K-means algorithm

select K points ($m_1,...,m_K$) randomly
do
  ($w_1,...,w_K$) = ($m_1,...,m_K$)
  all clusters C_i = {}
  for each row w in M
    find the closest point in ($w_1,...,w_K$)to w
    assign w to the corresponding cluster:
    $C_i = C_i \cup \{w\}$ (if w_i is closest point)
  end
  for each cluster C_i
    calculate the mean point m_i
while exists $m_i \neq w_i$

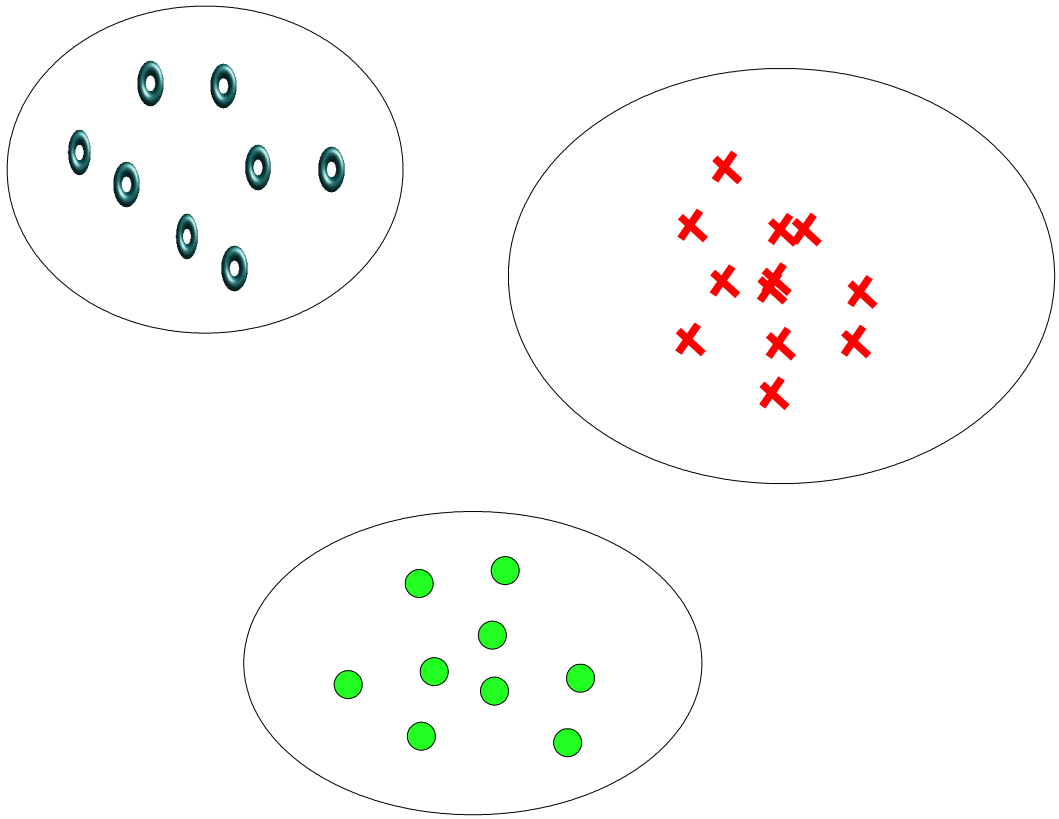
K-means clustering

- Input: M (set of points), K (number of clusters) $m_1,...,m_k$ (Initial centroids)
- Choosing K
  - Study the data
  - Measure how squared error decreases as more clusters are added
- Choosing centroids
  - Typically randomly

K-means clustering

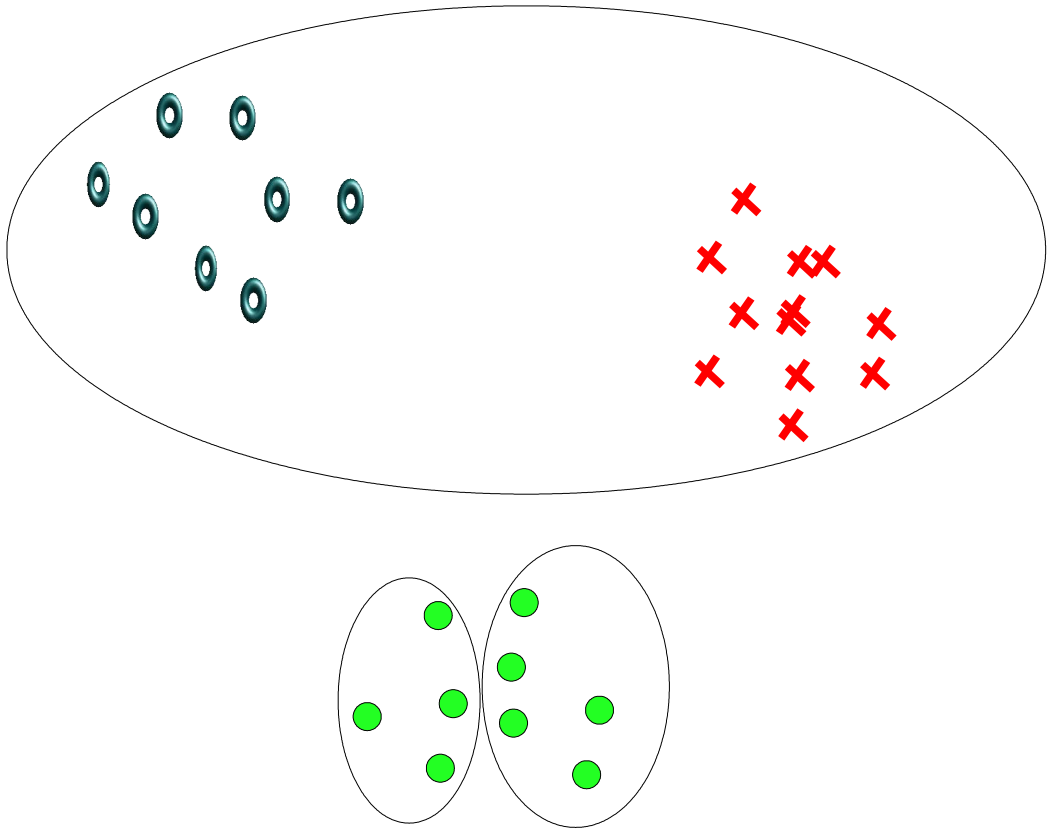
- Pros:
  - Easy
  - Scalable
- Cons:
  - Works only for certain clusters
  - Sensitive to outliers and noise

K-means clustering



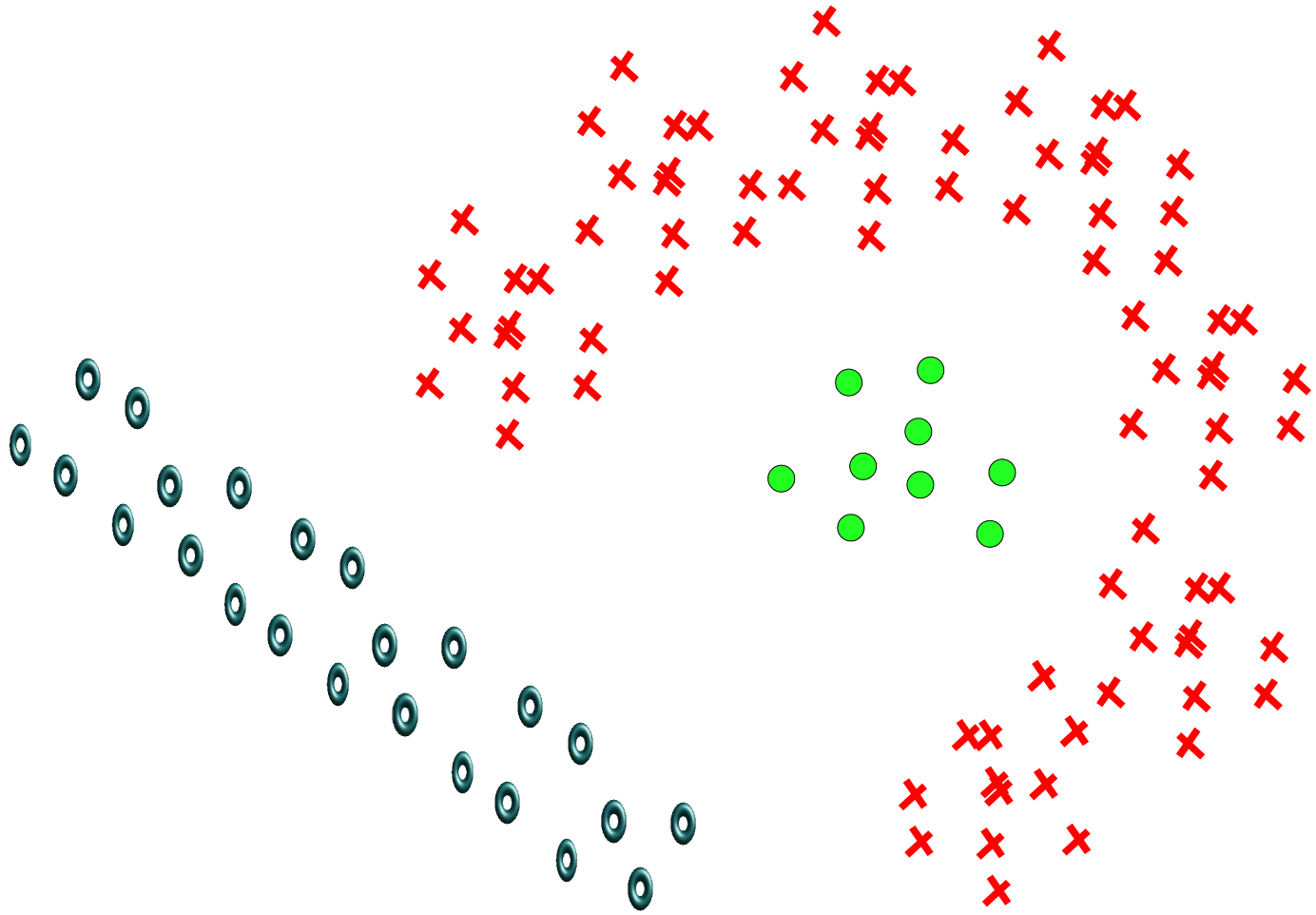
K-means clustering

Bad initial points



K-means clustering

Non-spherical clusters



Questions

- Using the euclidean distance one gets spherical clusters, what types of clusters does one get using the manhattan distance?
- If we assume that the K-means algorithm converges in I iterations, with N points and X characteristics for each point give an approximation of the complexity of the algorithm expressed in K,I,N and X
- Can the K-means algorithm be parallellized? if yes how?

Practical K-Means

I want to cluster this class into 5 different clusters. Assume that I know:

- Your Age
- What row you are sitting in
- Wether you handed in the first assignment on time or not
- How many years you have studied at university

Design a method to use K-means to create these clusters

DB Scan

- Density based clustering
- Connected regions with sufficiently high density
- Clusters with arbitrary shape
- Avoids outliers, noise

DB Scan

- key concepts

- **ϵ-neighbourhood**
  - the neighbourhood within a radius ϵ of an object
- **core object**
  - an object is a core object iff there are more than MinPts objects in its **ϵ-neighbourhood**
- **directly density reachable (ddr)**
  - An object p is ddr from q iff q is a **core object** and p is inside the **ϵ-neighbourhood** of q

DB Scan

- key concepts

- **density reachable (dr)**
  - an object q is **dr** from p iff there exists a chain of objects $p_1,...,p_n$ such that p_1 is **ddr** from p, p_2 is **ddr** from p_1, p_3 is **ddr** from ... and q is **ddr** from p_n.
- **density connected (dc)**
  - p is **dc** to q iff exist an object o such that p is **dr** from o and q is **dr** from o

DB Scan

- How to use DB scan to cluster

- Idea:
  - If object p is density connected to q, then p and q should belong to the same cluster
  - If an object is not density connected to any other object it is considered as noise

DB Scan

- How to use DB scan to cluster

- Naïve Algorithm:

```
i = 0
do
   take a point p from M
   find the set of points P which are density
     connected to p
   if P = {}
      M = M / {p}
   else C_i=P, i=i+1, M = M / P
   end
while M ≠ {}
```

How do you do this?

DB Scan

- How to use DB scan to cluster

- More practical Algorithm:

```
i = 0, Find the core points CP in M
do
   take a point p from CP
   find the set of points P which are density
     reachable from p
   C_i=P, i=i+1, CP = CP / (CP ∩ P)
while CP ≠ {}
```

How do you do this?

DB Scan

- How to use DB scan to cluster

find the set of points P which are density reachable from p

C={p},P={p}

do

Remove a point p' from C

Find all of the points X that are directly density reachable from p'

$C = C \cup (X \setminus (P \cap X))$

$P = P \cup X$

while $C \neq \{\}$

Questions

- Why is the density connected criterion useful to define a cluster, instead of density reachable or directly density reachable?
- For which points are density reachable symmetric?
- Express using only core objects and directly density reachable, which objects will belong to a cluster.

Practical db scan

Try to use the db scan algorithm with the following parameters:

MinPts:

Eps:

To determine if you are a core point, if you belong to a cluster.