Density-Based Clustering

Boston University CS 506 - Lance Galletti

Density-Based Clustering

Goal: cluster together points that are densely packed together.

How should we define density?

Density-Based Clustering

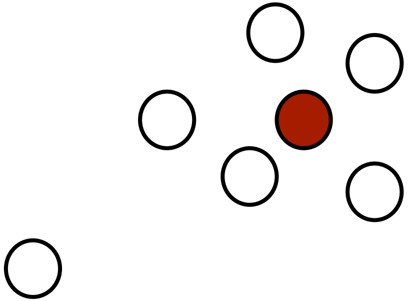
Goal: cluster together points that are densely packed together.

How should we define density?

Given a fixed radius **ε** around a point, if there are at least **min_pts** number of points in that area, then this **area** is dense.

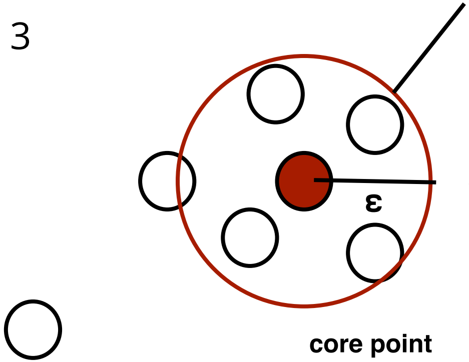
Example

Min_pts = 3



Example

Min_pts = 3



ε-neighborhood of this point

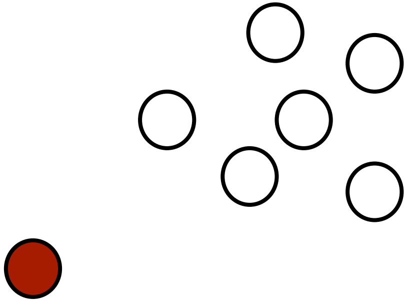
dense ✔

ε

core point

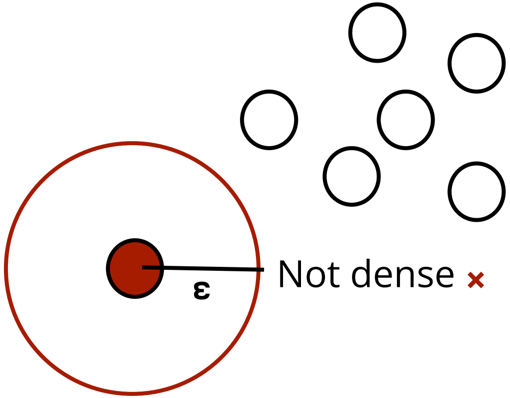
Example

Min_pts = 3



Example

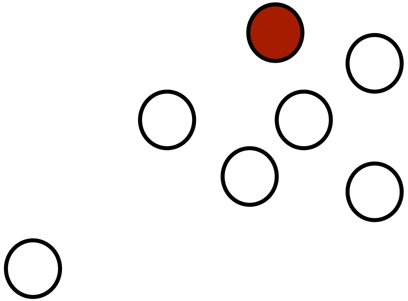
Min_pts = 3



noise point

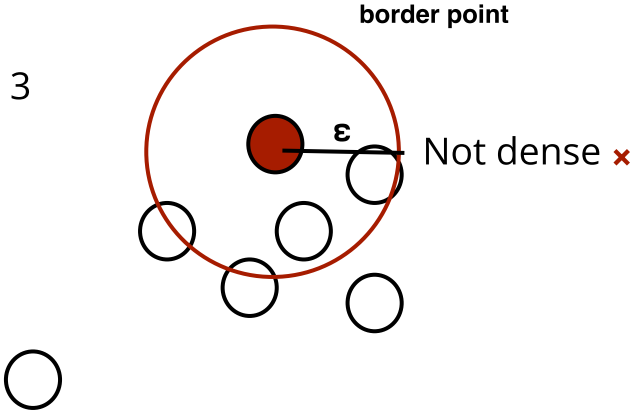
Example

Min_pts = 3



Example

Min_pts = 3



But… That point was part of a dense section earlier…

Density-Based Clustering

We need to distinguish between points at the core of a dense region and points at the border of a dense region.

Let’s define:

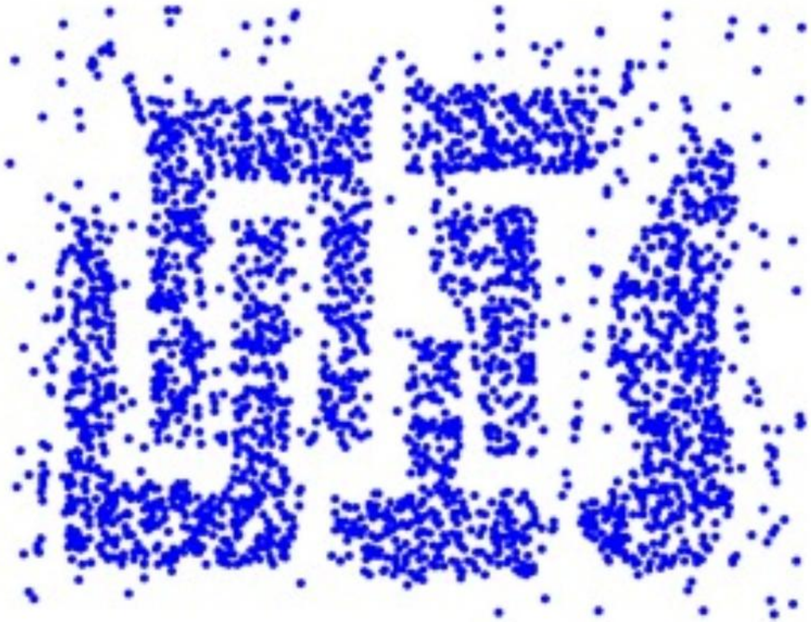
Core point: if its **ε**-neighborhood contains at least **min_pts**

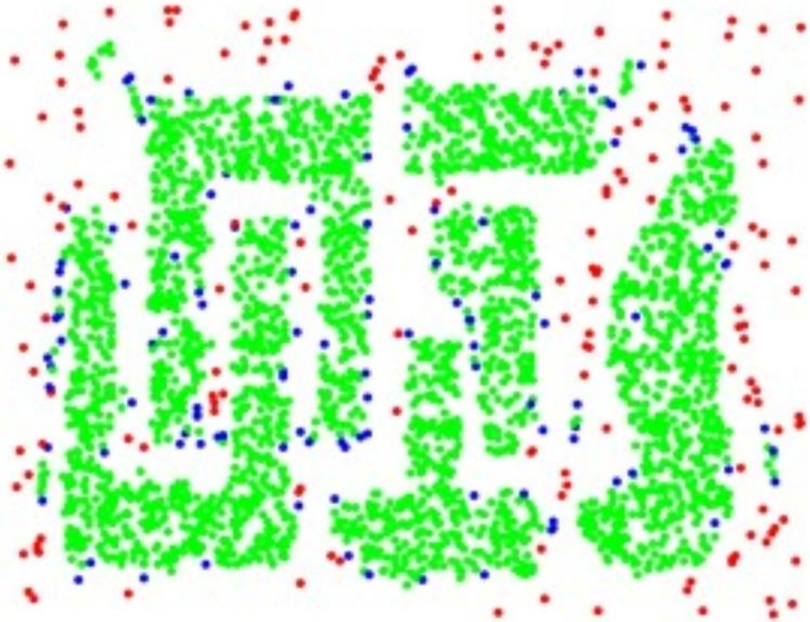
Border point: if it is in the **ε**-neighborhood of a core point

meaning it is in a dense zone but it does not generate the dense zone

Noise point: if it is neither a core nor border point

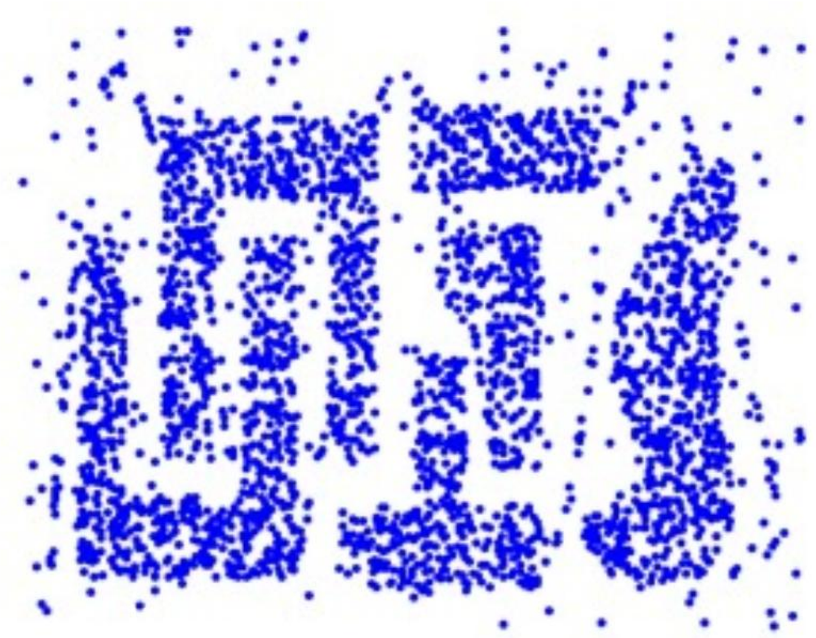
Density-Based Clustering

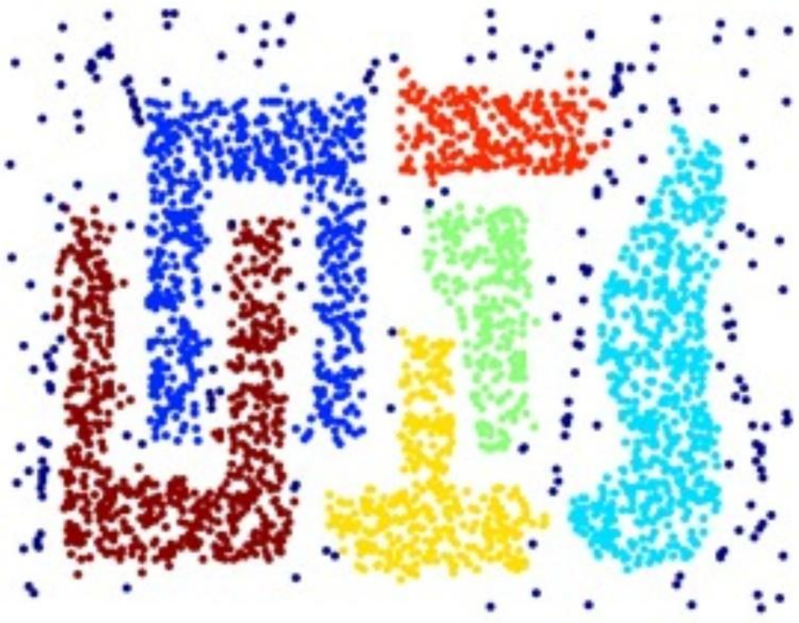




Core | Border | Noise

Density-Based Clustering





Create clusters by connecting core points

DBScan Algorithm **depth-first search algorithm**

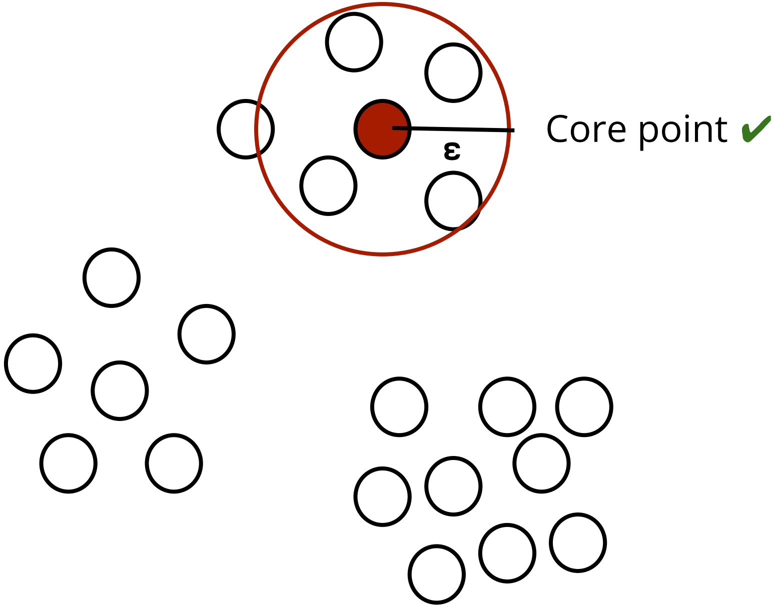
ε and **min_pts** given:

1. Find the **ε**-neighborhood of each point
2. Label the point as **core** if it contains at least **min_pts**
3. For each **core** point, assign to the same cluster all **core** points in its neighborhood (crux of the algorithm)
4. Label points in its neighborhood that are not **core** as **border**
5. Label points as **noise** if they are neither **core** nor **border**
6. Assign border points to nearby clusters

DBScan visualized

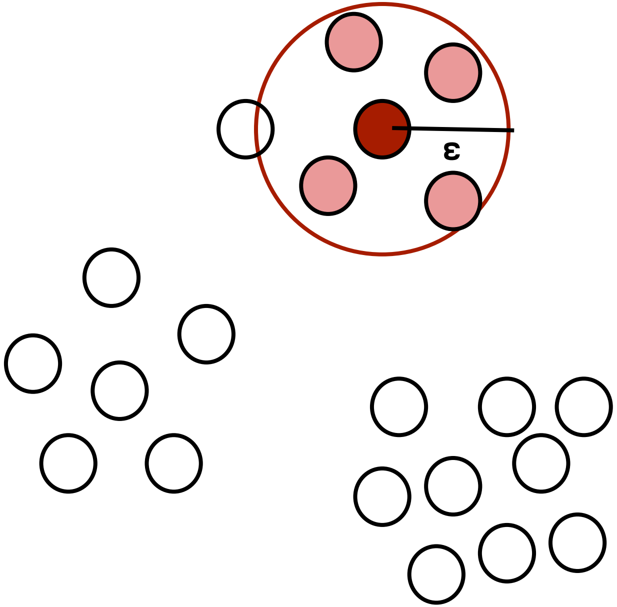
Min_pts = 3

Iterate through the dataset



DBScan visualized

Min_pts = 3

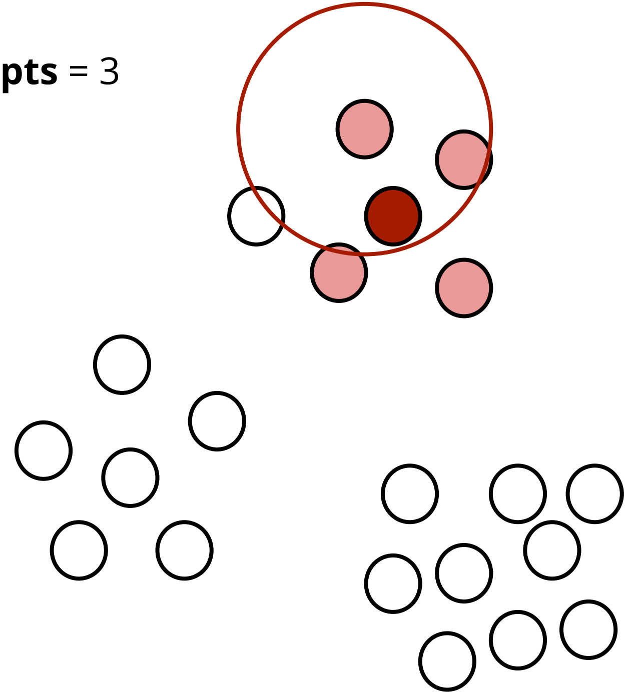


If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

We only add those neighbors if those neighbors make the light red into a cluster-generating "core points"

DBScan visualized

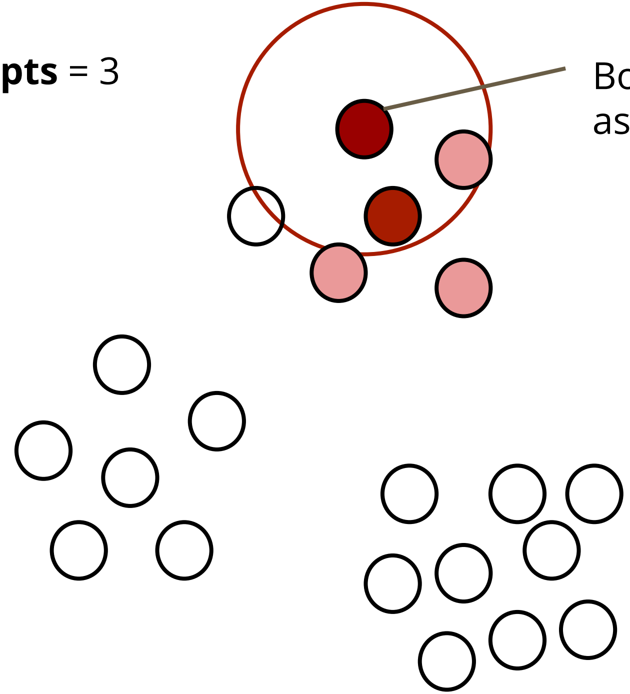
Min_pts = 3



If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

Min_pts = 3

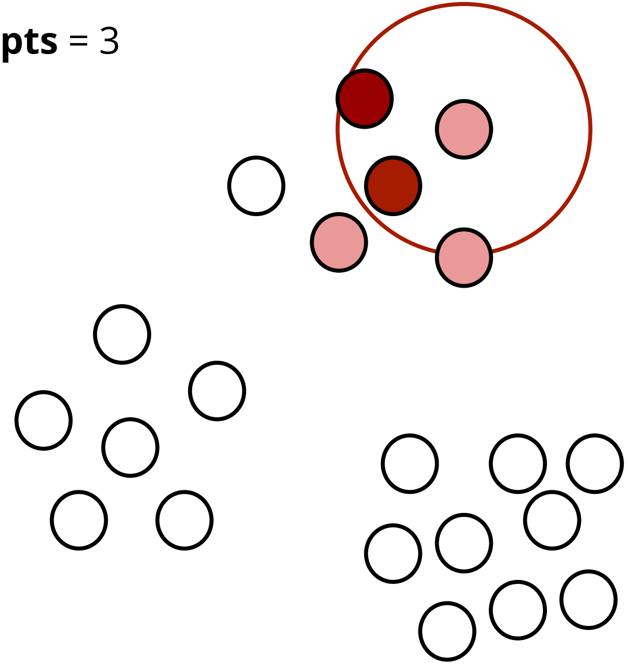


Border point but let's just assign it to this cluster

If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

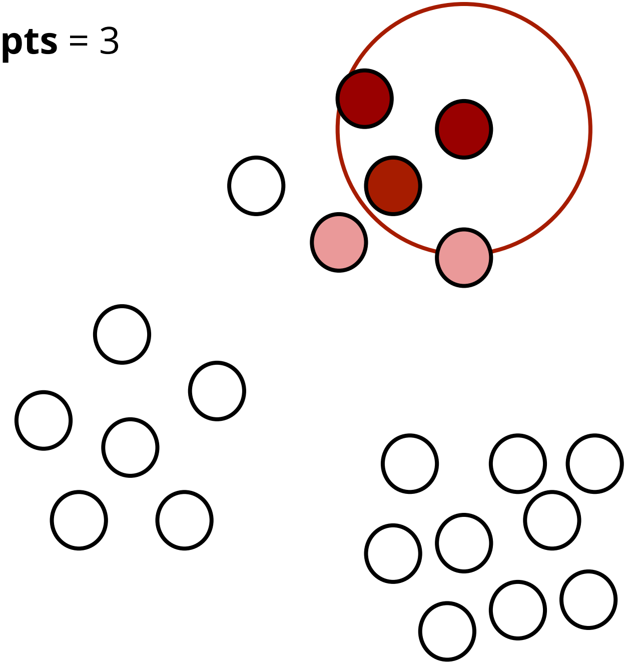
Min_pts = 3



If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

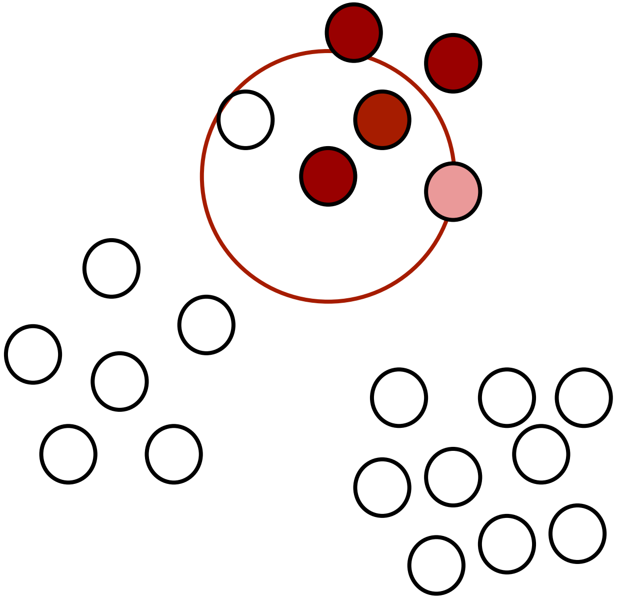
Min_pts = 3



If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

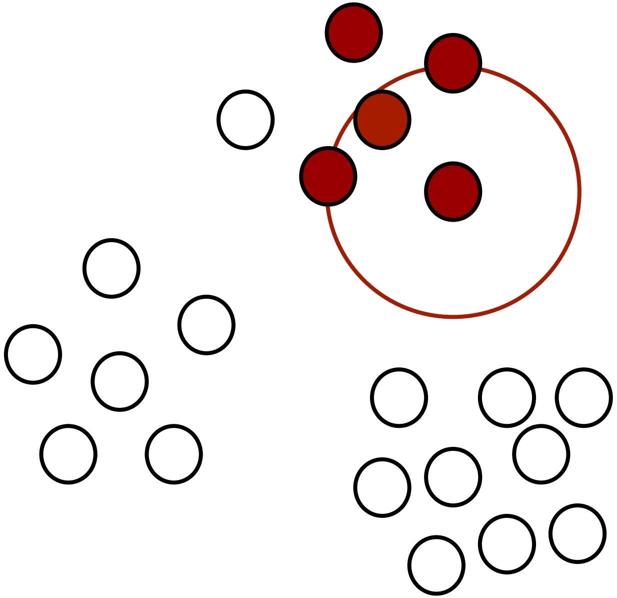
Min_pts = 3



If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

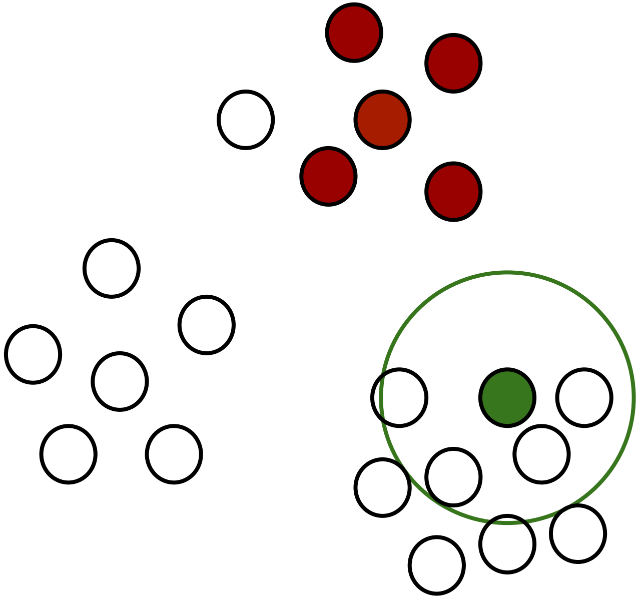
Min_pts = 3



If core point - iterate through its neighborhood to find more core points that should also be part of this cluster

DBScan visualized

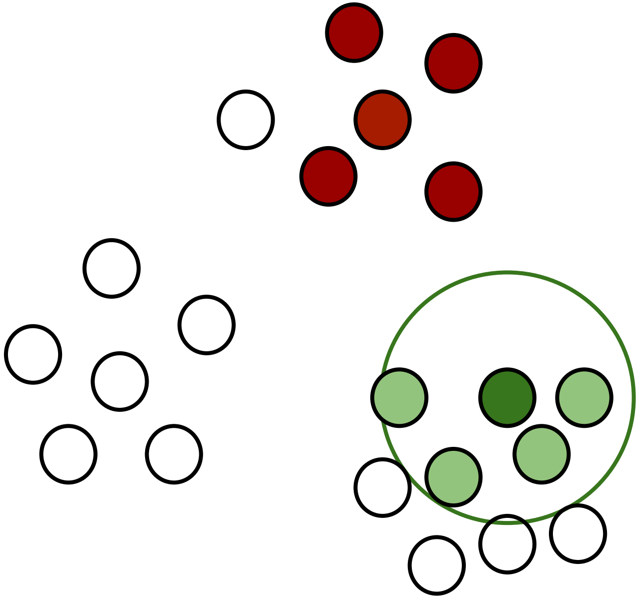
Min_pts = 3



Go to next data point in the dataset

DBScan visualized

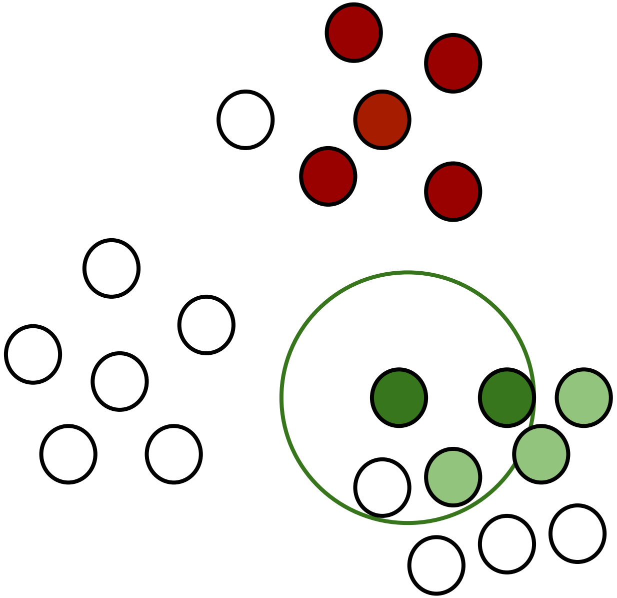
Min_pts = 3



Iterate over its neighborhood since it’s a core point

DBScan visualized

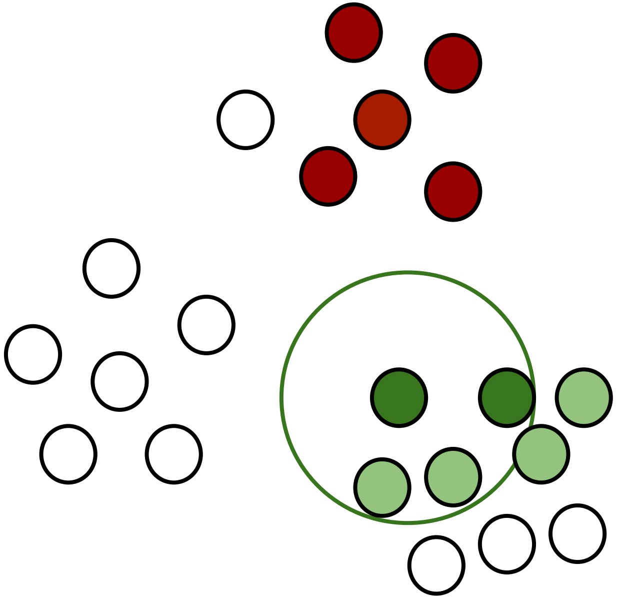
Min_pts = 3



Found another core point so we need to iterate over its neighborhood too

DBScan visualized

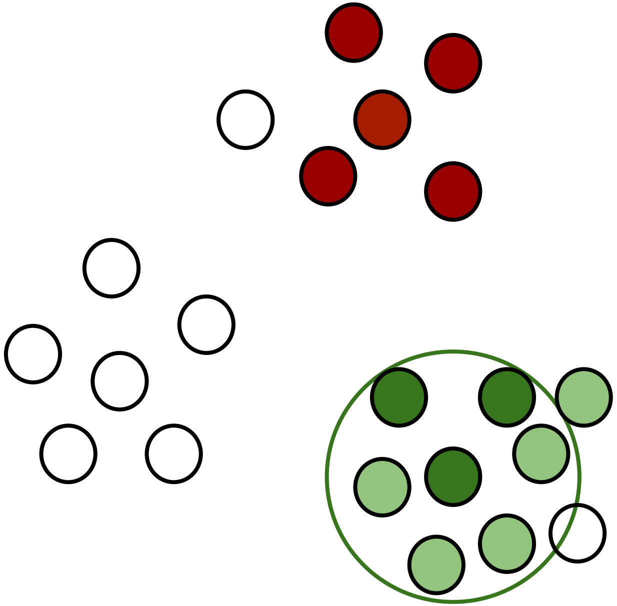
Min_pts = 3



Found another core point so we need to iterate over its neighborhood too

DBScan visualized

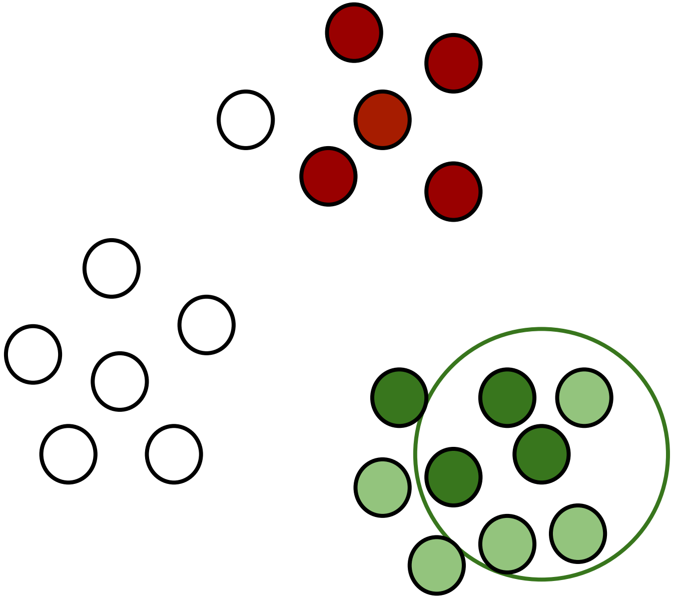
Min_pts = 3



Found another core point so we need to iterate over its neighborhood too

DBScan visualized

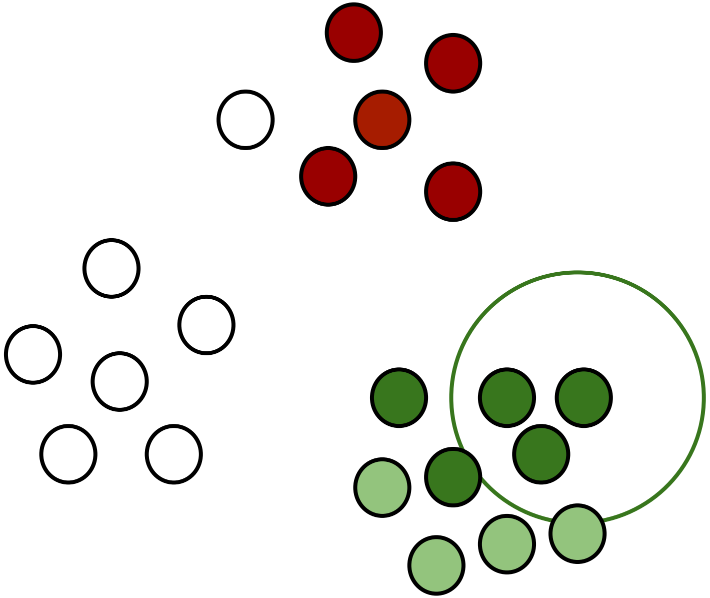
Min_pts = 3



Found another core point so we need to iterate over its neighborhood too

DBScan visualized

Min_pts = 3

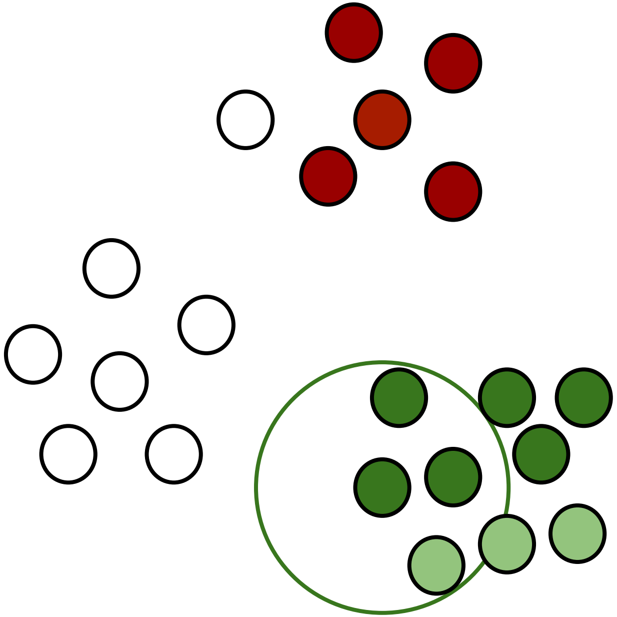


Border point but let’s assign it to the cluster now

후보 vs confirmed core point
if core point, add to the cluster

DBScan visualized

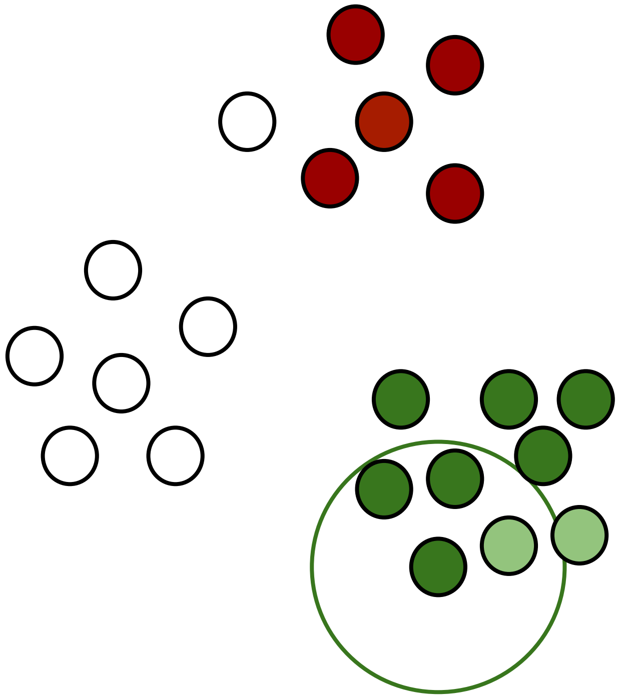
Min_pts = 3



Core point but all its neighborhood is already tracked

DBScan visualized

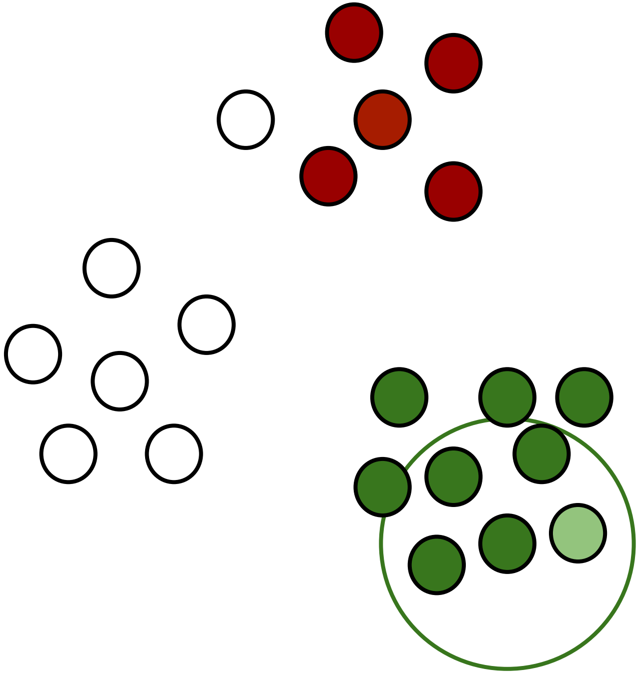
Min_pts = 3



Core point but all its neighborhood is already tracked

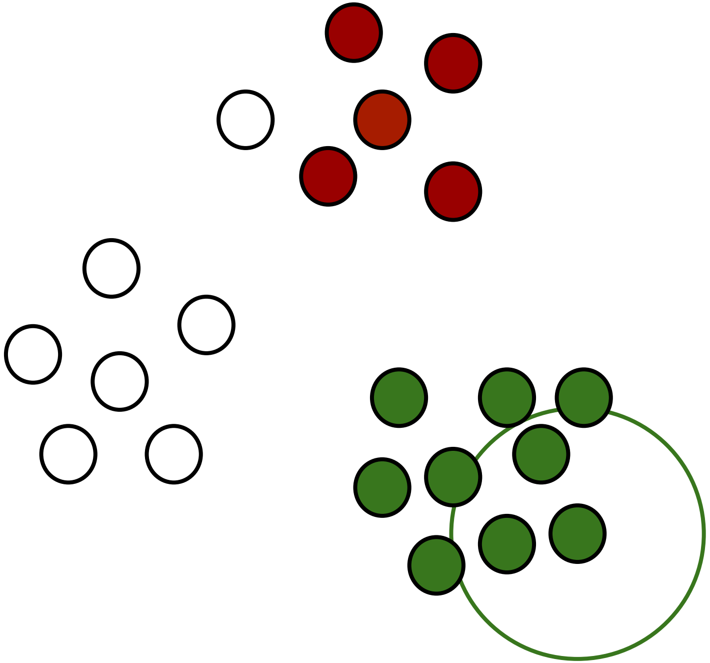
DBScan visualized

Min_pts = 3



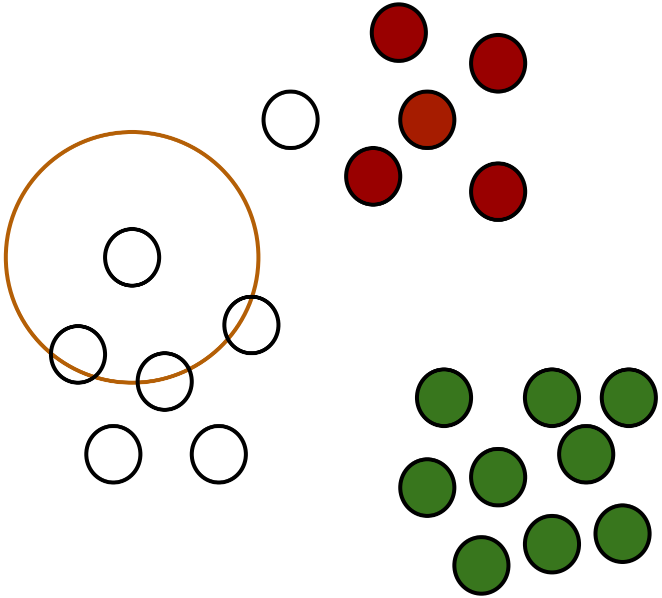
DBScan visualized

Min_pts = 3



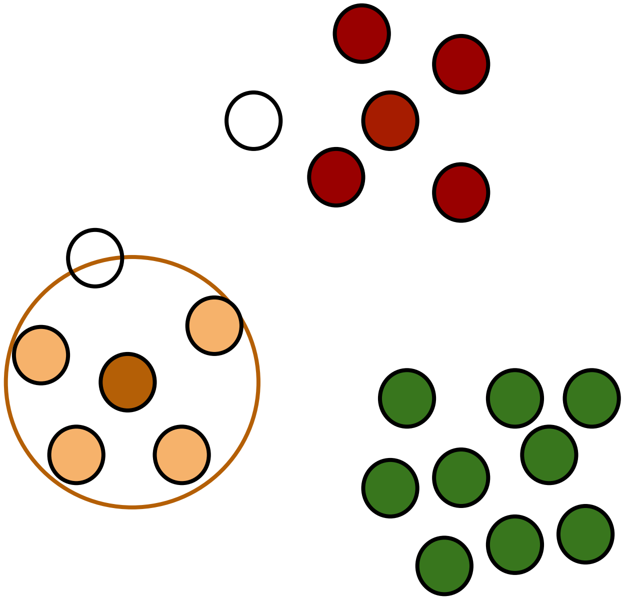
DBScan visualized

Min_pts = 3



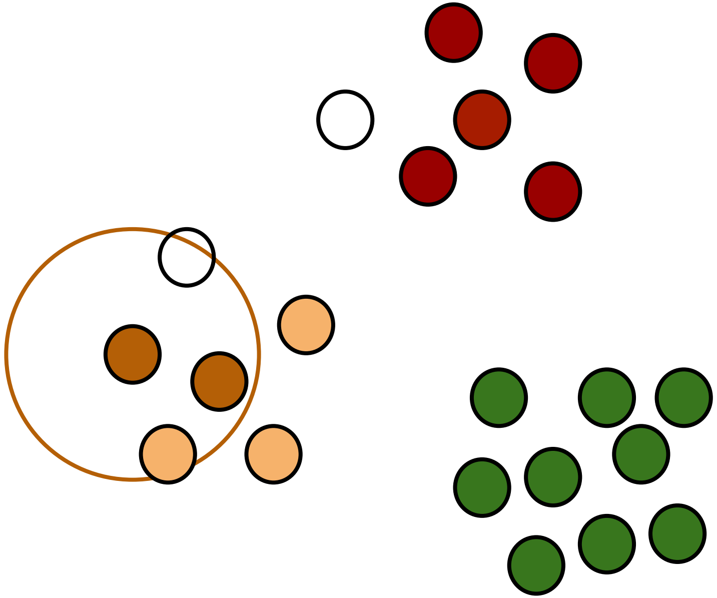
DBScan visualized

Min_pts = 3



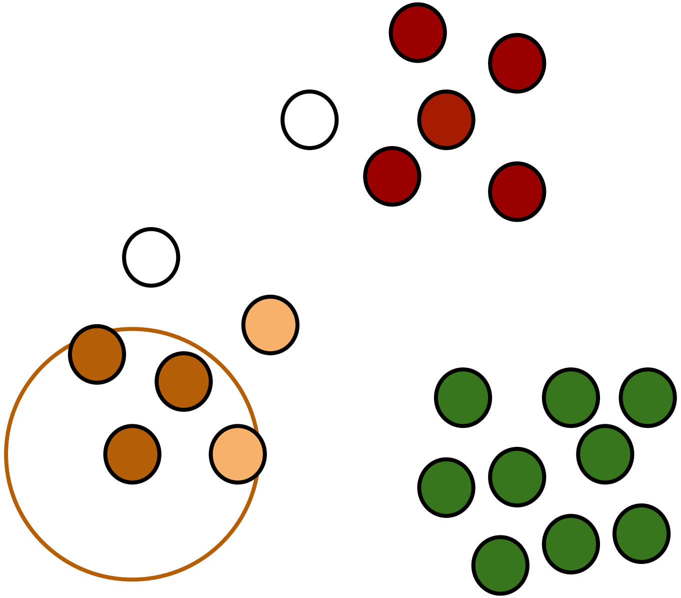
DBScan visualized

Min_pts = 3



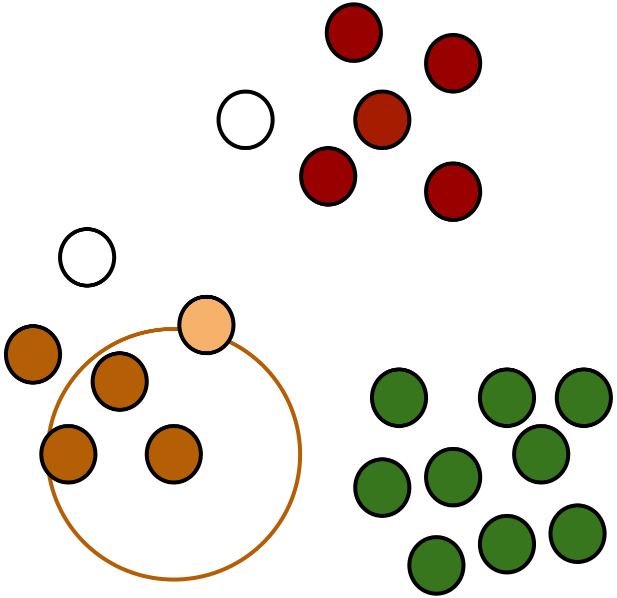
DBScan visualized

Min_pts = 3



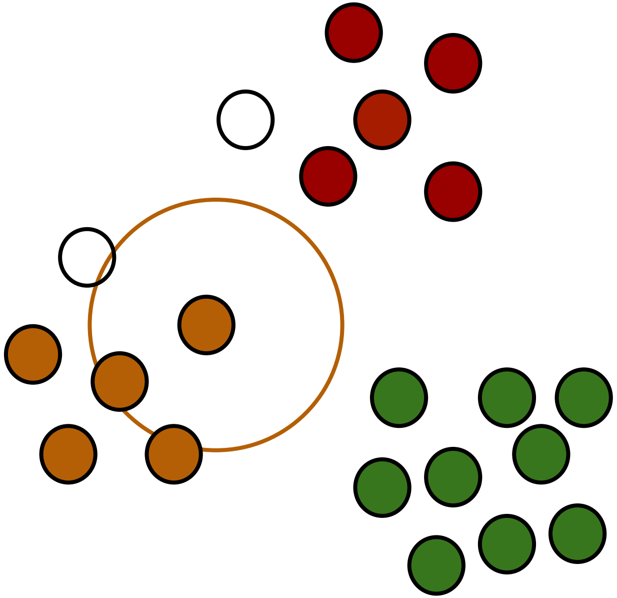
DBScan visualized

Min_pts = 3



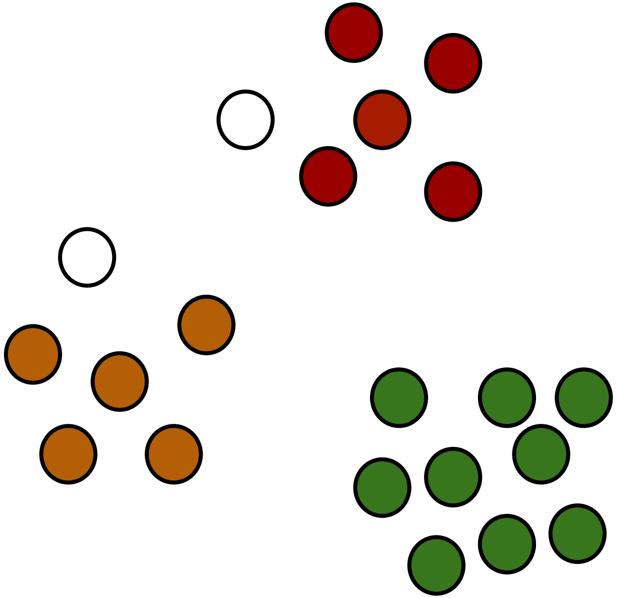
DBScan visualized

Min_pts = 3



DBScan visualized

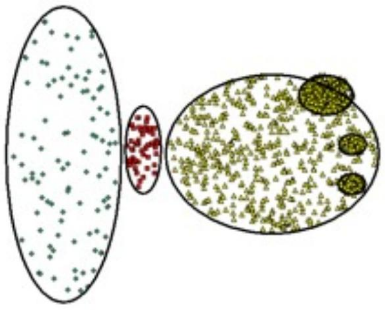
Min_pts = 3

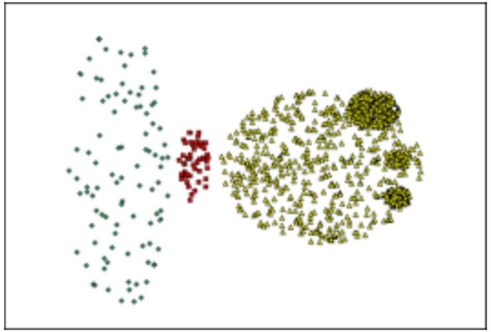


DBScan - Benefits

1. Can identify clusters of different shapes and sizes
2. Resistant to noise

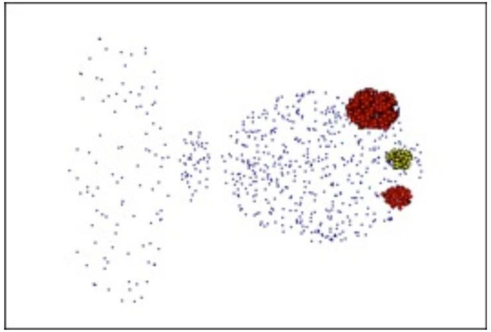
DBScan - Limitations





(MinPts=4, Eps=9.75).

1. Can fail to identify clusters of varying densities.
2. Tends to create clusters of the same density.
3. Notion of density is problematic in high-dimensional spaces



(MinPts=4, Eps=9.92)

Demo

Attribute A	Attribute B	Attribute C	Attribute D		Assignment
Yes	Single	125k	No	→	0
No	Married	100k	No	→	1
No	Single	70k	No		0
Yes	Married	120k	No		2
No	Divorced	90k	Yes	…	1
No	Married	60k	No		1
Yes	Divorced	220k	No		3
No	Single	85k	Yes		0
No	Married	75k	No		1
No	Single	90k	Yes	→	3