INT104 ARTIFICIAL INTELLIGENCE

LECTURE 2- DATA PRE-PROCESSING

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CONTENT

- Data Collection
- Discover and Visualize the Data
- Data Preprocessing
- Data Cleaning
- Data Transformation
- Data Reduction

Data Type

Structured

Example: tables

- Highly organized
- Usually with a label

Cust.Id	sex	employed	income	marital	vehicles	age	State of residence
2068	F	NA	11300	Married	2	49	Michigan
2073	F	False	0	Married	3	40	Florida
2848	M	TRUE	4500	Never Married	3	22	Georgia
5641	M	TRUE	20000	Never Married	0	22	New Mexico

Unstructured

Example: free text

“It was found that a female with a height between 65 inches and 67 inches had an IQ of 125–130”

Data Collection

Lots of places that host/share data online, or you can collect them yourself.

Open data collections

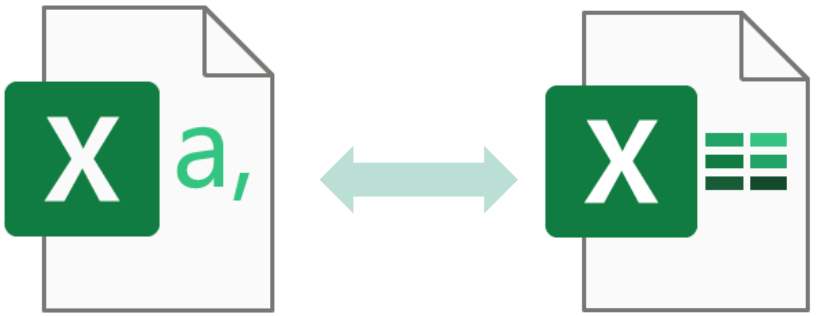
Social media data

Multimodal data

Data Storage and Presentation

- CSV (Comma Separated Values)

```
treat,before,after,diff
No Treatment,13,16,3
No Treatment,10,18,8
No Treatment,16,16,0
Placebo,16,13,-3
```



data.csv

- TSV (Tab Separated Values)

```
Name<TAB>Age<TAB>Address
Ryan<TAB>33<TAB>1115 W Franklin
Paul<TAB>25<TAB>Big Farm Way
Jim<TAB>45<TAB>W Main St
Samantha<TAB>32<TAB>28 George St
```

Data Storage and Presentation

- XML (Extensible Markup Language)

```
<?xml version="1.0" encoding="UTF-8"?>
<bookstore>
     <book category="information science" cover="hardcover">
          <title lang="en">Social Information Seeking</title>
          <author>Chirag Shah</author>
          <year>2017</year>
          <price>62.58</price>
     </book>
     <book category="data science" cover="paperback">
          <title lang="en">Hands-On Introduction to Data
            Science</title>
          <author>Chirag Shah</author>
          <year>2019</year>
          <price>50.00</price>
     </book>
</bookstore>
```

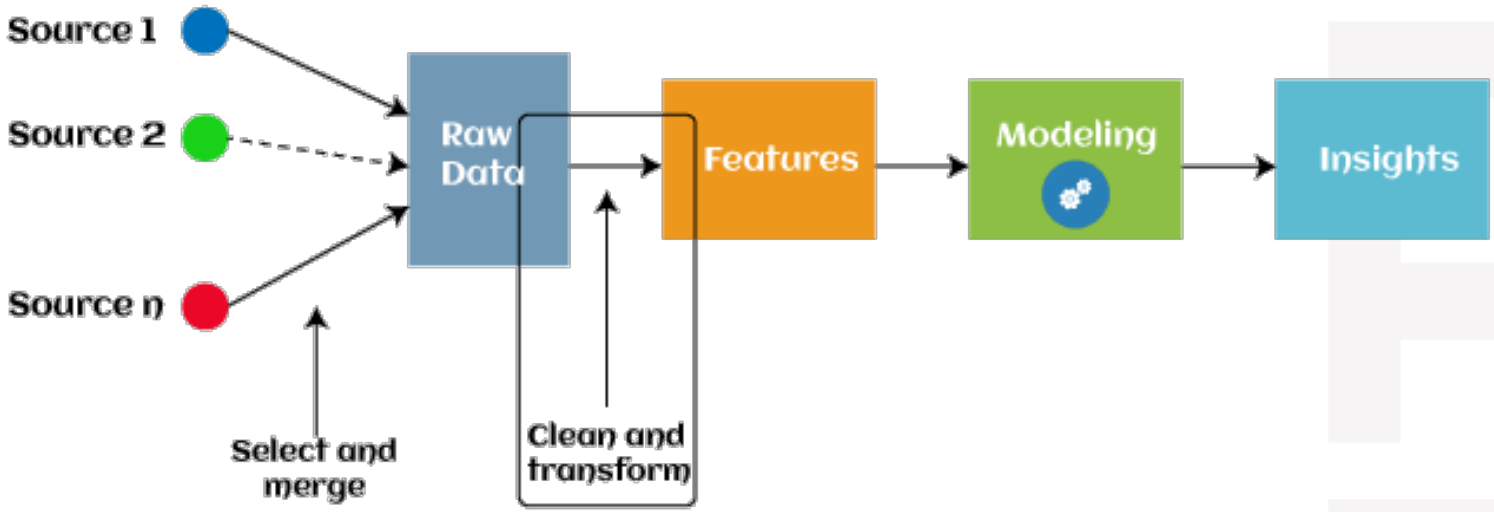
- JSON (JavaScript Object Notation)

```
{
  "squadName" : "Super Hero Squad",
  "homeTown" : "Metro City",
  "formed" : 2016,
  "secretBase" : "Super tower",
  "active" : true,
  "members" : [
    {
      "name" : "Molecule Man",
      "age" : 29,
      "secretIdentity" : "Dan Jukes",
      "powers" : [
        "Radiation resistance",
        "Turning tiny",
        "Radiation blast"
      ]
    }
```

Data Visualization

- Data Visualization in Python
  - Matplotlib
  - Seaborn
  - Pandas.plot
  - ……
- Common Format
  - Line Charts
  - Bar Graphs
  - Histograms
  - Scatter Plots
  - Heat Maps

Data Pre-processing



Goal: to improve the quality of data, reduce errors and inconsistencies, and prepare the data for further analysis or modeling.

Data Pre-processing

- Feature: an individual measurable property or characteristic of a phenomenon.
- Instance: a sample or data point, refers to a single observation or example in the dataset
- Target variable
- Dataset: A dataset is a collection of instances, features, and target variables that are used to train and test machine learning models.

Feature

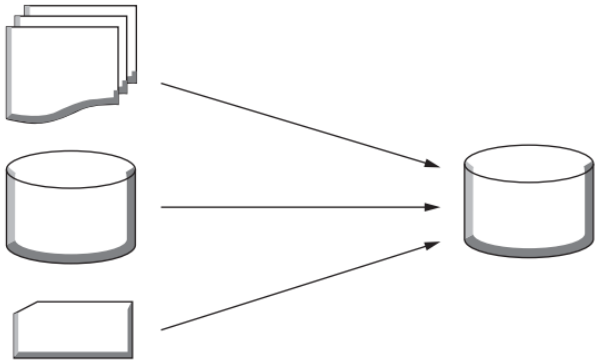
Cust.Id	income	vehicles	age
2068	11300	2	49
2073	0	3	40
2848	4500	3	22
5641	20000	0	22

Instance

Data Pre-processing

Data Cleaning

Data Integration



Data Transformation –17, 25, 39, 128, –39 → 0.17, 0.25, 0.39, 1.28, –0.39

Data Reduction

	A1	A2	A3	....	A200
T1					
T2					
T3					
....					
T200					

→

	A1	A2	A3	...	A120
T1					
T2					
T3					
....					
T150					

Data Cleaning

- Data Munging

Example: “Add two diced tomatoes, three cloves of garlic, and a pinch of salt in the mix.”

Table 2.2 Wrangled data for a recipe.

Ingredient	Quantity	Unit/size
Tomato	2	Diced
Garlic	3	Cloves
Salt	1	Pinch

Data Cleaning

- Handling Missing Data
  - Get rid of the corresponding instance.
  - Get rid of the whole column.
  - Set the values to some value (zero, the mean, the median, etc.).

- Smooth Noisy Data
  - Identify or remove the outliners
  - Try to resolve the inconsistent

  (there is no one way to remove noise, or smooth out the noisiness in the data)

Practice: Data Cleaning

#	Country	Alcohol (L/person)	Deaths (Per 100k)	Heart (Per 100k)	Liver (Per 100k)	Free healthcare
1	Australia	2.5	785	211	15.30000019	Y
2	Austria	3.000000095	863	167	45.59999847	Y
3	Belg/Lux	2.900000095	883	131	20.70000076	N
4	Canada	2.400000095	793	NA	16.39999962	Y
5	Denmark	2.900000095	971	220	23.89999962	Y
6	Finland	0.800000012	970	297	19	N
7	France	9.100000381	751	11	37.90000153	N
8	Iceland	-0.800000012	743	211	11.19999981	Y
9	Ireland	0.699999988	1000	300	6.5	Y
10	Israel	0.600000024	-834	183	13.69999981	Y
11	Italy	27.900000095	775	107	42.20000076	Y
12	Japan	1.5	680	36	23.20000076	N
13	Netherlands	1.799999952	773	167	9.199999809	N
14	New Zealand	1.899999976	916	266	7.699999809	Y
15	Norway	0.0800000012	806	227	12.19999981	N
16	Spain	6.5	724	NA	NA	Y
17	Sweden	1.600000024	743	207	11.19999981	N
18	Switzerland	5.800000191	693	115	20.29999924	N
19	UK	1.299999952	941	285	10.30000019	Y
20	US	1.200000048	926	199	22.10000038	N
21	West Germany	2.700000048	861	172	36.70000076	Y

Data Integration

How to integrate multiple databases or files:

Combine

- Combine data from multiple sources into a coherent storage place (e.g., a single file or a database).

Resolve conflicts

- Different representations or different scales; for example, metric vs. British units.

Remove redundant

- The same attribute may have different names in different databases.
- One attribute may be a “derived” attribute in another table; for example, annual revenue.
- Correlation analysis may detect instances of redundant data

Data Transformation

Data must be transformed so it is consistent and readable (by a system)

- Handling Text and Categorical Attributes

  i.e, [“cat1”], [“cat2”], [“cat3”], [“cat4”]

  - Ordinal encoder:

    ```
    from sklearn.preprocessing import OrdinalEncoder
    ```

    [0], [1], [2], [3]

  - One-hot encoder:

    ```
    from sklearn.preprocessing import OneHotEncoder
    ```

    [1,0,0,0], [0,1,0,0], [0,0,1,0], [0,0,0,1]

Data Transformation

- Normalization
  - Min–max normalization.

$$x_{scaled} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

  - Z-score normalization.

    Normalizing every value in a dataset such that the mean of all of the values is 0 and the standard deviation is 1

$$x_{scaled} = \frac{x - mean}{sd}$$

  - Normalization by decimal scaling.

$$x_{scaled} = \frac{x}{10^j}$$

Practice: Data Transformation

#	Country	Alcohol (L/person)	Deaths (Per 100k)	Heart (Per 100k)	Liver (Per 100k)	Free healthcare
1	Australia	2.5	785	211	15.30000019	Y
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20	US	1.200000048	926	199	22.10000038	N
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Data Reduction

Data reduction is a key process in which a reduced representation of a dataset that produces the same or similar analytical results is obtained.

	A1	A2	A3	....	A200
T1					
T2					
T3					
....					
T200					

→

	A1	A2	A3	...	A120
T1					
T2					
T3					
....					
T150					

Feature Selection

- Filter methods – features are selected and ranked according to their relationships with the target;
- Wrapper methods – it's a search for well-performing combinations of features
- Embedded methods – perform feature selection as part of the model training process.

longitude	latitude	housing_median_age	total_rooms	total_bedrooms	population	households	median_income	median_house_value	ocean_proximity
-122.23	37.88	41	880	129	322	126	8.3252	452600	NEAR BY
-122.22	37.86	21	7099	1106	2401	1138	8.3014	358500	NEAR BY
-122.24	37.85	52	1467	190	496	177	7.2574	352100	NEAR BY
-122.25	37.85	52	1274	235	558	219	5.6431	341300	NEAR BY
-122.25	37.85	52	1627	280	565	259	3.8462	342200	NEAR BY
-122.25	37.85	52	919	213	413	193	4.0368	269700	NEAR BY
-122.25	37.84	52	2535	489	1094	514	3.6591	299200	NEAR BY

Looking for Correlations

Correlation is a statistical analysis that is used to measure and describe the *strength* and *direction* of the relationship between two variables.

Pearson's r correlation:

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}}$$

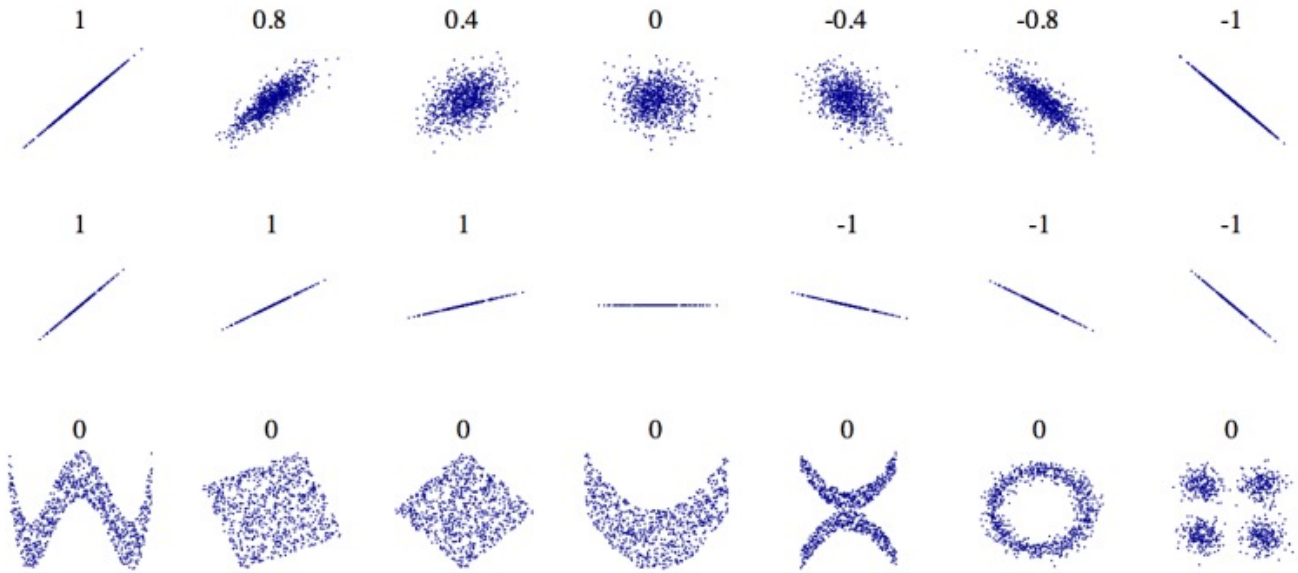


Figure 2-14. Standard correlation coefficient of various datasets (source: Wikipedia; public domain image)

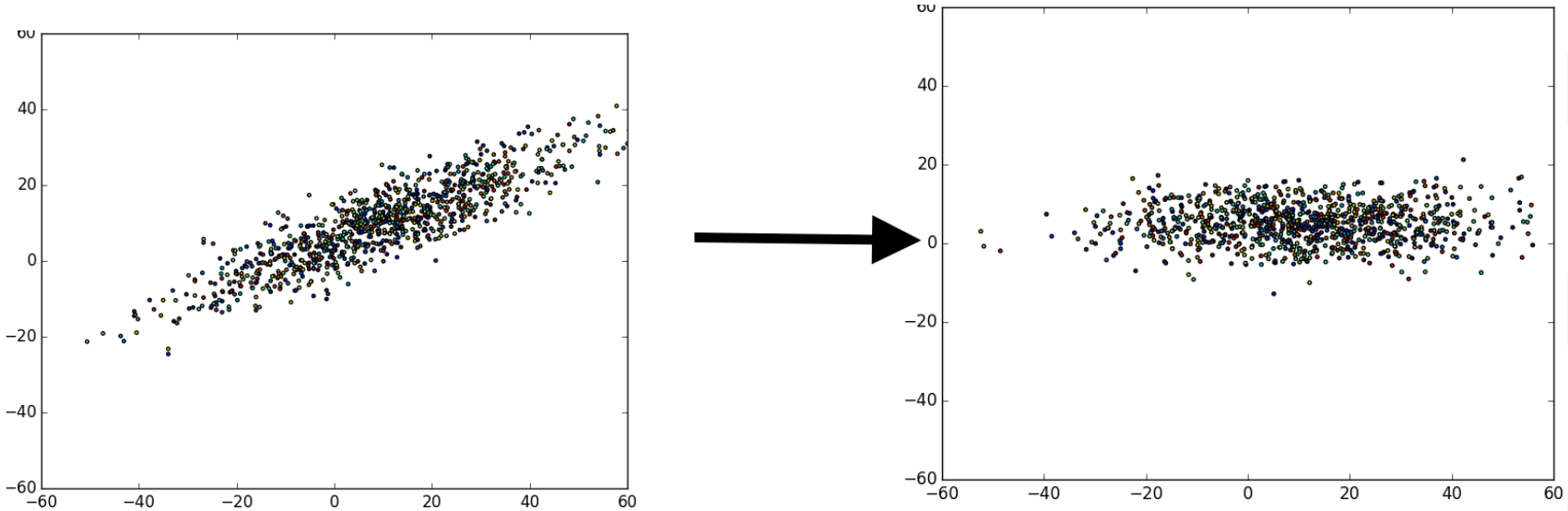
Feature Extraction

Technique in which new features are extracted from the existing ones.

- Identifying and selecting the most relevant and informative features from dataset
- Transforming them into a lower-dimensional space while preserving the most important information.

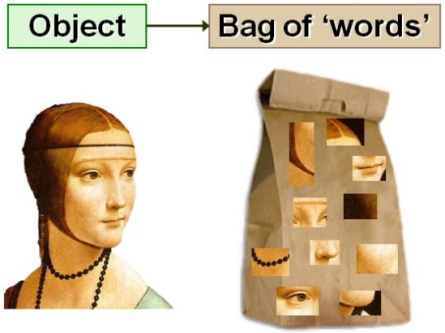
Examples

PCA



Examples

Bag of words:



CNN: