Ludwig-Maximilians-Universität München
Institut für Informatik
Prof. Dr. Matthias Schubert
Sebastian Schmoll

Munich, April 16th, 2018

Managing Massive Multiplayer Online Games

SoSe 2018

Exercise Sheet 2: Space

Discussion: April 25th, 2018

In the following regard an abstract game, where the players are in a two-dimensional world. In this world a player can perceive objects and other players inside a circular region with radius s_r (*sight distance*).

Exercise 2-1 *Visibility*

(a) How can one efficiently check if a player p with position $(p.x, p.y)$ is able to see a round object o with center o_m and radius o_r?

(b) Let R be a rectangular approximation of a set S of players. How can one efficiently check if it is possible that a player $p \notin S$ can see players in S without accessing the exact positions of the players in S?

(c) Let R_1 and R_2 be rectangular approximations of two disjunct sets S_1 and S_2 of players. How can one efficiently check if it is possible that there are pairs of players $(p_1, p_2) \in S_1 \times S_2$ which can see one another without accessing the exact positions of players in S_1 and S_2?

Hint: The following functions can be used:

- The Euclidean distance between two points p_1 and p_2:

$$Dist(p_1, p_2) = \sqrt{(p_1.x - p_2.x)^2 + (p_1.y - p_2.y)^2}$$

- The minimal Euclidean distance between a point p and a rectangle R:

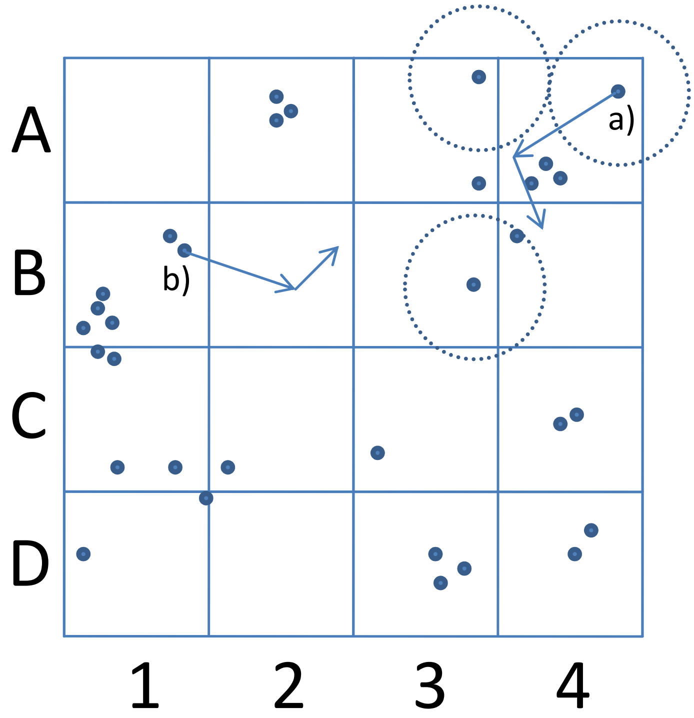
$$MinDist(p, R) = \sqrt{\sum_{i=1}^{2} \begin{cases} |R_i^{min} - p_i|^2, \text{ if } R_i^{min} > p_i \\ |p_i - R_i^{max}|^2, \text{ if } p_i > R_i^{max} \\ 0 \quad , \text{ else} \end{cases}} \tag{1}$$

- The minimal Euclidean distance between two rectangles A und B:

$$MinDist(A, B) = \sqrt{\sum_{i=1}^{2} \begin{cases} |A_i^{min} - B_i^{max}|^2, \text{ if } A_i^{min} > B_i^{max} \\ |B_i^{min} - A_i^{max}|^2, \text{ if } B_i^{min} > A_i^{max} \\ 0 \quad , \text{ else} \end{cases}} \tag{2}$$

Here A_i is the projection of A onto the dimension i (i.e. the i-th entry of a vector or the interval which describes the expansion of a rectangle in the i-th dimension) and X^{min} (resp. X^{max}) is the minimum (resp. maximum) of an interval X.

Exercise 2-2 *Spatial-Publish-Subscribe*



In the following the playing field is uniformly divided into a 4×4 grid of square micro-zones. 32 objects are moving on this field with initial positions as shown above. The "Area of Interest" (AoI) of an object is circular with its radius corresponding to exactly half the side length of a grid cell. In the playing field shown in the figure above the AoIs of some objects are exemplary plotted.

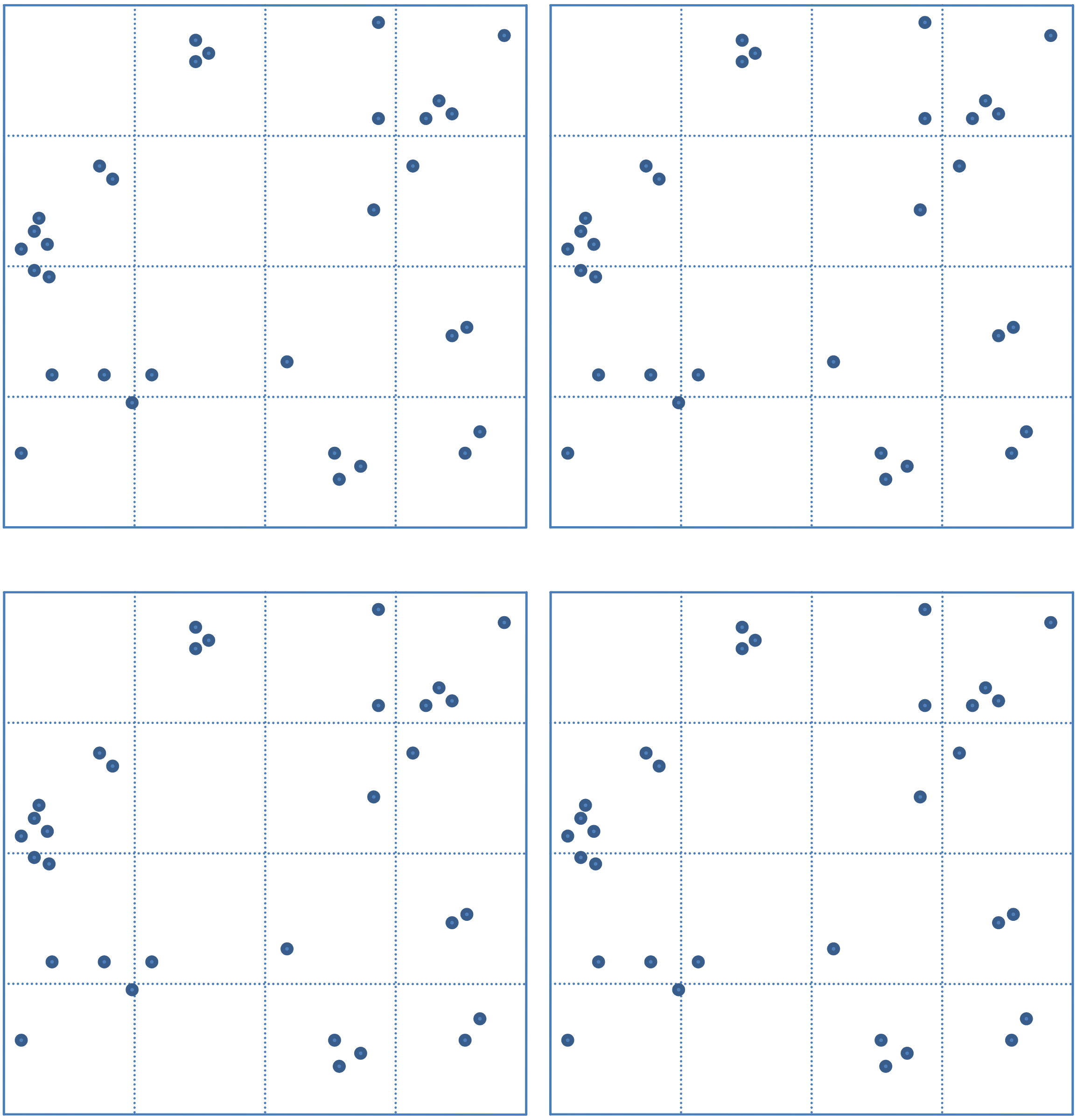
(a) Regard the object marked with *a)* in cell A4. In which micro-zones is this object first subscribed?

(b) From which objects does *a)* initially get positional information? Which objects initially get positional information from *a)*?

(c) To which micro-zones is *a)* subscribed if it moves as shown in the figure?

(d) To which micro-zones has the object marked with *b)* in cell B1 to subscribe (and un-subscribe) if it moves as shown in the figure?

Exercise 2-3 *Spatial index structures*



In the following the dataset given above shall be indexed. Therefore use:

(a) A quadtree with a bucket capacity of two objects. For the first splits subsidiary lines are given.

(b) A kD-Tree with a capacity of four objects. Begin with a split of the x-axis.

(c) An R-tree with a capacity of two objects. Build the R-tree with the sort-tile recursive algorithm.