Friedrich-Alexander-Universität
Technische Fakultät

Department of Computer Science
Computer Science 6
(Data Management)

Knowledge Discovery in Databases with Exercises
Summer Semester 2025

Exercise Sheet 5:
Clustering

About this Exercise Sheet

This exercise sheet focuses on the content of lecture *8. Clustering*.

It includes both theoretical exercises on K-means (Exercise 1) and DBSCAN (Exercise 2) and a practical data science exercise (Exercise 3).

The exercise sheet is designed for a two-week period, during which the tasks can be completed flexibly.

The sample solution will be published after the two weeks have elapsed.

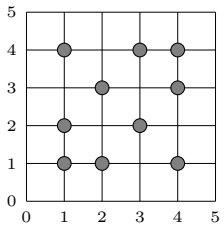
Preparation

Before participating in the exercise, you must prepare the following:

1. **Install Python and pip on your computer**
   - Detailed instructions can be found in `1-Introduction-Python-Pandas.pdf`.
2. **Download provided additional files**
   - Download `Additional-Files-Student.zip` from StudOn
   - Extract it to a folder of your choice.
3. **Install required Python packages**
   - Open a terminal and navigate to the folder where you extracted the files.
   - Run the command `pip install -r requirements.txt` within the extracted additional files folder to install the required Python packages.

Exercise 1: K-means

Given is a set of points in a two-dimensional space:



Points:

- (1,1), (1,2), (1,4), (2,1), (2,3), (3,2), (3,4), (4,1), (4,3), (4,4)

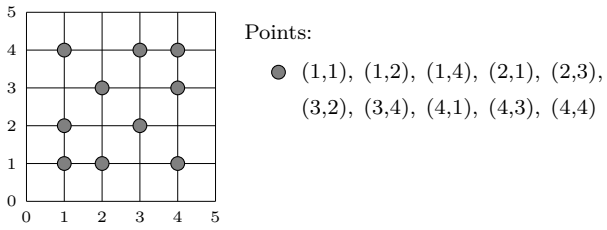
Use **K-means** to cluster the given points into three clusters. Use the **Euclidean distance** as the metric defining the similarity between points.

Write down **all** intermediate steps.

Exercise 2: DBSCAN

Task 1: Basic Terms

Given is a set of points in a two-dimensional space:



Task 1.1: Core Points

Determine whether $(1, 1)$, $(2, 1)$, $(2, 3)$, and $(1, 4)$ are **core points** if a density based clustering algorithm like **DBSCAN** is initialized with $\varepsilon = 1$ and $MinPts = 2$ and applied on the given point set. The distance is calculated using the Euclidean distance.

Task 1.2: Direct Density Reachability

Determine which of the points in the point set are **directly density reachable** from the core point $(1, 2)$ if a density based clustering algorithm like **DBSCAN** is initialized with $\varepsilon = 1$ and $MinPts = 2$. The distance is calculated using the Euclidean distance.

Task 1.3: Density Reachability

Task 1.3.1: Basic Density Reachability

Determine whether $(1, 1)$, $(2, 1)$, $(2, 3)$, and $(4, 4)$ are **density reachable** from the core point $(1, 2)$ if a density based clustering algorithm like **DBSCAN** is initialized with $\varepsilon = 1$ and $MinPts = 2$. The distance is calculated using the Euclidean distance.

Task 1.3.2: Reversal of Density Reachability

Determine whether $(3, 4)$ is density reachable from $(4, 4)$ and whether $(4, 4)$ is density reachable from $(3, 4)$ if a density based clustering algorithm like **DBSCAN** is initialized with $\varepsilon = 1$ and $MinPts = 3$. The distance is calculated using the Euclidean distance.

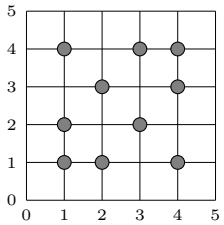
Be careful: $MinPts$ was increased in this task. Thus you have to reevaluate whether points are core points or not.

Task 1.4: Density Connectivity

Determine whether $(1, 1)$, $(3, 2)$, $(4, 3)$, and $(4, 4)$ are **density connected** to the point $(3, 4)$ if a density based clustering algorithm like **DBSCAN** is initialized with $\varepsilon = 1$ and $MinPts = 3$. The distance is calculated using the Euclidean distance.

Task 2: Application of DBSCAN

Given is a set of points in a two-dimensional space:



Points:

- (1,1), (1,2), (1,4), (2,1), (2,3), (3,2), (3,4), (4,1), (4,3), (4,4)

Apply the **DBSCAN** algorithm known from the lecture on the given point set while using $\varepsilon = 1$ and $MinPts = 2$.

Write down **all** intermediate steps.

Exercise 3: Clustering in Python

This exercise comprises practical data science tasks and thus utilizes a Jupyter Notebook:

1. Open `Clustering-in-Python.ipynb`.
2. Take a look at the tasks (blue boxes) in the notebook and try to solve them.

If you are unfamiliar with how to open a Jupyter Notebook, please refer to Exercise 1 of `1-Introduction-Python-Pandas.pdf`.