Pre-processing:
Data Cleansing

DSA 8102: Data mining, data storage and retrieval

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D. Owuor (Ph.D)

Objectives

- Describe data pre-processing and the concept of data quality.
- Differentiate data exploration from EDA.
- Discuss ways to fix missing value problems.
- Determine what an outlier is and ways to detect and remove it.

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Data Quality

Data Quality

- **Definition (standard-based perspective):**
  - "degree to which the inherent characteristics of data fulfills requirements" (how well does it represent the real-world construct to which it refers).
  - "measure of the condition of data (i.e. accuracy, completeness, consistency, reliability, up-to-date etc.) for its application" (fit for its intended use).
- **Data governance:**
  - used to form agreed upon definitions and standards for data quality.
  - to achieve this: data pre-processing among other techniques are used.

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Data Exploration

Data Exploration

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- Originally known as **Exploratory Data Analysis (EDA)**, created by statistician John Tukey.
  - Currently EDA techniques (outlier detection, clustering) have evolved into independent areas of research.
- **Description:**
  - visualization and computation to better understand characteristics of data.
- **Objectives:**
  - aims at creating a mental understanding of the data (relationship between variables)
  - quickly identify faulty points in data (errors, missing values etc.)

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Data Exploration

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- **Motivations:**
  - Help select right tool for preprocessing
  - Make use of human's ability to recognize patterns (e.g., it takes a lot of work for an algorithm to recognize faces than humans)
- **Technique & Tools:**
  - Statistical graphics and data visualizations (i.e., Box plot, Histogram, Run chart, Scatter plot etc.)

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Class Exercise

1. Differentiate data exploration from EDA.

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Processing vs Pre-processing

Data Processing

- **Definition:**
  - task of collecting data and translating it into usable information.
- **Stages:**
  - **Data extraction:** pulling from numerous sources.
  - **Data pre-processing:** preparation stage.
  - **Data input:** clean data is uploaded into its destination (i.e., data warehouse like Redshift).
  - **Processing:** actual processing for interpretation/results.
  - **Data output:** Interpretations simplified for non-data scientists (i.e., charts, graphs etc.).
  - **Data storage:** for future use.

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Data Pre-processing

- **Definition 1:**
  - technique used to convert raw data into a clean data set, preparing the data set for modelling (i.e., ML, DM).
- **Definition 2:**
  - a technique used to transform raw data into a useful and efficient format.
- **Definition 3:**
  - step in which data gets transformed/encoded, in order to bring it to a state where its features can be easily interpreted by an algorithm.

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Pre-processing Significance

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- **Analogy:** data is like crude oil
  - cannot be used directly from its source; so,
  - must be processed before being used for diff. purposes.
- **Real-world data issues:**
  - comes from different sources with different structures and data types.
  - Often incomplete, inconsistent, noisy (i.e., errors, outliers) and/or lacking in certain behaviors.
- **Pre-processing:**
  - used to improve data quality (purify data).
  - prepare data set for meaningful analysis.
  - product is a clean data/training set.

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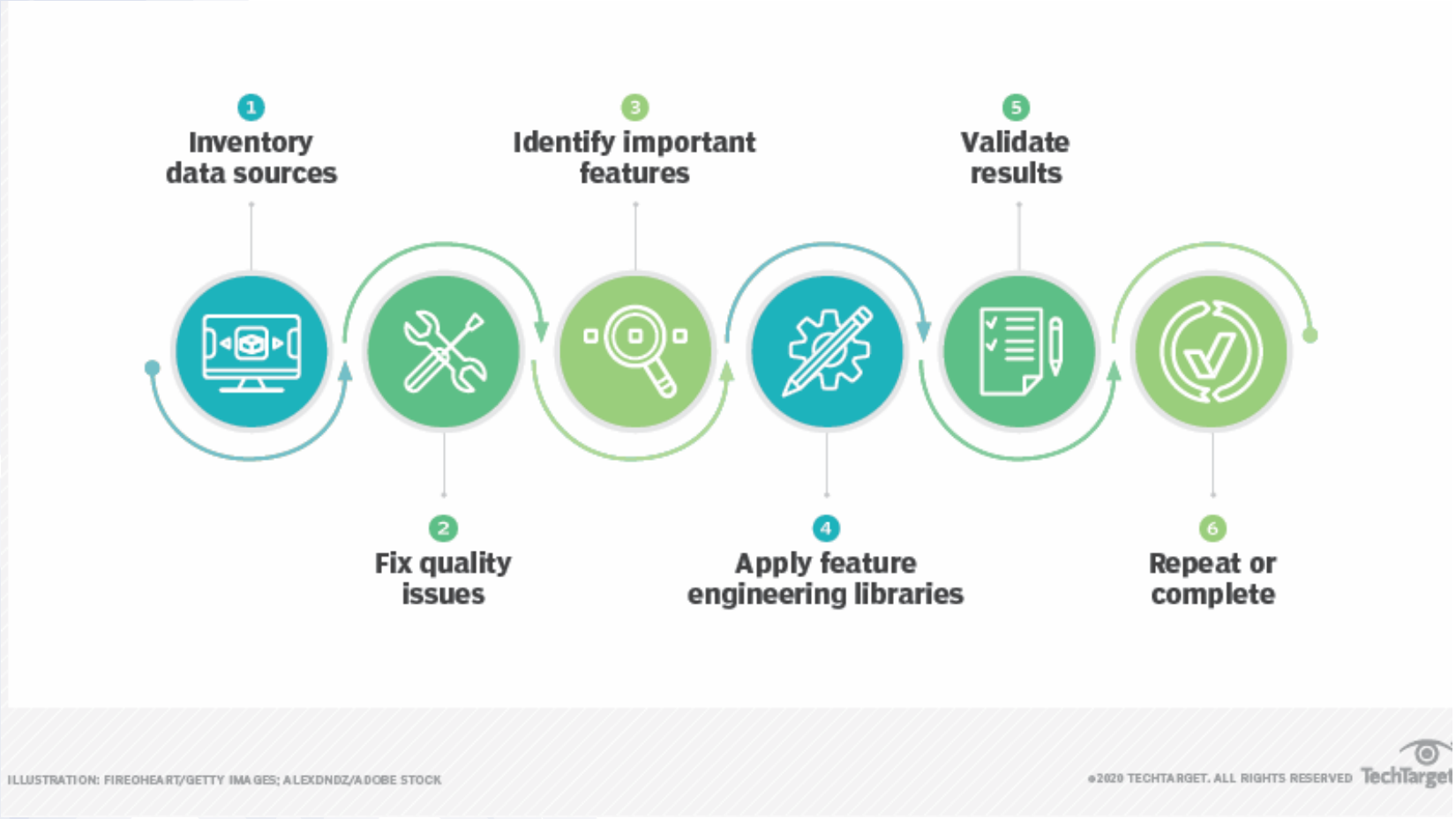
Pre-processing steps



Source: https://searchsqlserver.techtarget.com/definition/data-preprocessing

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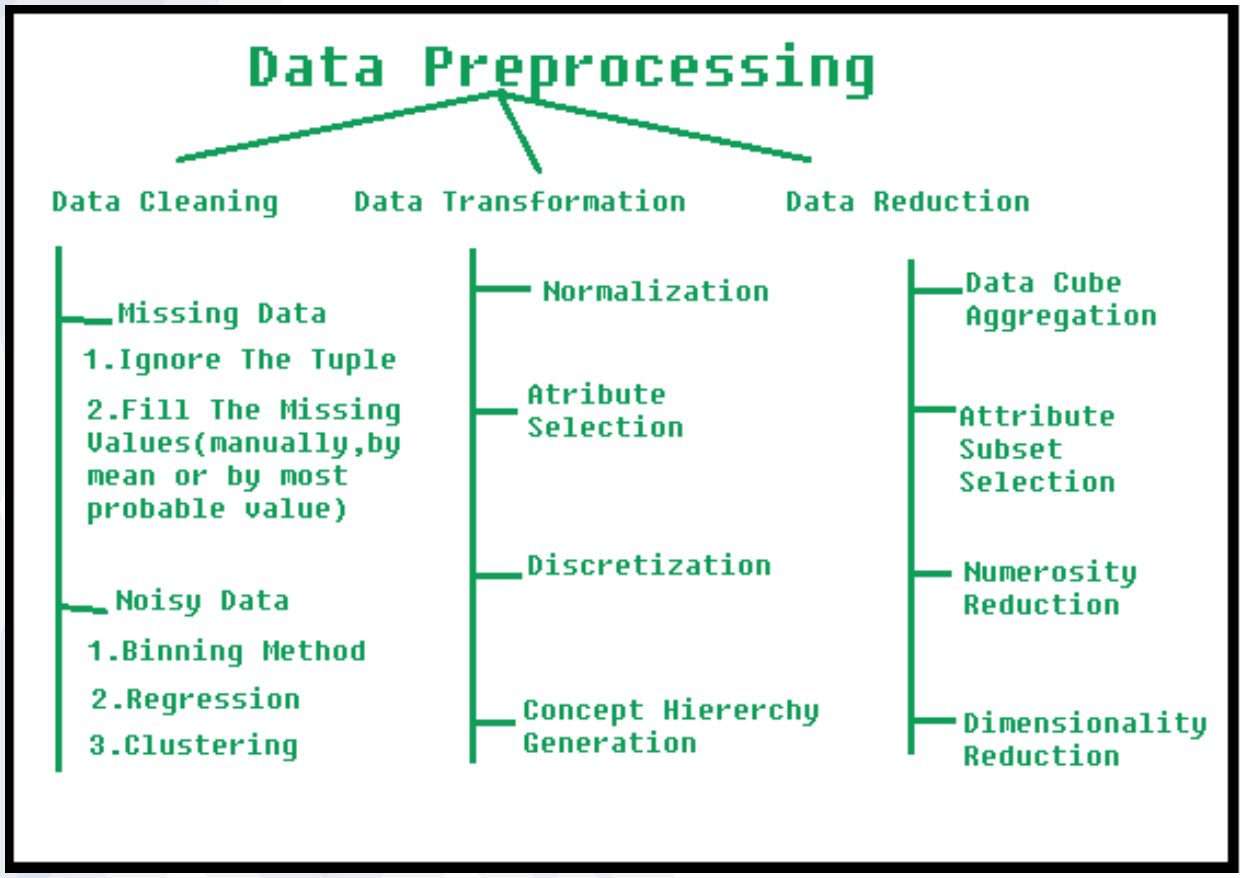
Pre-processing Tasks



Source: https://www.geeksforgeeks.org/data-preprocessing-in-data-mining/

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Class Exercise

1. What could be the possible reasons for data to be inconsistent?
2. Why is data quality important? Or what could be the benefits of pre-processing data before using it?

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Pre-processing steps

1. Inventory (data sources)
2. Data Cleansing
3. Feature Selection
4. Feature Transformation
5. Validation (2, 3, 4)

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Pre-processing (step 2):
data cleansing

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Data cleansing (or cleaning)

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Data Cleansing

- **Definition:**
  - process of detecting and correcting the corrupt parts of a data set.
- **Benefits:** (purify data)
  - correct errors;
  - detect and analyze outliers.
- **Data cleansing tasks (examples):**
  - cleaning missing values
  - reducing noise (i.e., class and attribute noise)

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Fixing missing values

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Missing Values

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- **Description:**
  - also known as **data holes**
  - incomplete data point (s) in records
  - most data mining and machine learning techniques do not support data with missing values
- **Possible Reasons:**
  - No information is provided;
  - Incorrect data types for attributes during extraction;
  - Integrating data from multiple sources
  - List goes on ...

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Dealing with Missing Values

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- **Ignore incomplete records**
  - Not practical for data sets that contain large portions of missing values (poor rep. of initial pop.)
- **Update with descriptive/sensible values**
  - e.g., mean, mode, median etc.
  - Introduces inconsistencies
- **Investigate an identify patterns of missing values. E.g.**
  - Data is truly unavailable
  - Duplicate records (one updates another)
  - Simple human errors (like wrong input types)
  - List goes on ...

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Detecting and handling outliers

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Noise

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- **Description:**
  - Refers to erroneous values (i.e., outliers)
  - Random error or abnormal variance in a measured variable
  - Adversely influences model/data mining performance
  - Requires detection and removal
- **Types:**
  - Class noise (categorical variables): erroneous class labels
  - Attribute noise (numeric variables): corruptive values and outliers
- **Possible Reasons:**
  - Data entry errors (i.e., human mistakes)
  - Faulty data collection (i.e., automated record collection)
  - List goes on ...

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Handling Outliers

- **Binning**
  - Segmenting data into small bins (or buckets) and smoothing (or replacing) bin values by mean, mode etc.
- **Clustering**
  - Group (numeric) data by similarity {detects outliers}
- **Classification**
  - Arrange (categorical) data according to shared classes {erroneous classes have very few members}
- **Regression**
  - Fit data into regression functions (i.e., linear) {remove random variance}

$y = mx + b$: where y is predicted value, x is actual value

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Class Exercise

1. Which collection errors may lead to:
   a. missing values
   b. noisy data

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Research Perspectives

- **Pre-processing**
  - ReTallón-Ballesteros A.J., Riquelme J.C. (2015) Data Cleansing Meets Feature Selection: A Supervised Machine Learning Approach.
- **Missing Values:**
  - Shah, Faaiz, Arnaud Castelltort, and Anne Laurent. "Handling missing values for mining gradual patterns from NoSQL graph databases." *Future Generation Computer Systems* 111 (2020): 523-538.
  - Li, Zhenghui, et al. "Grid-Constrained Data Cleansing Method for Enhanced Busload Forecasting." *IEEE Transactions on Instrumentation and Measurement* 70 (2021): 1-10.
  - Dakka, M. A., et al. "Automated Detection of Poor-Quality Data: Case Studies in Healthcare." (2021).
- **Outlier Detection:**
  - Tushar, Deoras Tejas. "Binary Priority Outlier Classifier Based Outlier Elimination." *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* 12.3 (2021): 4261-4266.

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Thank you!

Any Questions?