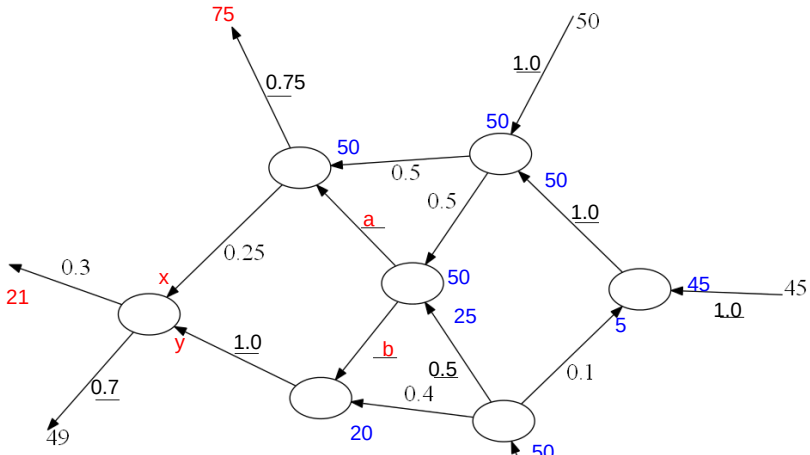
50
45
45
1.0
25
5
?
1.0
0.5
0.1
0.7
0.4
49
20
50
1.0
50

$$\sum \text{all ingoing edges} = \sum \text{all outgoing edges}$$



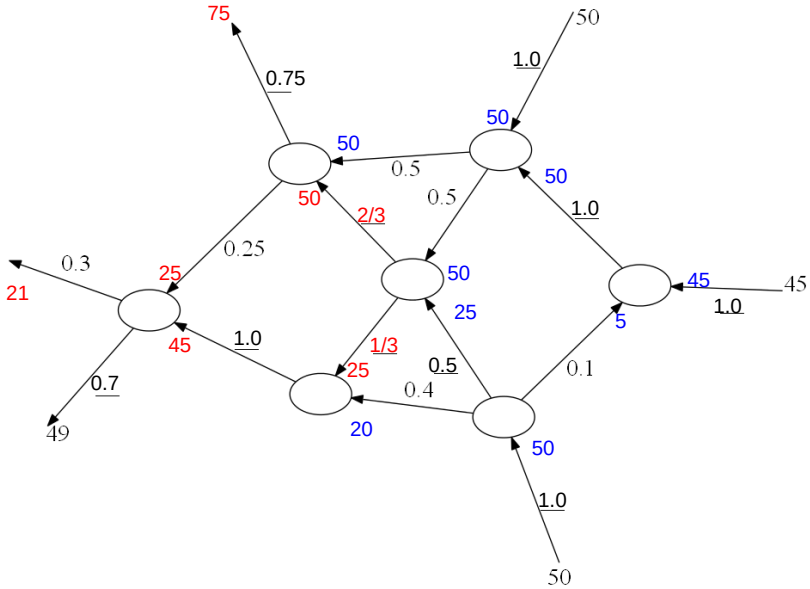


x = 0.25*(50+75a)
y = 1.0 * (20+75b)
x+y = 70
a+b = 1.0



x = 0.25*(50+75a)
y = 1.0 * (20+75b)
x+y = 70
a+b = 1.0

a = 2/3
b = 1/3
y = 45
x = 25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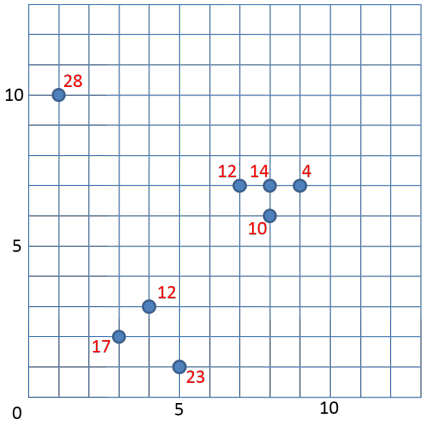
Spatial Outlier Detection



In the following relevant spatial positions (e.g. starting positions in an FPS or frequent camp positions in an MMORPG) are given. For every position a score is given additionally which depicts semantic information about the quality of the position (e.g. the average number of frags in an FPS or the average count of EP/coins per hour in an MMORPG).

Find the three strongest outliers in this dataset applying the Point Outlier Detection Algorithm with $k = 2$. Use the absolute score difference as weighting function.

Parameters:

k = #neighbors [here: = 2]

m = #(outliers to look for) [here: = 3]

Approach:

a) Compute *kNN*-graph (directed edge from p to q exists if and only if *q* is a *kNN* of *p*) [here: using the euclidean distance]

b) For every edge in the *kNN*-graph calculate its weight [here: the absolute score difference]

c) Beginning with the highest weighted edge, delete edges with descending weights from the graph

d) If a point is isolated (having neihter in- nor out-going edges) after the successive removal of edges, it is an outlier

e) Proceed like that until *m* outliers are found

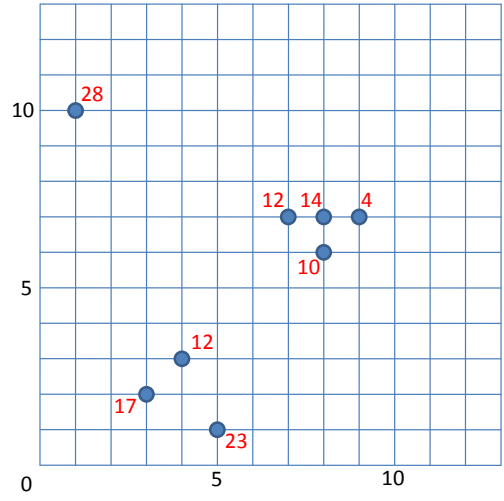
Possible options for equality of *kNN*-distance:

1) Add all points with equal *kNN*-distance to the *kNN*-set (potentially *#kNN >=k*)
2) Choose non-deterministically one of the points with equal *kNN*-distance (=> *#kNN=k*)

Possible options for equality of weighting of edges in the kNN-graph:

1) Delete all edges with equal weight at once
2) Delete one of the edges non-deterministically

We choose strategy 1) and 1)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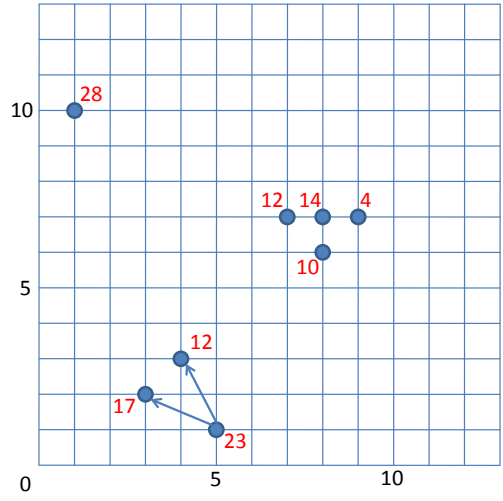
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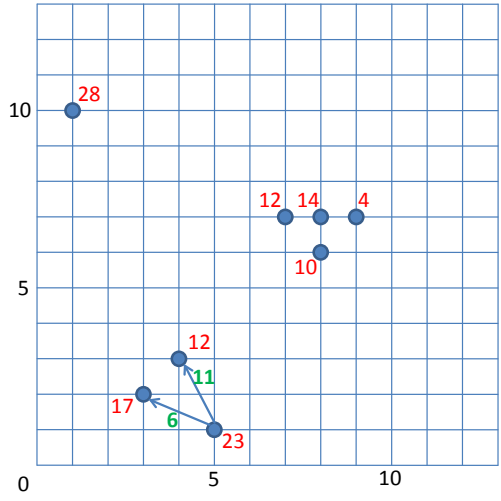
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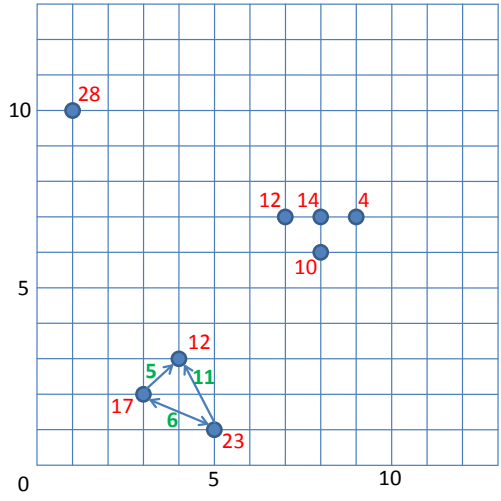
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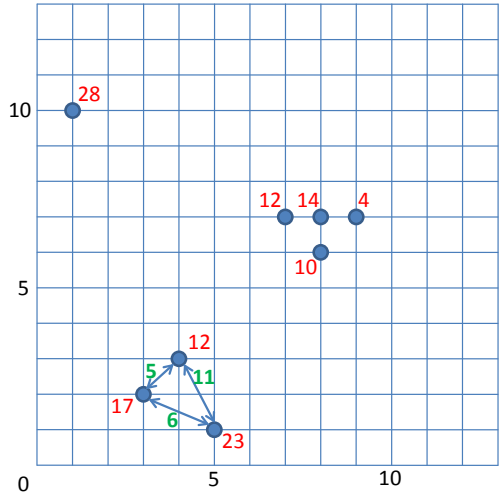
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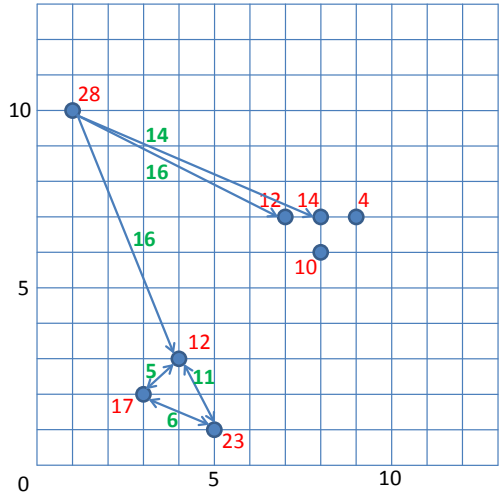
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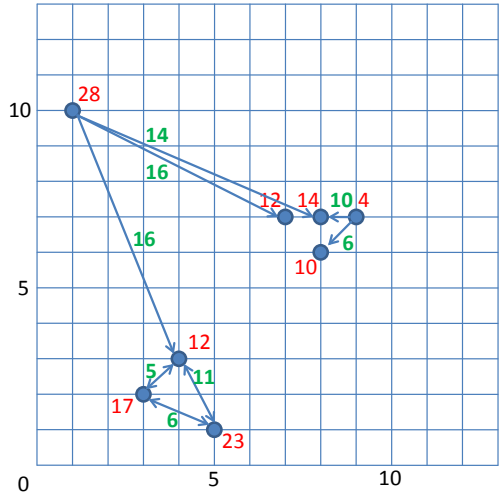
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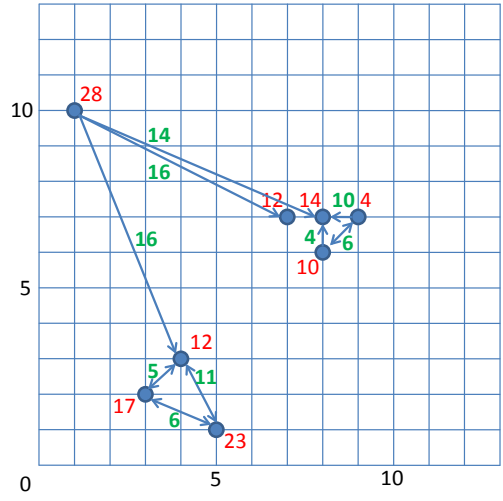
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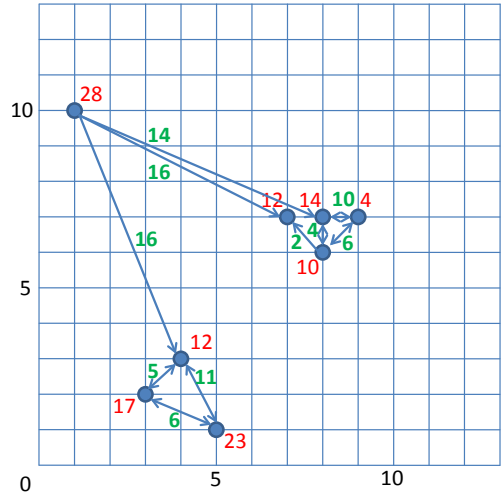
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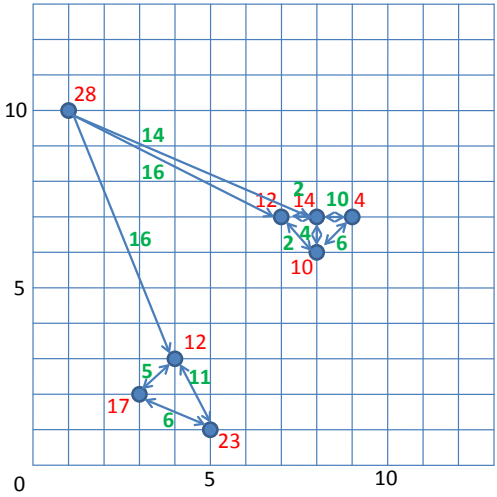
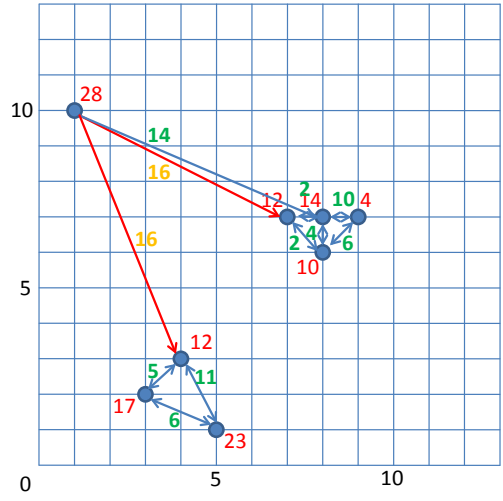
Construction of neighborhood graph finished
Now delete the edges with highest weights (=score difference) in a descending order

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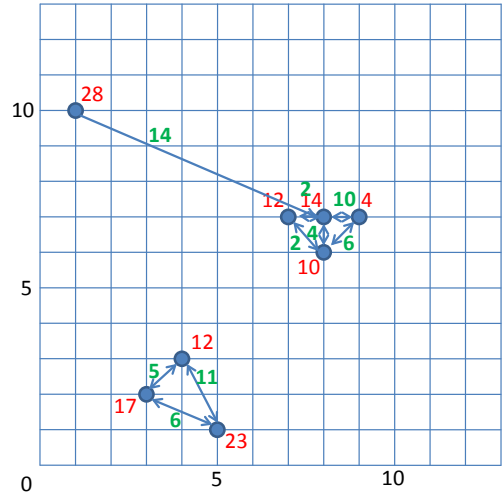
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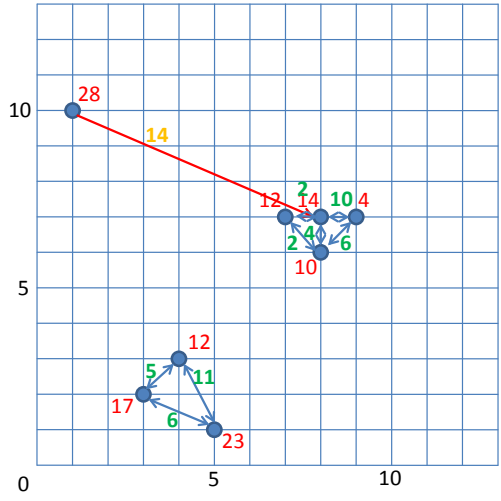
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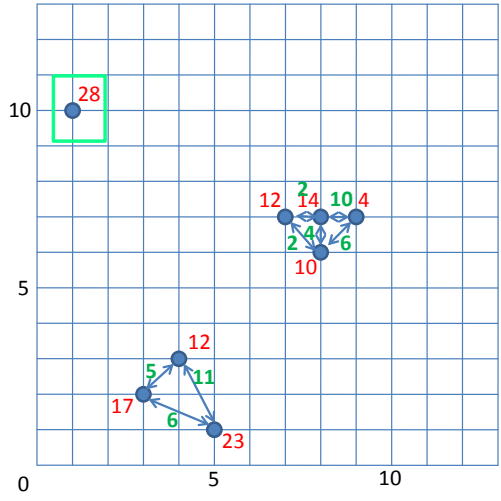
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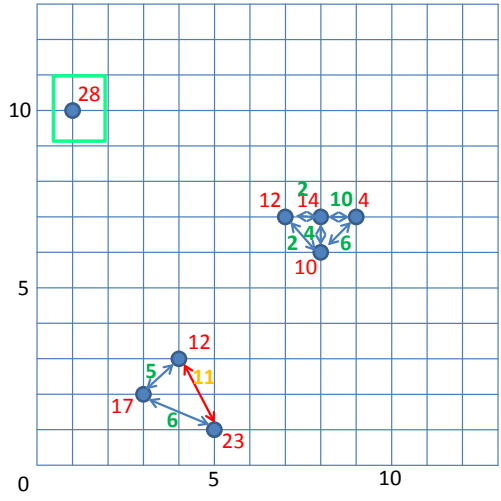
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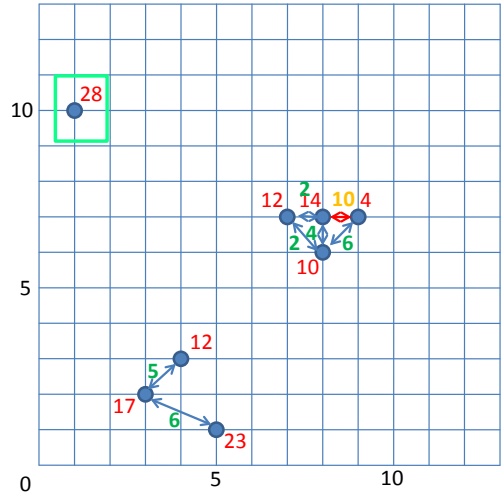
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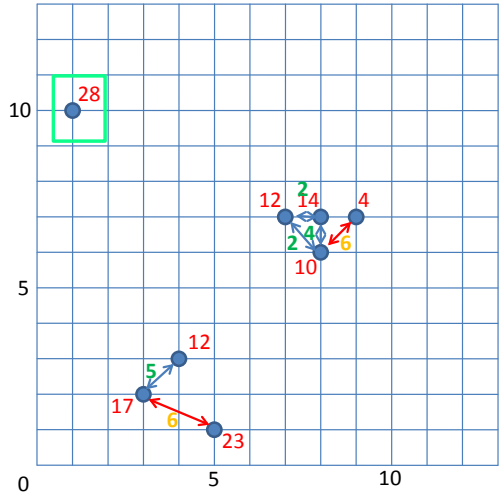
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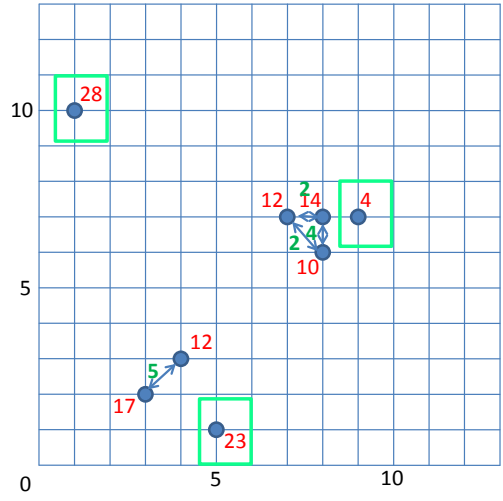
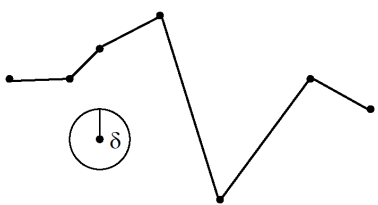
The three strongest outliers are determined



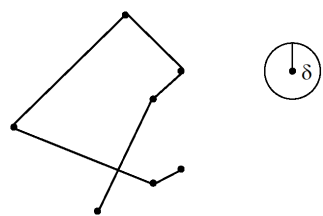
Exercise 10-3 *Compression of trajectories*

Approximate the following trajectories with the Douglas Peucker Algorithm

a)



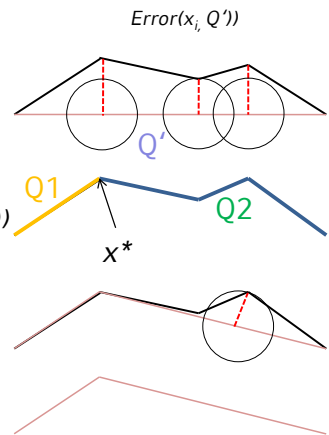
b)



Douglas-Peucker Algorithm

Given: A trajectory $Q=((x_1,t_1), \ldots, (x_l,t_l))$ of l length.
Searched: Q' with | Q' |<< l and approximation error smaller than δ .
Algorithm:

DP(Q, δ)
Q' = $((x_1,t_1), (x_l,t_l))$
FOR ALL (x_i,t_i) *in Q*
  IF $Error(x_i, Q') > \delta$ THEN
    determine x^* with $\max(Error(x_i, Q'))$
    $(Q1,Q2) = split(Q,x^*)$
    RETURN DP(Q1, δ) DP(Q2, δ)
ENDFOR
RETURN Q'



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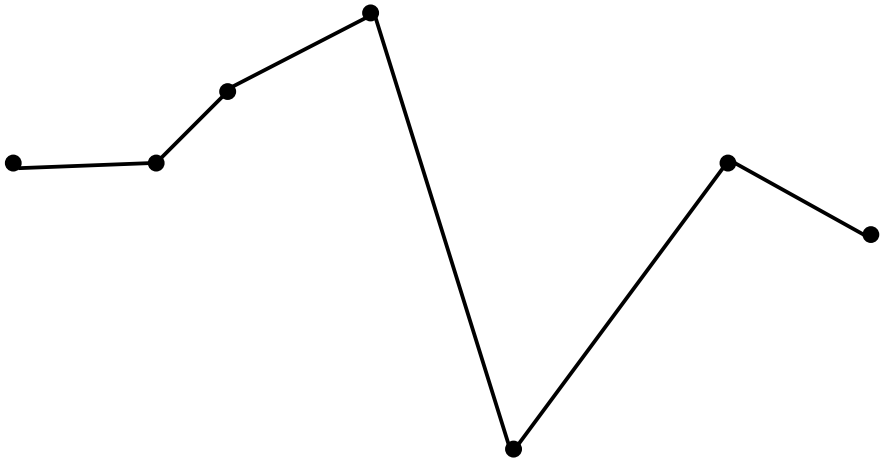

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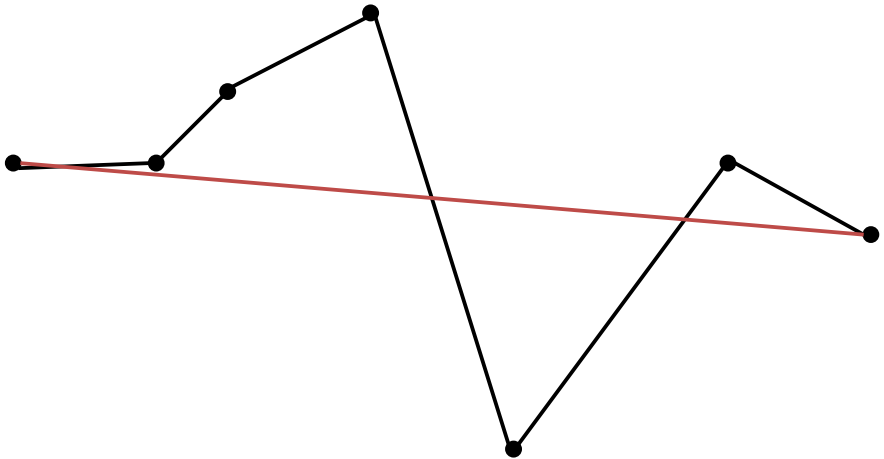

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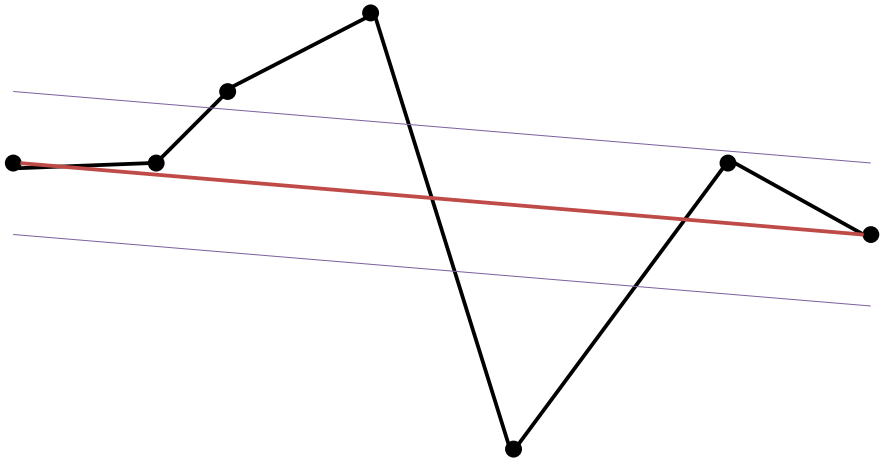

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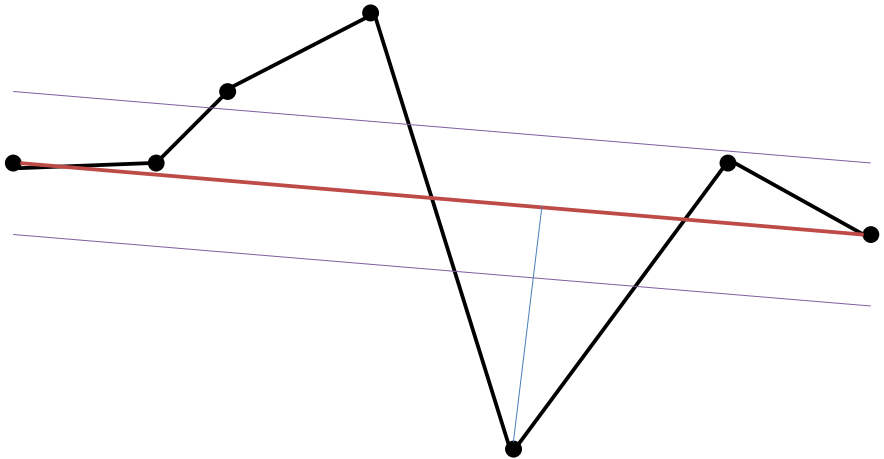

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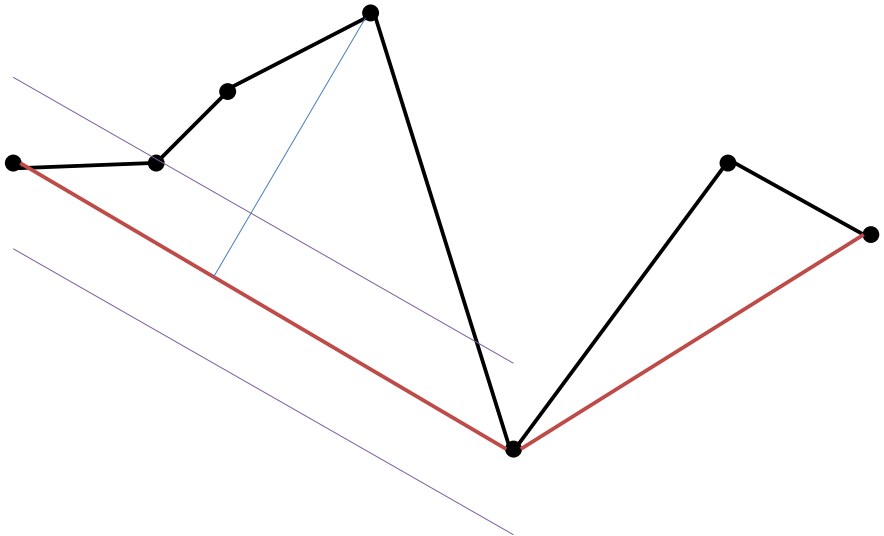

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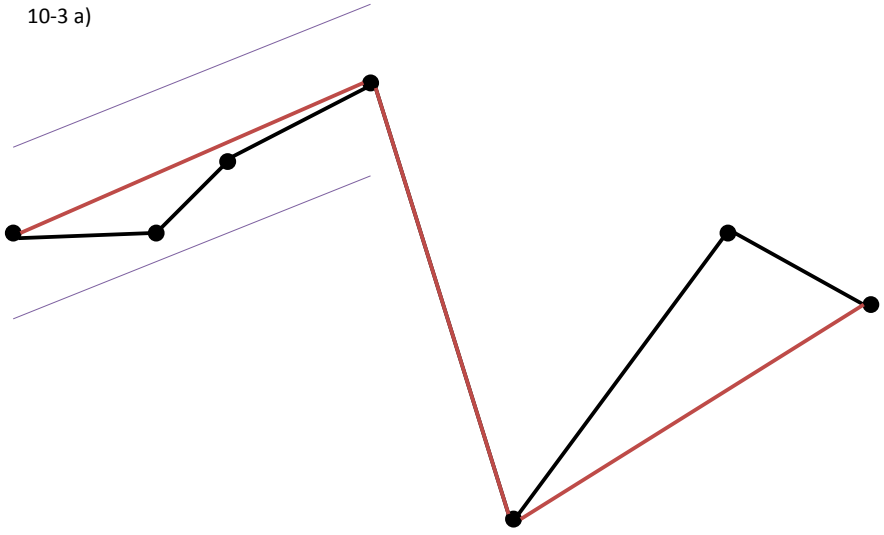

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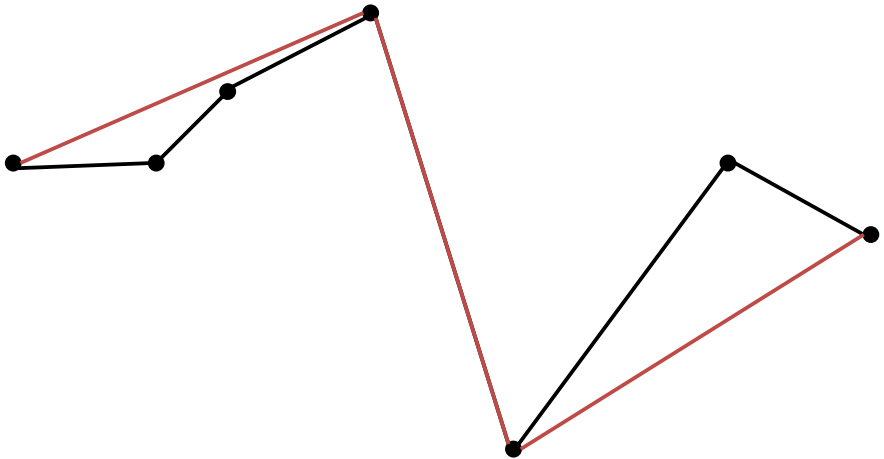

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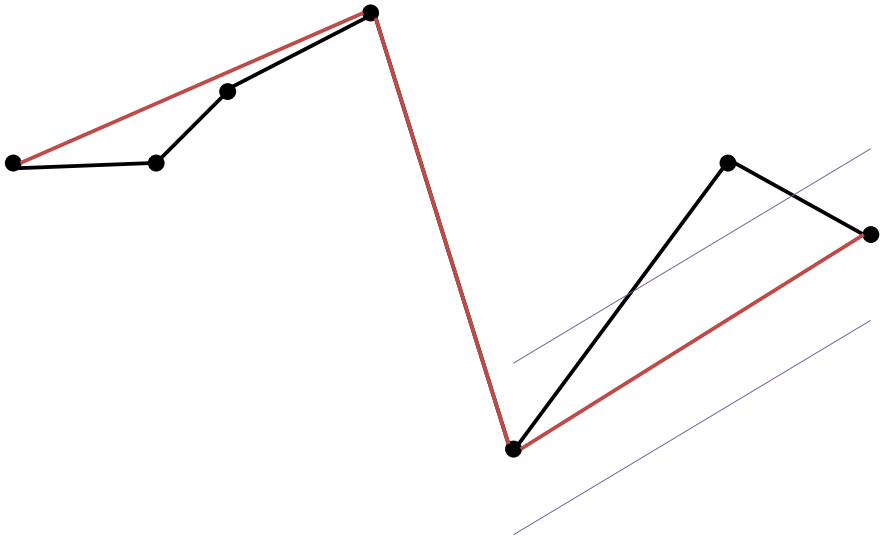

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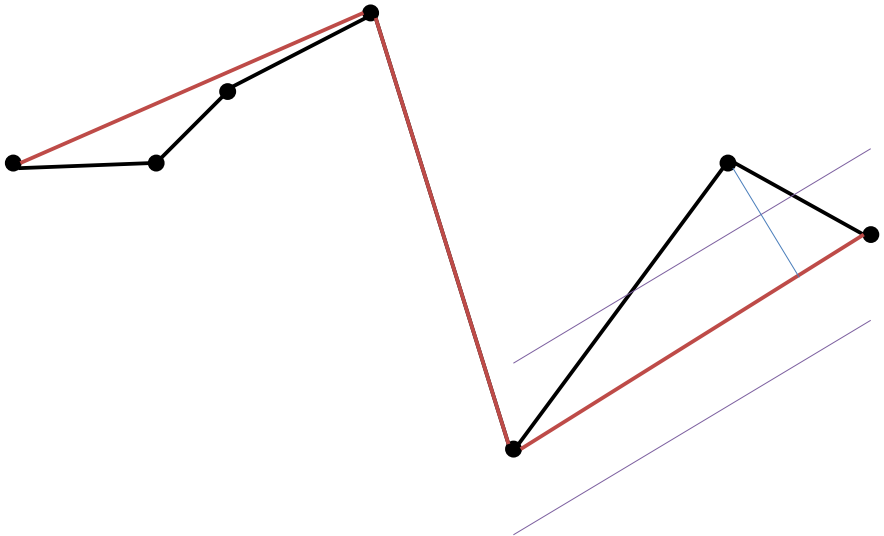

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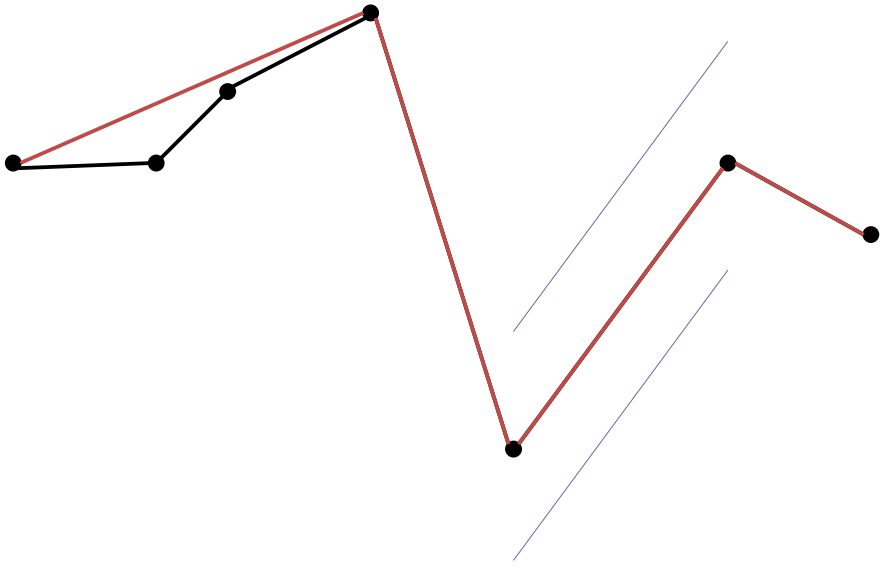

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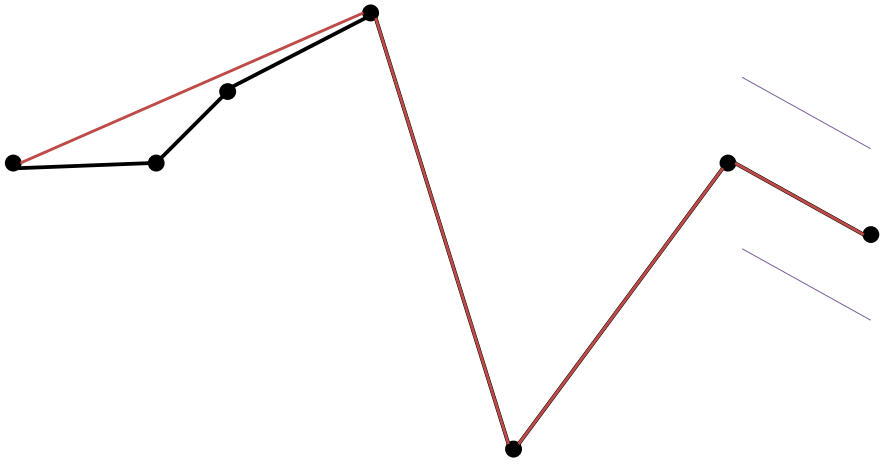
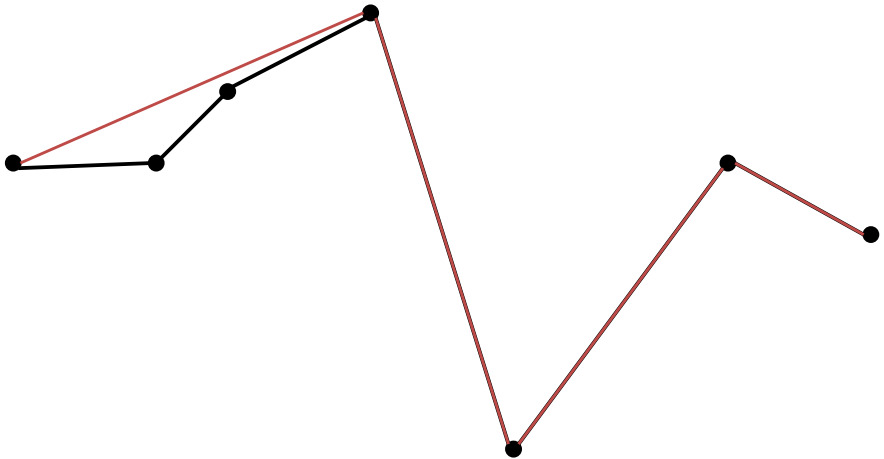


10-3 a) Result



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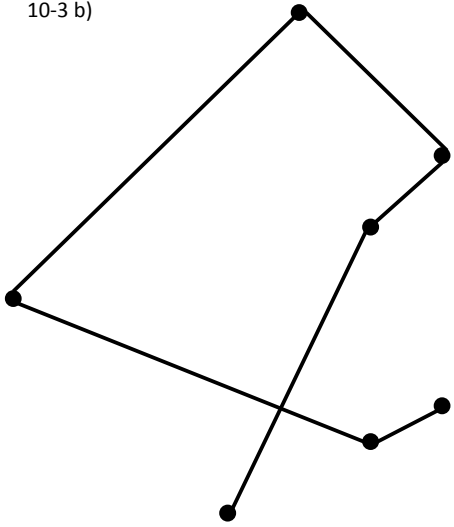

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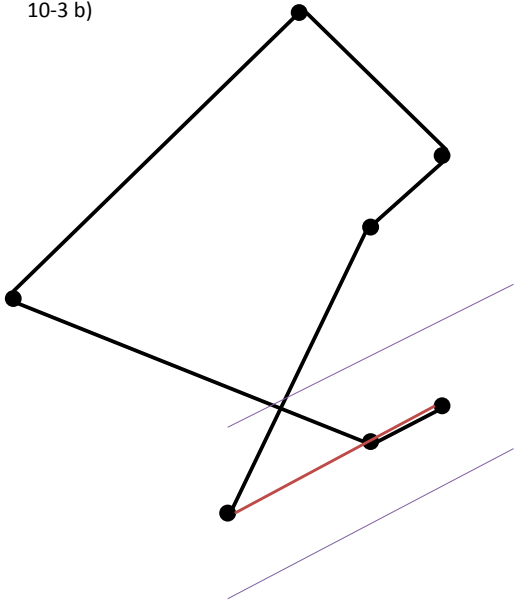

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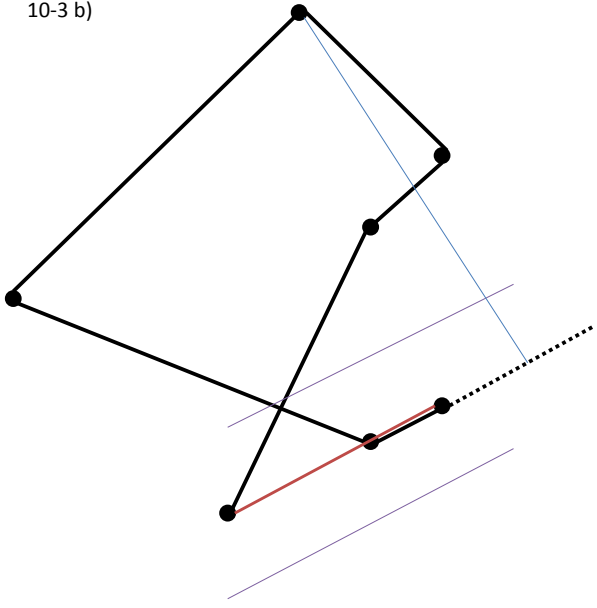

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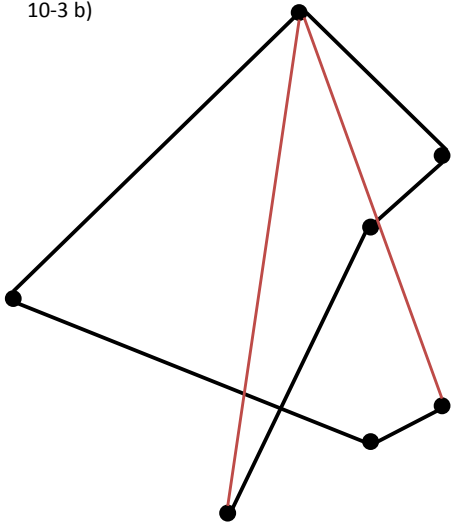

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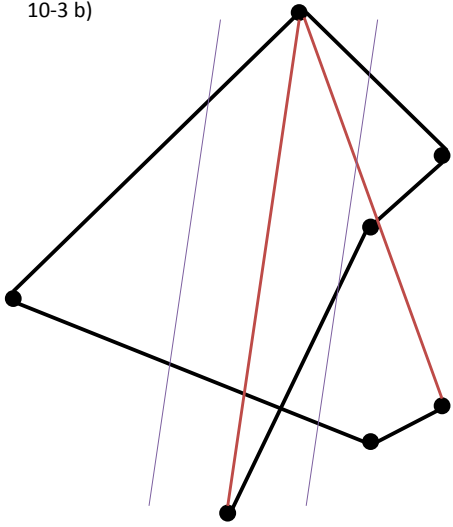

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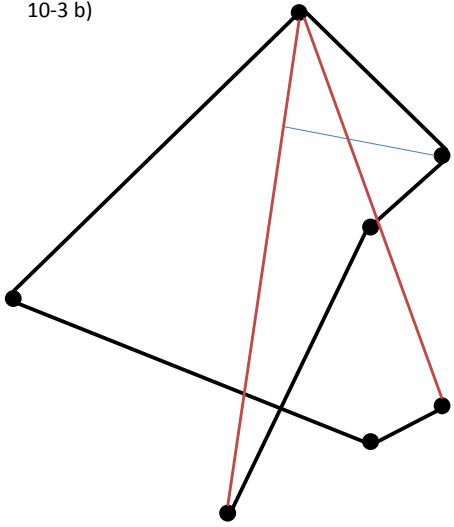

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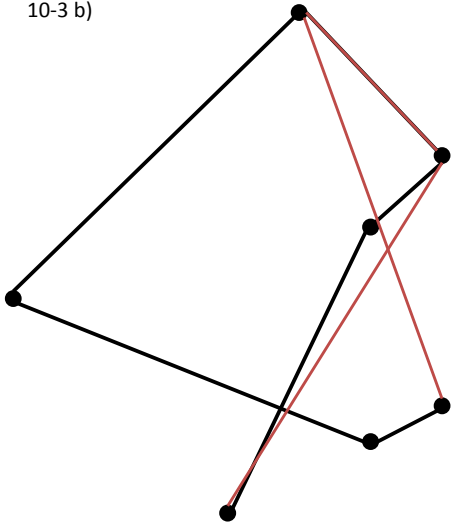

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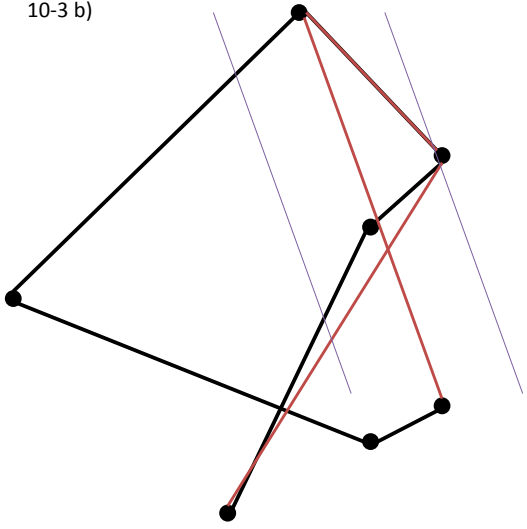

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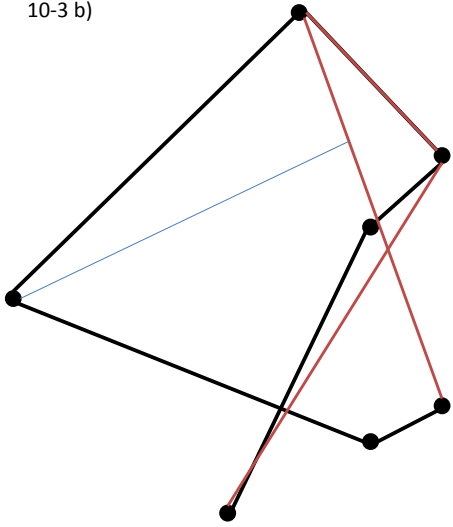

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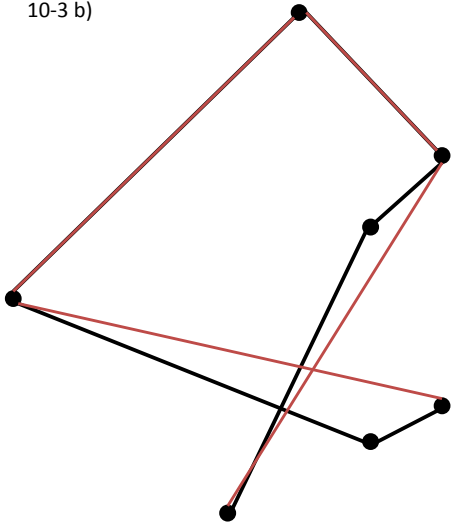

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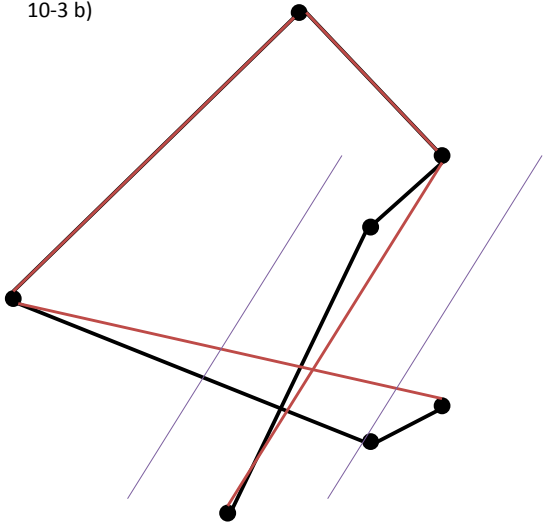

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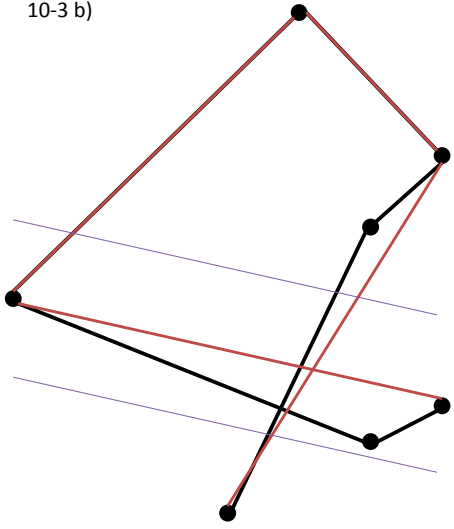

10-3 b) Result