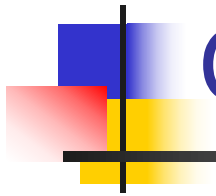


CSIT5210

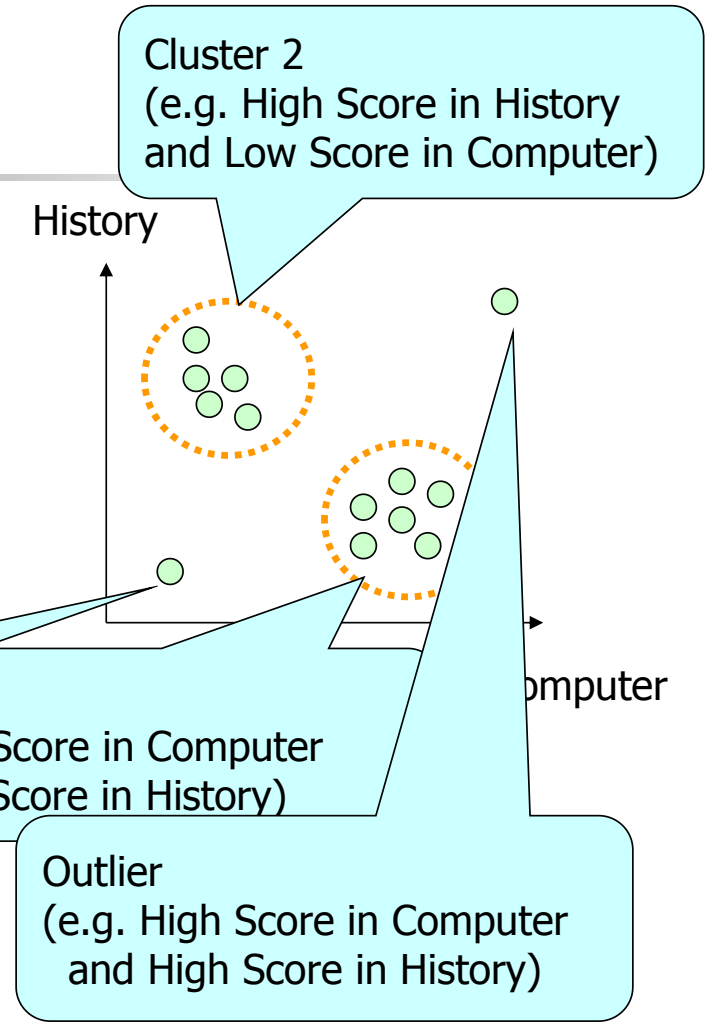
Outlier

Prepared by Raymond Wong
Presented by Raymond Wong
raywong@cse

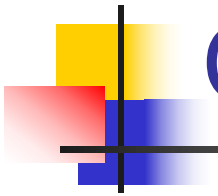
Outlier

Clustering:

	Computer	History
Raymond	100	40
Louis	90	45
Wyman	20	95
...	...	...

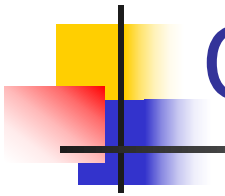


Problem: to find all outliers



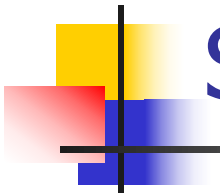
Outlier

- Applications
  - Fraud Detection
    - Detect unusual usage of credit cards or telecommunication services
  - Medical Analysis
    - Finding unusual response to various medical treatment
  - Customized Marketing
    - Customers with extremely low or extremely high incomes
  - Network
    - A potential network attack
  - Software
    - A potential bug



Outlier

- Statistical Model
- Distance-based Model
- Density-Based Model

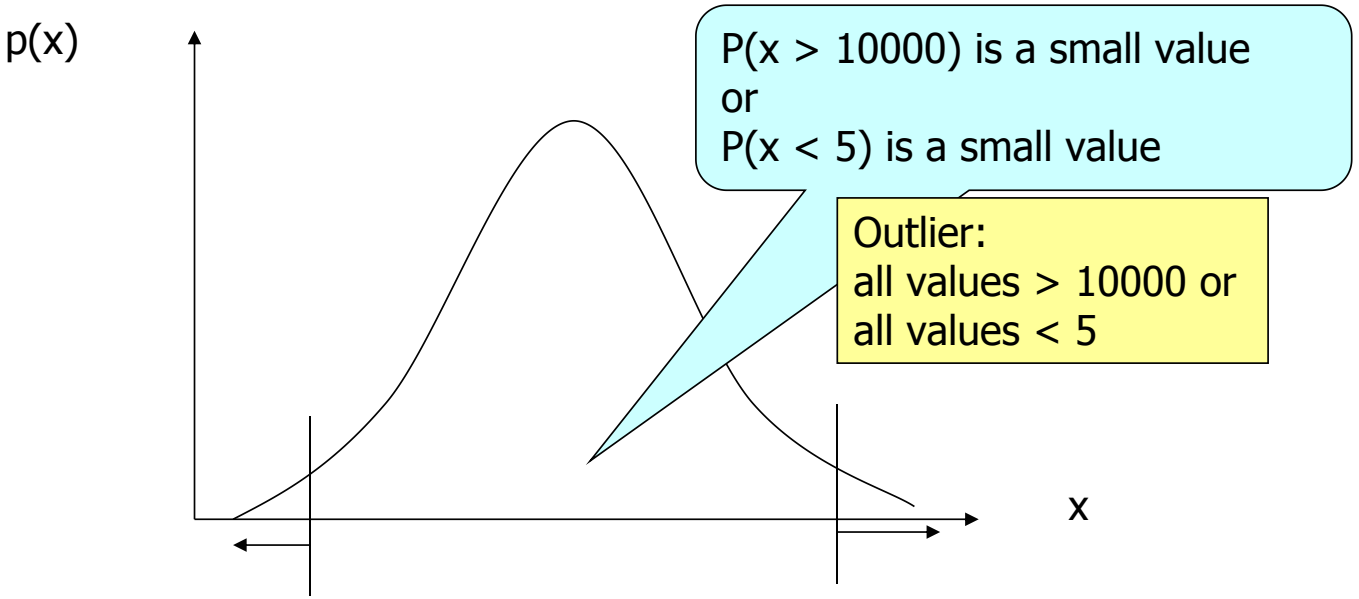


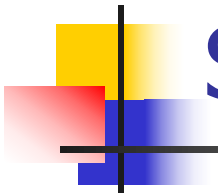
Statistical Model

- An outlier is an observation that is numerically distant from the rest of the data
- E.g.,
  - Consider 1-dimensional data
  - How is a data point considered as an outlier?

Statistical Model

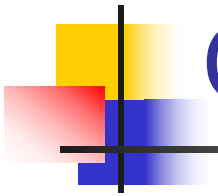
- Assume the 1-dimensional data follows the normal distribution





Statistical Model

- Disadvantage
  - Assume that the data follows a particular distribution



Outlier

- Statistical Model
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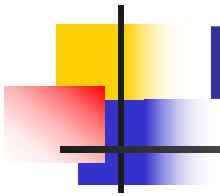
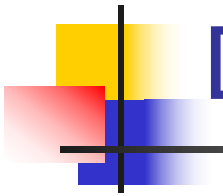


Distance-based Model

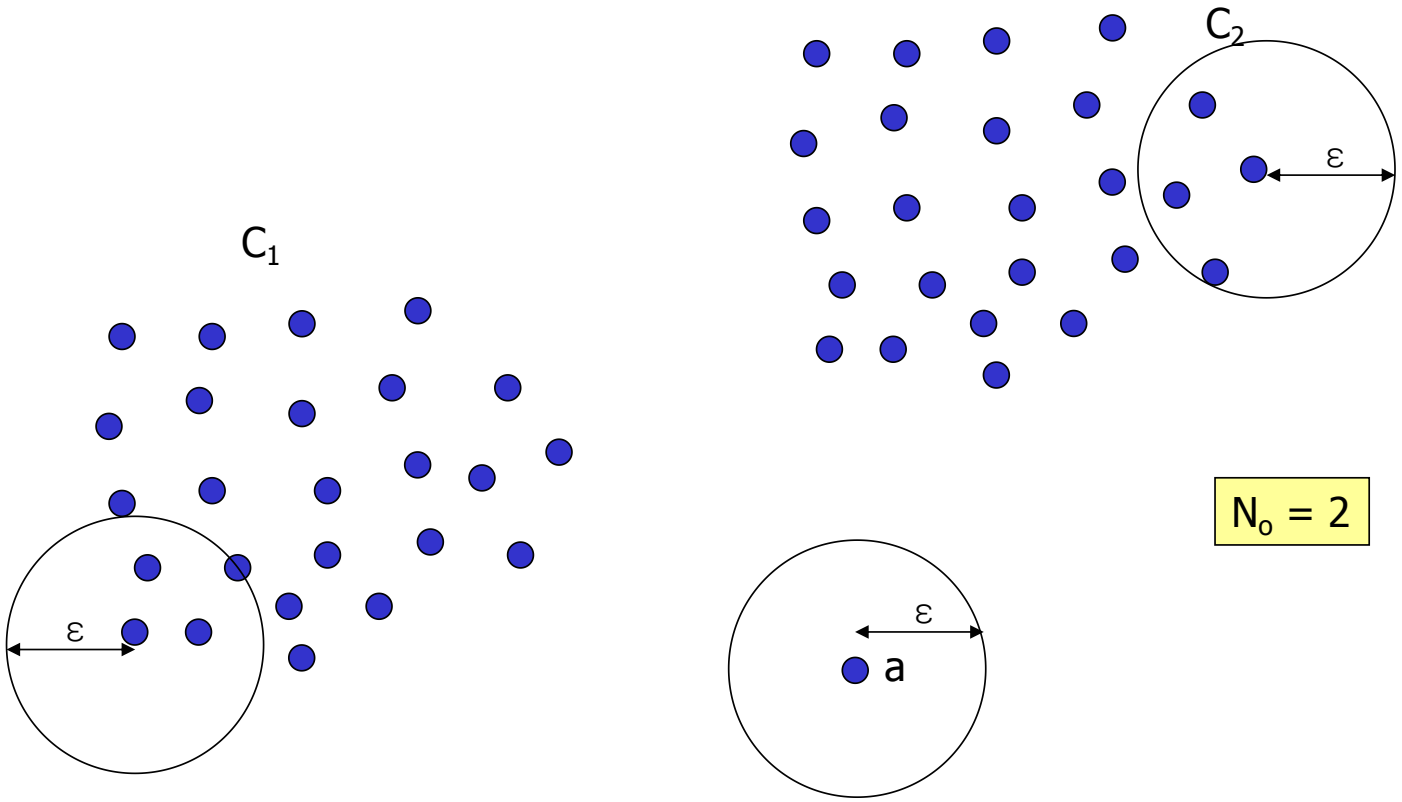
- Advantage
  - This model does not assume any distribution
- Idea
  - A point p is considered as an outlier if there are too few data points which are close to p

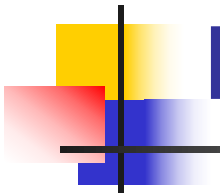


Distance-based Model

- Given a point p and a non-negative real number ε,
  - the ***ε-neighborhood*** of point p, denoted by N(p), is the set of points q (including point p itself) such that the distance between p and q is within ε.
- Given a non-negative integer N_o and a non-negative real number ε
  - A point p is said to be an outlier if
    - $N(p) <= N_o$

Distance-based Model

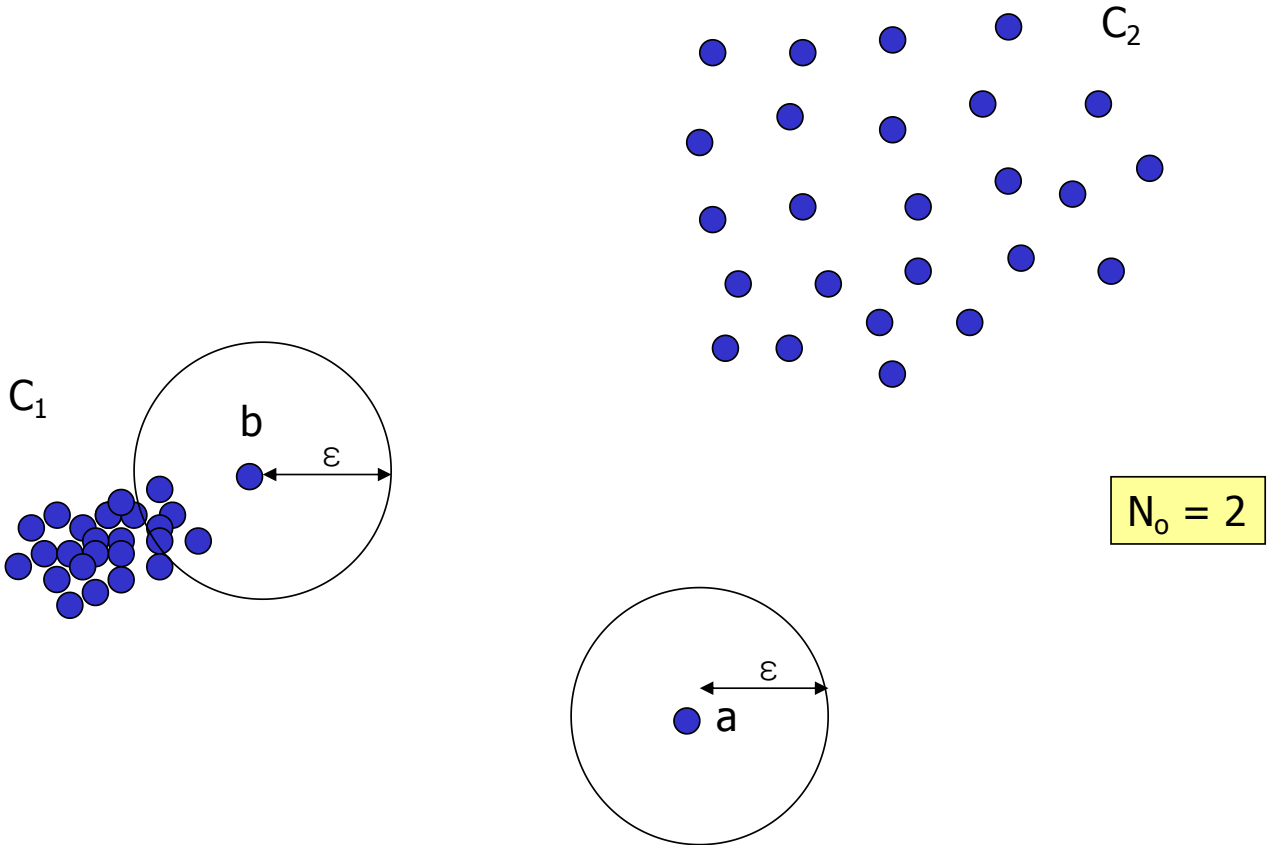


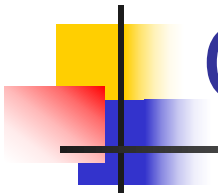


Distance-based Model

- Is the distance-based model “perfect” to find the outliers?

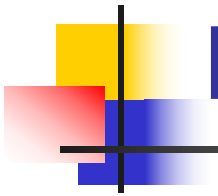
Distance-based Model





Outlier

- Statistical Model
- Distance-based Model
- Density-Based Model

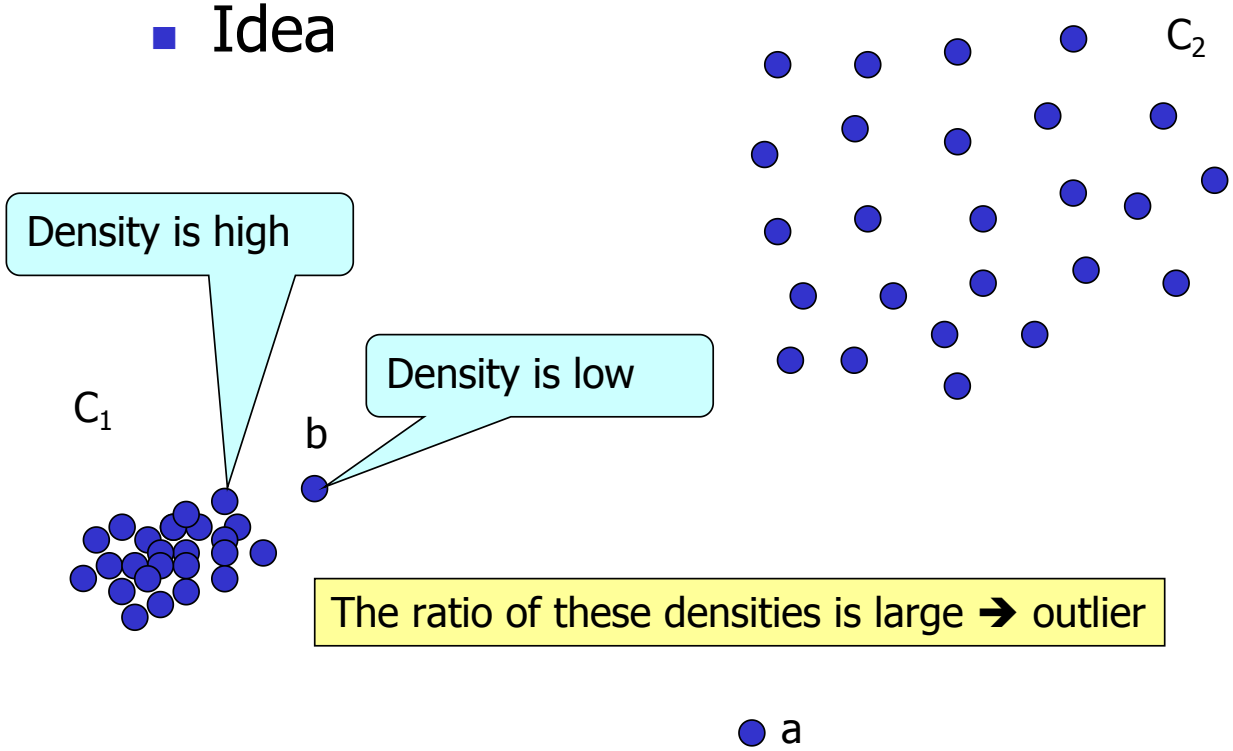


Density-Based Model

- Advantage:
  - This model can find some “local” outliers

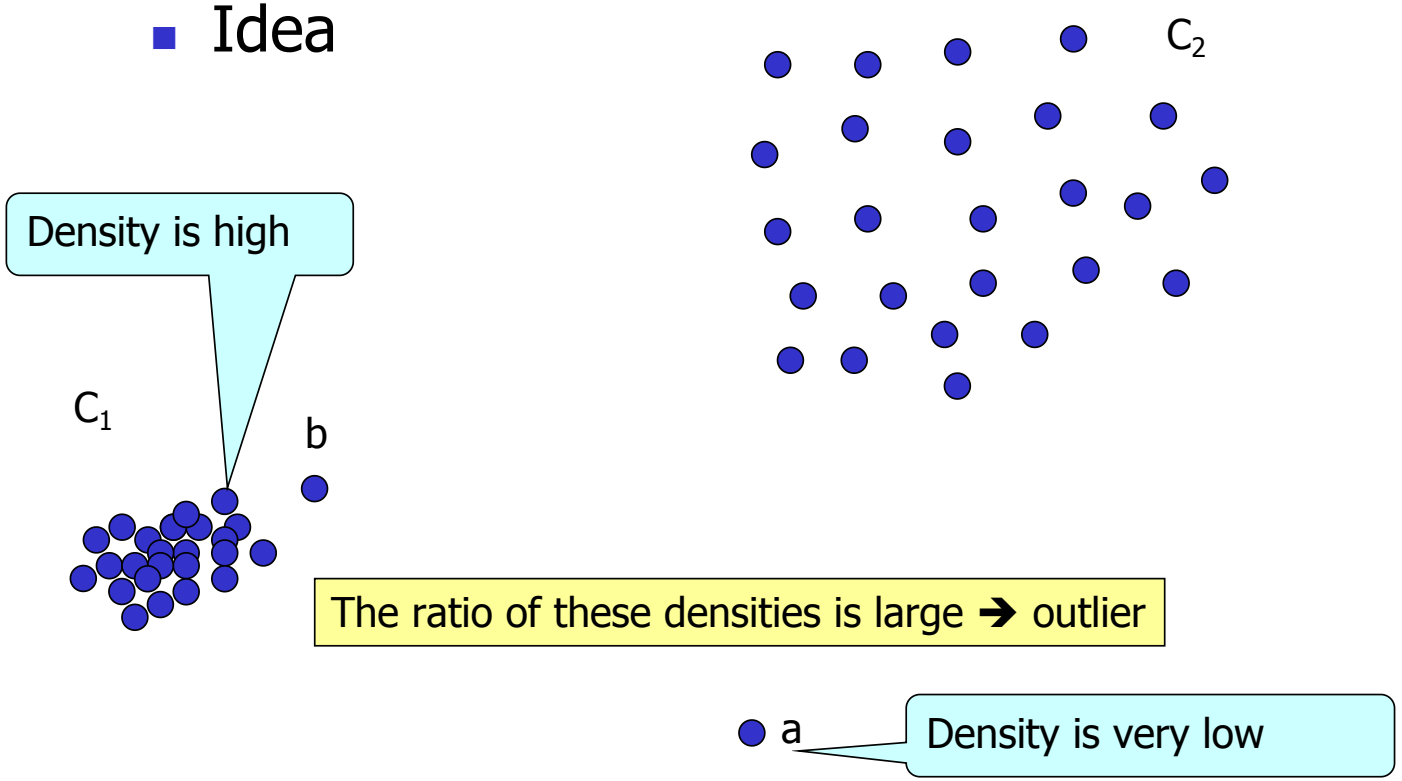
Density-Based Model

- Idea



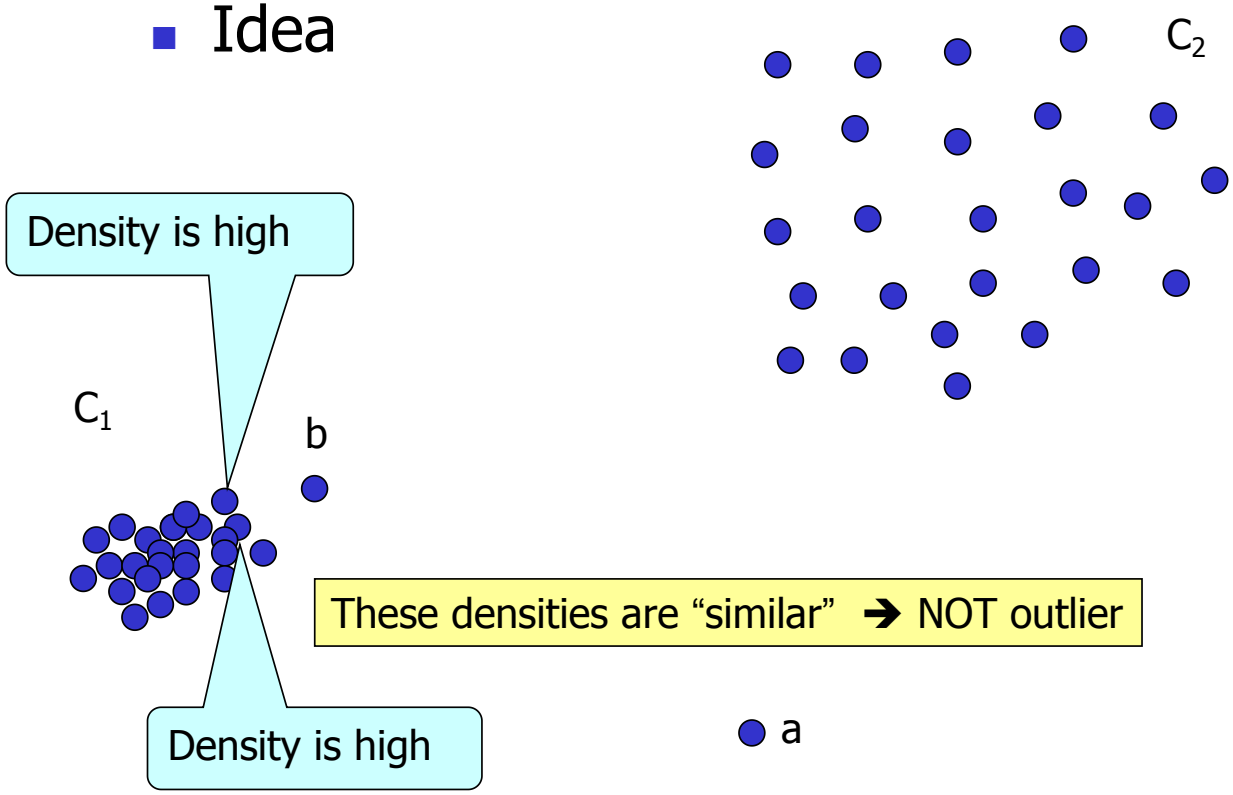
Density-Based Model

- Idea



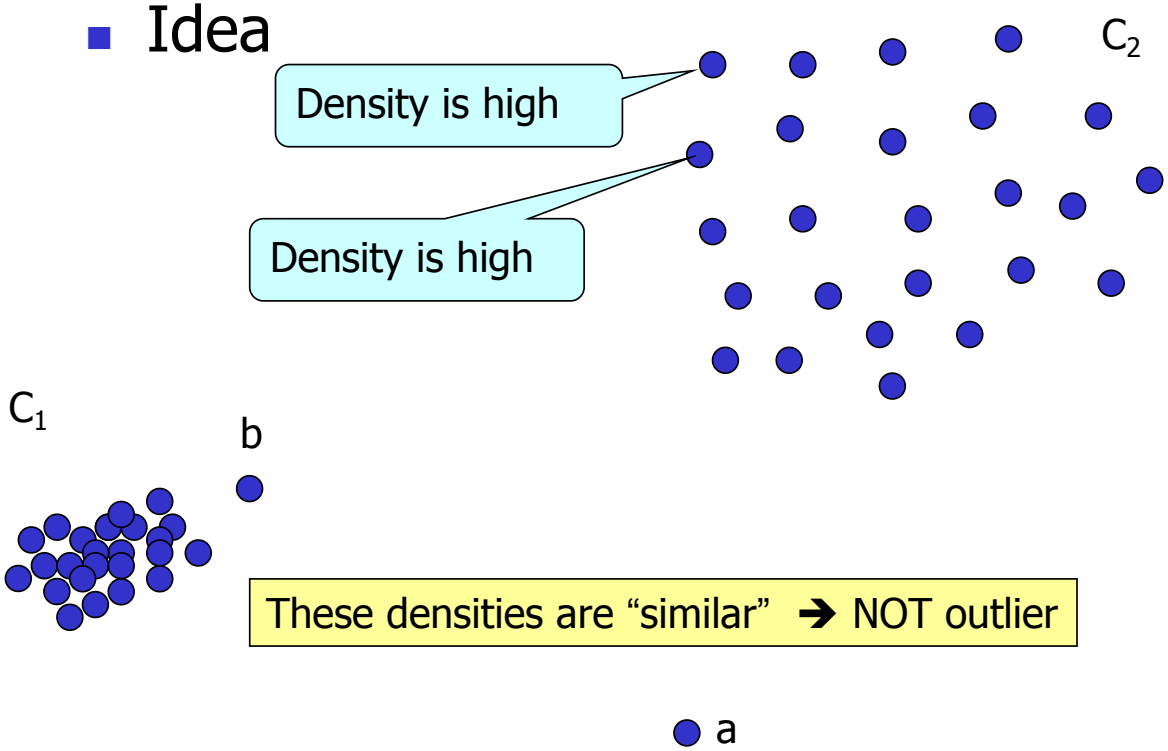
Density-Based Model

- Idea



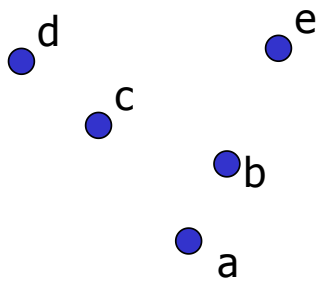
Density-Based Model

- Idea



Density-Based Model

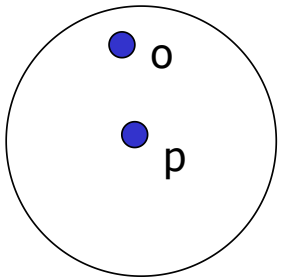
- Formal definition
  - Given an integer k and a point p,
    - $N_k(p)$ is defined to be the ε-neighborhood of p (excluding point p)
    - where ε is the distance between p and the k-th nearest neighbor



$N_1(a)$ = ?

$N_2(a)$ = ?

Density-Based Model



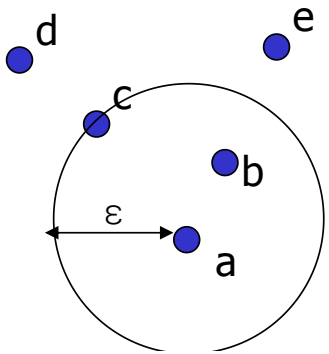
- Reachability Distance of p with respect to o
  - Given two points p and o and an integer k,
    - $Reach\_dist_k(p, o)$ is defined to be $\max\{dist(p, o), \varepsilon\}$
    - where ε is the distance between p and the k-th nearest neighbor

$Reach\_dist_2(a, b) = ?$

$Reach\_dist_2(a, c) = ?$

$Reach\_dist_2(a, d) = ?$

$Reach\_dist_2(a, e) = ?$



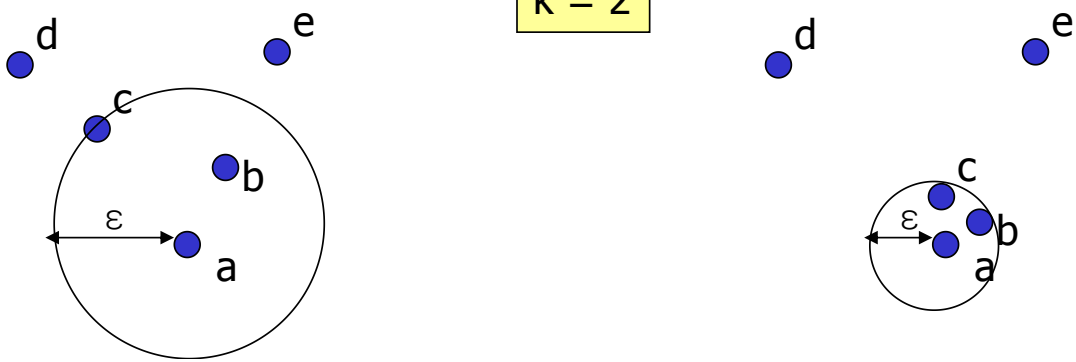
k = 2

Density-Based Model

- The **average reachability distance** of p among all k nearest neighbors is equal to ε
  - where ε is the distance between p and the k-th nearest neighbor
- The **local reachability density** of p (denoted by $lrd_k(p)$) is defined to be $1/\varepsilon$

Why?

k = 2



Density-Based Model

- The **local outlier factor (LOF)** of a point p is equal to

$$\frac{\sum_{o \in N_k(p)} \frac{lrd_k(o)}{lrd_k(p)}}{k}$$

Density-Based Model

- Idea