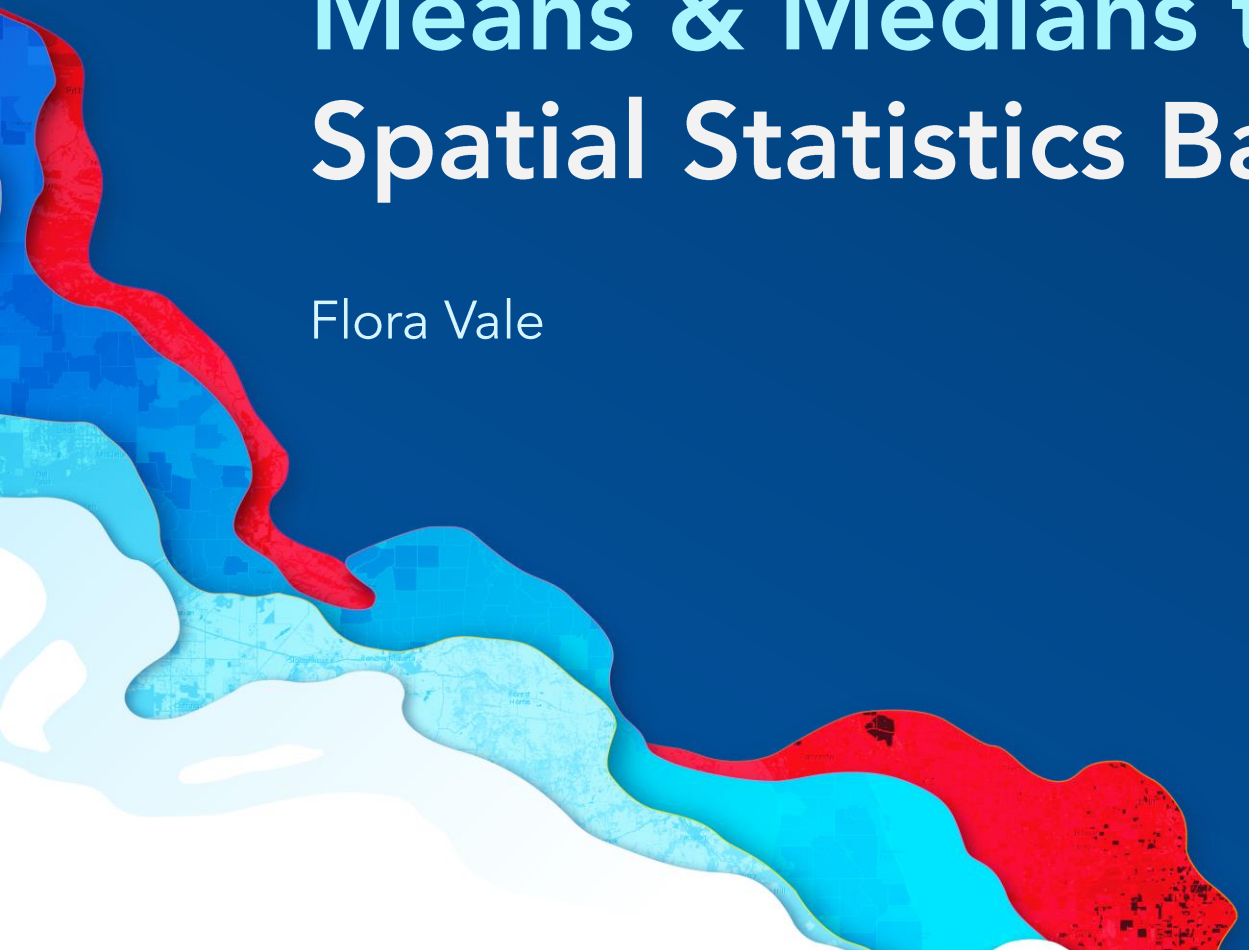
Means & Medians to Machine Learning: Spatial Statistics Basics and Innovations

Flora Vale

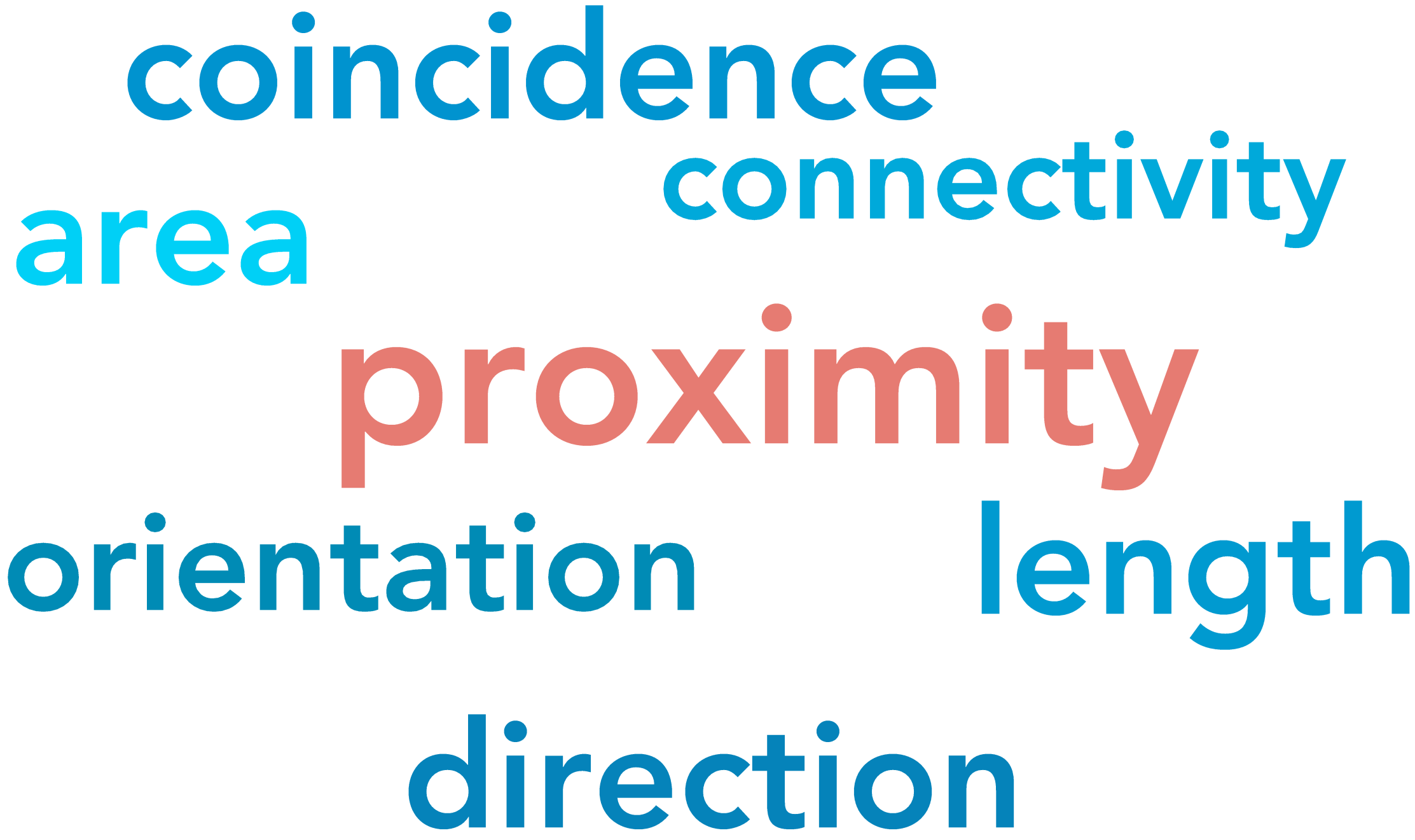


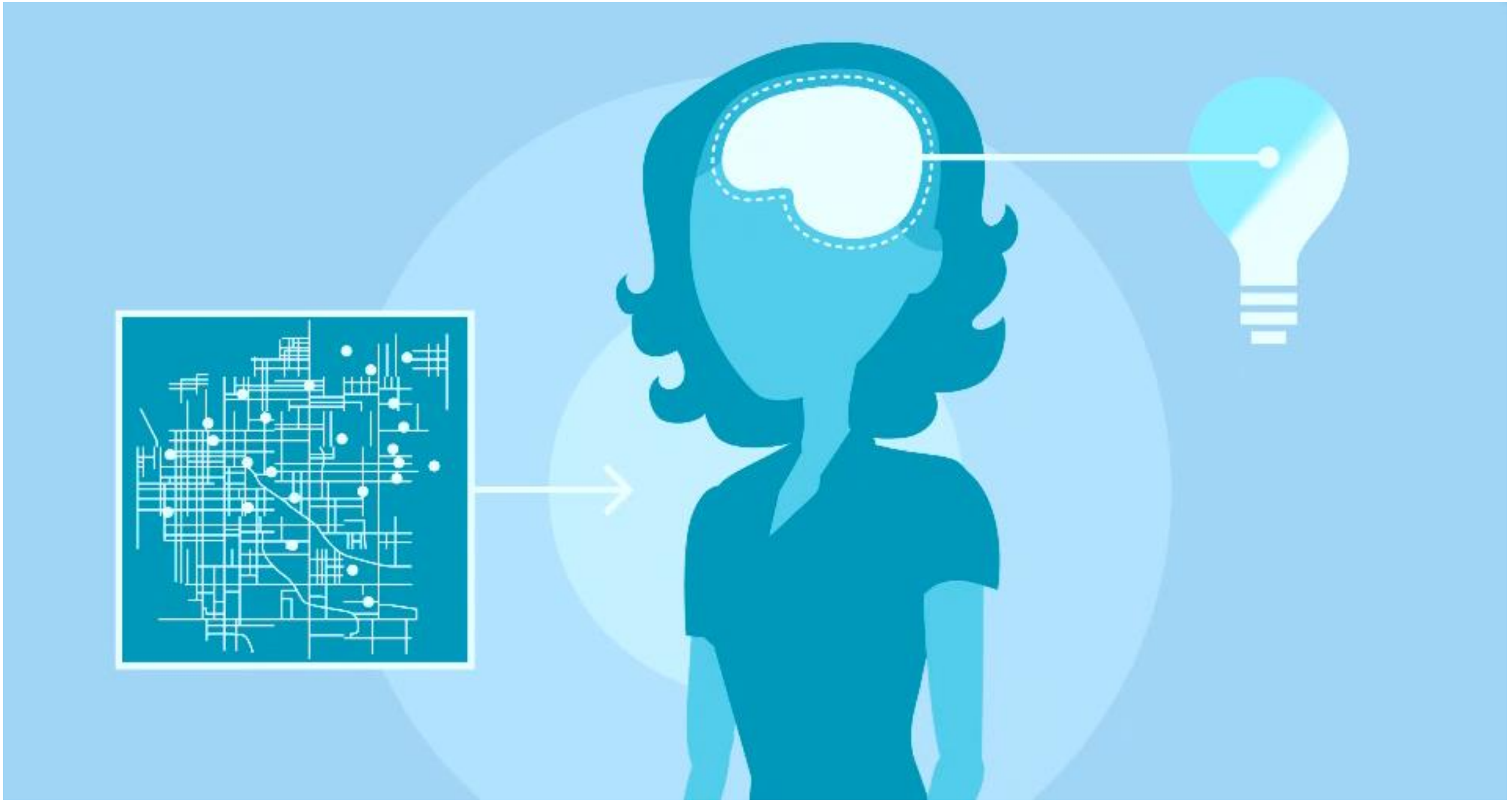
esriurl.com/spatialstats

2018 **Esri Federal GIS Conference** | Washington, DC

What are Spatial Statistics?

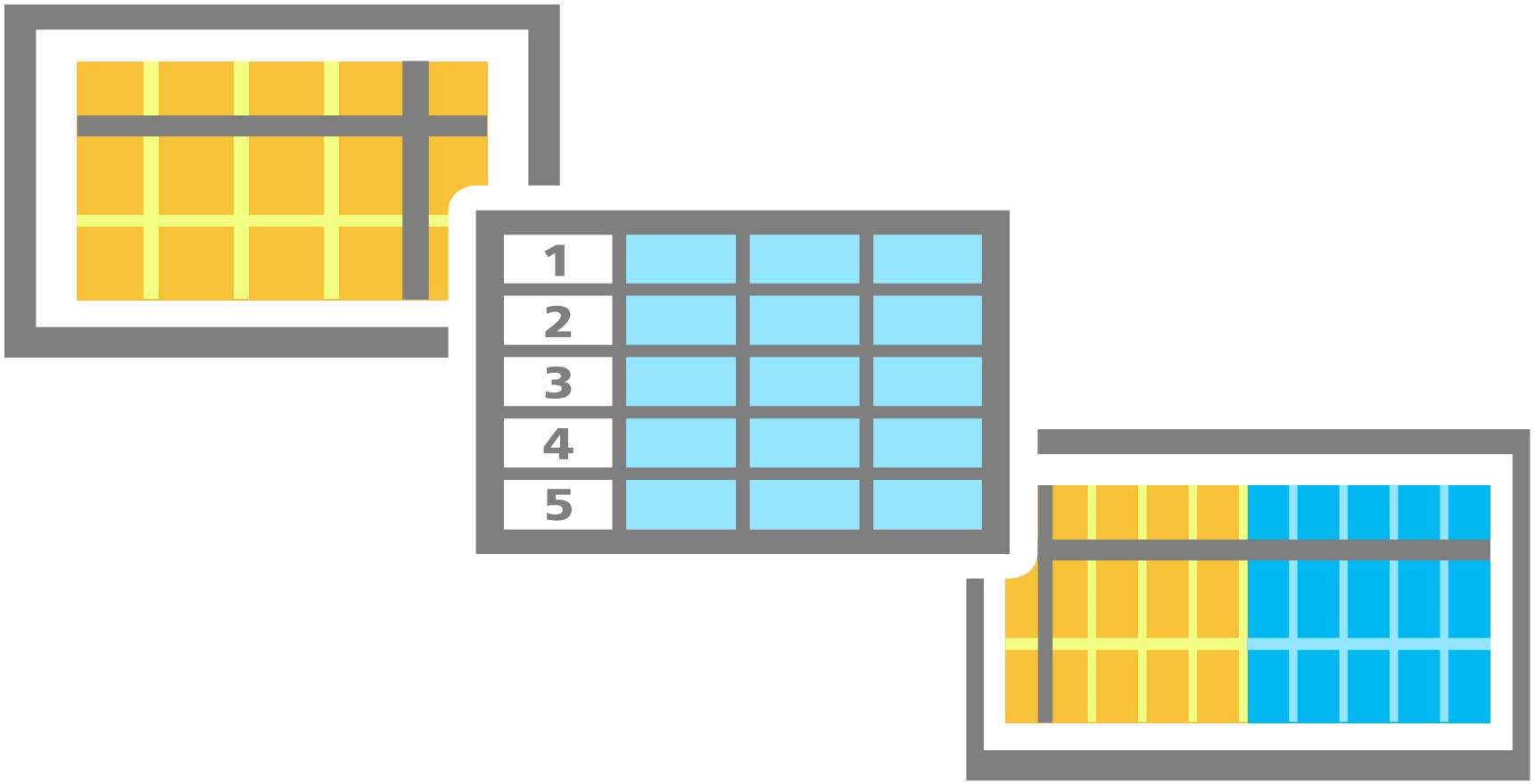
Spatial Statistics are a set of exploratory techniques for describing and modeling spatial distributions, patterns, processes, and relationships.


coincidence
connectivity
area
proximity
orientation
length
direction



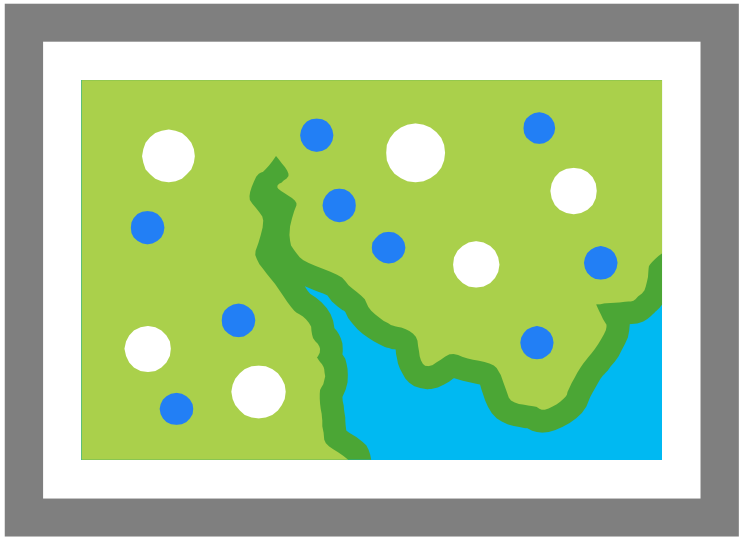
Spreadsheets

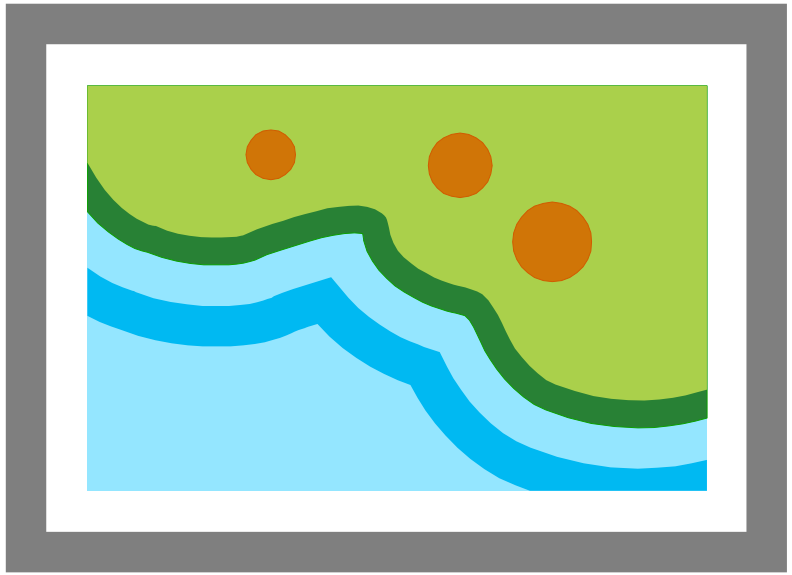
Data or Information?



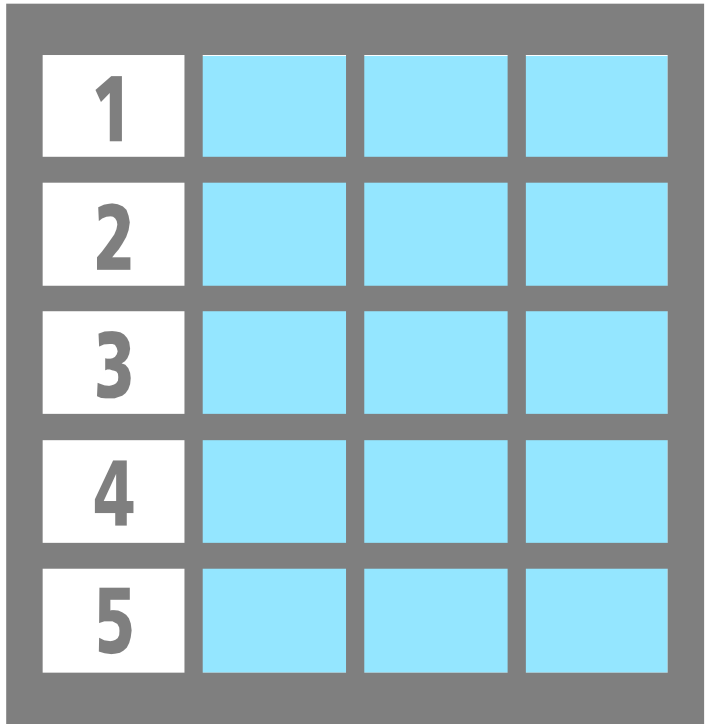
Maps

Data or Information?

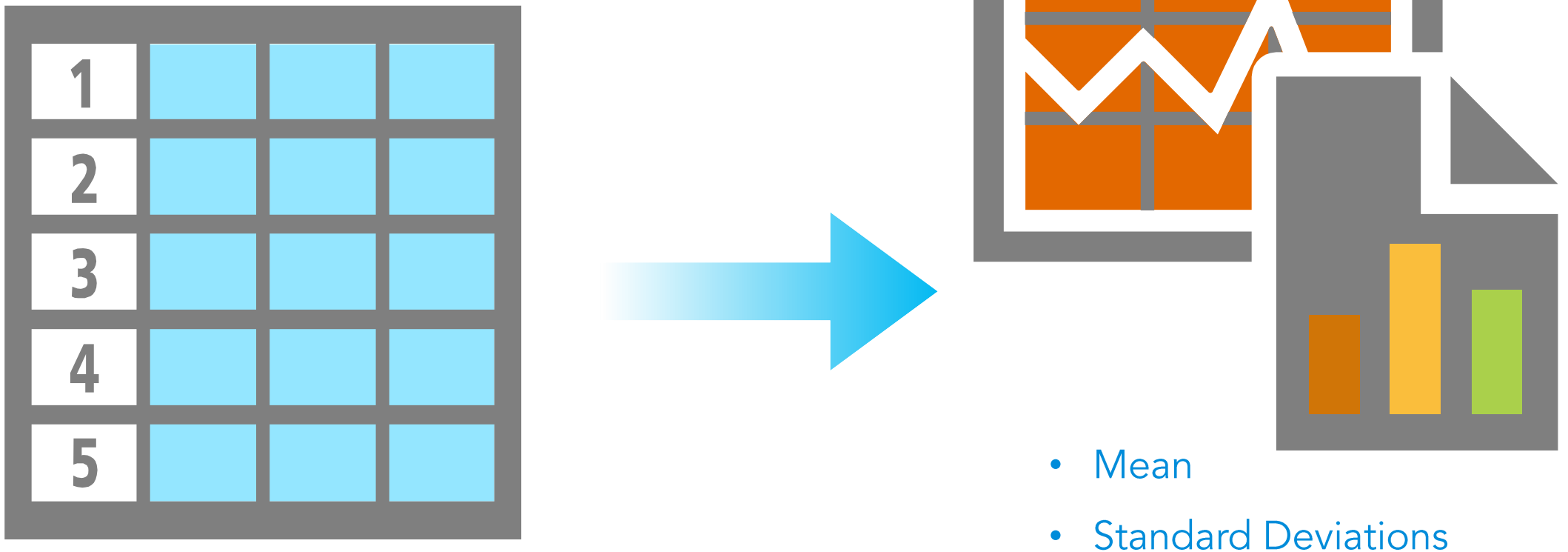




When you look at a spreadsheet...



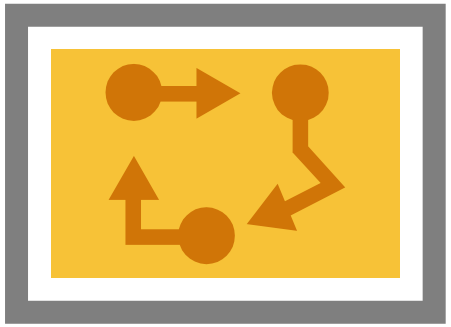
You ask for more

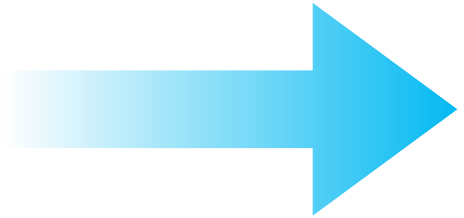


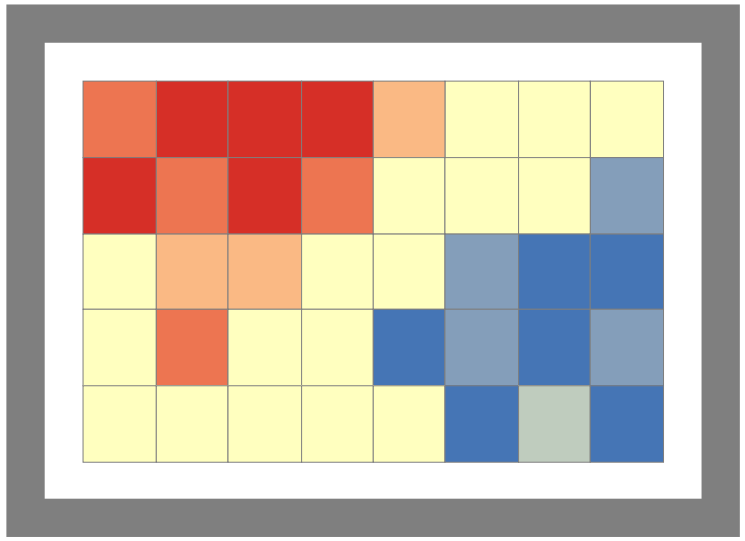
- Mean
- Standard Deviations
- Min and Max
- …

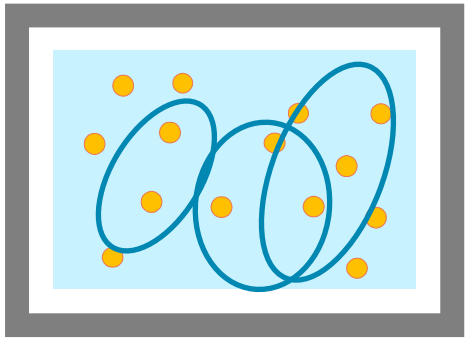
Same goes for maps!

We can do more







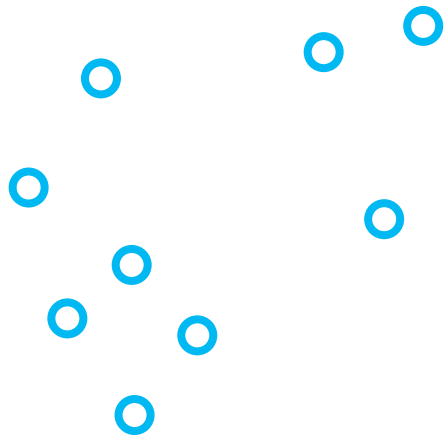


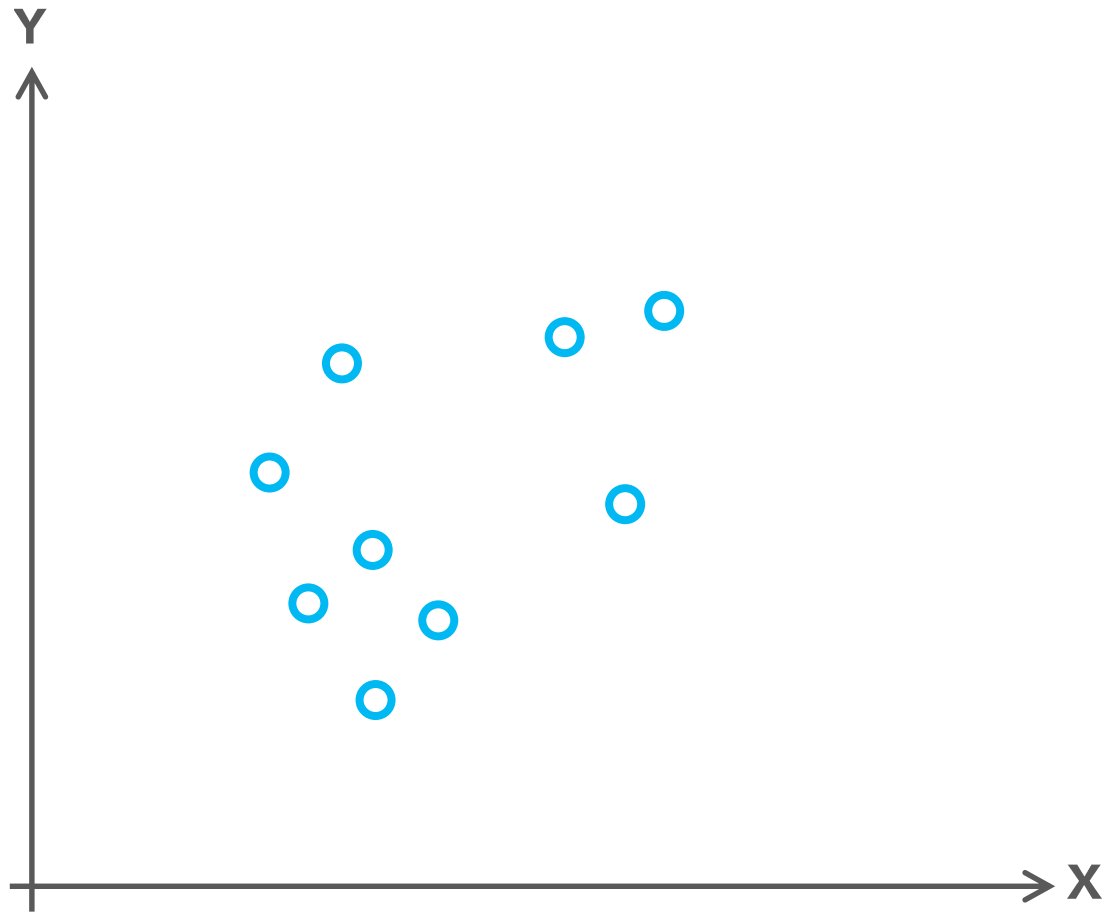
Means and Medians

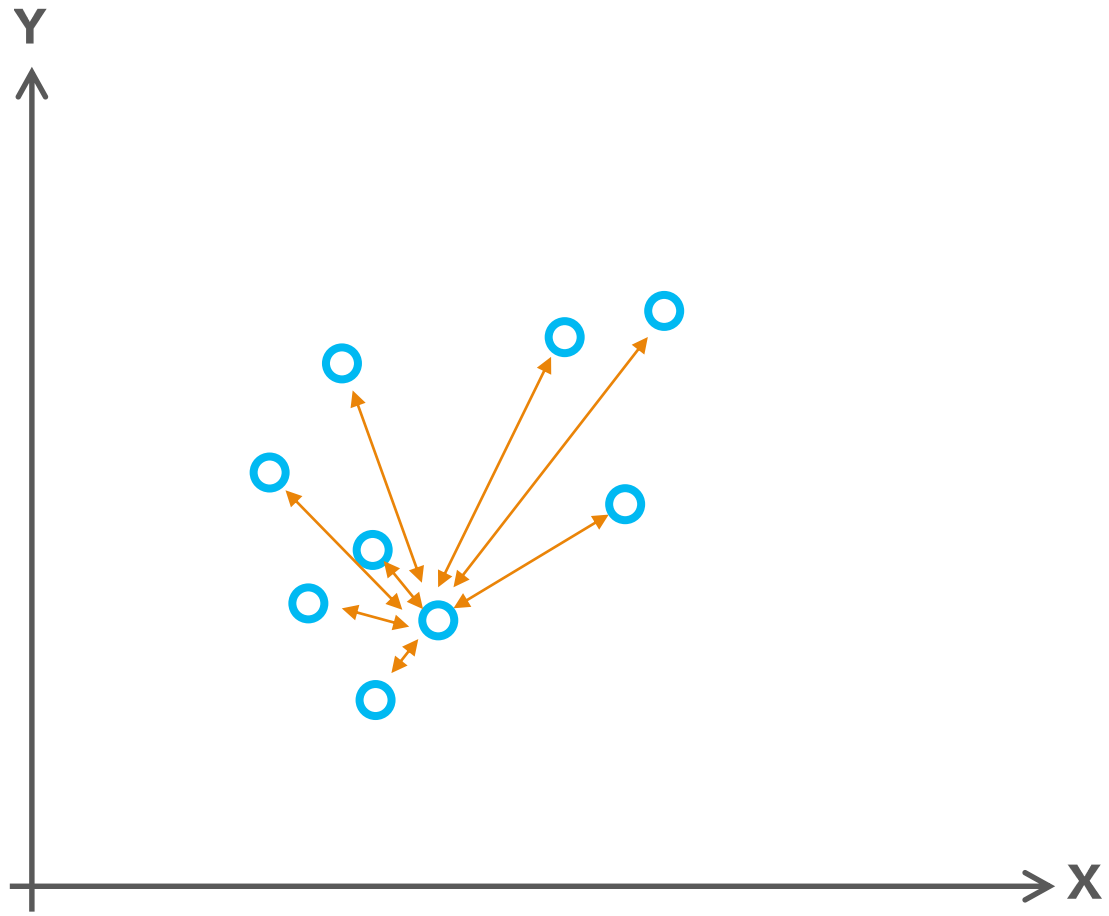
summarizing spatial distributions

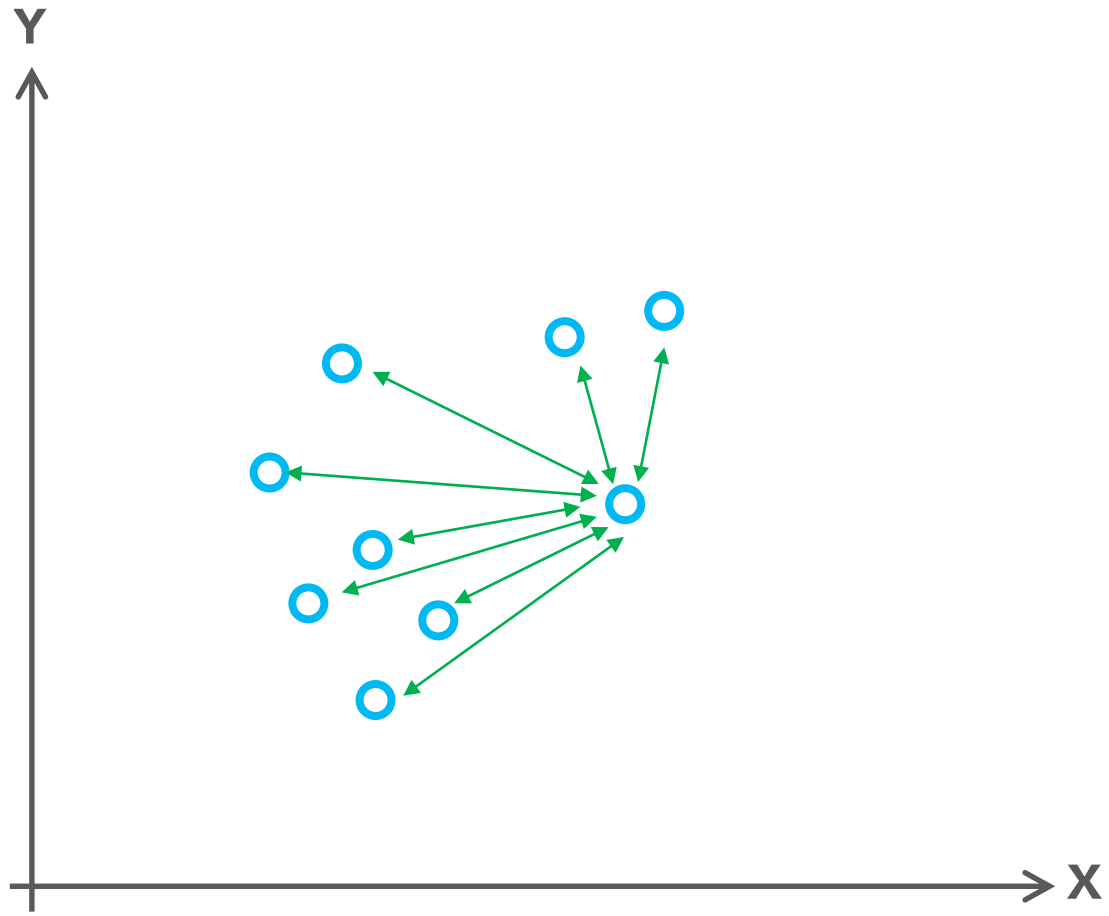
Central Feature

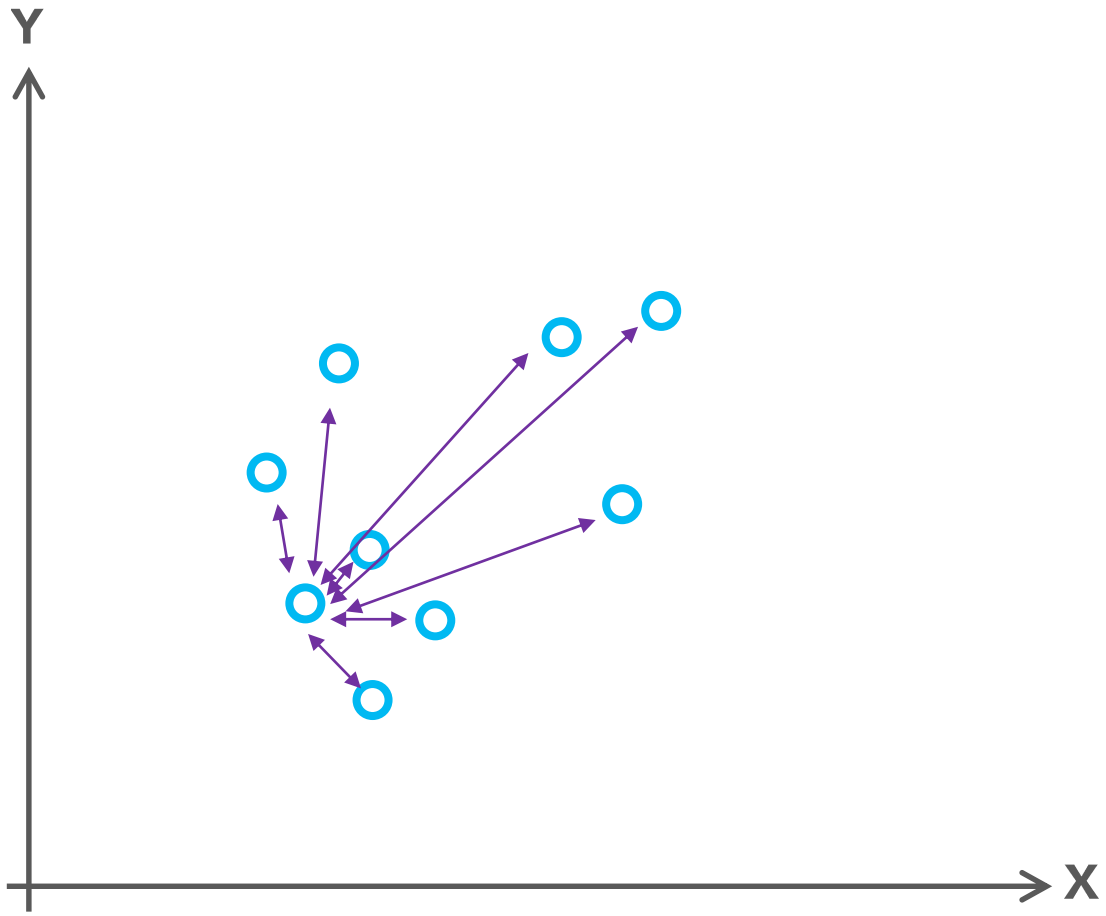
identifies the most centrally located feature in a point, line, or polygon feature class

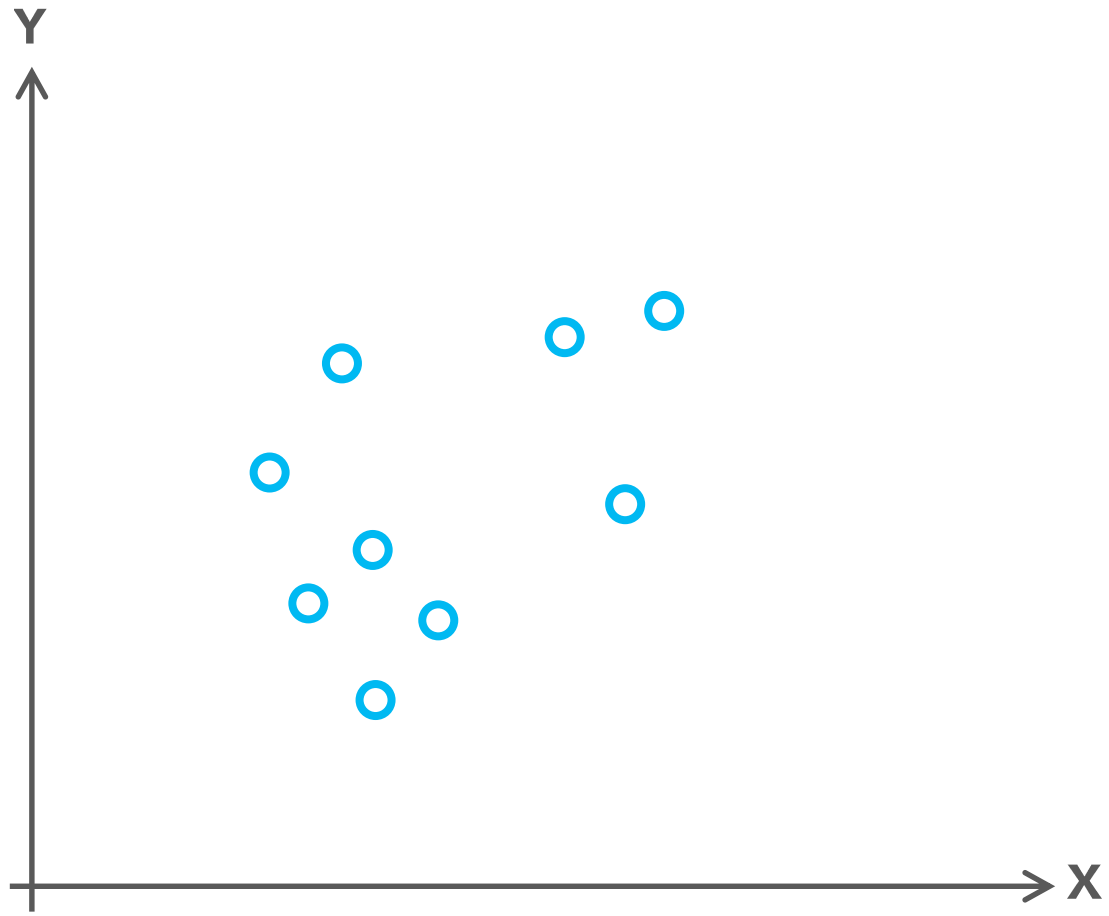


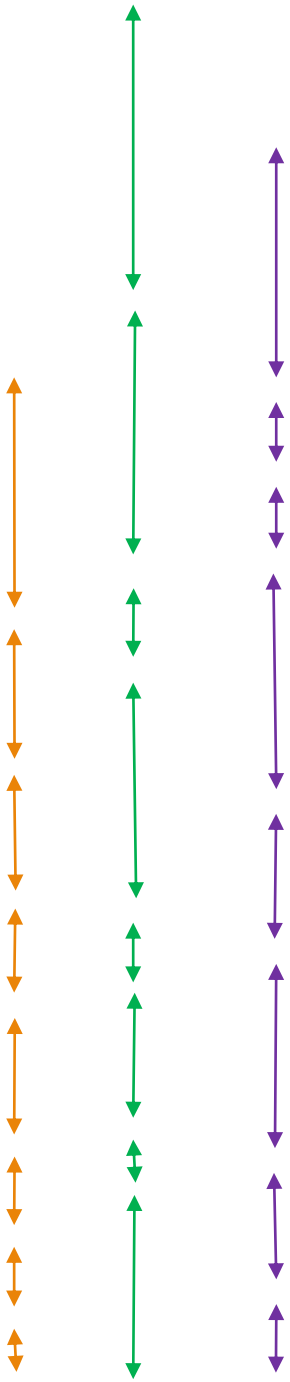

Y
X

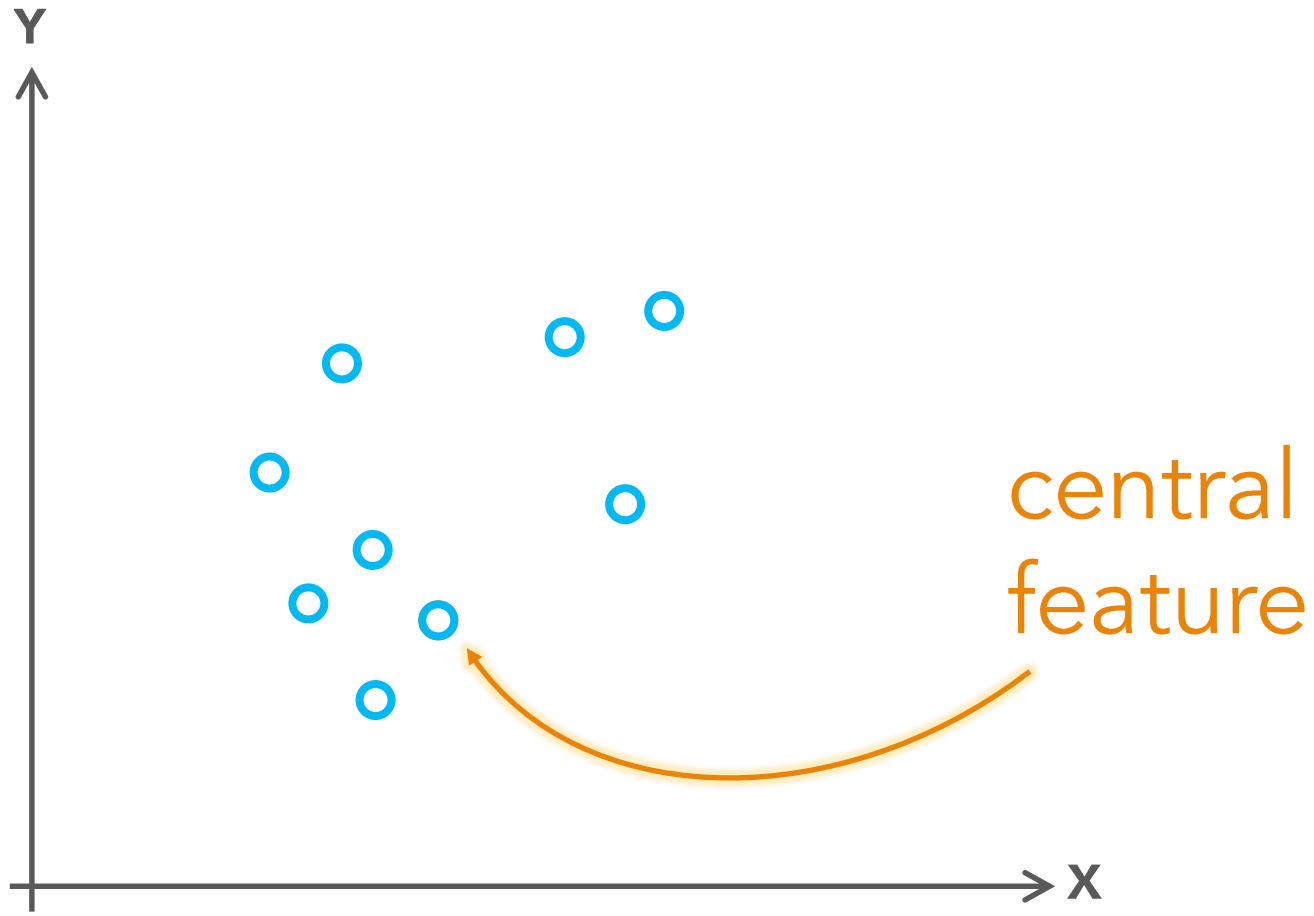

Y
X

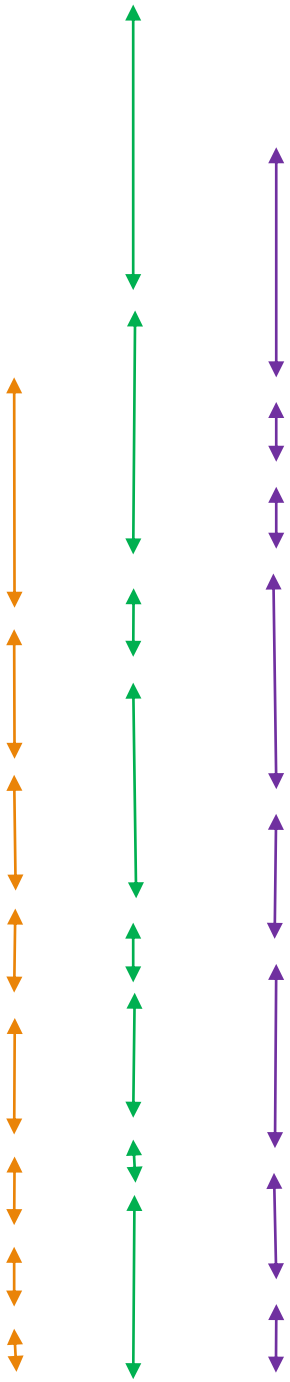

Y
X


Y
X


Y
X

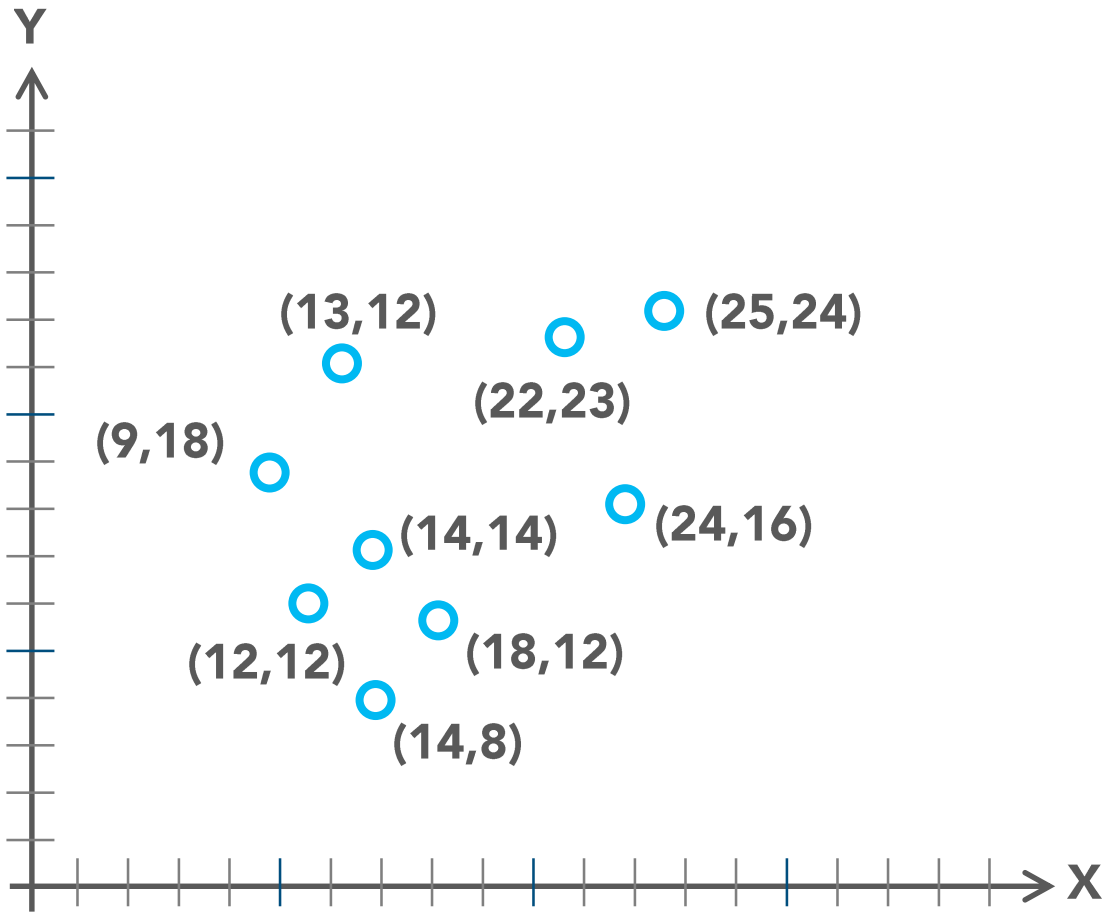


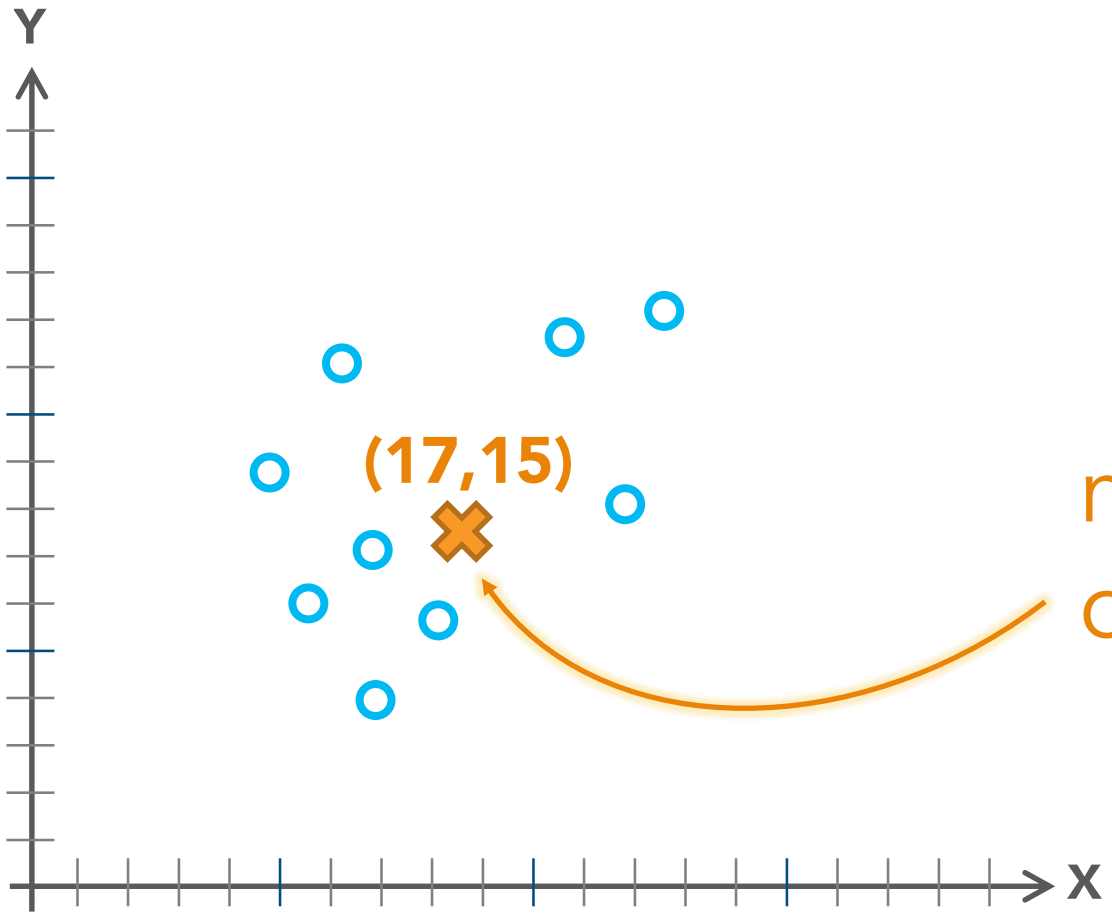

Y
X
central
feature



Mean Center

identifies the geographic center (or the center of concentration) for a set of features


Y
X
(13,12)
(25,24)
(22,23)
(9,18)
(14,14)
(24,16)
(12,12)
(18,12)
(14,8)



(14,14)

(13,12)

(25,24)

(24,16)

(22,23)

(18,12)

(12,12)

(14,8)

(9,18)

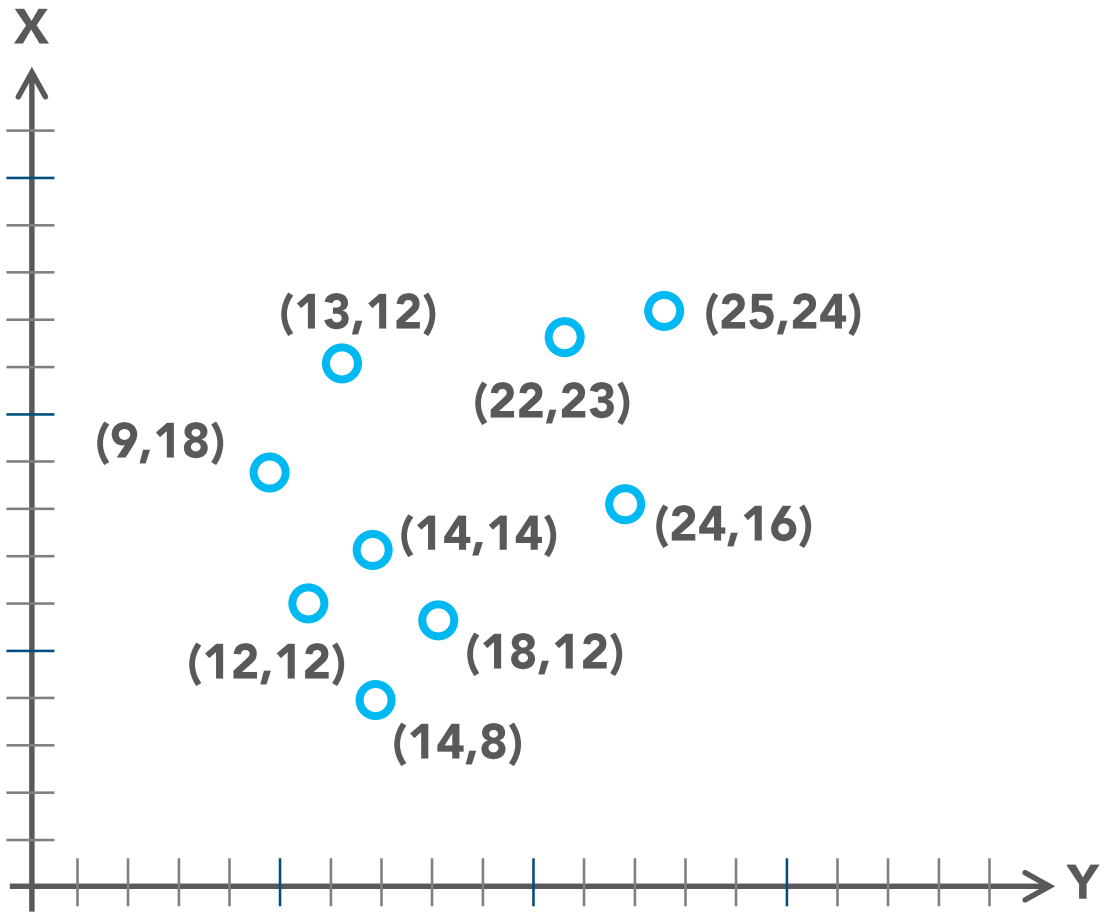
---

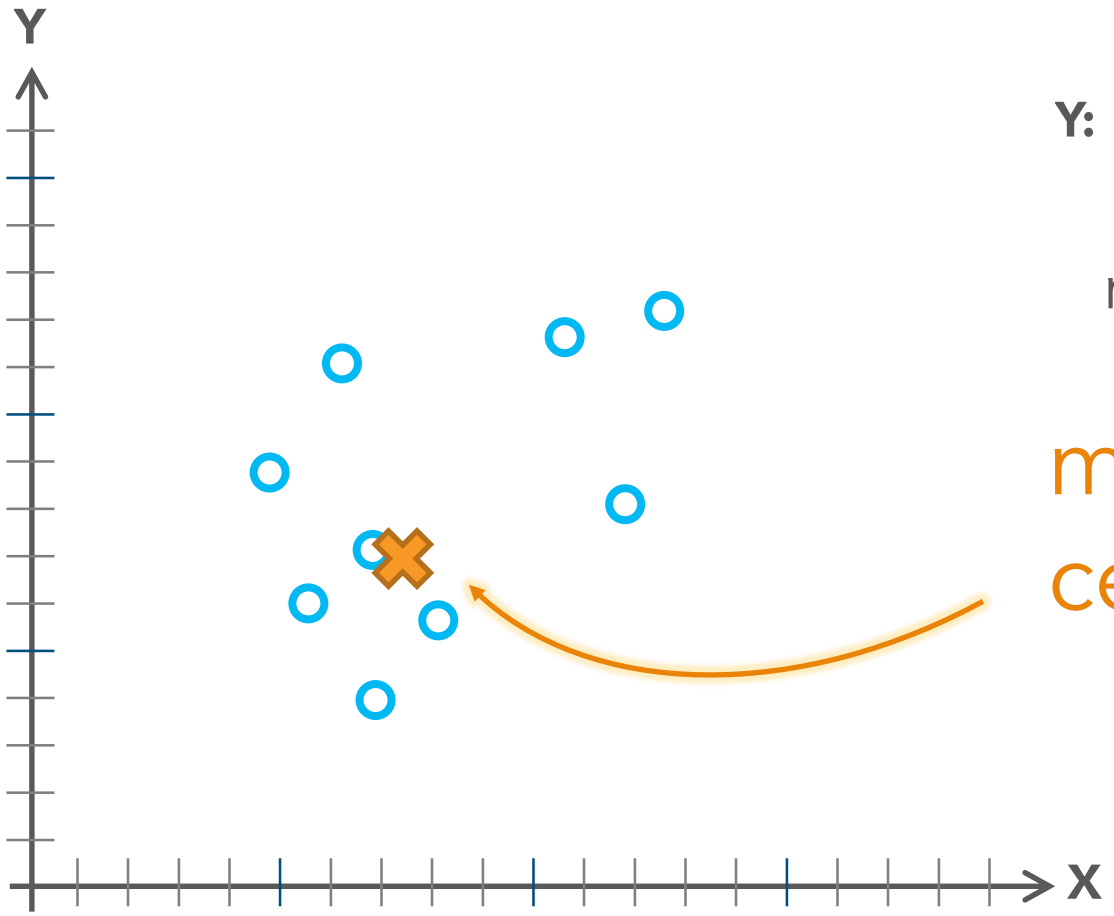
mean =

(17,15)

Median Center

identifies the location that minimizes overall Euclidean distance to the features in a dataset


X
Y
(13,12)
(25,24)
(22,23)
(9,18)
(14,14)
(24,16)
(12,12)
(18,12)
(14,8)



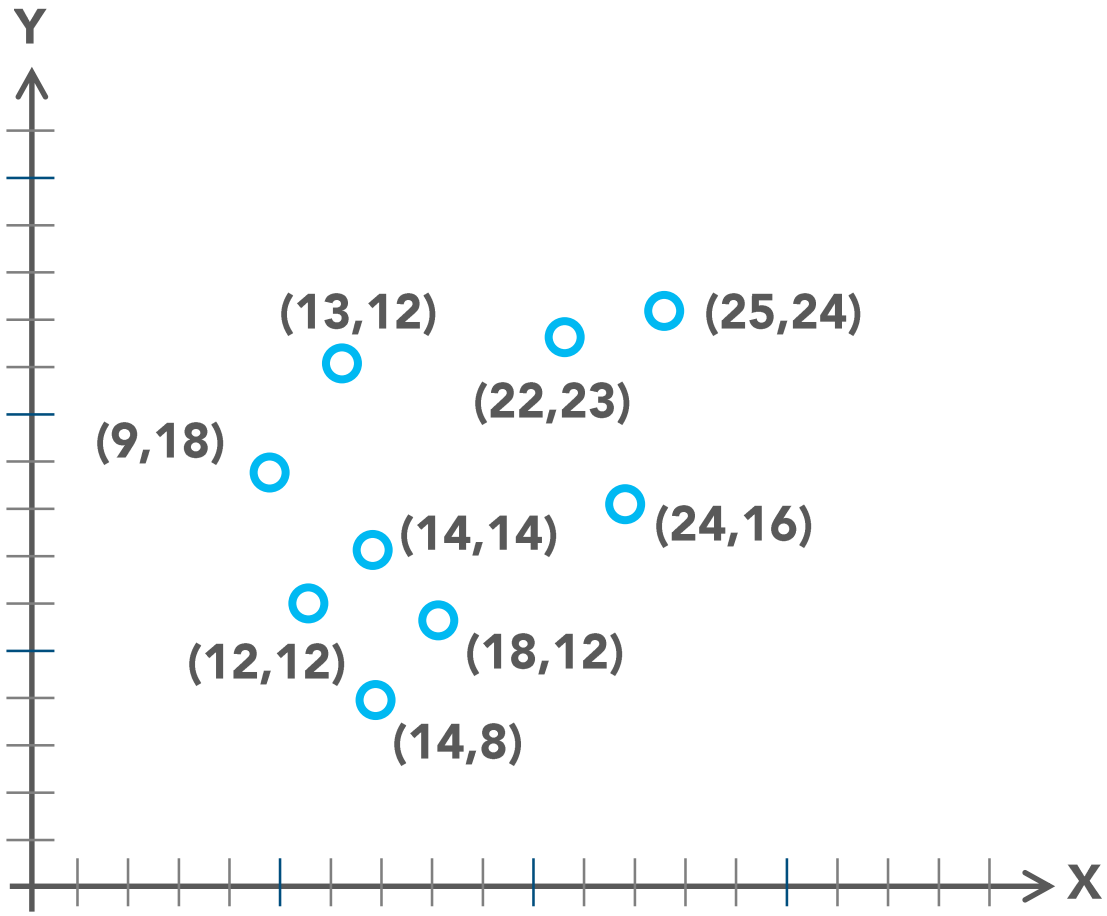
X: ~~25~~ . ~~24~~ . ~~22~~ . ~~18~~ . 14 . ~~14~~ . ~~13~~ . ~~12~~ . ~~8~~

Y: ~~24~~ . ~~23~~ . ~~18~~ . ~~16~~ . 14 . ~~12~~ . ~~12~~ . ~~12~~ . ~~8~~

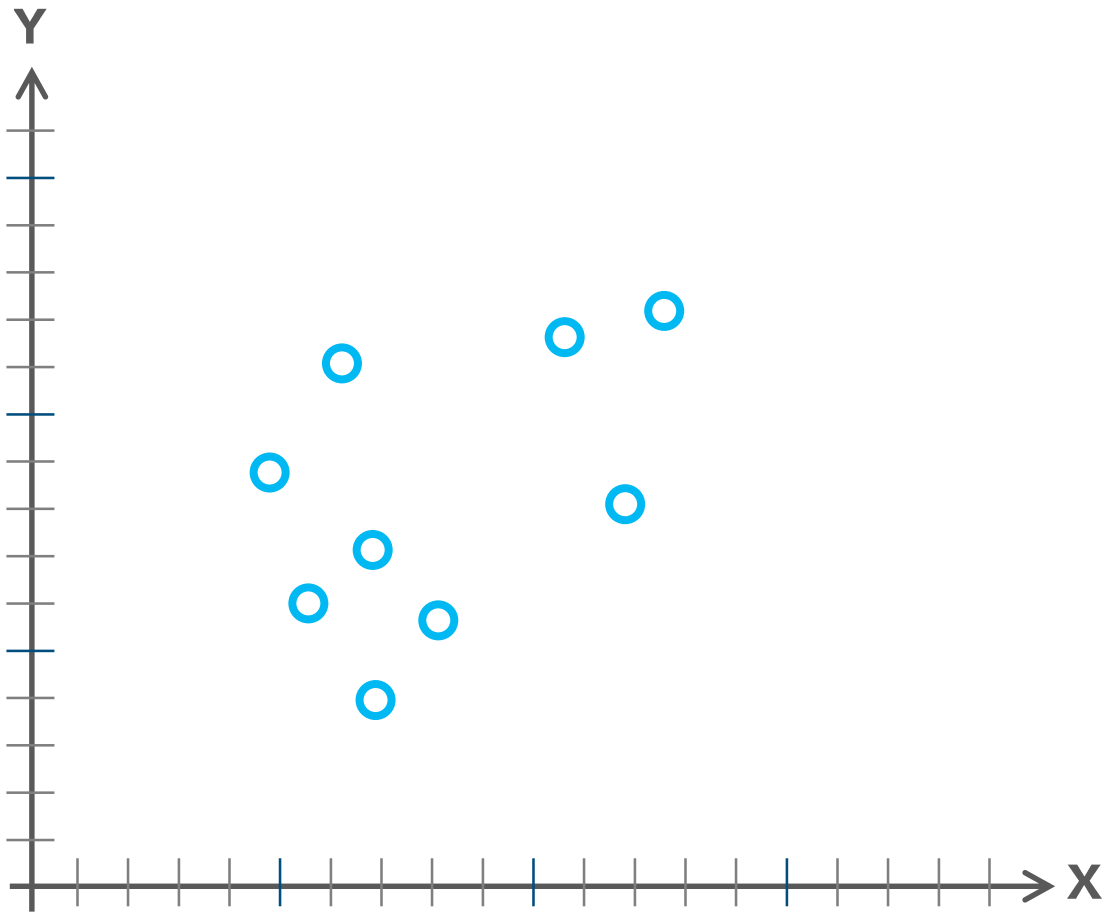
median = **(14,14)**

median
center

Mean vs Median?



(176,138)



(14,14)

(13,12)

(25,24)

(24,16)

(22,23)

(18,12)

(12,12)

(14,8)

(9,18)

(74,38)

---

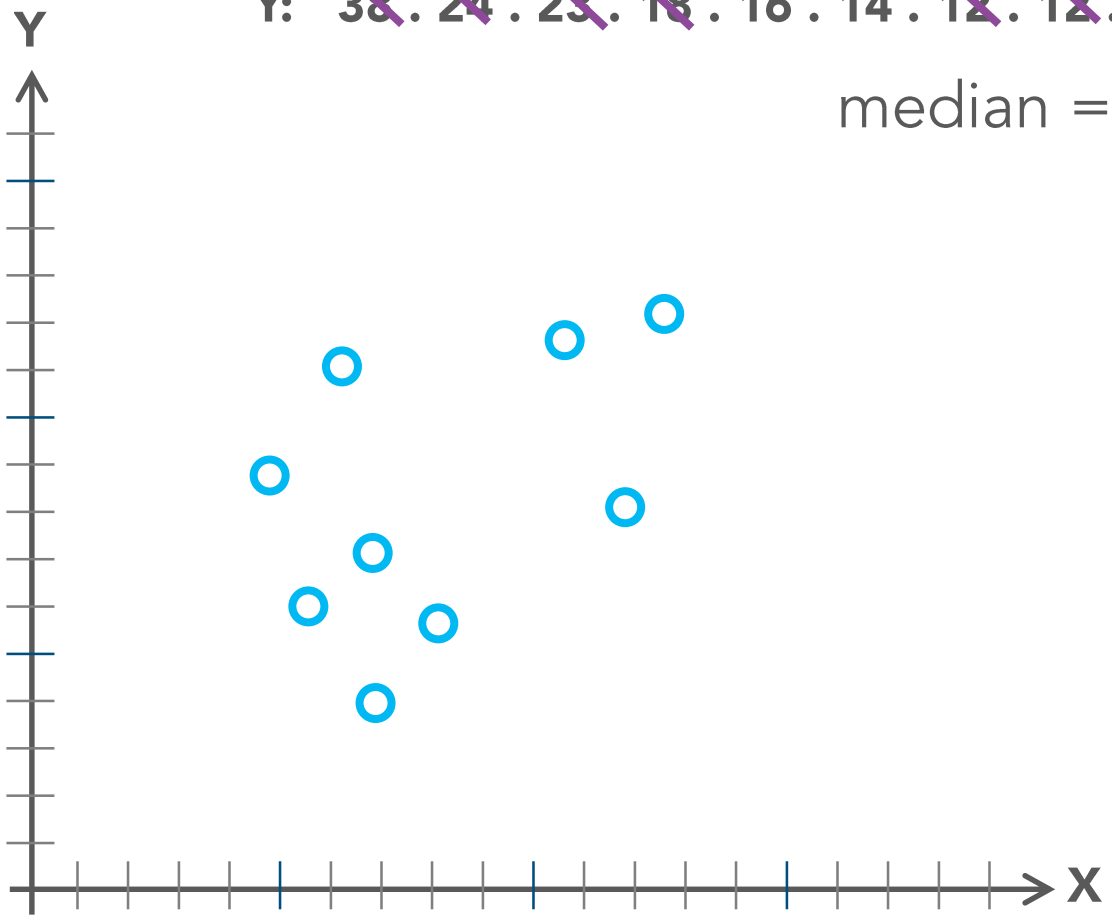
mean =

(33,28)

X: ~~74~~ . ~~25~~ . ~~24~~ . ~~22~~ . 18 . 14 . ~~14~~ . ~~13~~ . ~~12~~ . ~~9~~

Y: ~~38~~ . ~~24~~ . ~~23~~ . ~~18~~ . 16 . 14 . ~~12~~ . ~~12~~ . ~~12~~ . ~~8~~

median = **(16,15)**



(14,14)

(13,12)

(25,24)

(24,16)

(22,23)

(18,12)

(12,12)

(14,8)

(9,18)

(74,38)

---

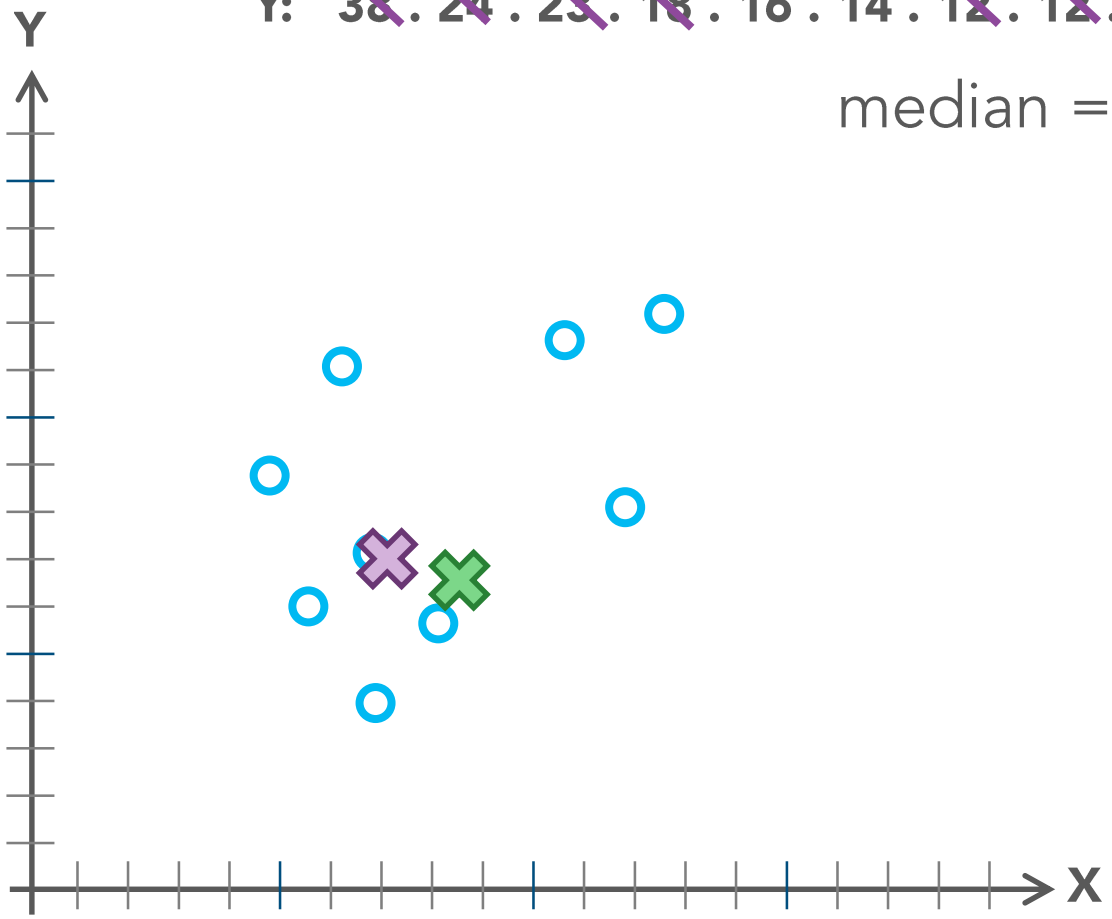
mean =

(33,28)

X: ~~74~~ . ~~25~~ . ~~24~~ . ~~22~~ . 18 . 14 . ~~14~~ . ~~13~~ . ~~12~~ . ~~9~~

Y: ~~38~~ . ~~24~~ . ~~23~~ . ~~18~~ . 16 . 14 . ~~12~~ . ~~12~~ . ~~12~~ . ~~8~~

median = **(16,15)**



(14,14)

(13,12)

(25,24)

(24,16)

(22,23)

(18,12)

(12,12)

(14,8)

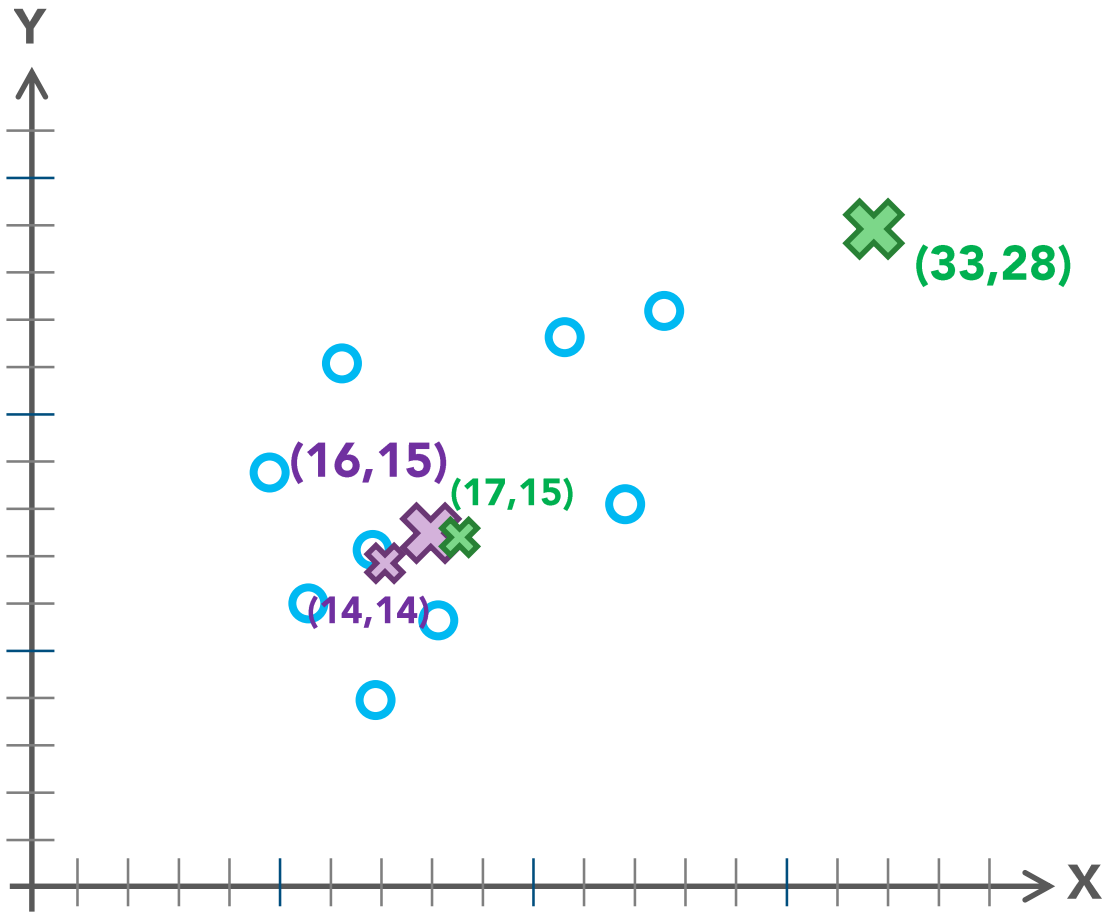
(9,18)

(74,38)

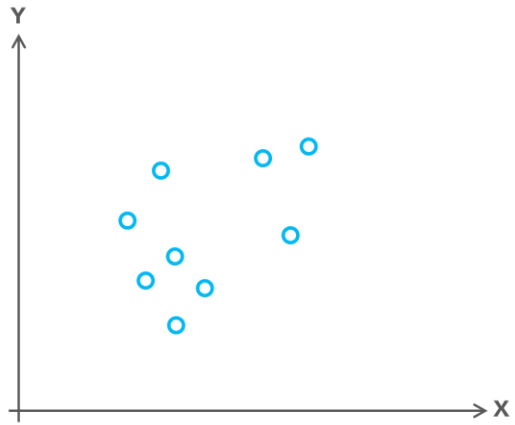
---

mean =

(33,28)

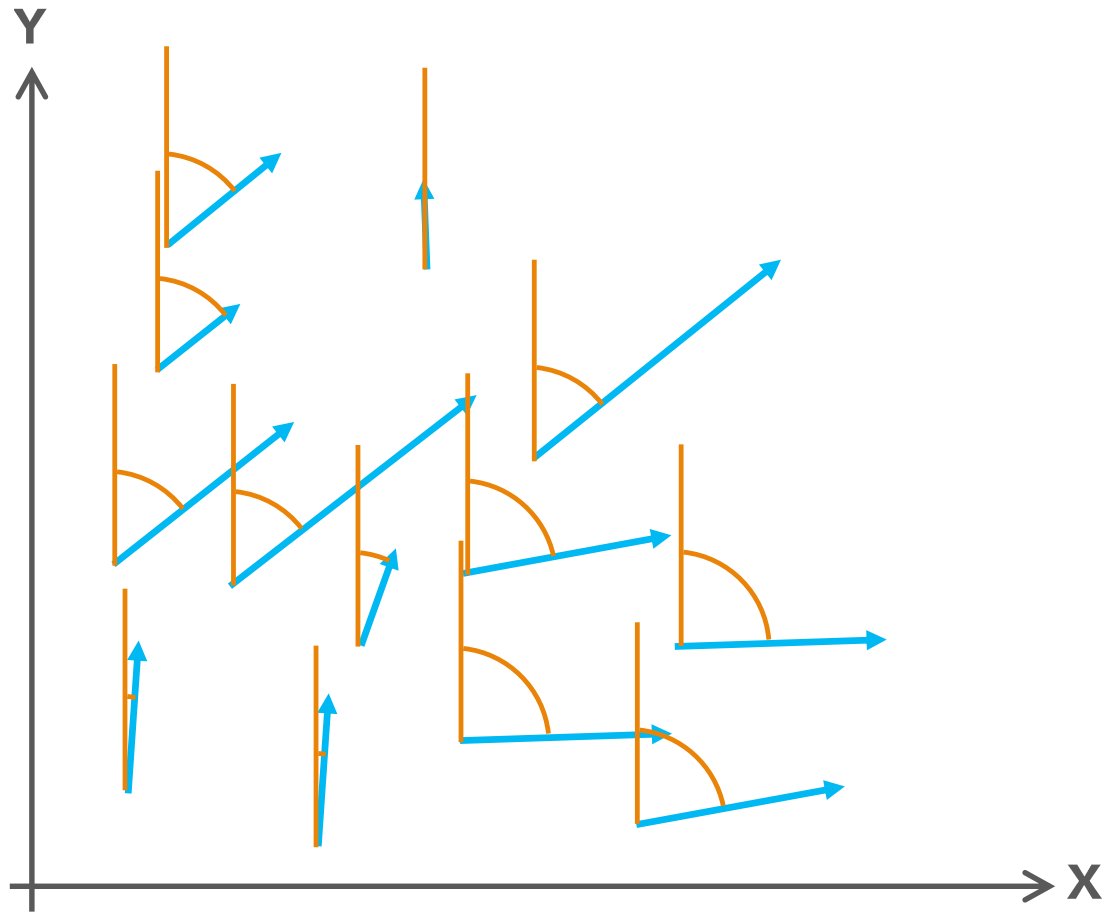

Y
X
(33,28)
(16,15)
(17,15)
(14,14)

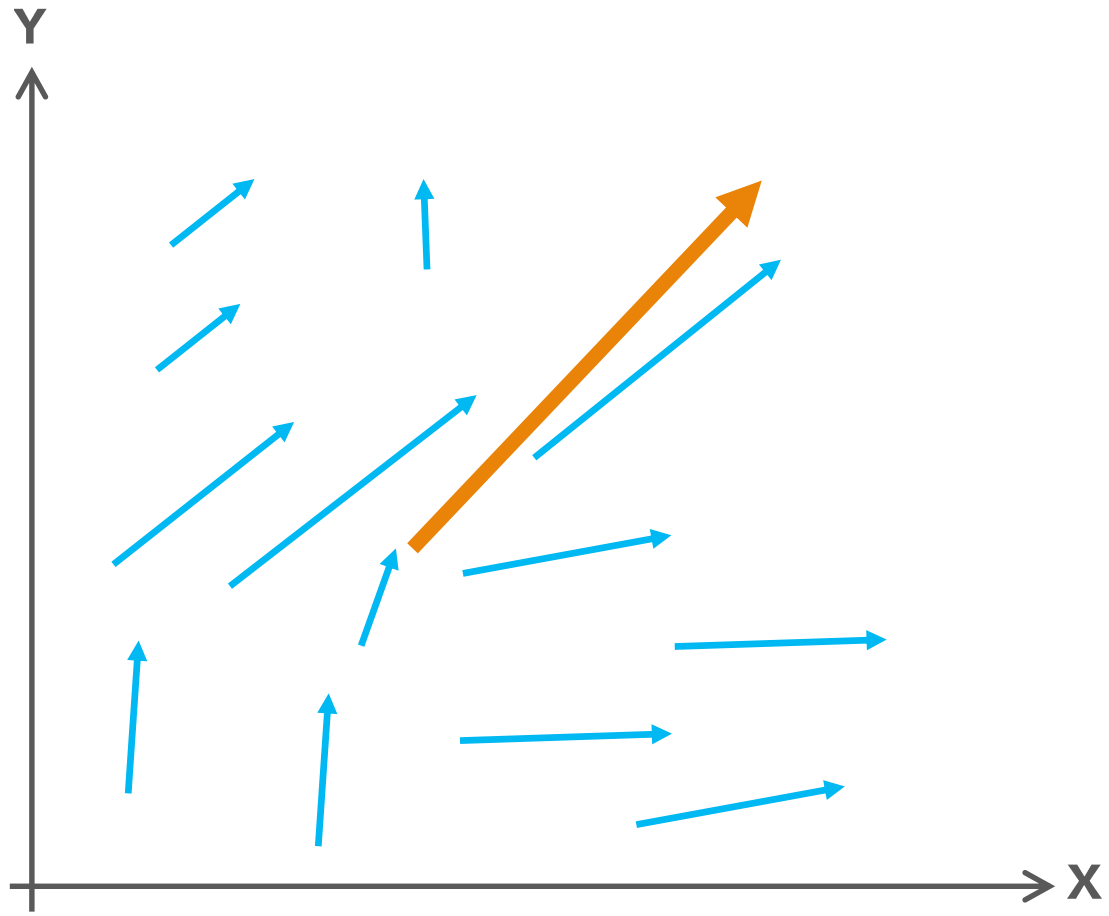
Demo



Linear Directional Mean

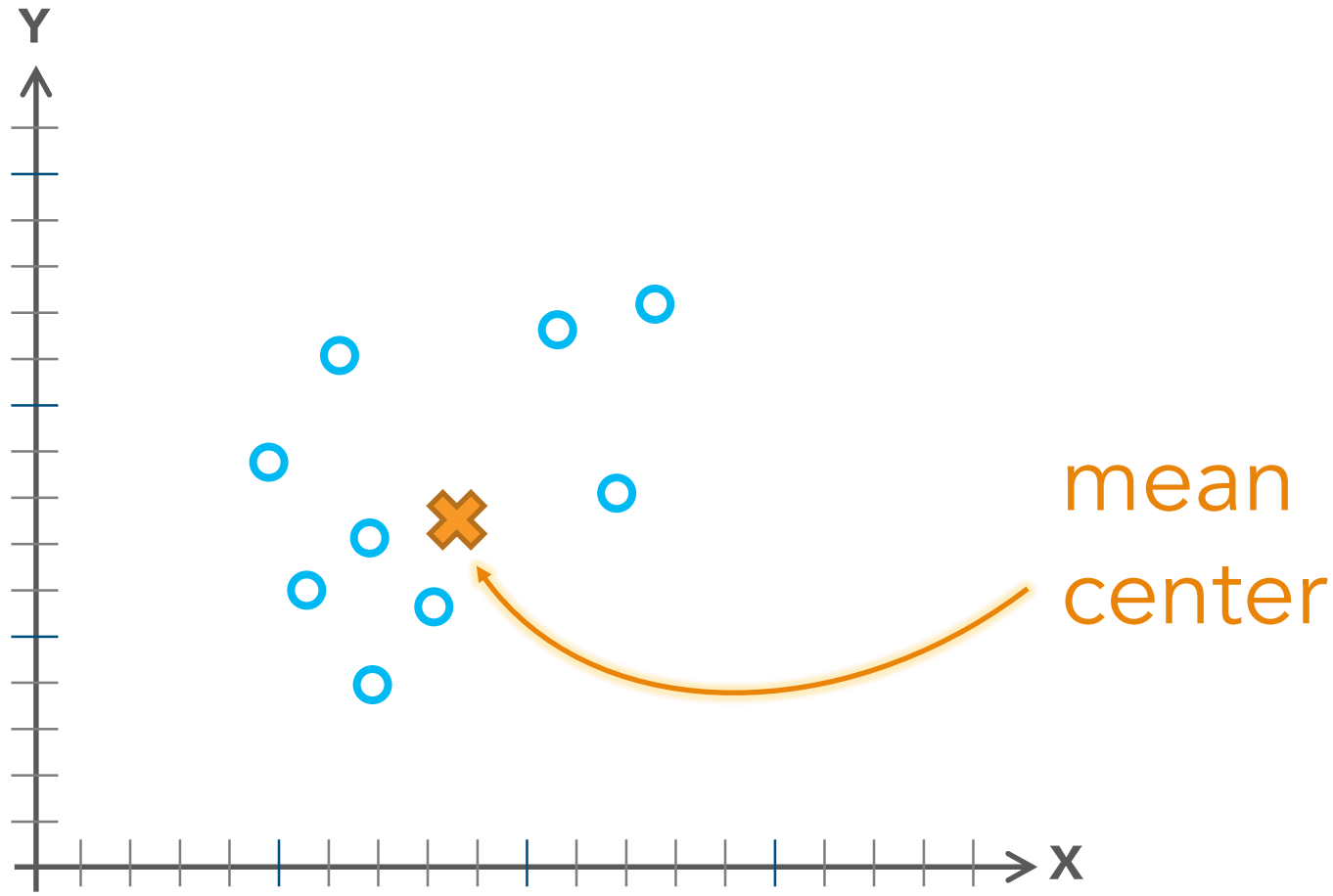
identifies the mean direction, length, and geographic center for a set of lines

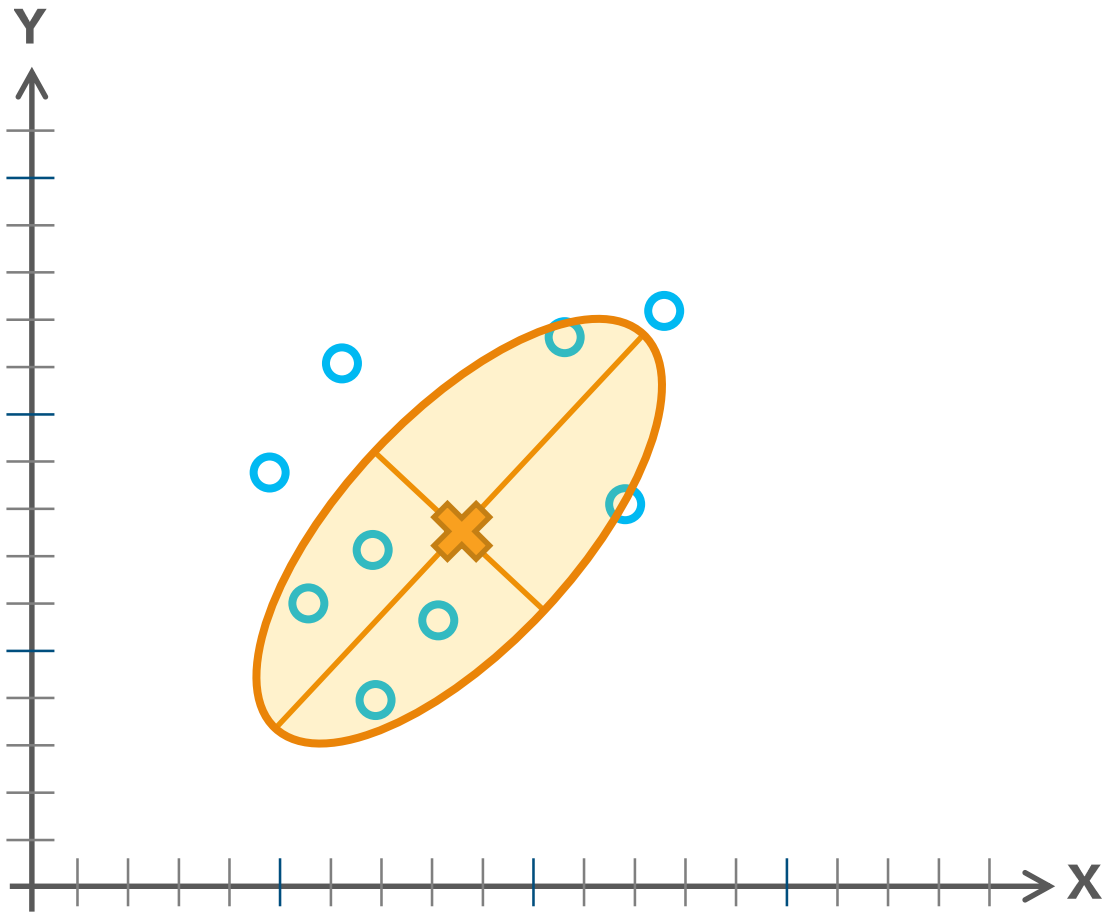

Y
X


Y
X

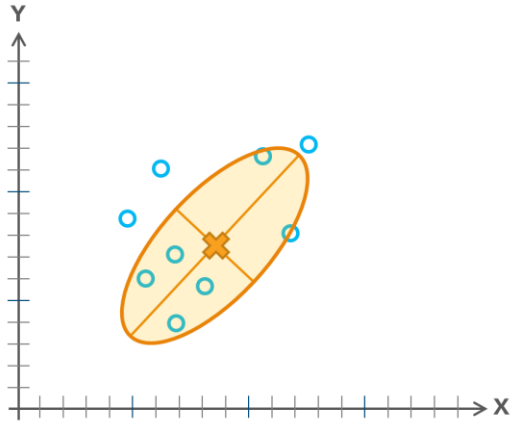
Directional Distribution
(Standard Deviational Ellipse)

creates standard deviational ellipses to summarize the spatial characteristics of geographic features: central tendency, dispersion, and directional trends


Y
X
mean
center


Y
X

Demo

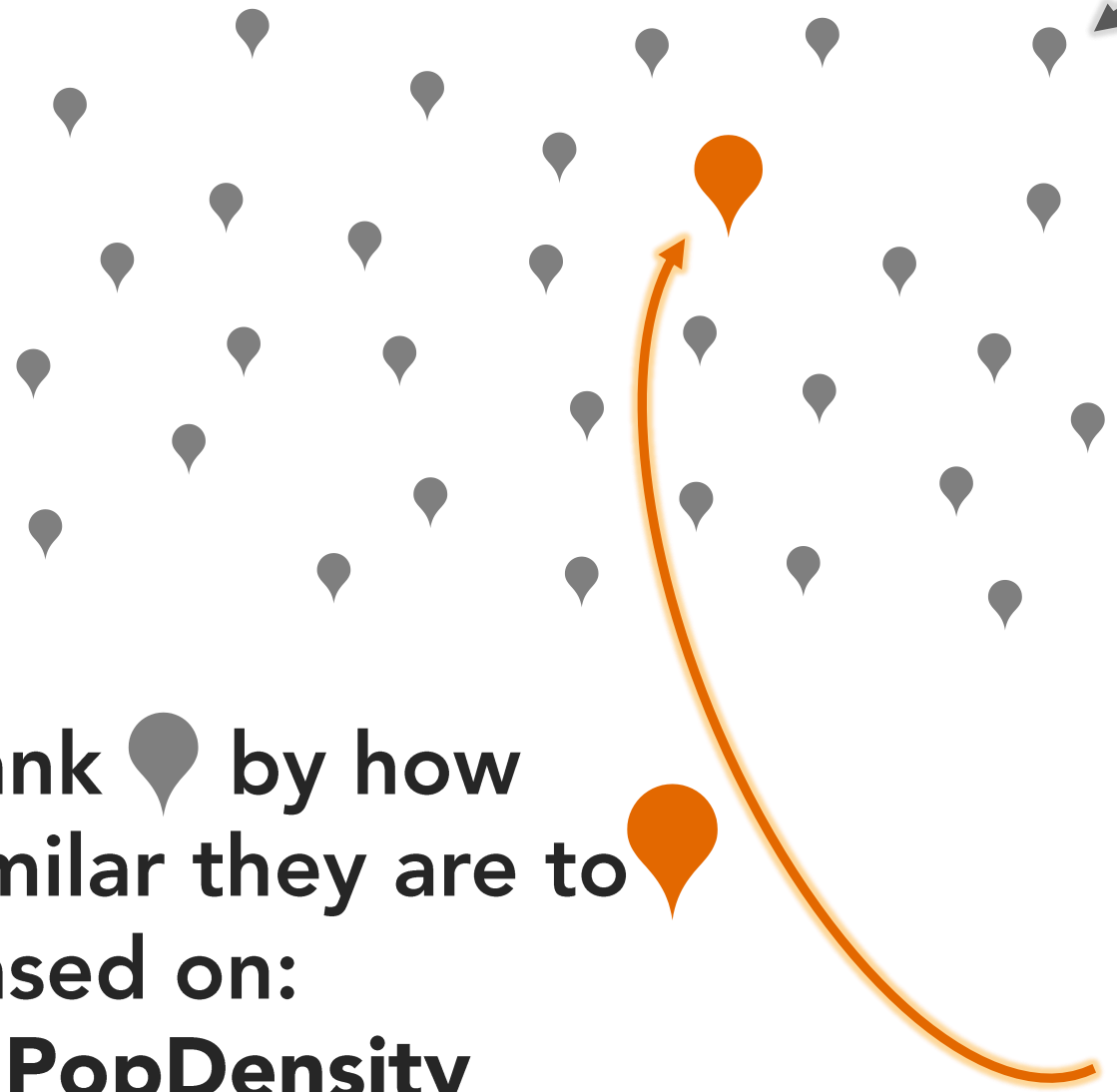


Similarity Search

identifies which candidate features are most similar or most dissimilar to one or more input features based on feature attributes


potential
store
locations


high performing store
potential store locations

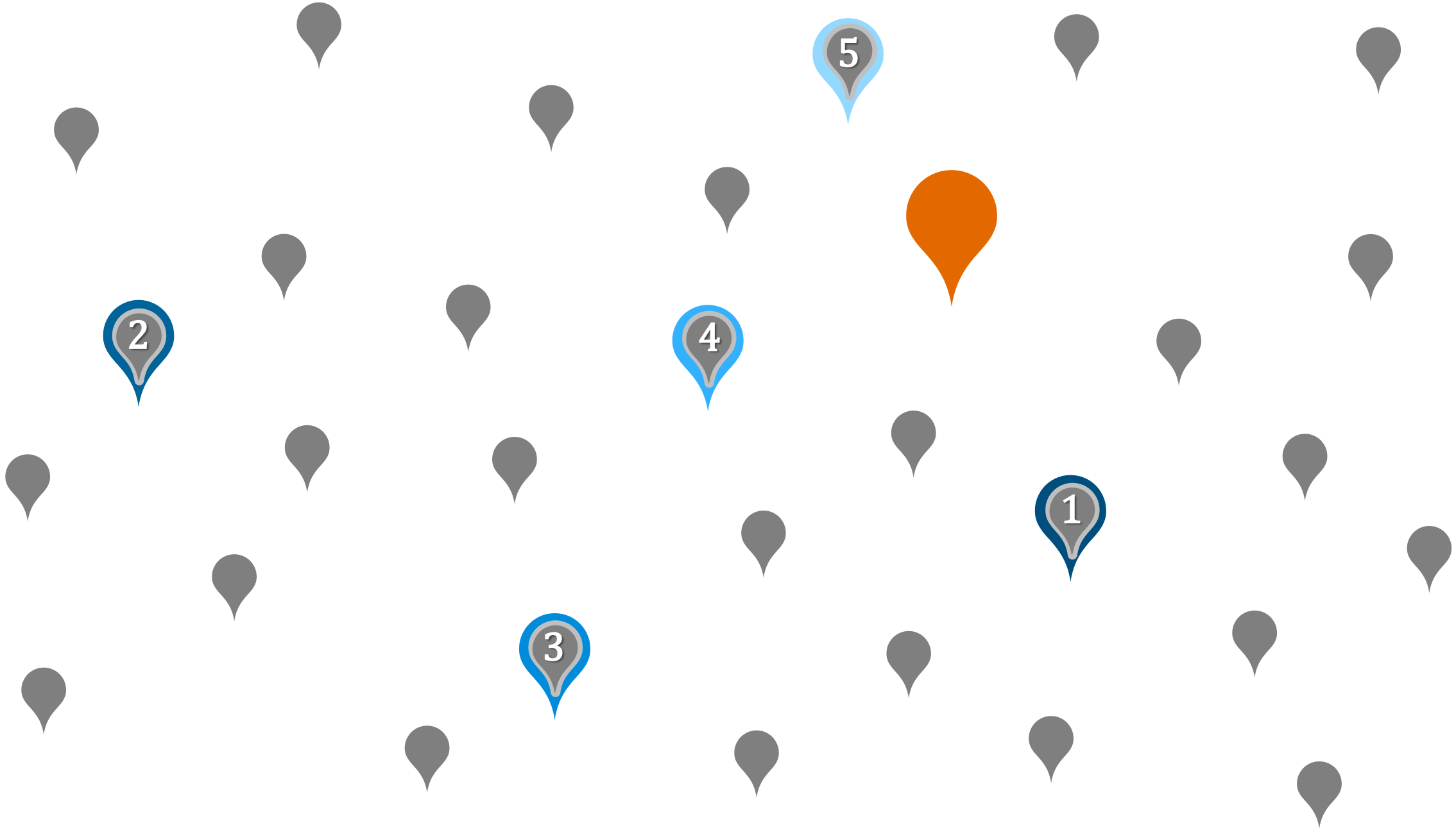


Rank by how similar they are to based on:

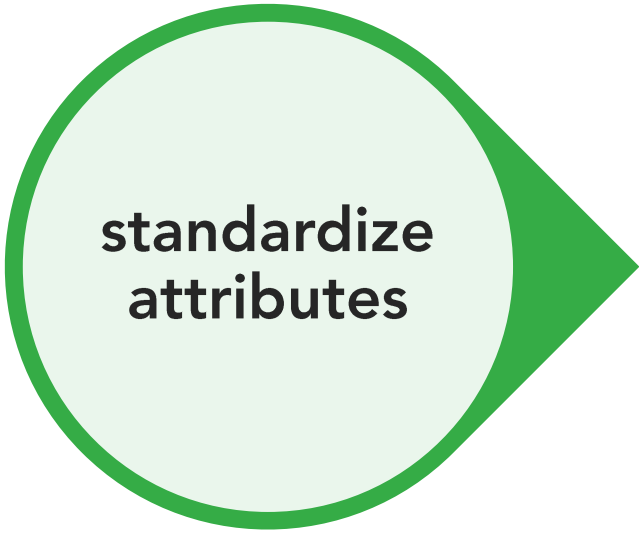
- **PopDensity**
- **AvIncome**
- **DistToCompetition**

LocID	PopDensity	AvIncome	DistToCompetition

LocID	PopDensity	AvIncome	DistToCompetition


5
2
4
1
3

Attribute Values



Z-transform:

$(x - \bar{x}) / SD$

Attribute Values

standardize attributes

Population = 14,159

% Uninsured = .26

Distance (km) = 535.89

Attribute Values

standardize attributes

Population = -.7932

% Uninsured = 3.8462

Distance (km) = .6433

Attribute Values

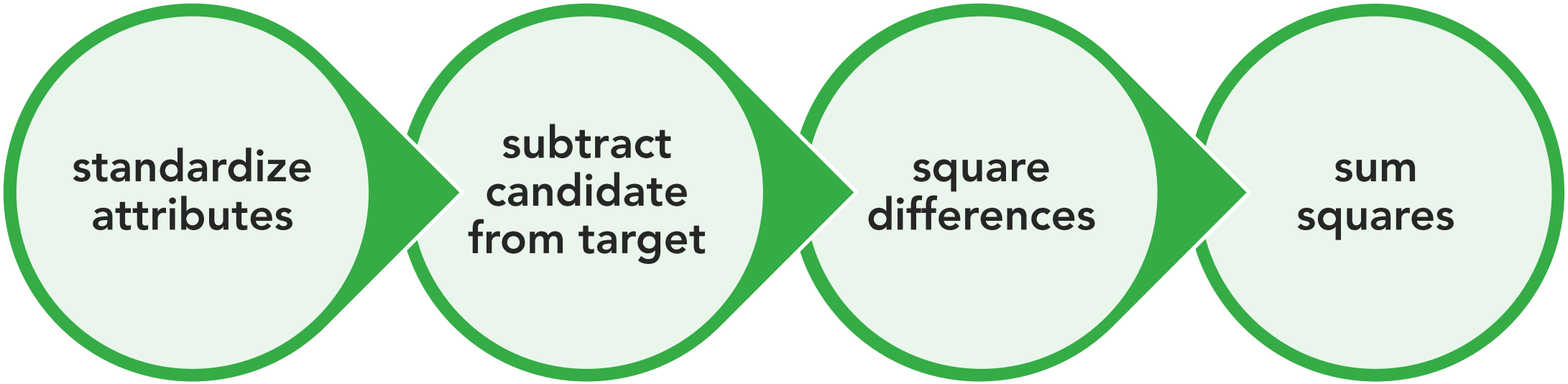
standardize attributes

Population = -.7932

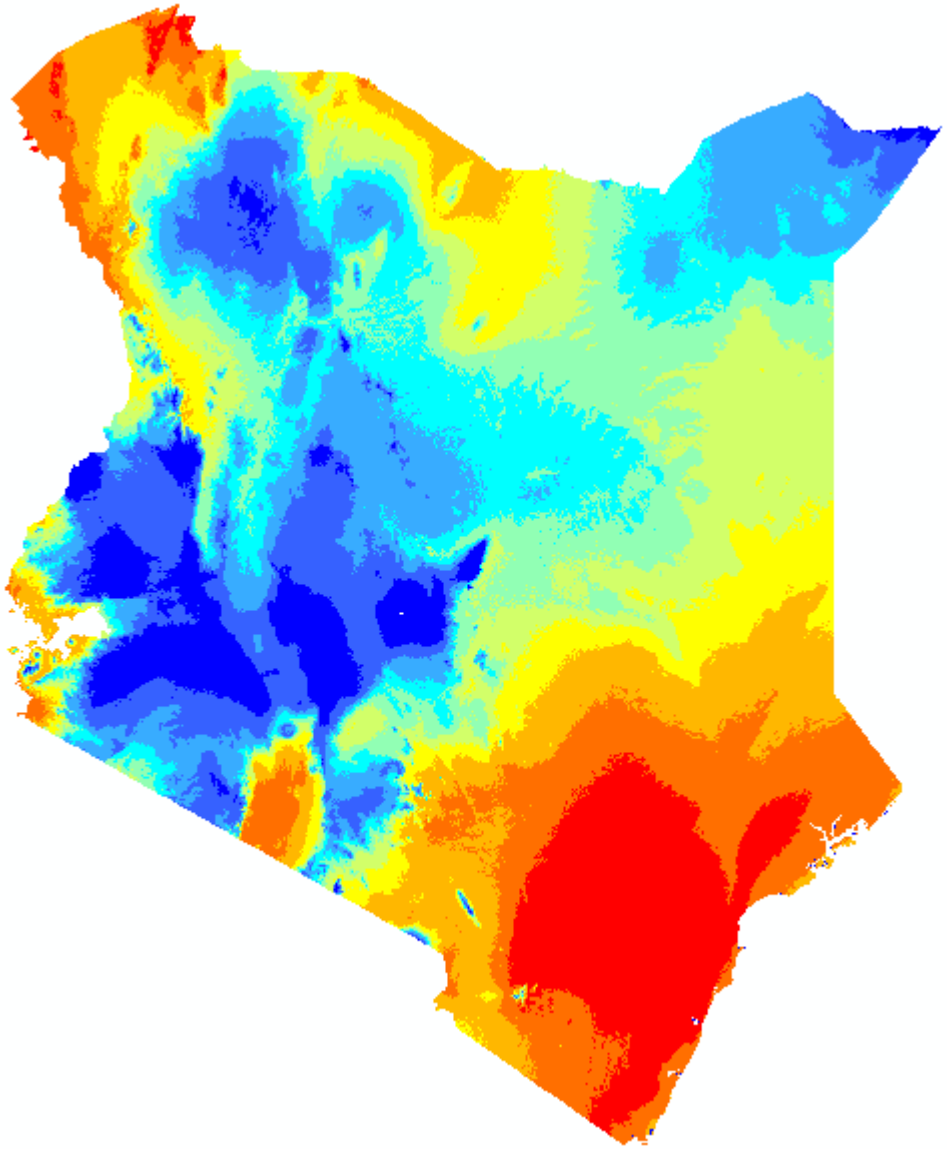
% Uninsured = 3.8462

Distance (km) = .6433

Attribute Values



Dengue Fever Risk in Kenya

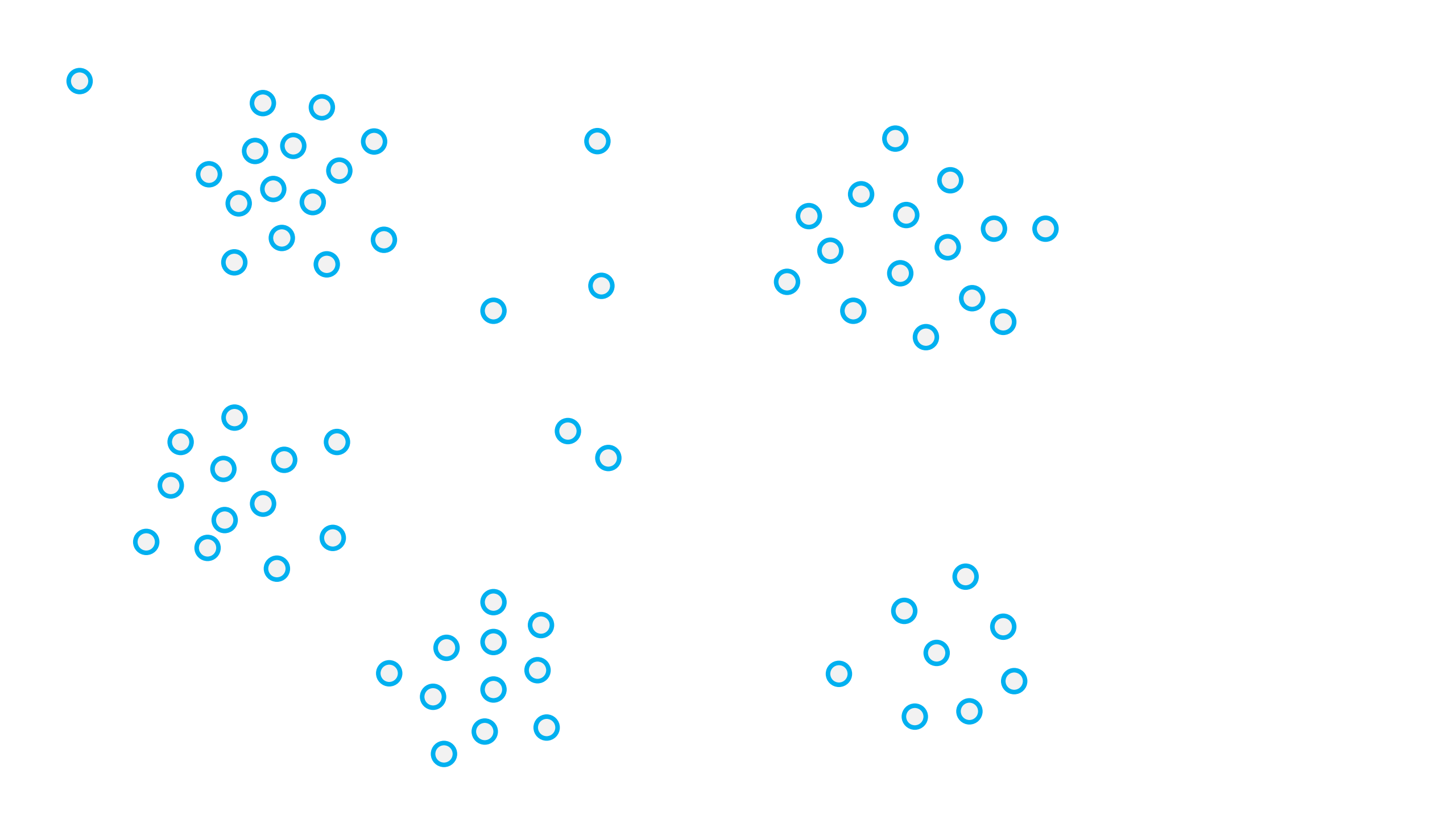


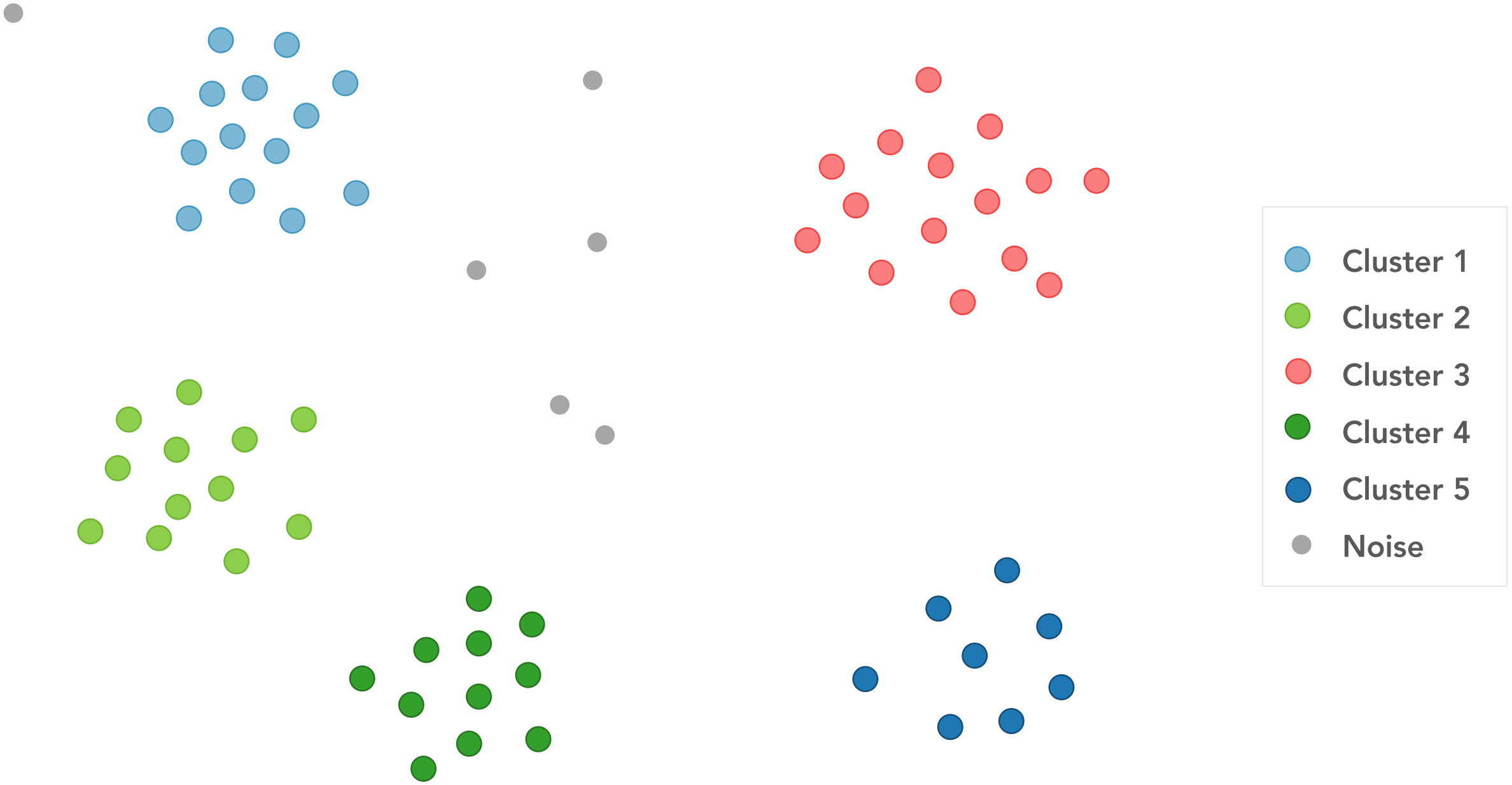
Machine Learning

clustering methods

Density-based Clustering

finds clusters based on feature locations



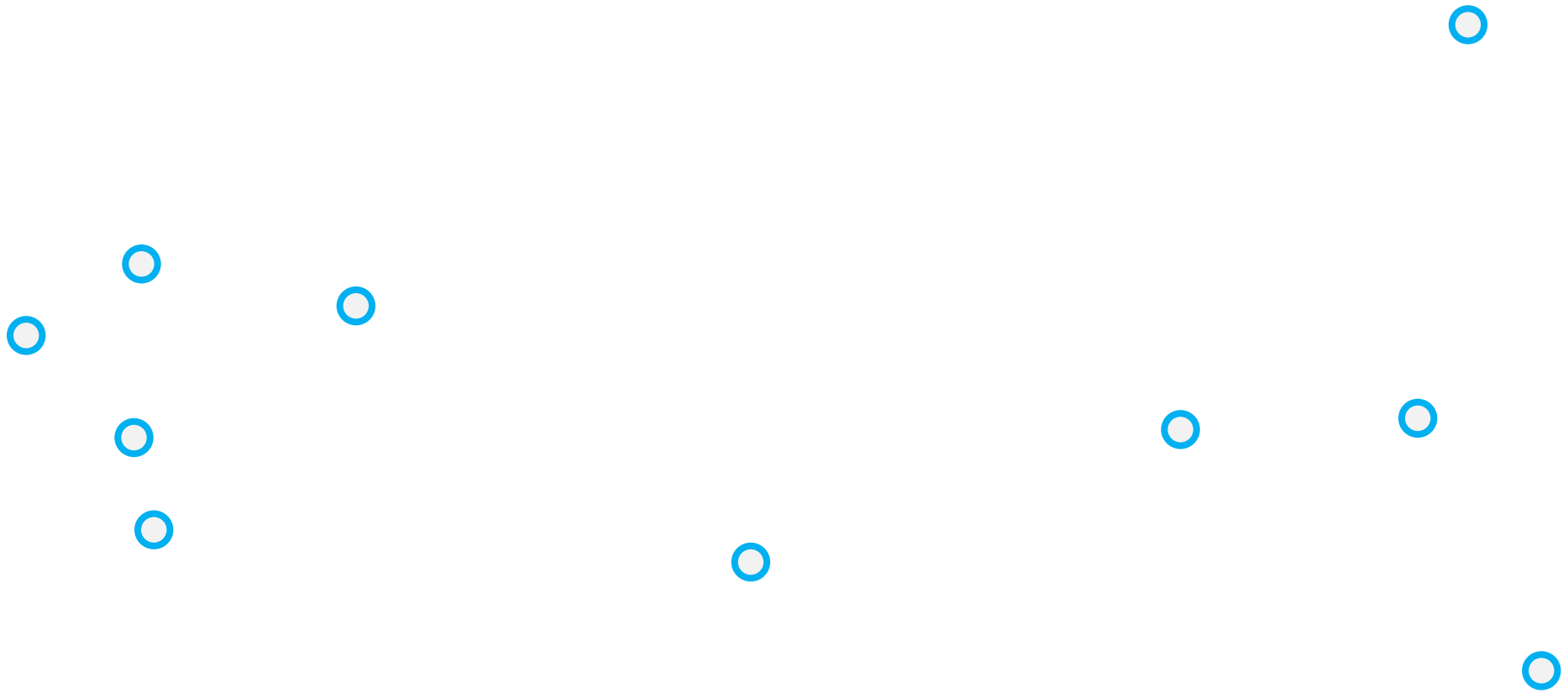

Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Noise

DBSCAN – defined distance

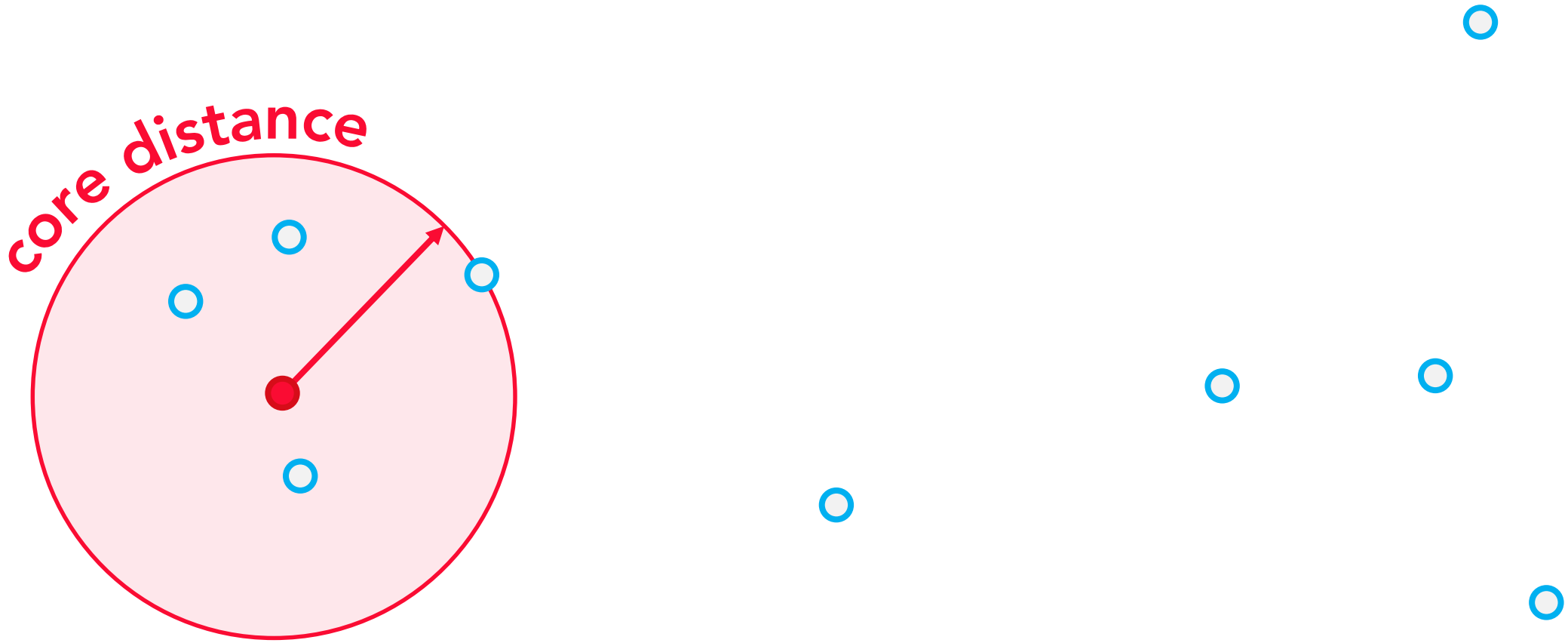
HDBSCAN – self adjusting

OPTICS – multi-scale

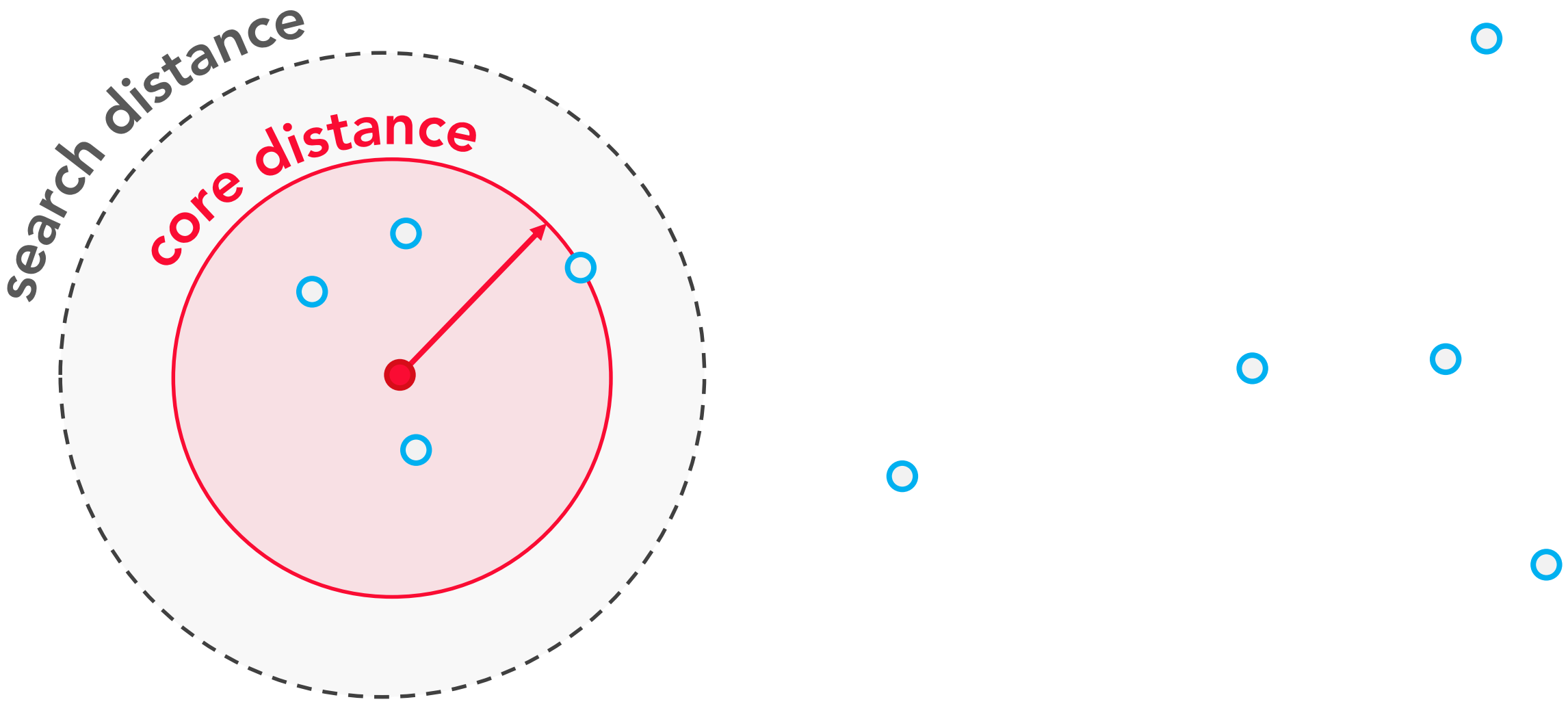
DBSCAN – defined distance



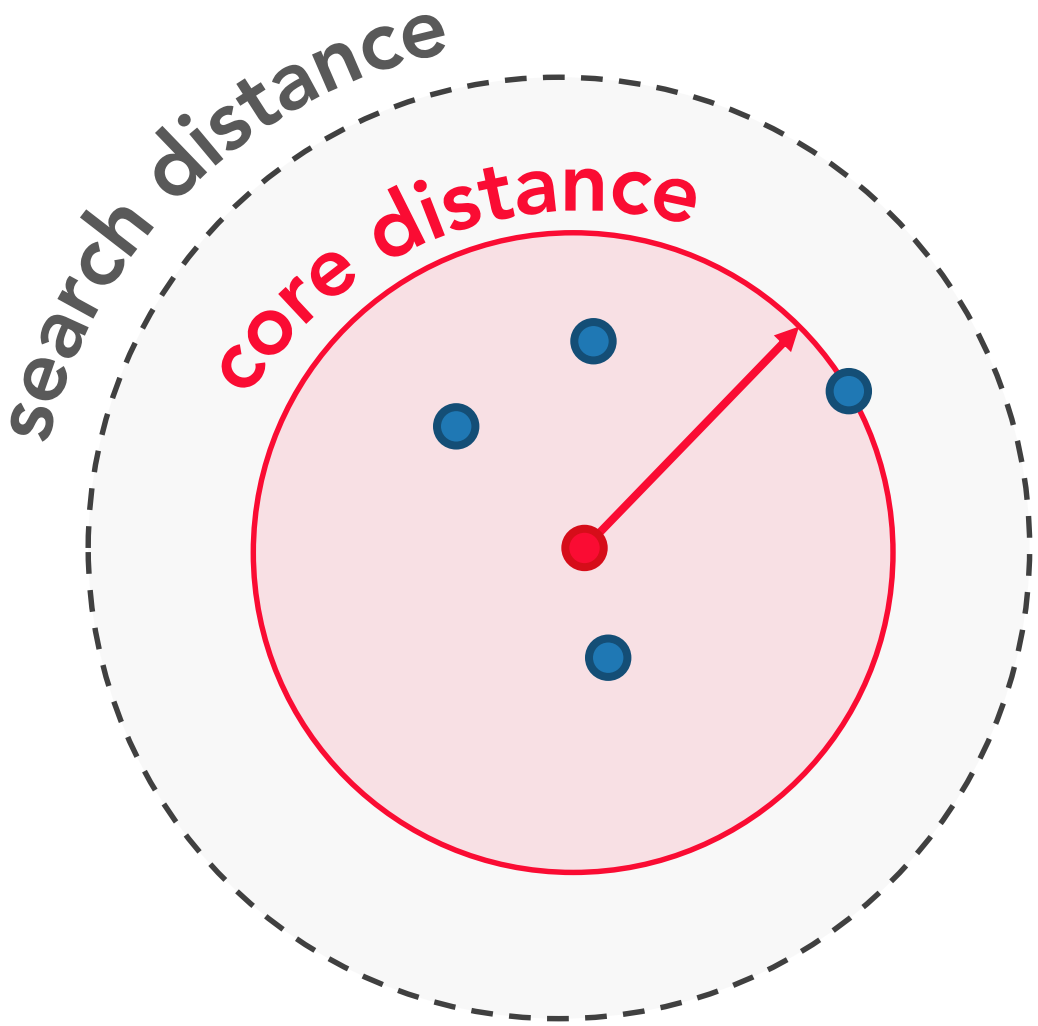
DBSCAN – defined distance



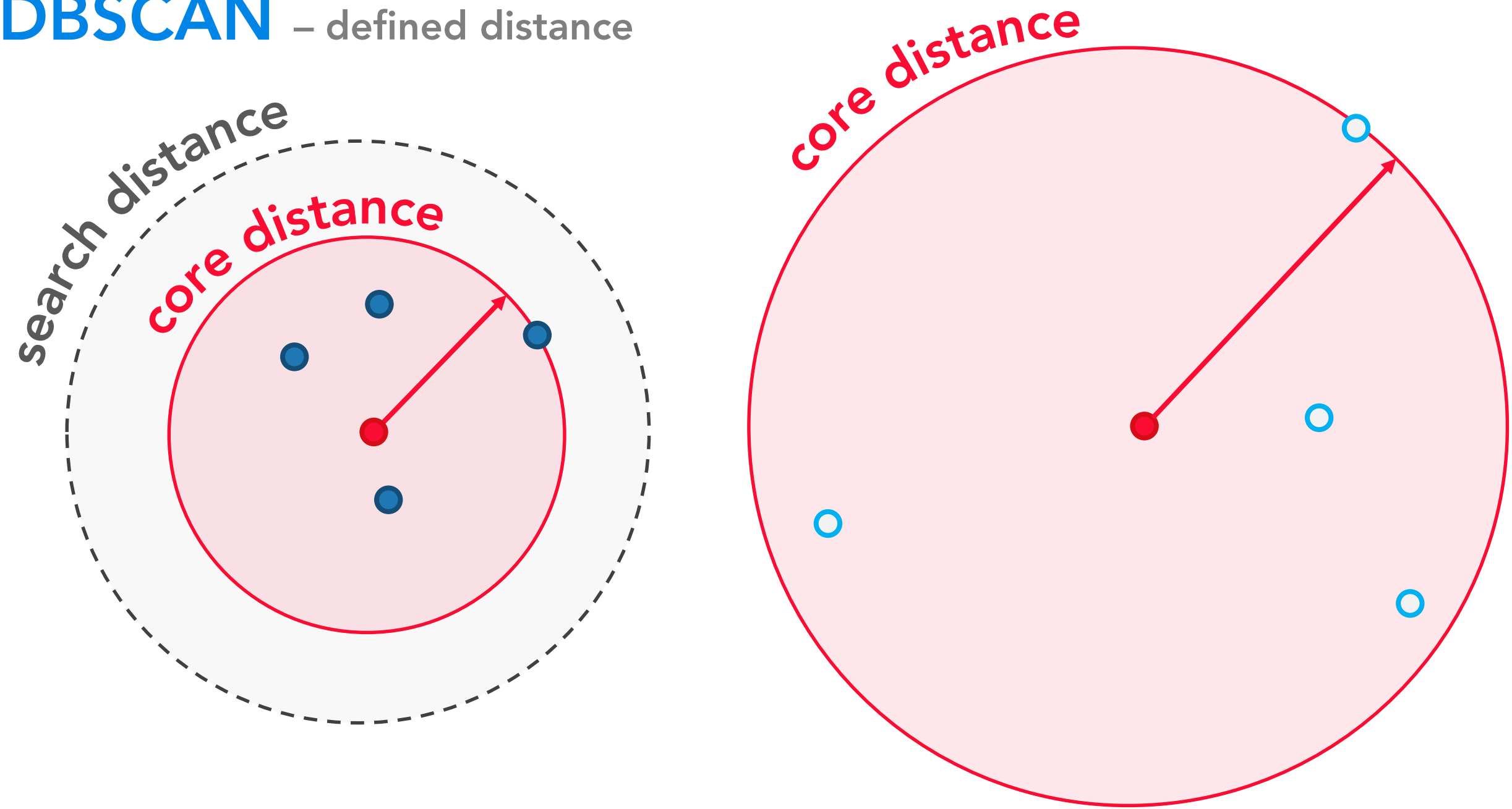
DBSCAN – defined distance



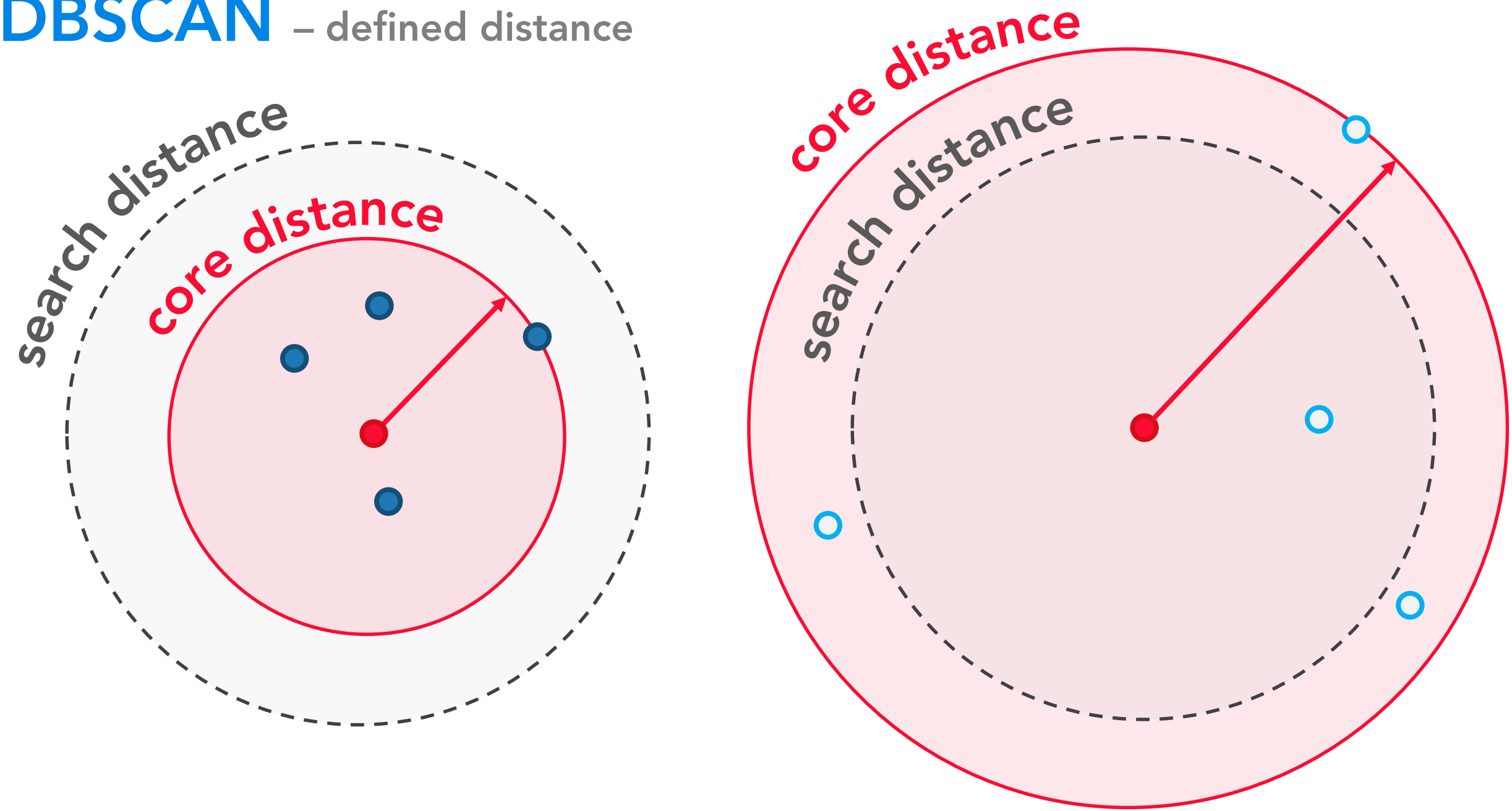
DBSCAN – defined distance



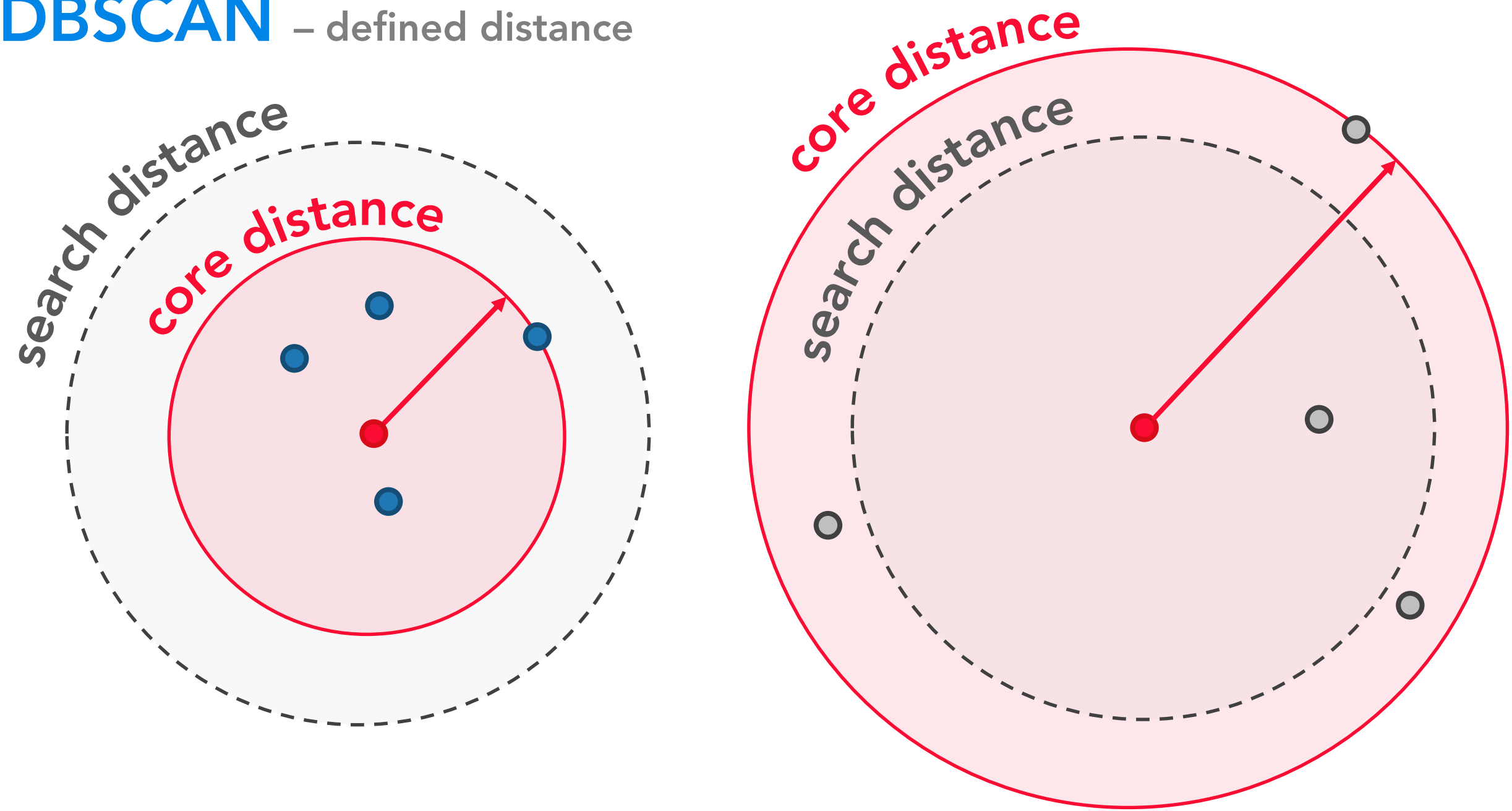
DBSCAN – defined distance



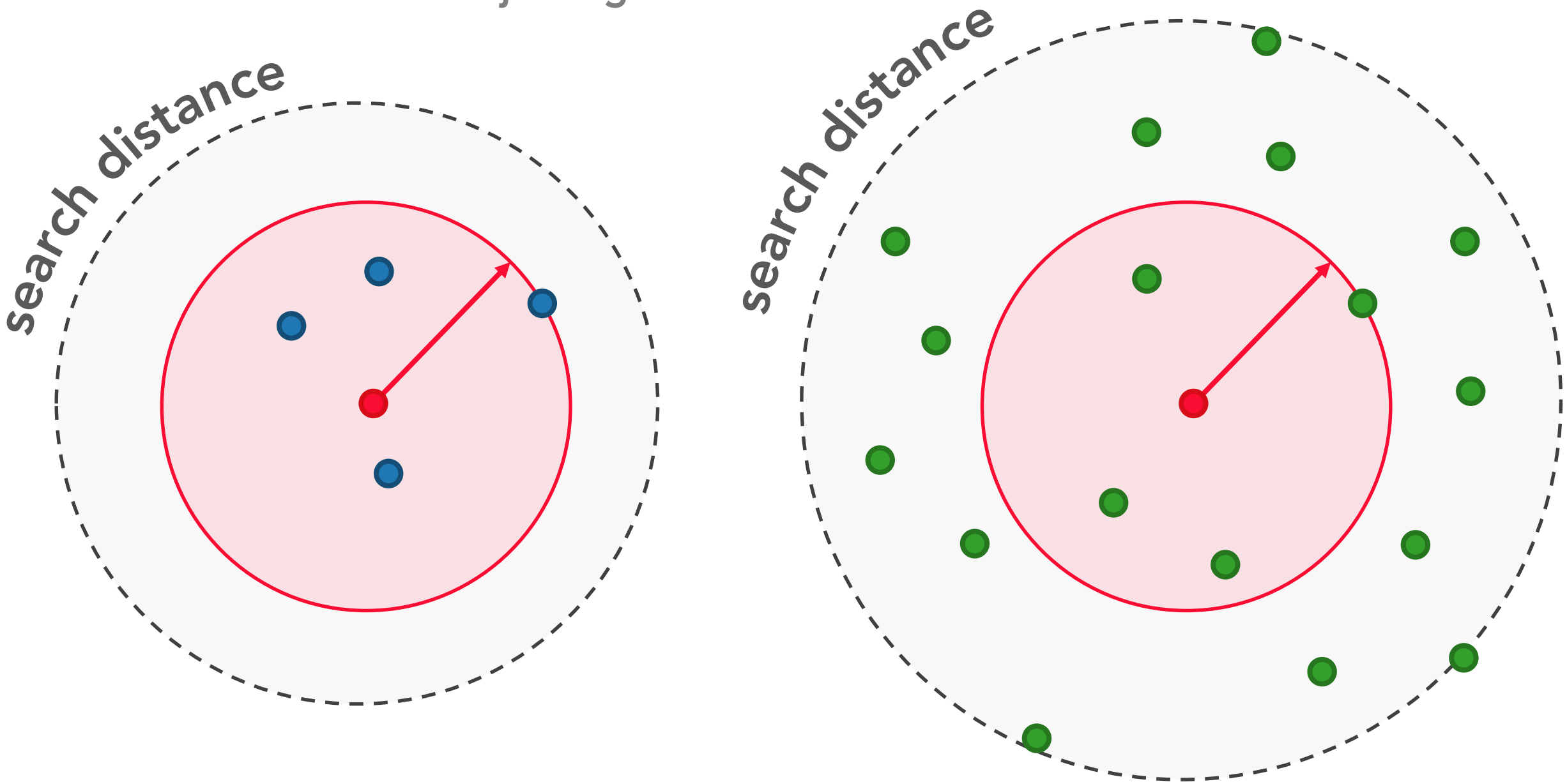
DBSCAN – defined distance



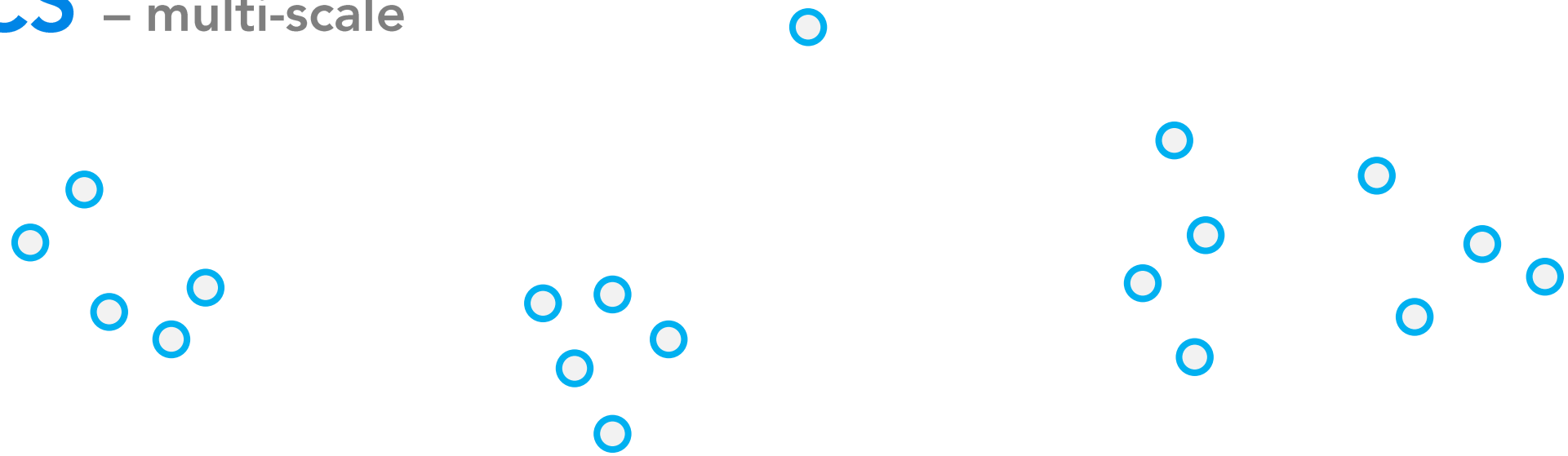
DBSCAN – defined distance



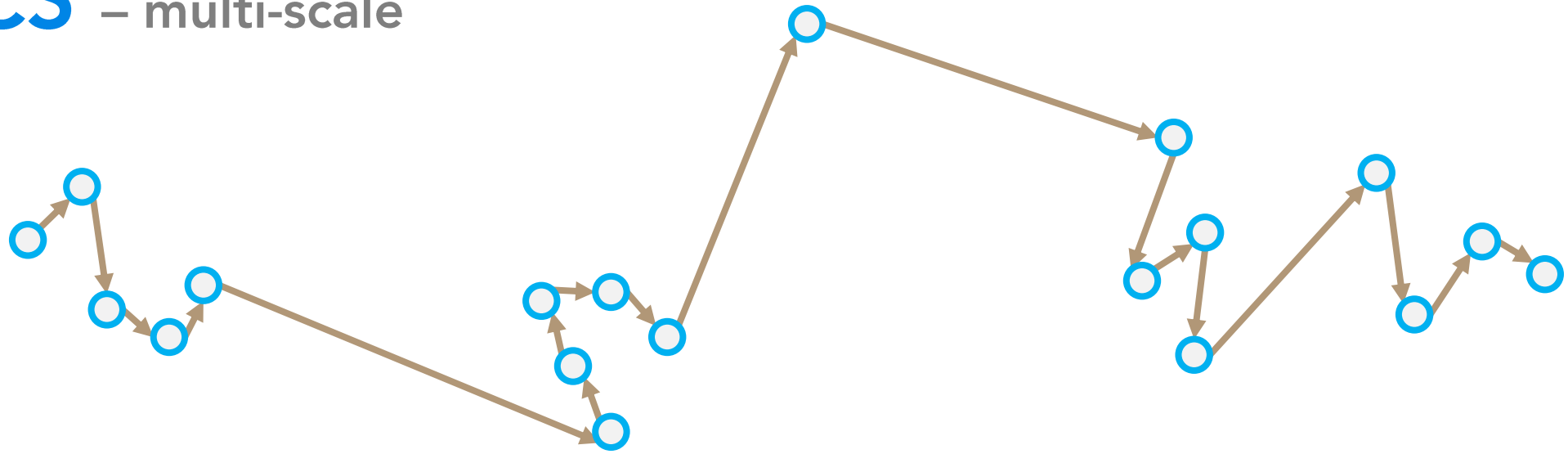
HDBSCAN – self adjusting



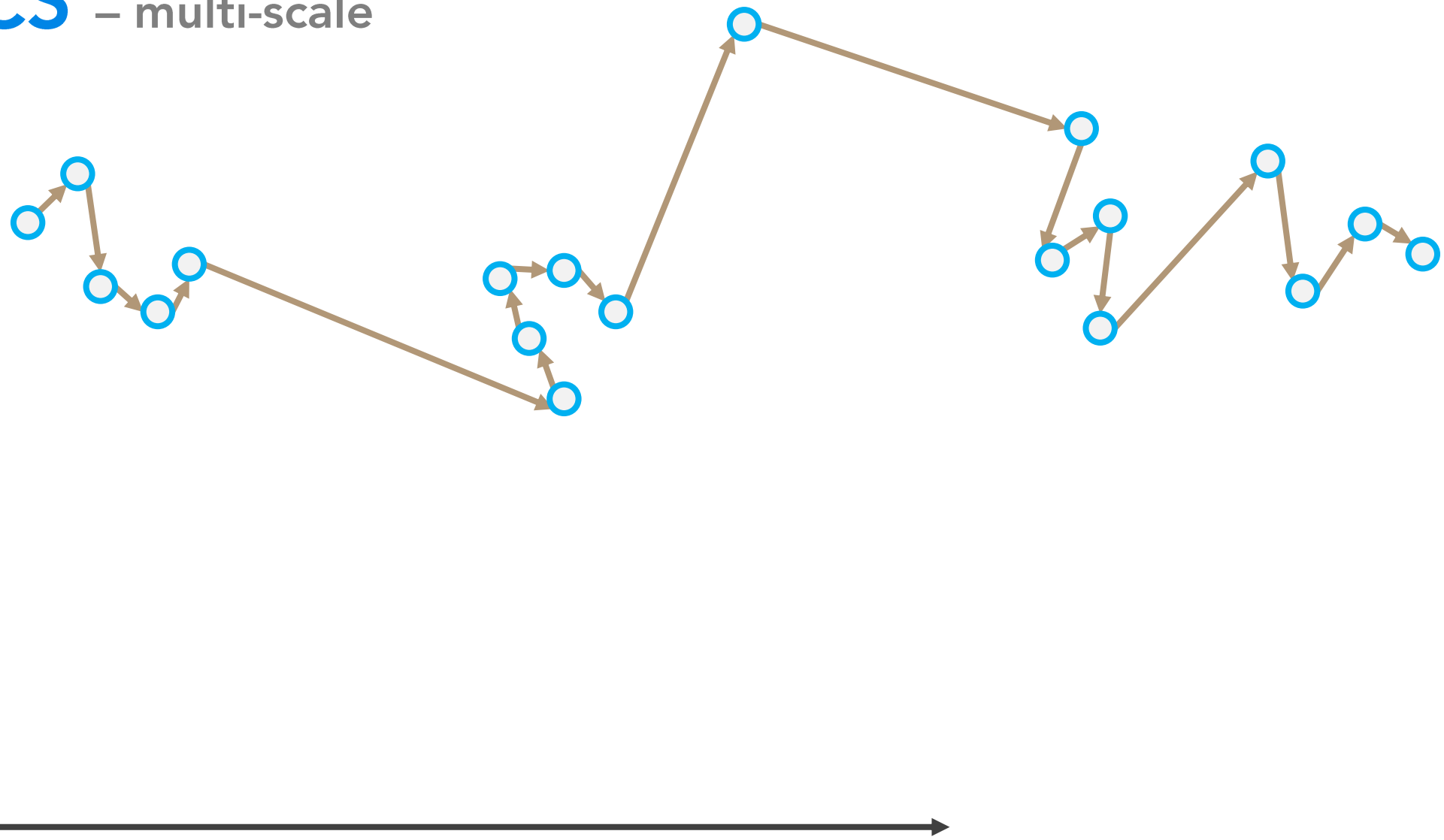
OPTICS – multi-scale



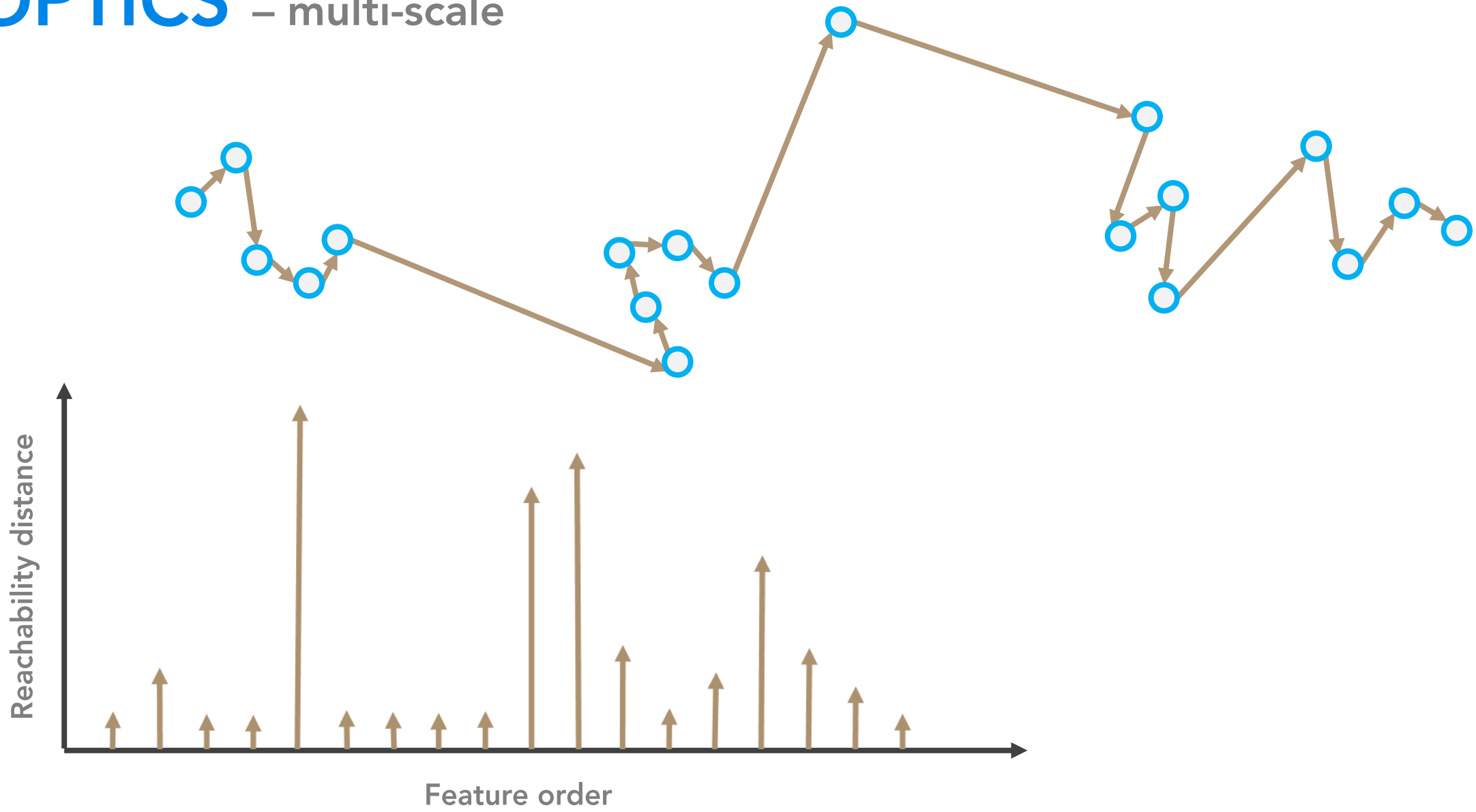
OPTICS – multi-scale



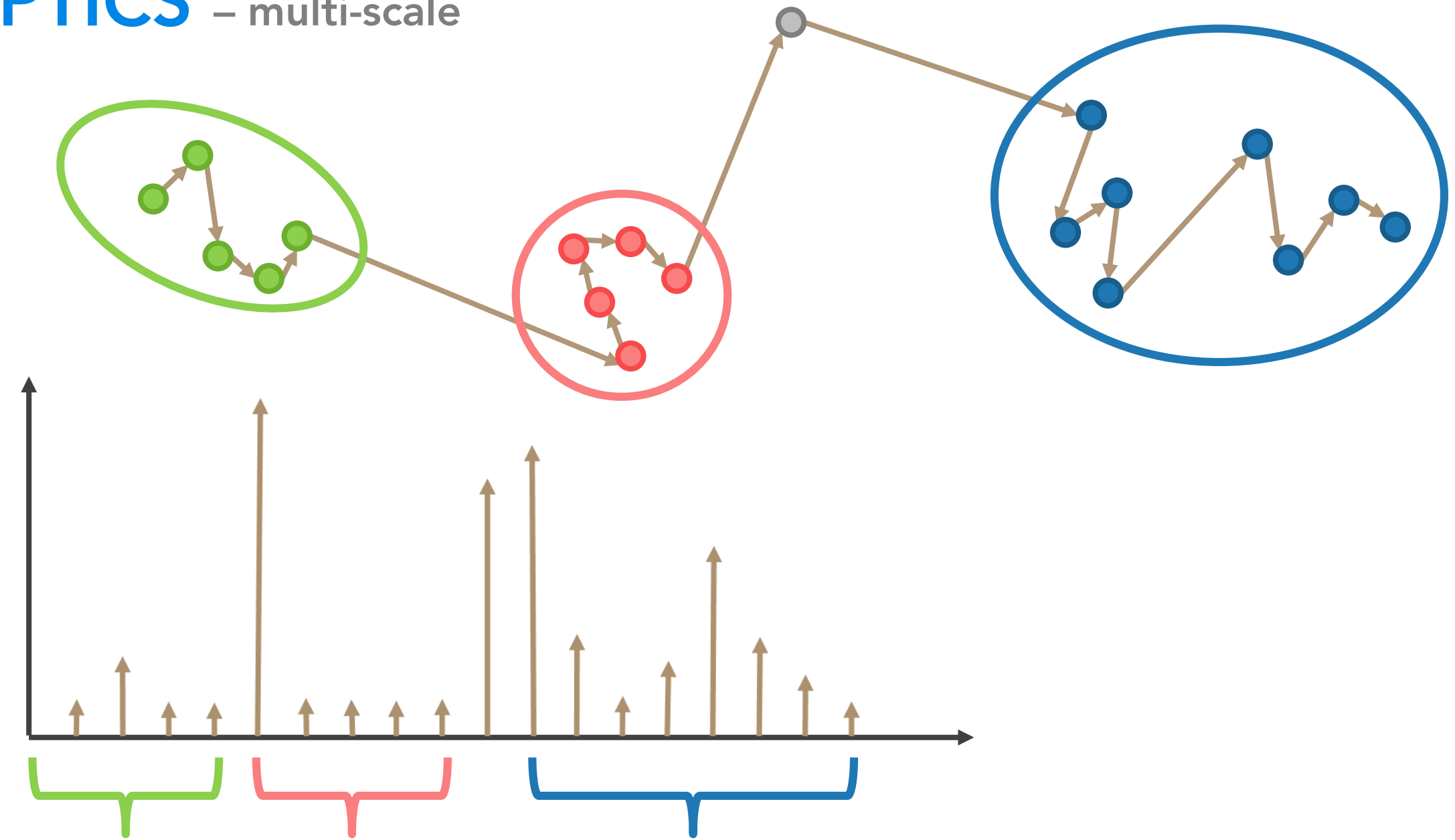
OPTICS – multi-scale



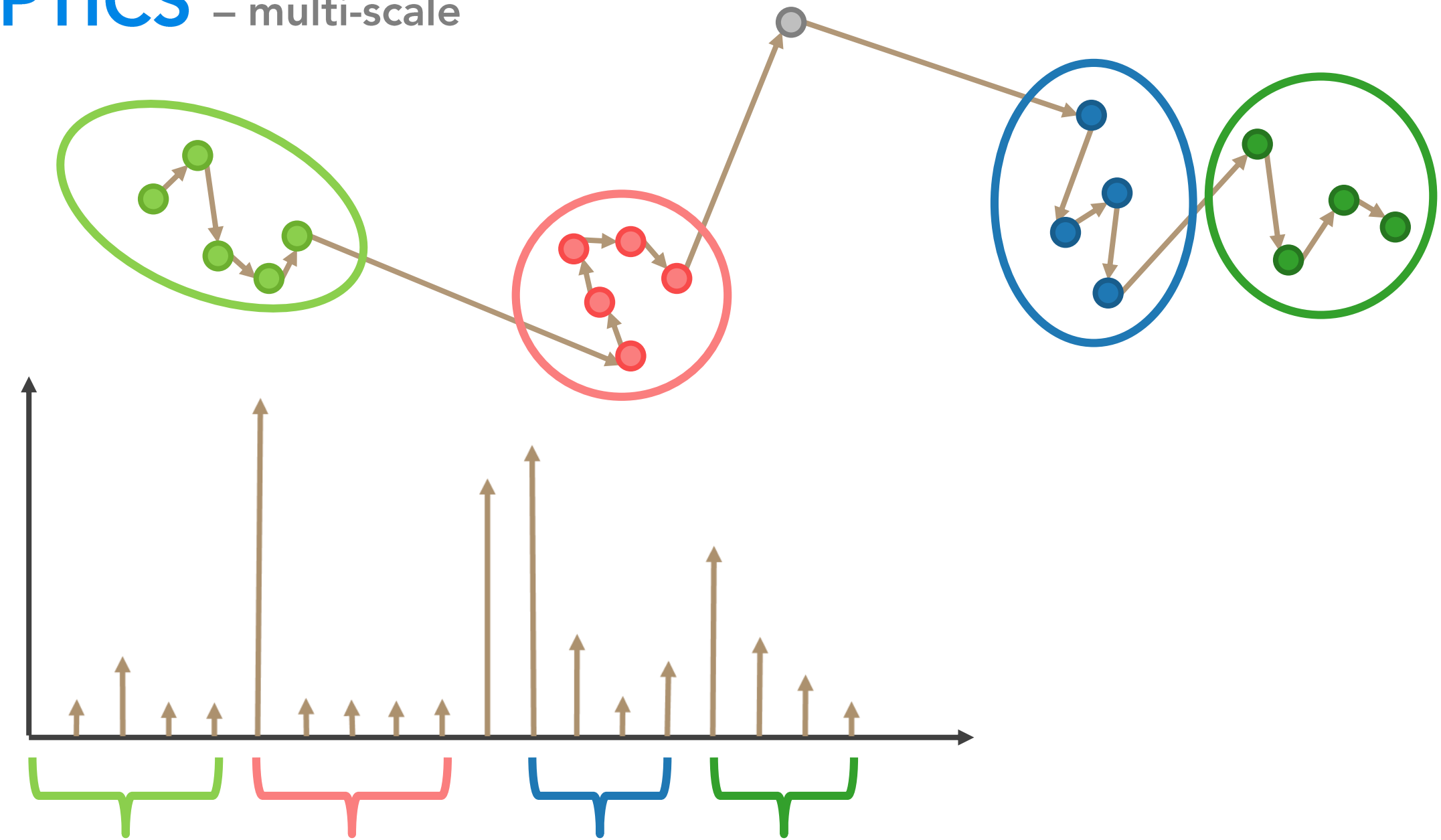
OPTICS – multi-scale



OPTICS – multi-scale



OPTICS – multi-scale



DBSCAN

- Uses fixed search distance
- Clusters of similar densities
- Fast

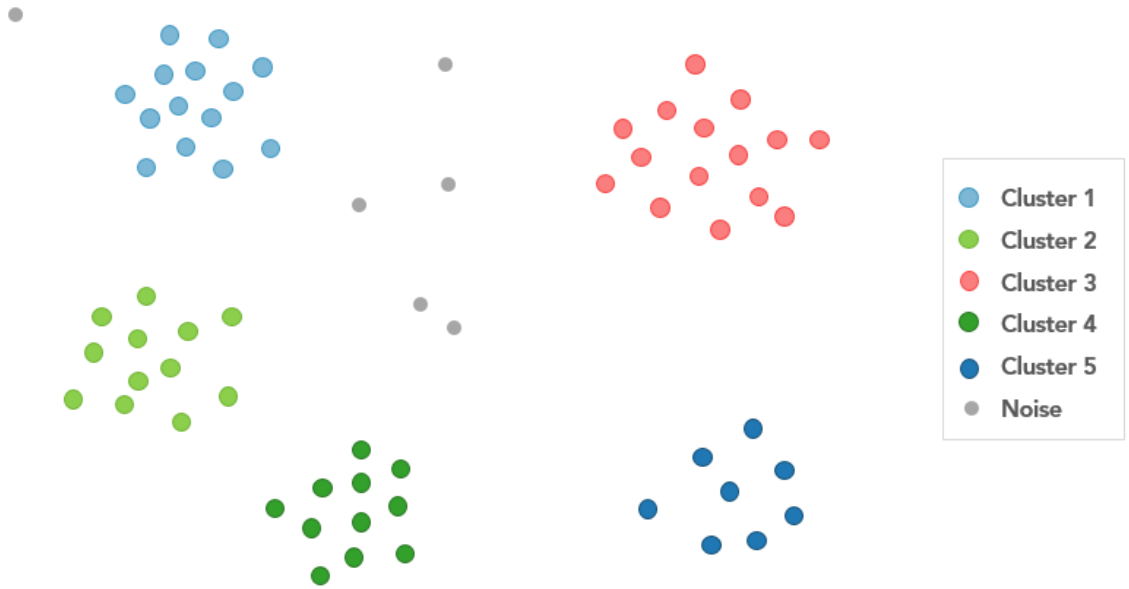
HDBSCAN

- Uses range of search distances to find clusters of varying densities
- Data driven, requires least user input

OPTICS

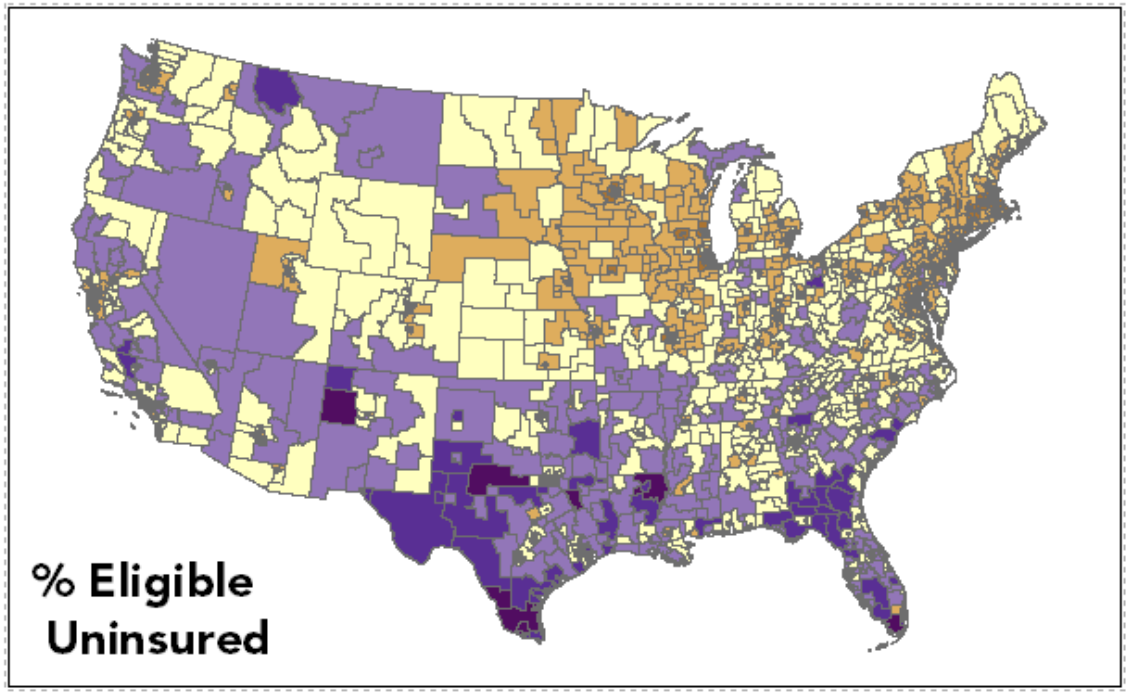
- Uses neighbor distances to create reachability plot
- Most flexibility for fine tuning
- Can be computationally intensive

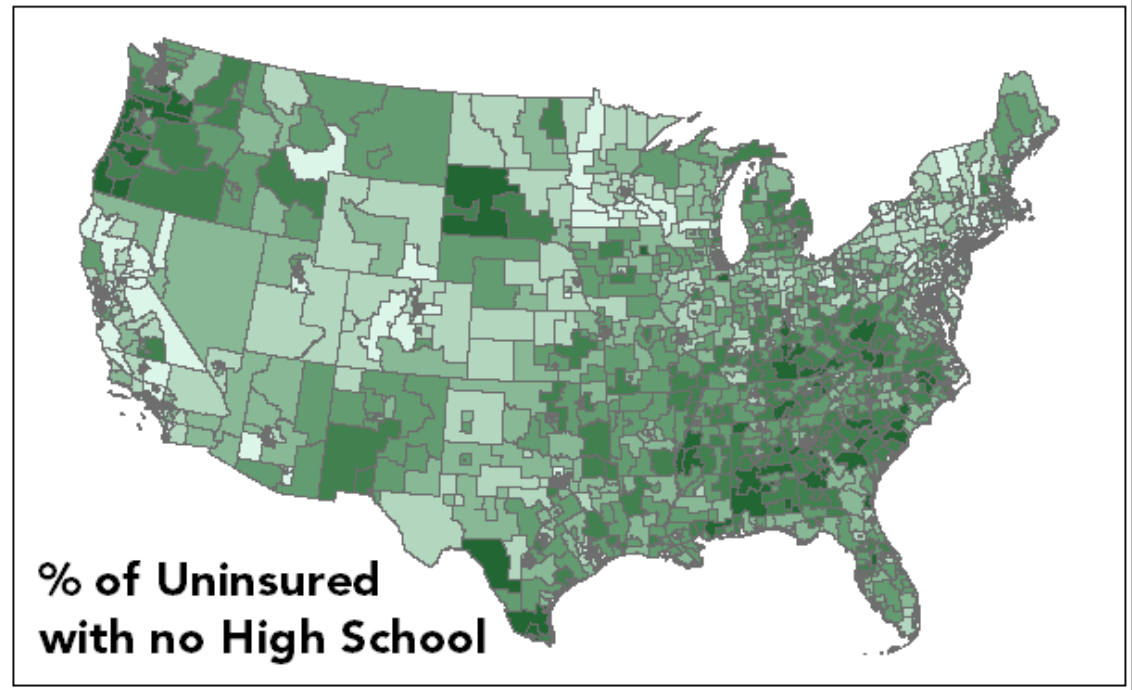
Demo

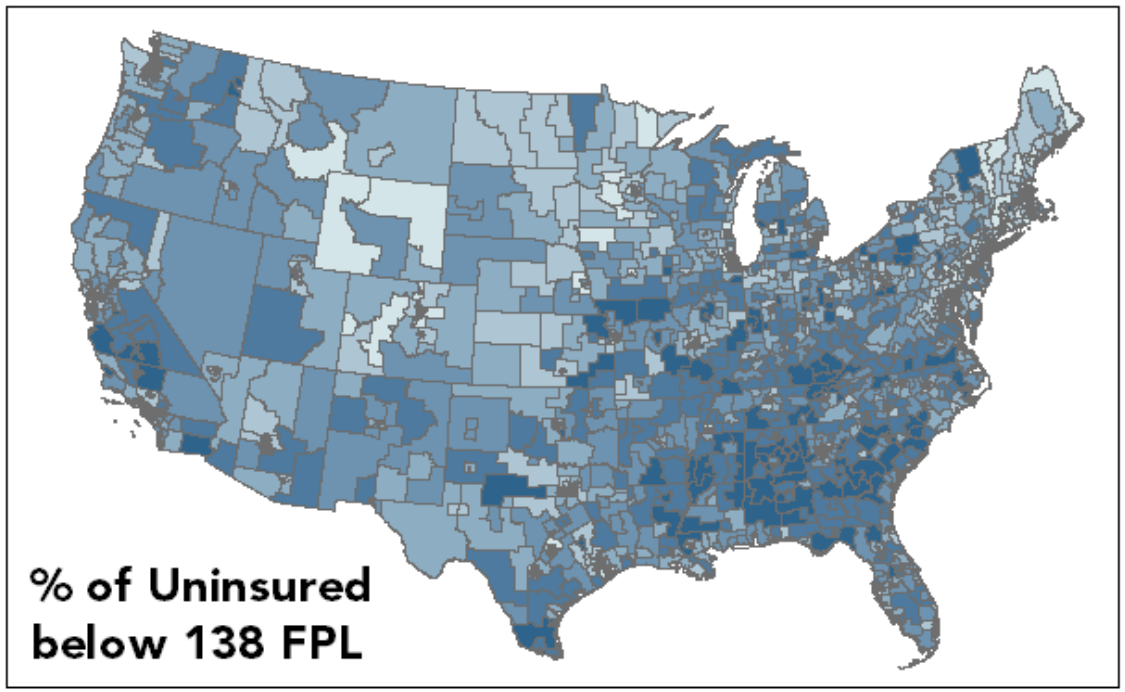


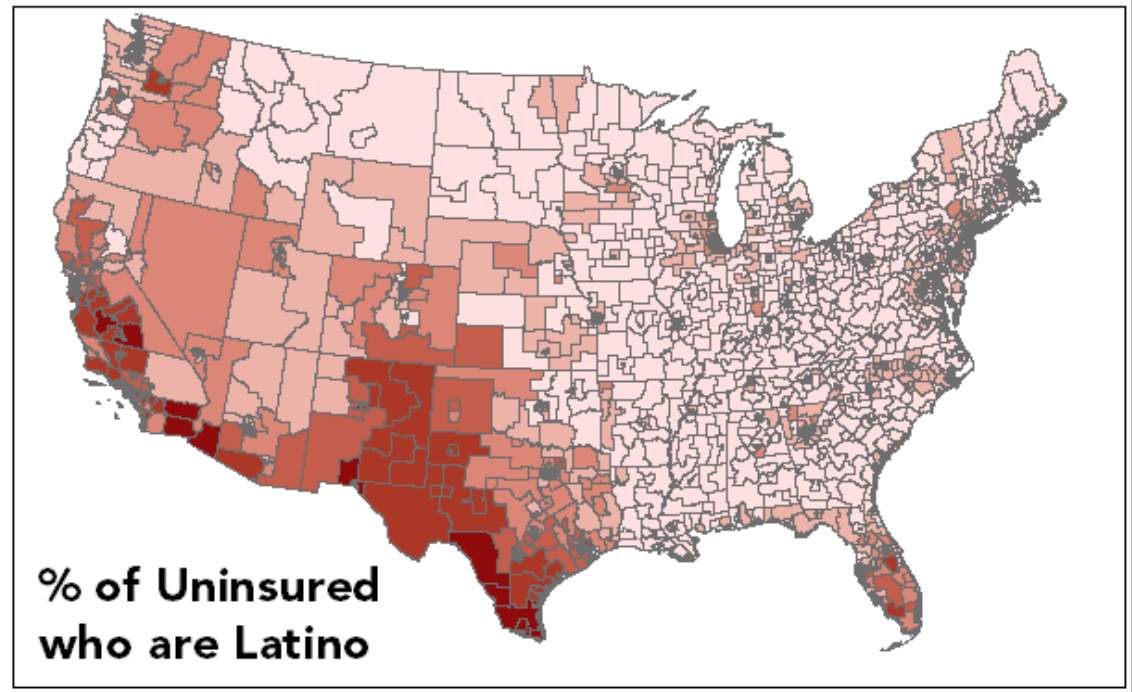
Multivariate Clustering

finds clusters based on feature attributes

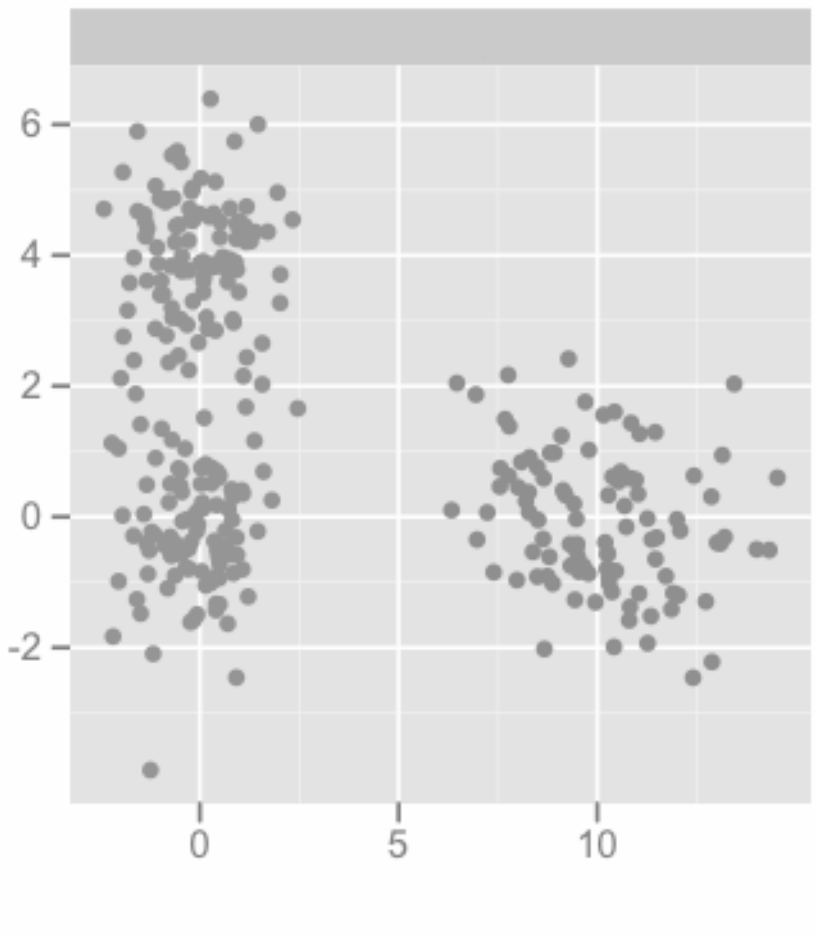

% Eligible
Uninsured


% of Uninsured
with no High School


% of Uninsured
below 138 FPL

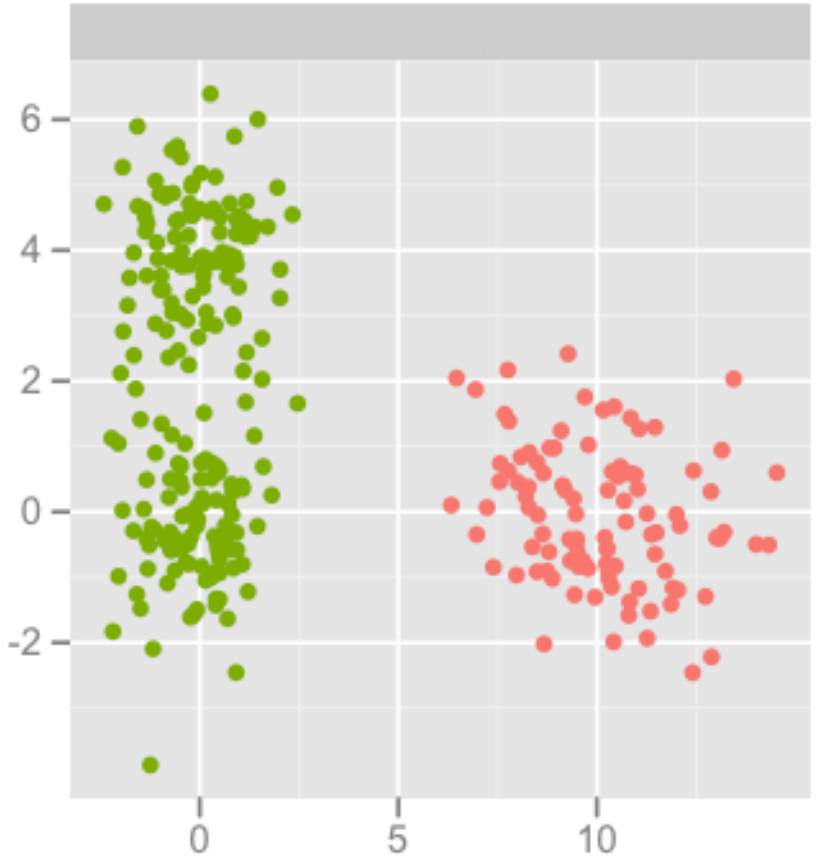

% of Uninsured
who are Latino

K Means

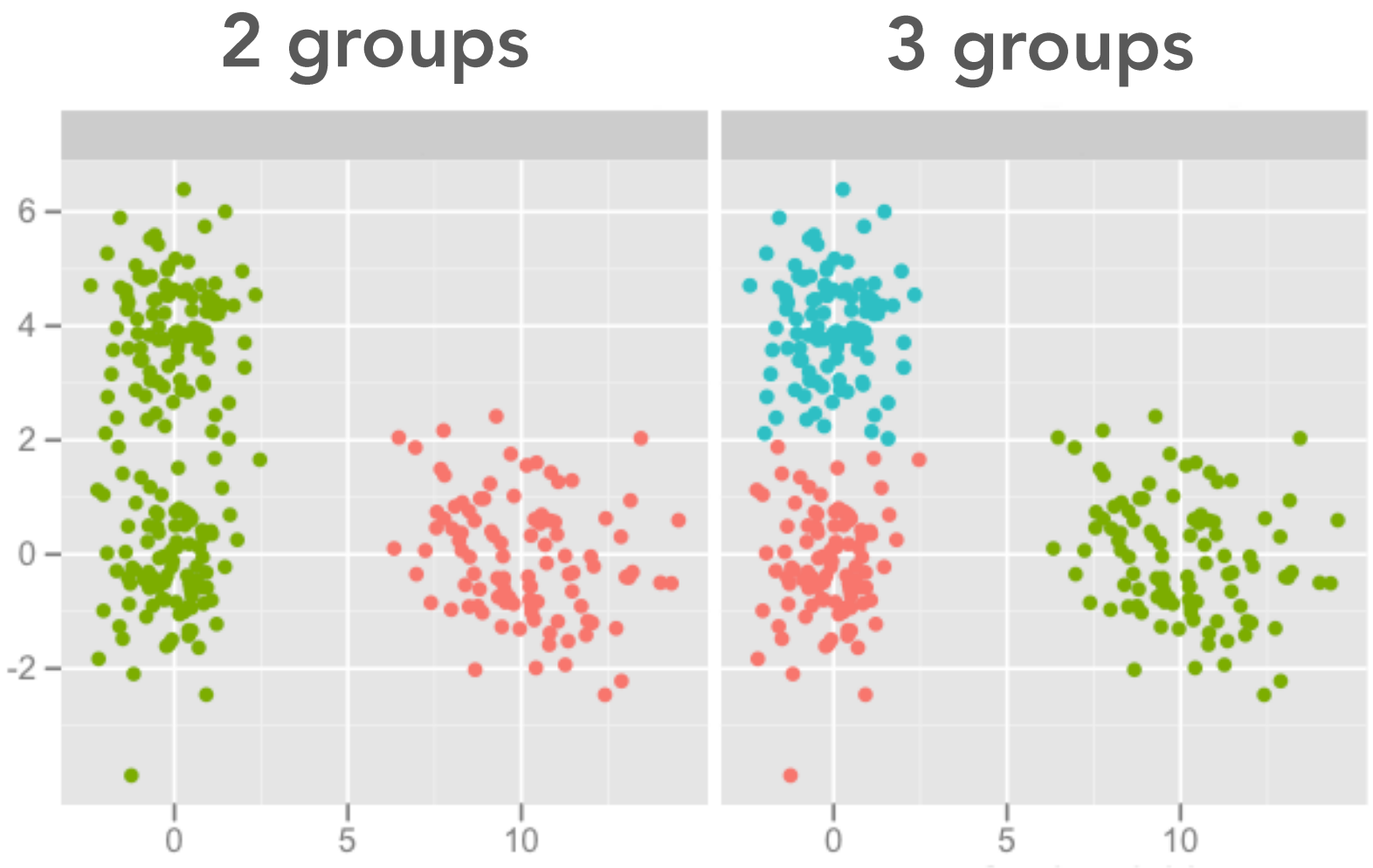


K Means

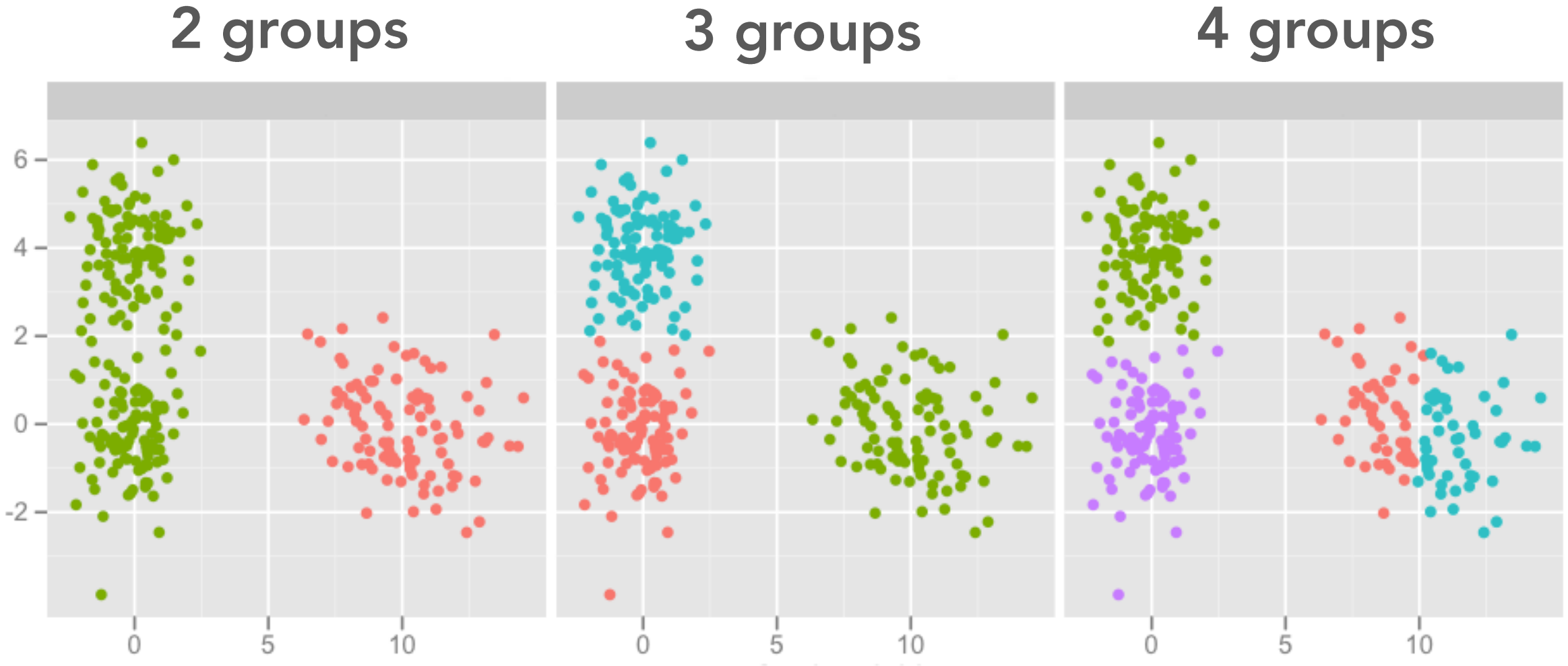
2 groups



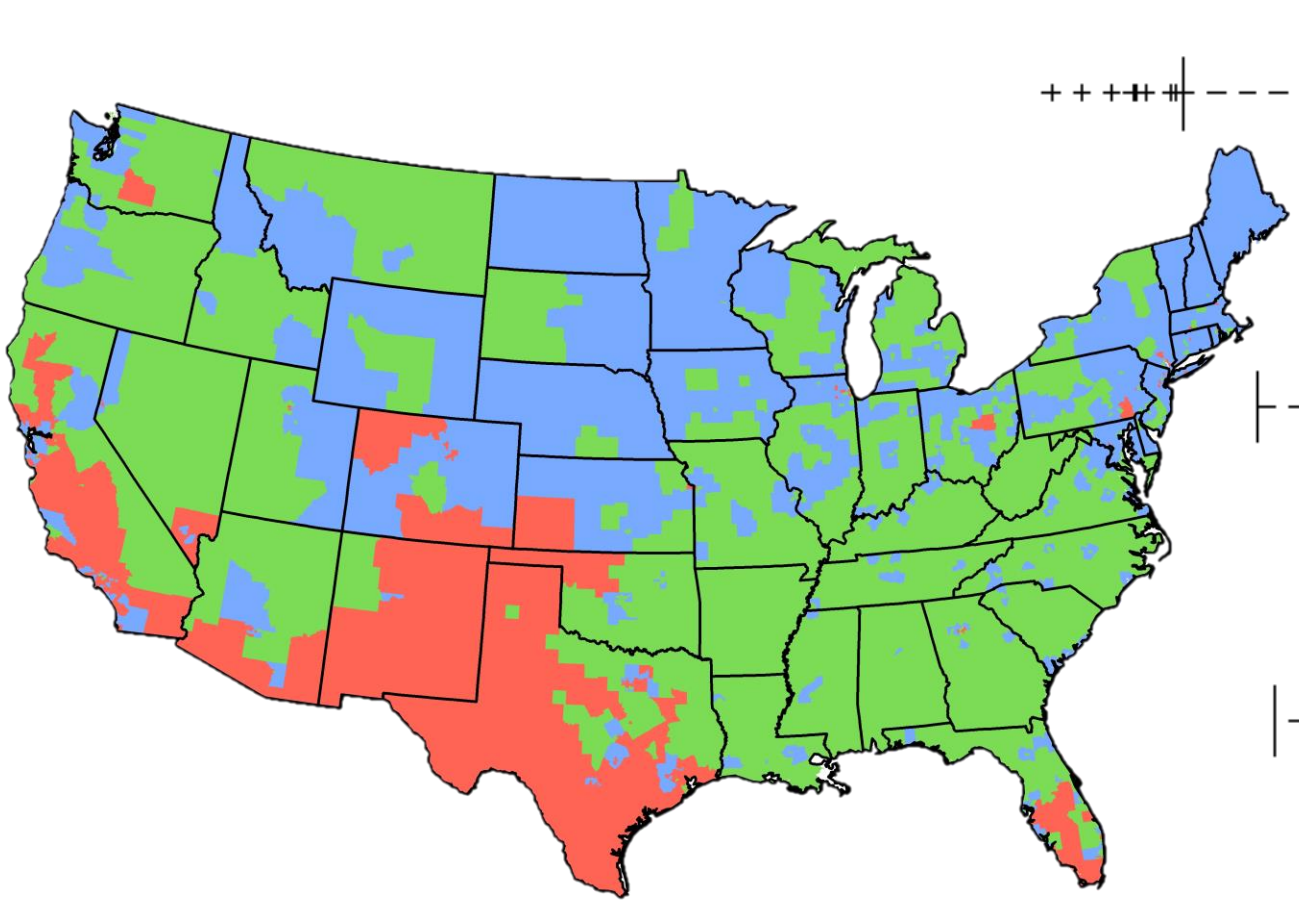
K Means

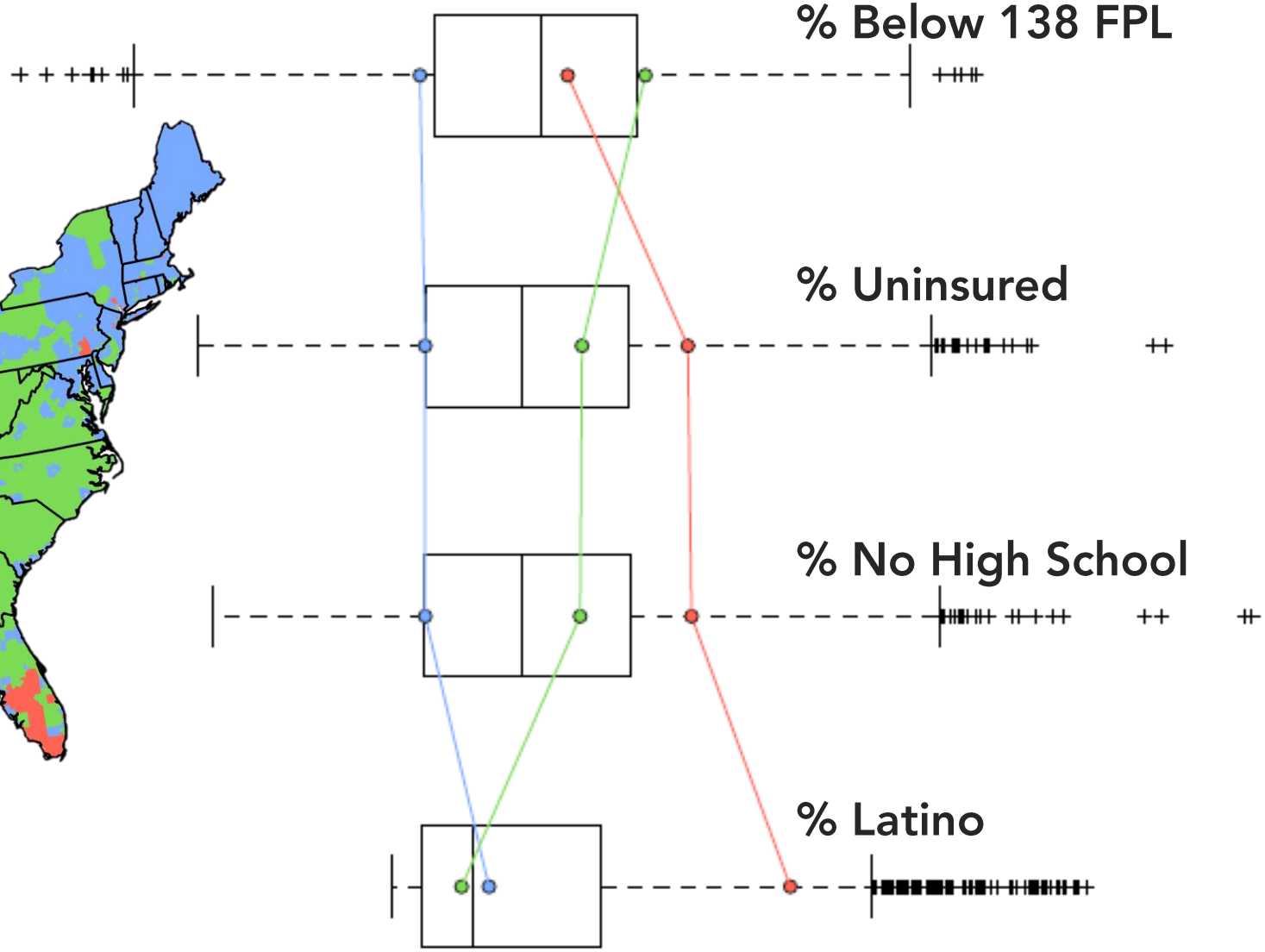


K Means

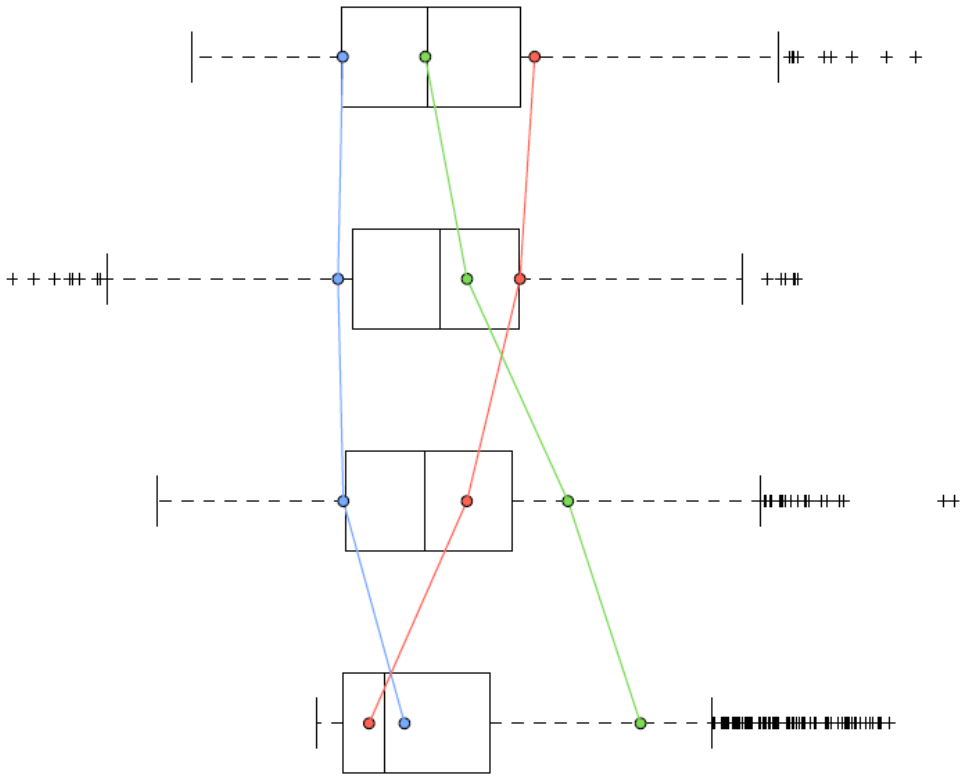


Eligible Uninsured Americans



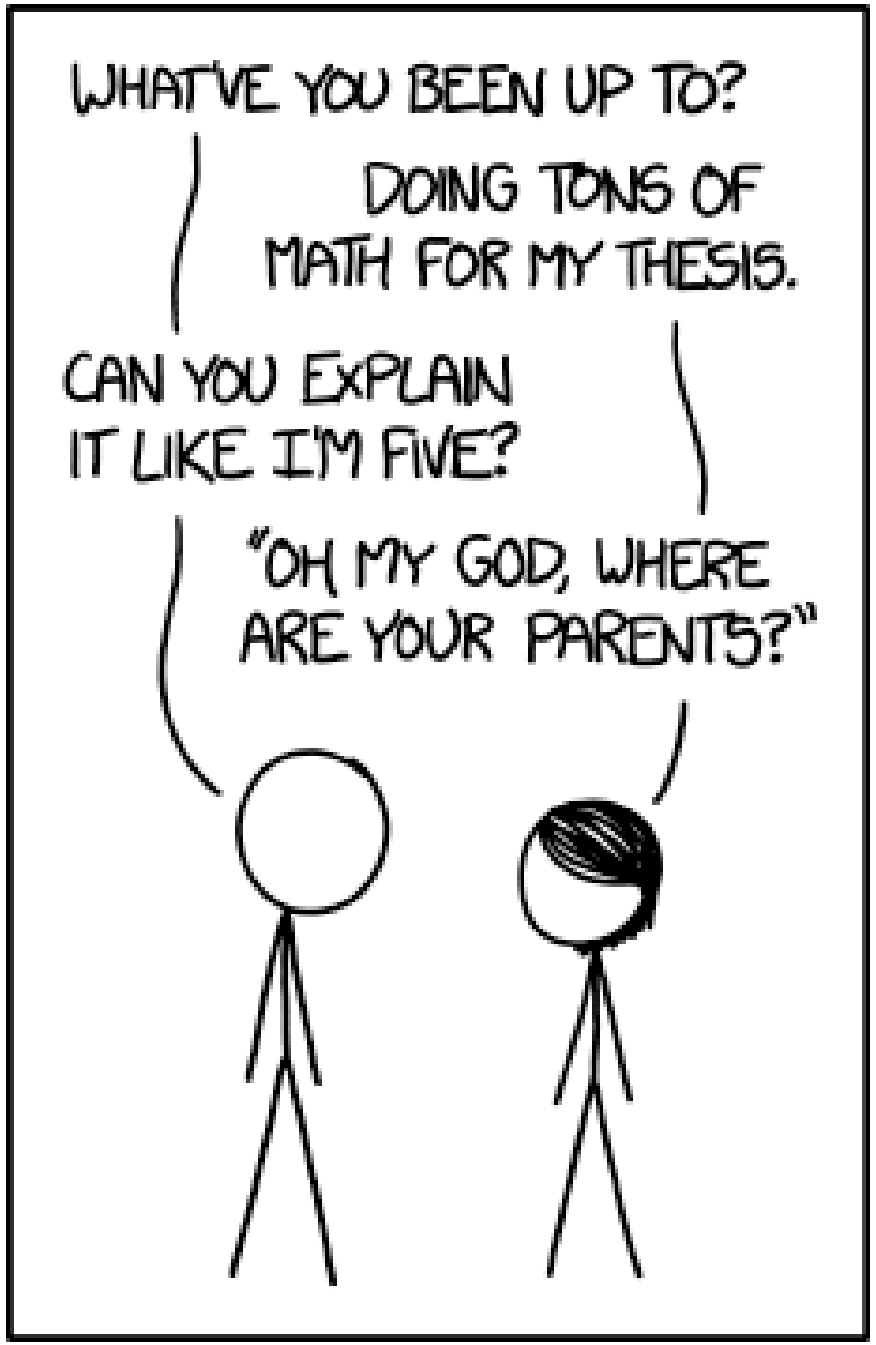


Demo



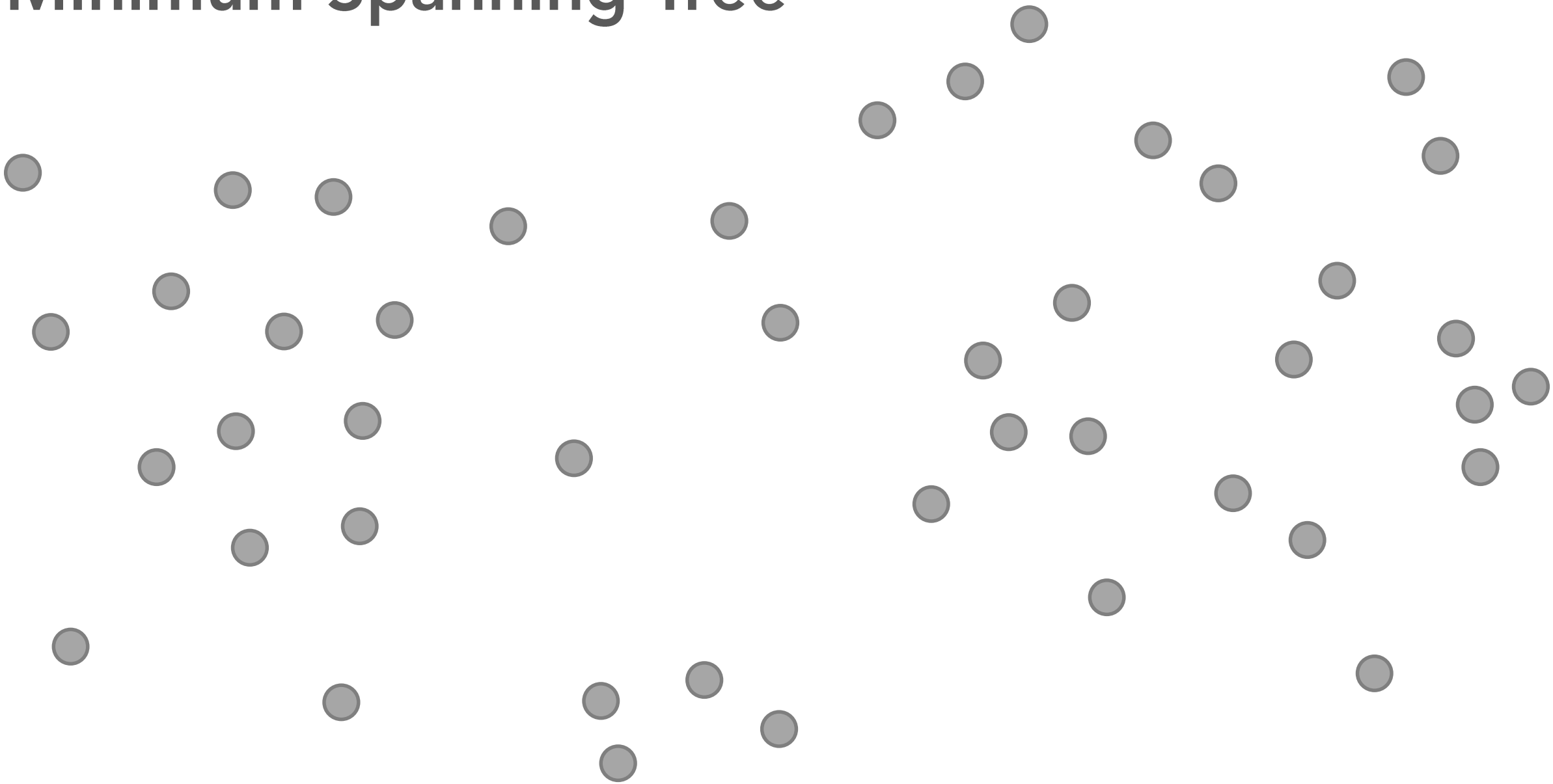
Spatially Constrained Multivariate Clustering

finds clusters based on feature attributes and proximity



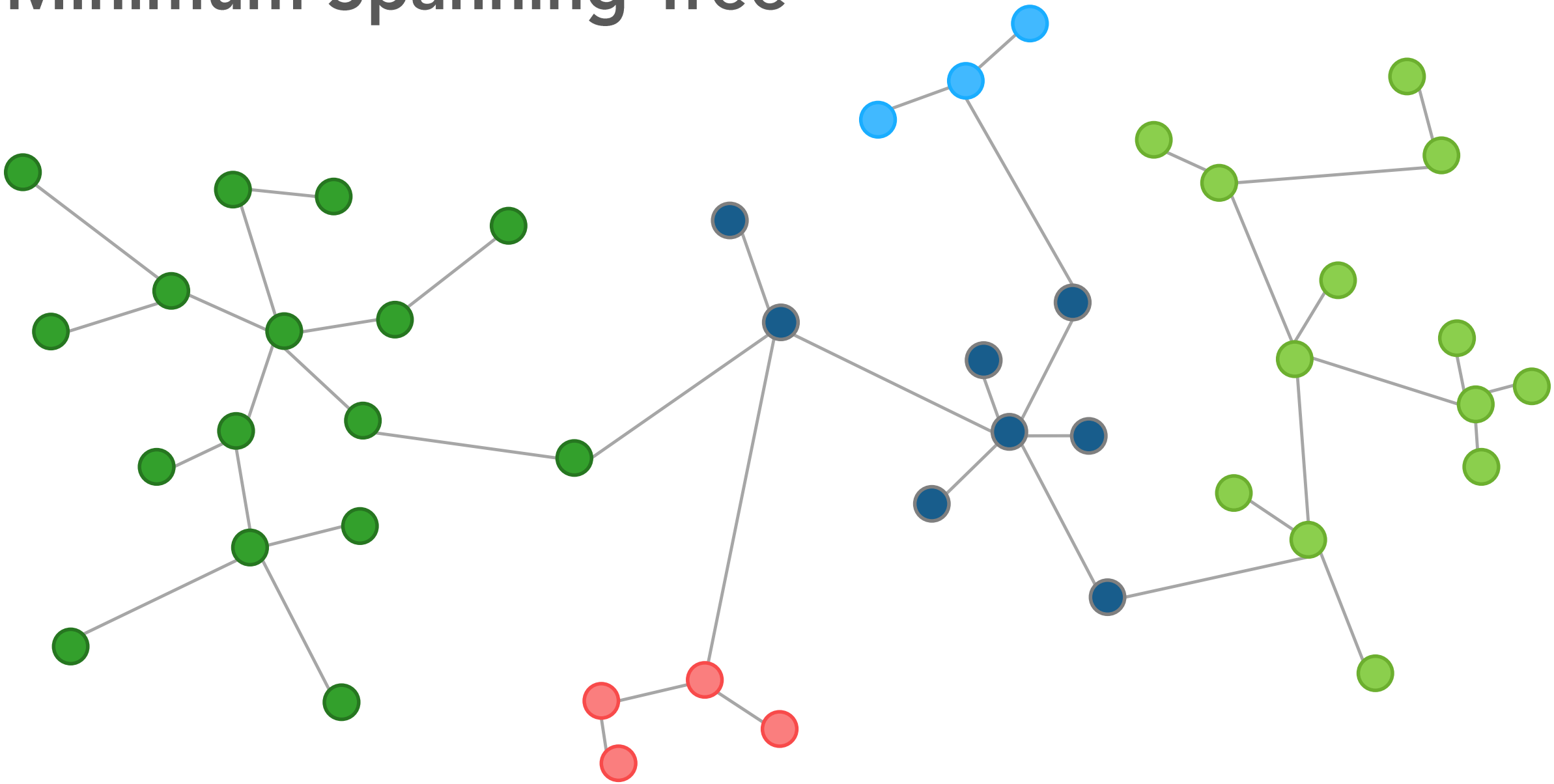
https://xkcd.com/1364/

Minimum Spanning Tree

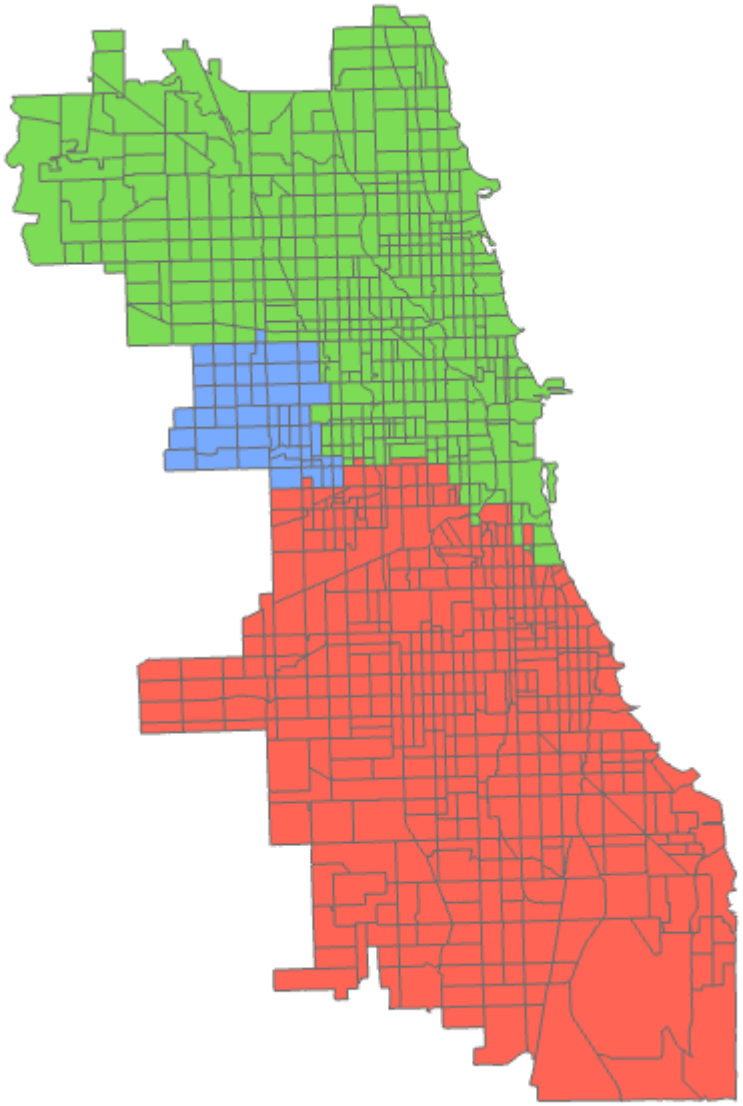


Minimum Spanning Tree

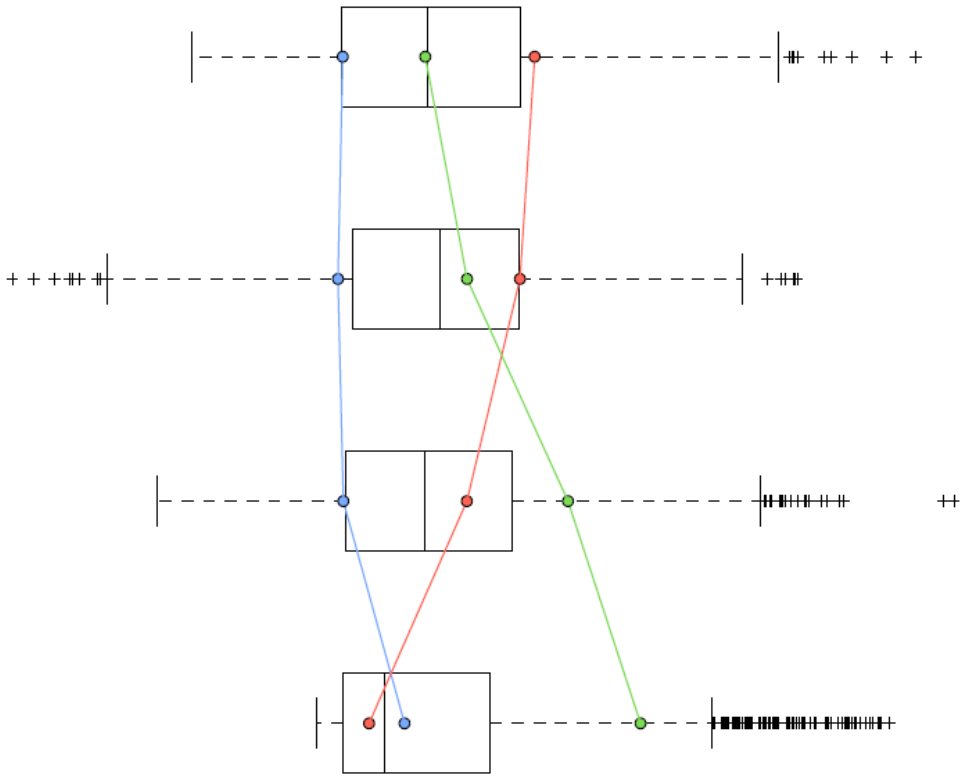
Minimum Spanning Tree



Crime in Chicago



Demo

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