Data Preprocessing

Need to Preprocess Data

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- Data quality is a key issue with data mining
- To increase the accuracy of the mining, has to perform data preprocessing.
  - » Otherwise, garbage in => garbage out
- 80% of mining efforts often spend their time on data quality

How to Preprocess Data?

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- Data Cleaning
- Data Integration
- Data Normalization
- Data Reduction

Why Data Cleaning?

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- Real-world data are:
  - » Incomplete:
    - – missing values, missing attributes, or containing only aggregate data
  - » Noisy:
    - – containing errors or outliers
  - » Inconsistent:
    - – containing discrepancies in codes or names
- Solution: Data Cleaning

Why Data Integration?

- Data comes from different Sources with
  - » Same concept but different attribute name:
    - – (Example: ssn ; social_security ; student_ssn)
  - » Same value expressed differently:
    - – (Example: undergraduate ; UG…)
  - » Repeated tuples in different source databases.

=> Causes inconsistencies and redundancies.

- Solution: Data Integration (schema re-consolidation)

Why Data Reduction?

- Huge amount of data
  - » decreases the efficiency
  - » Make analysis difficult
- Solution: Data Reduction (reducing huge dataset to smaller representation that can show the same analysis)

Why Data Normalization?

- The range of attributes (features) values differ, thus one feature might overpower the other one.
- Solution: Normalization (Scaling data values in a range such as [0..1], [-1..1] prevents outweighing features with large range like ‘salary’ over features with smaller range like ‘age’.

Data Cleaning: Handling Missing Values

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- Use attribute mean.
- Use attribute mean for all samples belonging to same class.
- Use most probable value based on existing data (via Decision Tree, Bayesian,…).

  ex.: What would probably be the salary of a person with age *x* and education *y* based on the other data we currently have?
- As these are all estimates, they can lead to invalid results!

Data Cleaning: Detect Noisy Data

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- **Histogram** - data distribution analysis
- **Cluster Analysis**- by detecting data that are outside any cluster.
- **Regression**- by using regression function.

Data Cleaning: Smoothing Noisy Data

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- **Binning-** by arranging the data into buckets.
- **Concept Hierarchy**
  - » Example: presenting numeric values such as age as young, middle age, and old.
- **Ignoring outliers detected by**

(Outliers are data that are outside of the range of or inconsistent with the remaining data)

- – Histogram
- – Clustering
- – Regression

Binning (Example)

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- Step 1: Partition sorted values into equal size bins.
- Step 2: Smooth by bin means/medians/boundaries.
- => reduces distinct values and gets rid of outliers:
  - » 4,8,15,21,21,24,25,28,34

    Bin 1: 4, 8 , 15

    Bin 2: 21, 21, 24

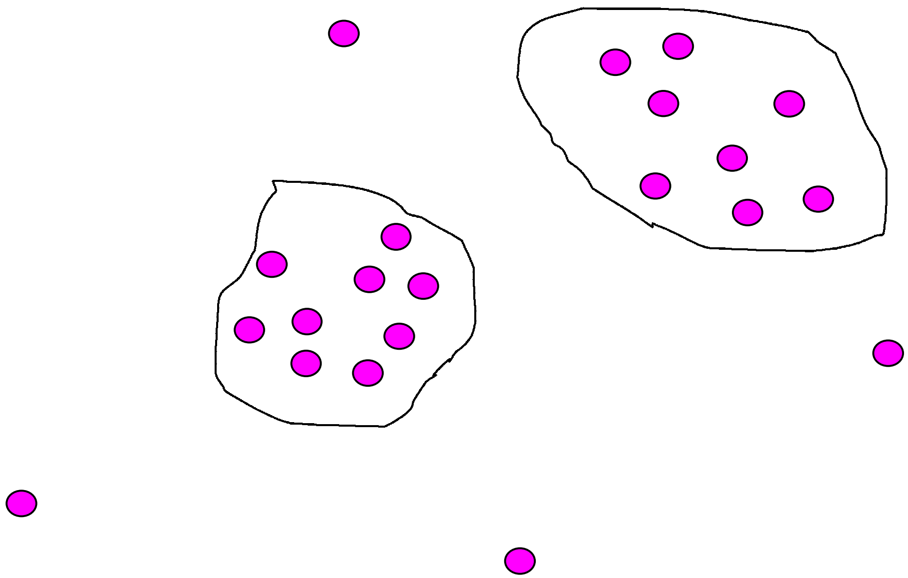
    Bin 3: 25, 28, 34
  - » By bin mean:

    Bin1: 9, 9, 9; bin 2: 22, 22, 22 ; bin 3: 29, 29, 29
  - » Smoothing by bin boundary

    Bin 1: 4, 4, 15; bin 2: 21, 21, 24; bin 3: 25, 25, 34

Clustering

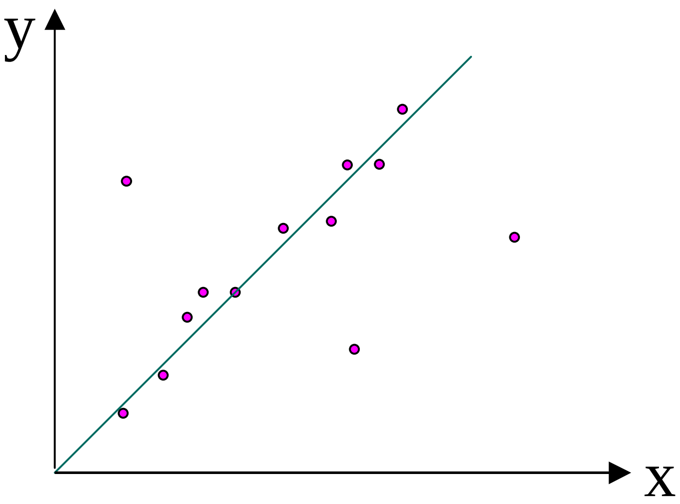
- Find clusters and look for elements outside of any cluster.



Regression

- Find “best fitting” curve to existing data points.
- Points not matching curve are outliers.

Example:
y = x is best fitting curve
For current data. The
outliers are the three points
outside of the curve.



Data Cleaning: Handling Inconsistent Data

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- Using known Functional dependencies
  - (example: item# → item)

- Revisiting data integration, as some inconsistencies might exist because of different names of the same attribute.

Data Integration

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- Consolidate different source into one repository, usually data warehouse (schema re-consolidation)
  - » Using metadata
  - » Correlation analysis (measure how strongly one attribute implies the other attribute).

Data Reduction

- To increase the efficiency, can reduce the huge data set to a smaller representative.
- Methods:
  - » Data aggregation (data cubes)
    - – example: number of items sold in year vs. in month.
  - » Dimension/attribute reduction
  - » Data Compression
  - » Discretization

Discretization and Concept Hierarchy

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- Discretization is to transform the numeric (Continues) data to Categorical values.
- Some data Mining Algorithms only accept categorical values.
- Example:
  - » Continues data: 1,2,3,4,5,…,20
    - – Discretized values: 1-5; 6-10; 11-15; 16-20
  - » Continues data for feature Age: 1,…,99
    - – categorical values: 1-15 : assign this range to concept “child”
      - » 16- 40 : assign this range to concept “Young”
      - » and so on ………..

Data Normalization

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- Scale the data value to a range using methods such as:
  - » **Min-Max**
  - » **Z-Score**
  - » **Decimal Scaling**

Data Normalization: Min-Max

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- Linear transformation of the original input range into a newly specified data range (typically 0-1).

$$y' = \frac{y - \min}{\max - \min}(\max' - \min') + \min'$$

- Old min value is mapped to new min, *min'*.
- Old max is mapped to new max, *max'*.
- Let *y* be the original value, *y'* be the new value.
- *min*, *max* are the original min and max.
- *min'*, *max'* are the new min and max.

Min-Max (Example)

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- Consider old data that ranged from 0-100, we now obtain an equation to migrate it to 5-10 range.

$$y' = \frac{y - \min}{\max - \min}(\max' - \min') + \min'$$

  - » y’ = (y/20) + 5
  - » y = 0, y’= 5
  - » y= 10, y’= 5.5
  - » y = 90, y’ = 9.5

Data Normalization: Z-Score

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- useful when min and max are unknown or outliers dominate the value min-max.
- The goal is that most of the data will lie within the origin to a standard deviation.
- If majority of data falls within 50 and 100, but you have a few data points outside of that range, zscore will compress most of the data into a small range.

$$y' = \frac{y - mean}{std}$$

Z-Score (Example)

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y	y'							y	y'					
0.18	-0.84		**Avg**	0.68	**std**	0.59		20.00	-0.26		**Avg**	34.30	**std**	55.86
0.60	-0.14							40	0.11					
0.52	-0.27							65	0.55					
0.25	-0.72							70	0.64					
0.80	0.20							**32**	**-0.05**					
0.55	-0.22							8	-0.48					
0.92	0.40							5	-0.53					
0.21	-0.79							15	-0.35					
0.64	-0.07							250	3.87					
0.20	-0.80							32	-0.05					
0.63	-0.09							18	-0.30					
0.70	0.04							10	-0.44					
0.67	-0.02							-14	-0.87					
0.58	-0.17							22	-0.23					
0.98	0.50							45	0.20					
0.81	0.22							60	0.47					
0.10	-0.97							-5	-0.71					
0.82	0.24							7	-0.49					
0.50	-0.30							2	-0.58					
3.00	3.87							4	-0.55					
0.68	**0.00**													

Data Normalization: Decimal scaling

- divide the value by 10^n where n is the number of digits of the maximum absolute value.

$$y' = \frac{y}{10^n}$$

» Example: X=900 is maximum value

$\Rightarrow n = 3$

$\Rightarrow$ 900 scales to 0.009.

Summary

- A main portion of Data Warehousing and Data Mining effort is to preprocess the data.
- Data cleaning, integration, reduction, and normalization are used to preprocess the data.