Summary of Data Mining and Analytics I

Overview of Data Mining

Objective: Decision assistance

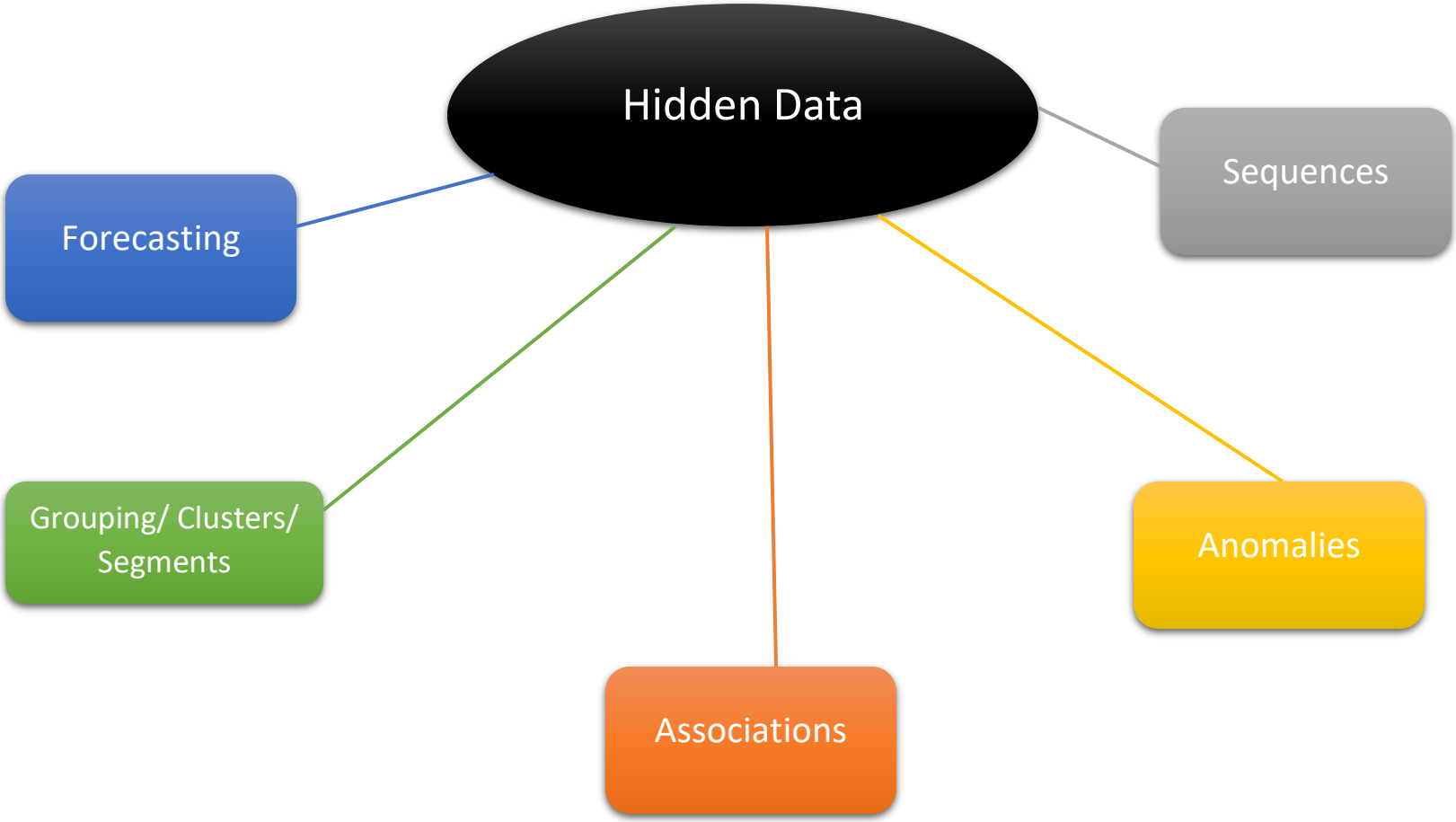
Definition: Combination of artificial intelligence and statistical analysis to discover information that is "hidden in the data"

Types of Data Mining		
Basis for Comparison	**Descriptive/Exploratory Mining**	**Predictive Mining**
Basic	Brings out information that is present but **hidden** in a mass of data. Finds **clusters/groups/ associations** between different products	Extrapolates new information based on present information. New information is qualitative (classification/scoring) or quantitative (regression).
Requirements	Data aggregation and data mining	Statistics and forecasting methods
Preciseness	Provides accurate data	Produce results that does not ensure accuracy.
Approach	Reactive	Proactive
Practical Analysis Methods	Standard reporting, query/drill down and ad-hoc reporting.	Predictive modelling, forecasting, simulation and alerts.
Examples	*Adverse events of a drug were explored by clustering the therapeutic classes; A data analyst receives detailed customer purchasing data and finds associations of any type among customers.*	*An automobile company scored customers for likelihood to return to buy a new model within the next 6 months; A credit card company offered a valued customer product for their card holder based on past card usage to determine the risk pattern; Road traffic was forecasted hourly*

Data Mining Aims

Important Terms

Univariate	Explores the statistics and details of 1 variable (*e.g. mean, median, mode, standard deviation, outliers, etc.)*. Useful for summarizing data and finding patterns.


Hidden Data
Sequences
Forecasting
Grouping/ Clusters/ Segments
Associations
Anomalies

Commercial Data Types

Transactional

Data describing an event.

e.g. orders, payments, deliveries.

Always has a time dimension and a numerical value.

Product

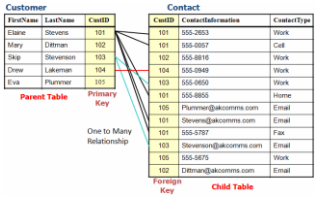
Data that is describing a product.

e.g. shoes, cars.

Customer

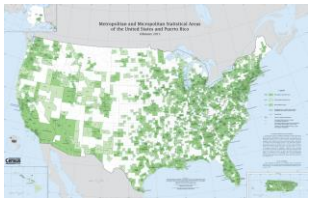
Data that describes a customer.

e.g. customer ID, first and last name.



Geodemographic

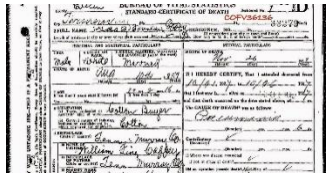
Data about a population in an area.



Technical

Data that gives a status report on something.

e.g. date of death, official titles, payer status.



Customer Data Types

Relational

Customer reactions to marketing.

Attitudinal

Customer satisfaction/ loyalty.

Psychographic

Customer personality.

Lifetime

How long one has been a customer.

Channel

Channel through which contact was made. (sponsorship, ads)

Preferred channel for contact

Preferred channel for orders

Preferred delivery channel

Sociodemographic

Personal (sex, level of education)

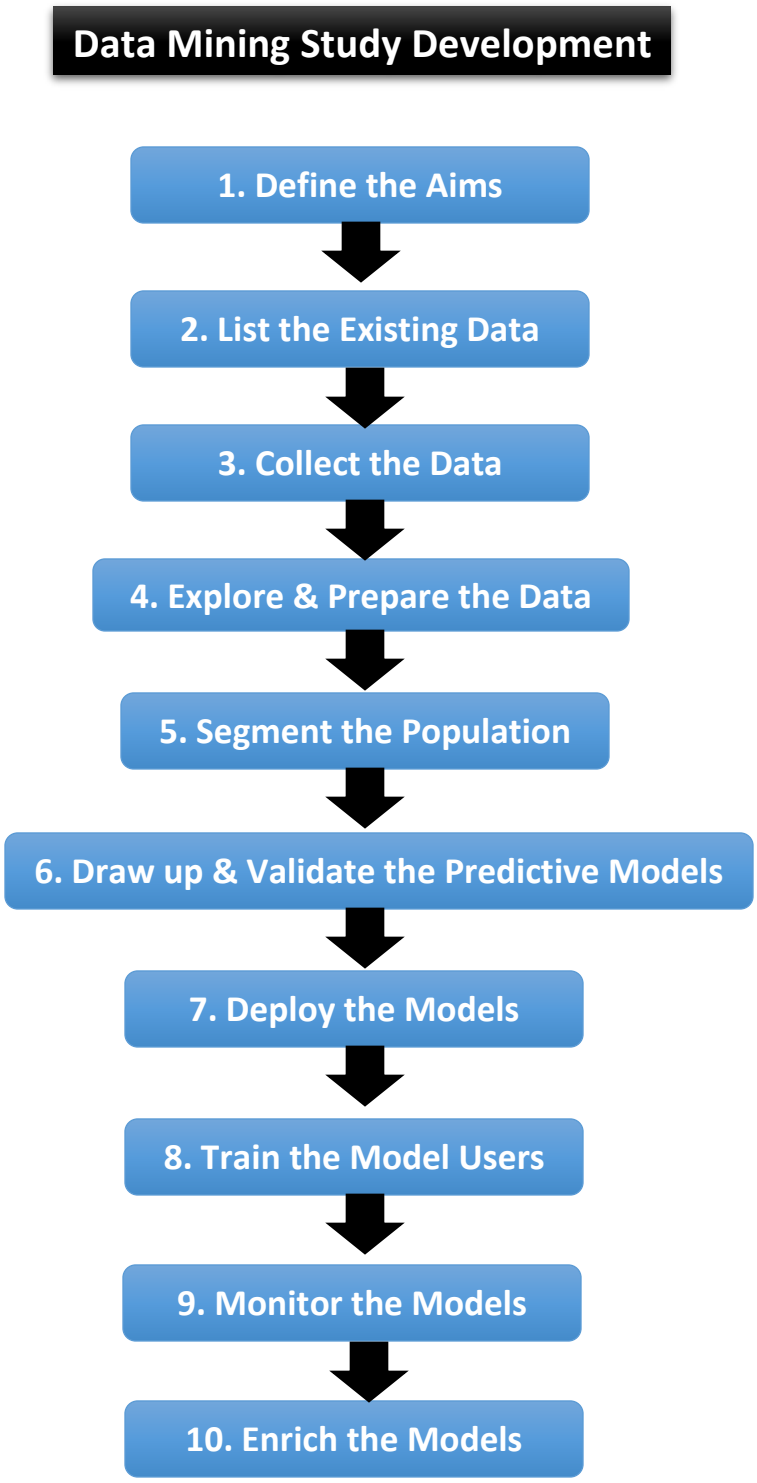
Family (family situation, # & ages of children, # dependents)

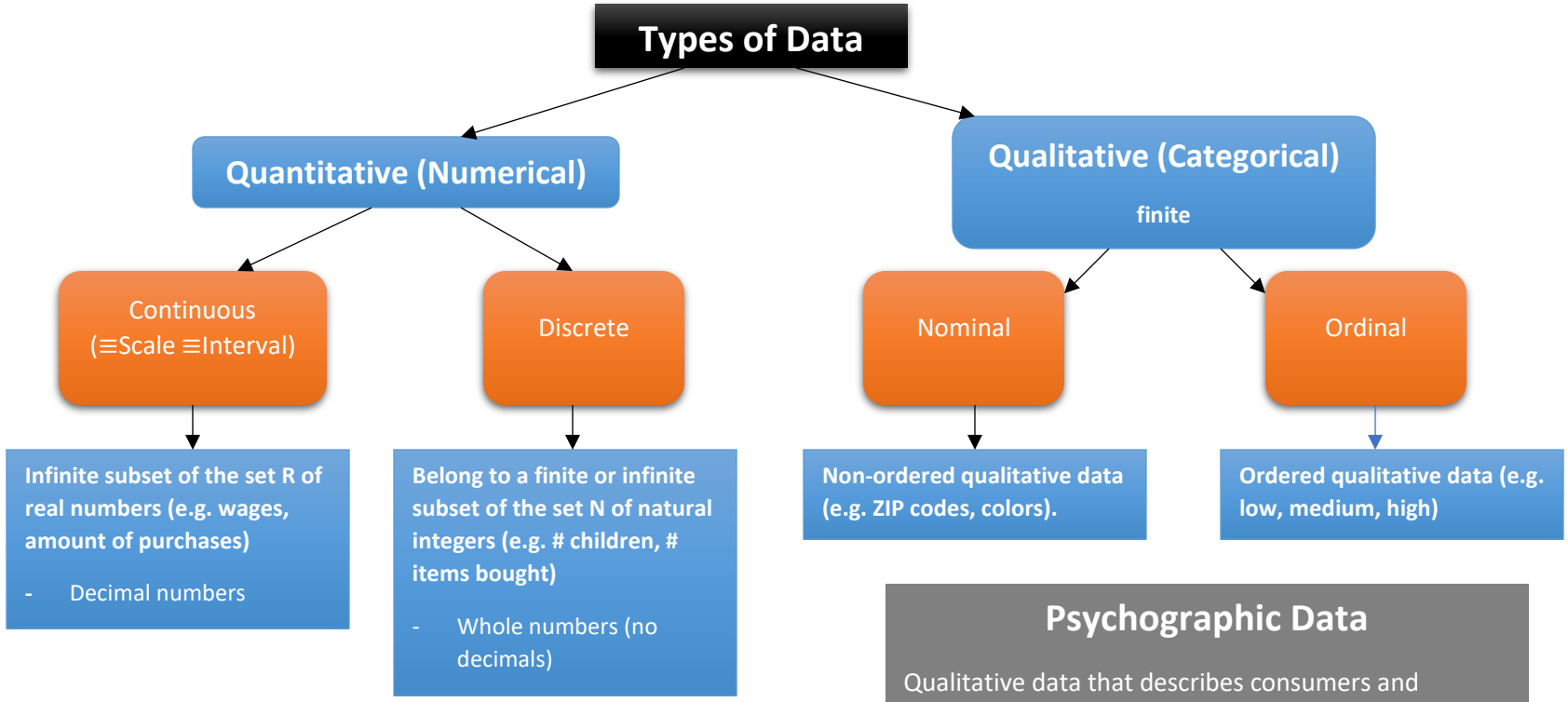
Occupational (income, occupation, social category, # working & retired people)

Wealth

Geographical

Environmental & Demographic (competition, population, working population, unemployment rates)


Data Mining Study Development
1. Define the Aims
2. List the Existing Data
3. Collect the Data
4. Explore & Prepare the Data
5. Segment the Population
6. Draw up & Validate the Predictive Models
7. Deploy the Models
8. Train the Model Users
9. Monitor the Models
10. Enrich the Models



Psychographic Data

Qualitative data that describes consumers and customers based on psychological attributes:

- Lifestyle
- Personality (shy, prudent, ambitious, outgoing, etc.)
- Values (conservative, liberal, materialistic, etc.)
- Risk aversion (trustful, mistrustful, anxious, demanding, etc.)
- Knowledge
- Focus of interest
- Opinions and behavior

Types of Values

Rare Value

Can create bias in factor analysis and other analysis, by appearing more important than they are.

What to do:

Remove

Replace with a more frequent value.

Missing Value

Gaps in the data.

What to do:

<10% data not excluded: **Remove** corresponding observations

Mean substitution

Missing Value

Name	Income	Job	name	children
Alice	8000000	trust fund retiree	Ethan	2
Bob	40000	rideshare driver		2
Charlie	1	racecar driver	Refuse to answer	1
Danielle	90000	marketing mgr	Gerald	2

Extreme Value, Aberrant Value, Rare Value

Aberrant Value

Erroneous value corresponding to incorrect measurement, a calculation error, or a false declaration.

***Incorrect dates**: Unknown DOB replaced by 'round numbers', subscription dates before customer's DOB, dates of last updates in the year 2050, 29/Feb in non-leap year.*

Customers declared as 'private' when they are 'business'.

Amount input as cents when it should be in Euros.

What to do:

Delete if not too numerous and if their distribution is suitably random.

Replace with statistically imputed value.

Age	Gender	Hair	Eye	Weight	Salary
14	F	Blue	Blue	143	12500
28	F	Brown	Brown	9	32150
22	M	Blue	Brown	215	34200
46	F	Brown	Orange	190	53200
75	M	Gray	Green	187	28040

Aberrant Values

Extreme Value

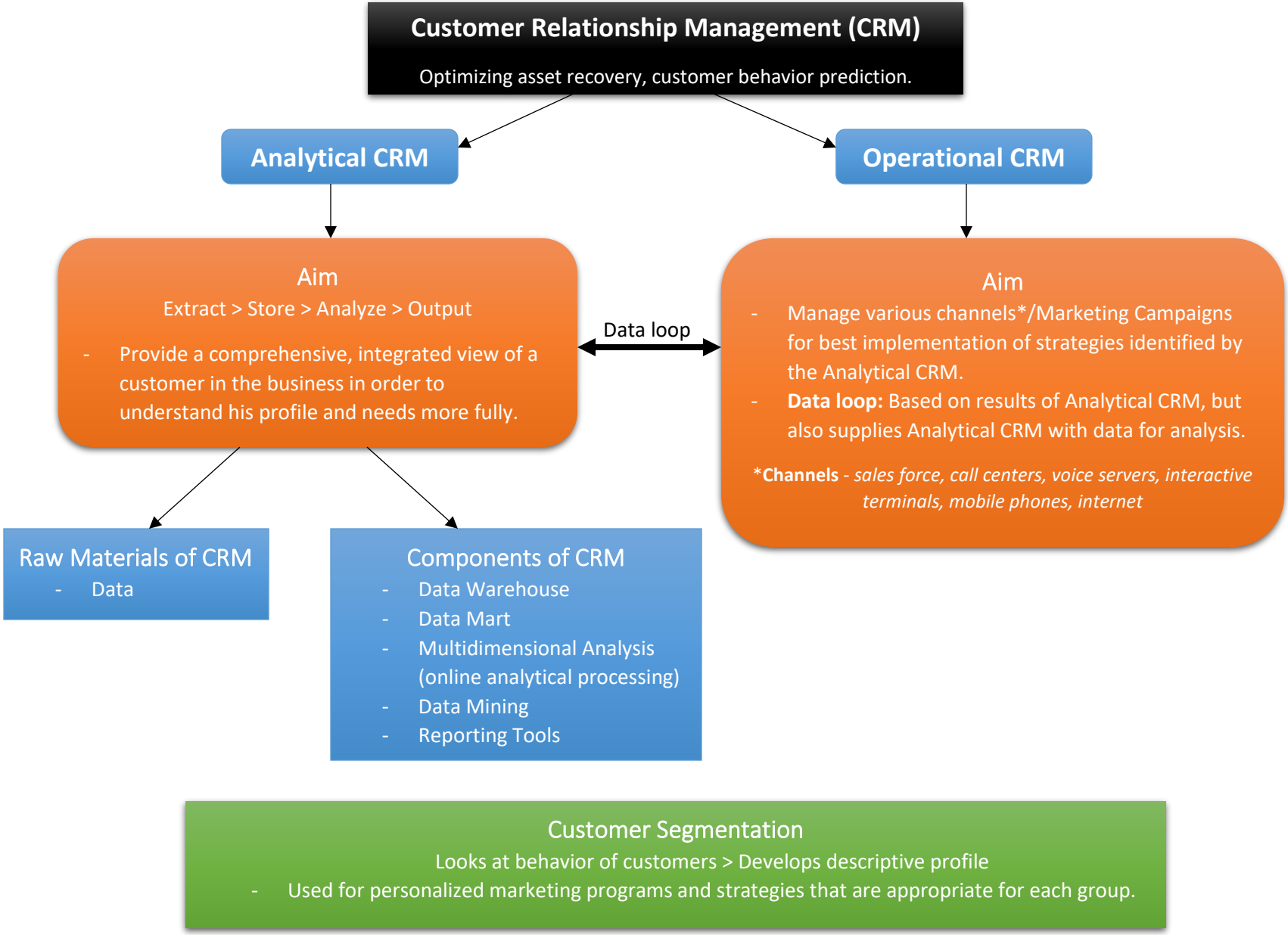
Observations in a sample so far separated in value from the remainder as to suggest they may be from a different population, or the result of an error in measurement.

What to do:

1-2% data not excluded: Exclude outliers

Neutralize: Divide continuous values into classes

Winsorizing: Replace values of the variable beyond 99th percentile with this percentile.


Customer Relationship Management (CRM)
Optimizing asset recovery, customer behavior prediction.
Analytical CRM
Operational CRM
Aim
Extract > Store > Analyze > Output
- Provide a comprehensive, integrated view of a customer in the business in order to understand his profile and needs more fully.
Data loop
Aim
- Manage various channels*/Marketing Campaigns for best implementation of strategies identified by the Analytical CRM.
- Data loop: Based on results of Analytical CRM, but also supplies Analytical CRM with data for analysis.
*Channels - sales force, call centers, voice servers, interactive terminals, mobile phones, internet
Raw Materials of CRM
- Data
Components of CRM
- Data Warehouse
- Data Mart
- Multidimensional Analysis (online analytical processing)
- Data Mining
- Reporting Tools
Customer Segmentation
Looks at behavior of customers > Develops descriptive profile
- Used for personalized marketing programs and strategies that are appropriate for each group.

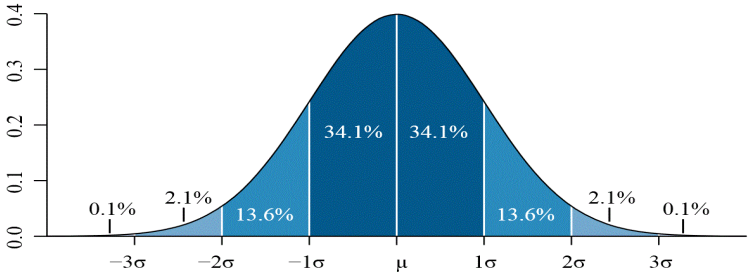
Tests Summary

Type	Test Name	When to use
Normality	**Shapiro-Wilk** (best)	+ Straight line, Slope = 1 Test to see if data deviates from a straight line.
	Kolmogorov-Smirnov (general)	- p<0.05 or p<0.1 Compares the cdf (cumulative density function) of the variable tested vs. cdf of a gaussian variable and determines the probability of observing a deviation as large or larger.
	Lilliefors	
	Anderson-Darling	
Homoscedasticity	**Levene (best)**	Best for non-normal distributions
	Bartlett	Best for normal distributions
	Fisher	Least robust if normality is not present
Bivariate (2 discrete variables)	**Cramer's V**	
	Chi-Square	
Bivariate (1 continuous, 1 discrete)	**Parametric ANOVA**	Requires normality & homoscedasticity
	Wilcoxon-Mann-Whitney	Non-parametric, 2 groups
	Kruskal-Wallis	Non-parametric, >2 groups

Mean comparison tests		
Form of distribution	Two samples	Three or more samples
Normality & Homoscedasticity	Student's *t* test	ANOVA
Normality & Heteroscedasticity	Welch's *t* test	Welch – ANOVA
Non-normality & Heteroscedasticity	Wilcoxon–Mann–Whitney	Kruskal–Wallis
	Median test	Median test
		Jonckheere–Terpstra test (ordered samples)

Tests

Tests for Normality



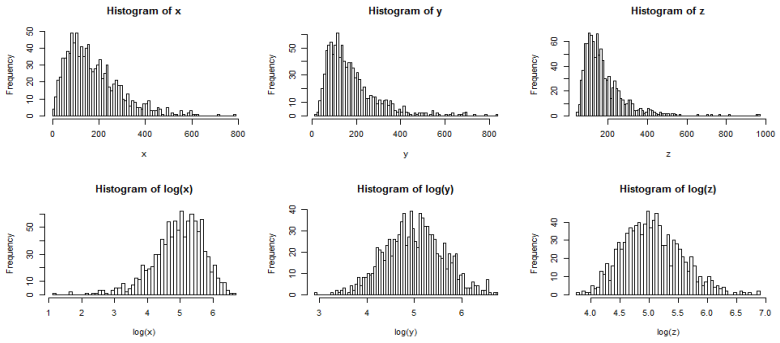
The normality of a variable can be verified by the following tests:

1. **Shapiro–Wilk test (the best)**
    a. Normal distribution: Straight Line with **Slope = 1**
2. **Kolmogorov–Smirnov test (the most general)**
    a. NOT a Normal distribution: If probability **<0.05** or **<0.10** we reject H_0
3. Lilliefors test
4. Anderson–Darling test

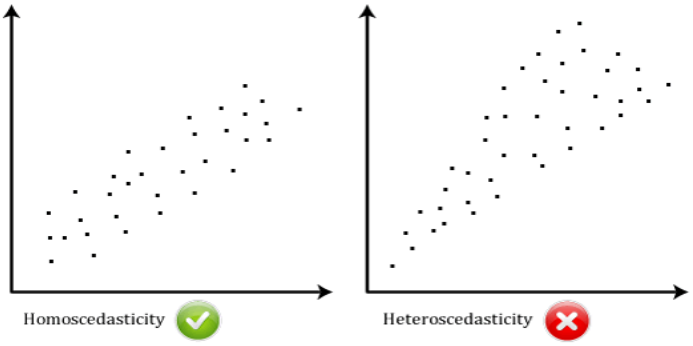
Tests for Normality				
Test	**Statistic**		**P-Value**	
Shapiro-Wilk	W	0.992264	Pr < W	0.9845
Kolmogorov-Smirnov	D	0.051999	Pr > D	> 0.1500
Cramer-von Mises	W-Sq	0.02621	Pr > W-Sq	> 0.2500
Anderson-Darling	A-Sq	0.162071	Pr > A-Sq	> 0.2500

Transformations Used to Reduce Skewness

1. **Log transformation** (has to be adjusted for 0 and negative values)
    a. If data is skewed, log transformation will transform the data to a form where we see a more normal distribution.
2. Square (left skew)
3. Square root (right skew)
4. Cube (right skew)



Test for Homoscedasticity and Heteroscedasticity



1. **Levene Test (best – low sensitivity to non-normality)**
2. **Bartlett Test (best if distribution is equal)**
3. Fisher Test (least robust if normality is not present)

Test of Homogeneity of Variance			
Levene Statistic	**Df1**	**Df2**	**Significance**
50.448	2	396	.000

Bivariate Tests

Measuring Links between Two Discrete Variables

e.g. gender and smoking

1. **Cramer's V**
2. **Chi-Square**

Discrete  Discrete

Measuring Links between One Discrete & One Continuous Variable

e.g. dosage of a medicine and recovery time

Discrete  Continuous

1. **Parametric ANOVA Test**
    a. Requires normality/homoscedasticity assumption
2. **Non-Parametric Approaches**
    a. **Wilcoxon-Mann-Whitney (2 groups)**
    b. **Kruskal-Wallis (>2 groups)**

Descriptive Learning Methods (Unsupervised)

K-means, moving centers

Market Basket Analysis

Cluster Analysis

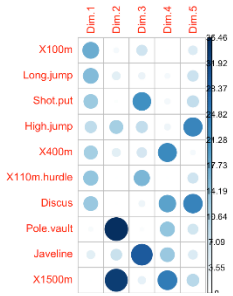
Clusters similar data points to each other that are less like those in separate clusters.

E.g. Consider a bookstore with different areas for the types of books: History, Self-Help, Romance, Mystery & Crime etc. The books in each of these clusters are more like each other than they are to other clusters.

PCA

Help you identify which variables are important so you can compress the data by reducing the number of dimensions.

E.g. gender, days of week they typically shop, amount spent on average trip.



Association Analysis

In a given set of records, each will contain a number of items. Association analysis allows you to determine the degree to which the items tend to be associated with one another.

E.g. people who buy hamburger buns will also likely buy mustard and hamburger meat. You can associate the items together and create rules.

Neural Clustering

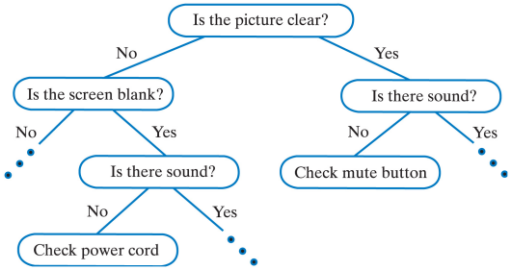
Kohonen Network (SOM)

Factor Analysis

CPA, CMA, CA

Decision Trees

Both Descriptive and Predictive.



1. **PCA – Principal Component Analysis**
    a. Help you identify which variables are important so you can compress the data by reducing the number of dimensions.
    b. *E.g. gender, days of week they typically shop, amount spent on average trip.*
2. **Cluster Analysis (K-means, moving centers)**
    a. Clusters similar data points to each other that are less like those in separate clusters
    b. *E.g. Consider a bookstore with different areas for the types of books: History, Self-Help, Romance, Mystery & Crime etc. The books in each of these clusters are more like each other than they are to other clusters.*
3. **Association Analysis (≡ Market Basket Analysis)**
    a. In a given set of records, each will contain a number of items. Association analysis allows you to determine the degree to which the items tend to be associated with one another.
4. **Neural Clustering (Kohonen Network (SOM))**
5. **Factor Analysis (CPA, CMA, CA)**
6. **Decision Trees (both Descriptive and Predictive).**

Neural Network

Can be used for clustering as well as classifying data (predictive and descriptive, qualitative or quantitative dependent variable).

- Supervised or unsupervised learning
- The patterns recognized by neural networks are numerical and contained in vectors. Input data is translated from its raw form into numerical vector values.

+	**Handles non-linear relations between the variables**
-	**Requires massive amounts of computer power.**

Cluster Types

Reduce Processing Times

- Work on **structured files** (SAS, SPSS, DB2, etc.) rather than flat files.
- Limit analyses to the lines and variables relevant to the current process.
- Recode the variables and make them smaller by using formats.
- Create **Booleans** such as alphanumeric variables of length 1, rather than numerical variables.
- Clearly define the length of the variables used, limiting it to the minimum possible.
- Remove intermediate files which are no longer required.
- Keep enough free space on the hard disk.
- Defragment the hard disk if necessary.
- Do not place the analyzed file or the temporary workspace on a remote network since network latency and speed will become an issue.
- **Increase the amount of RAM**.

Reduce Processing Times – SAS

- Use KEEP and DROP commands to analyze only the relevant variables.
- Use the LENGTH command to clearly define the length of the variables used.
- Use the PROC DATABASES LIB = WORK KILL NOLIST command to clear out the temp WORK directory often since it is not automatically purged until the end of the SAS session.
- Use BY command instead of CLASS in the MEANS procedure.
- Create index on variables used at least 3 times in a WHERE or BY filter.
- Use COMPRESS = YES command to reduce hard disk space occupied by file by removing all blank characters and spaces in data set.
- For copying tables, use PROC COPY or PROC DATASETS rather than a DATA SET step.
- Use TAGSORT option when sorting a large table.
- Use the PRESORTED option to sort the table if it has not been done already.

To do:

Why might an online retailer mine the order history of its customers?

- To source new products

A data analyst is using analytical CRM to extract, store, analyze, and output relevant customer information. What is the first step within the analytical CRM phase that this analyst will be performing?

- Combining a customer's records to develop a holistic view.

Which feature of application development is unique to data mining?

- The development phase cannot be completed in the absence of data.

After performing a normality test on a dataset, results show the null hypothesis should be rejected. Which type of test should be performed to analyze the data?

- Non -parametric test

A data analyst is looking at continuous independent variables. The data analyst discovers both hypotheses of normality and homoscedasticity are not satisfied. The variables in question consist of three or more categories.

Which test is appropriate for this non-parametric scenario?

- Kruskal-Wallis

Statistical tests applied to a dataset reveal the dataset exhibits non-normality and heteroscedasticity.

Which comparison test should be used for three or more samples?

- Kruskal-Wallis

Use the given dataset to answer the following question:

Name	Age	Gender	Income
Alice	23	F	$40,000
Bob	55	M	$50,000
Charlie	22	M	$20,000
Dana	48	F	$250,000
Ethan	34	M	$110,000
Eric	55	M	$5,000,000
Roberta	30	F	$2,500
Paulette	42	F	$90,000

Which technique should be used to discover links between Age and Income?

- Pearson Correlation

Use the given contingency table to answer the following question:

	nodule color variation: high	nodule color variation: medium	nodule color variation: low	TOTAL
malignancy: low	5	10	15	30
malignancy: medium	10	20	15	45
malignancy: high	30	15	10	55
TOTAL	45	45	40	130

Which method can a data analyst use to identify the links between malignancy and nodule color variation?

Cramer's V

Use the given dataset to answer the following question:

	Lives in urban area	Does not live in urban area	Total
Likes sushi	950	100	1050
Does not like sushi	50	1900	1950
Total	1000	2000	

Which test should be used to identify a link between the variables?

Cramer's V

Use the given table to answer the following question:

Race Number	Place	Body Temp	Weight
147	1	98.9	140
764	3	100.3	205
399	42	100.0	115
004	16	99.5	165

Match the column name to the type of data it contains.

Answer options may be used more than once or not at all. Select your answer from the pull-down list.

		YOUR ANSWER	CORRECT ANSWER
✔	Race Number	Nominal	Nominal

		YOUR ANSWER	CORRECT ANSWER
✔	Place	Ordinal	Ordinal
✔	Body Temp	Interval	Interval
✔	Weight	Ratio	Ratio

Which statement characterizes statistical software versus data mining software?

Statistical software: SAS/STAT is an example software package.

What are two characteristics of the R statistical software?

Free to redistribute and modify the code.

New packages are available quickly

A data analyst needs to analyze the churn rate (customer retention) and the time of possible churn of customers for a local wireless company.

Which method should be used?

Survival analysis

Which algorithm is both a prediction model and a classification model?

Decision tree

Which function is considered data preparation?

File handling

Which two functions are data preparation functions?

Transformation of variables

Analysis and imputation of missing values

43.

A data scientist is reading an extremely large SAS dataset.

Which two commands should the data scientist use to decrease processing time?

Data Table1(Compress=YES);

Data Data1(keep= total_units price customer_id);

Which two methods should a data analyst use to reduce processing time when working in SAS?

Create Booleans as alphanumeric variables of length 1.

Increase the amount of RAM.

A fast-growing international insurance company with 10 million customers wants to improve the data analytics methods it is using in SAS.

Which solution should be utilized to reduce data mining processing time?

Use structured files.

Which two changes can be made to code in SAS in order to reduce processing time?
Use BY rather than CLASS in the MEANS procedure.

Use PROC COPY or PROC DATASETS rather than a DATA SET step.

A data analyst wrote the following code:

MyData <- read.table(file, header = TRUE, sep = ",")

Which software did the data analyst use?

R

Use the given characteristics of a data mining and statistical analysis software to answer the following question:

1. **It is based on the same language as S-PLUS.**
2. **It is programmable, so users can easily create a new function.**
3. **It has a console for command, data editor command window, graphics window, and program editor window.**
4. **Its source code is available.**

Which software is described?

R

A retailer is looking for interesting and recurring patterns in data that will be used for targeted marketing. The retailer has given a data analyst a large list of transactions, with data on what customers purchased during each visit to the store.

Which data mining method should the data analyst use in order to accomplish this task?

Association rules

A data analyst is trying to determine how many home runs, to the exact number, a player will hit based on the player's home run total from the previous year.

Which method should be used?

Linear regression

An automobile manufacturer has obtained access to customer-related data that was previously unavailable.

Which method should the manufacturer use to perform descriptive data mining?

Parametric or semi-parametric models

A data analyst has been tasked by a pizza company to provide recommendations for three new restaurants. The best indication of success is based on the population of a surrounding area.

Which descriptive data mining method should the data analyst use to provide the recommendations?

Clustering

A marketing research team is mining customer demographic data for segmentation purposes. The team's data analyst wants to apply the hierarchical clustering method, but researchers are reluctant to use the method.

What might be the disadvantage of using the hierarchical clustering method in this scenario when restrictive assumptions about the problem to be solved are absent?

The model at level n will be decided by clustering at level n-1.

A data analyst has performed the following on a dataset:

Data preparation techniques
Exploratory data analysis
Identification of the dependent and independent variables

The single dependent variable is quantitative, and the single independent variable is qualitative.

Which data mining method should the data analyst be using?

Decision trees

A data analyst is choosing a method to use on a dataset and needs the following capabilities for a project:
1) Capacity to process the data within a reasonable period 2) Ability to handle the possibility of incomplete and heterogeneous data that may not be numeric
Which method can the data analyst use?

DISQUAL

Which technique should a data scientist use to predict the unknown probability of a white marble, given the known probability of red and green marbles as shown in the graphic?
Naïve Bayes

55.
A researcher has a data set containing socio-demographic data about study participants.

Use the given sample of the data to answer the following question:

Participant	Eye Color	Gender	Height	Type
J	Blue	M	5'5"	B
C		F	5'6"	B
M	Brown	M	6'0"	C

L	Blue	M	5’9”	C
N	Blue	F	5’8”	A
F	Brown	F	6’3”	F
Z	Green	M	5’8”	D
...	...	...	...	...

Knowledge about which characteristic is required in order to choose a data mining method for this scenario?

If Type is Ordinal

The following table contains an example of unstructured data of keywords, using content analytics with ranking:

urban,resource,public,animal,planning,ecological,sustainanability,residents	56
tolerance,accepatable,latent,statistic,tolerances,toleranc,metrology,statis	52
prize,award,medal,awarded,recipients,recipient,achievement,outstanding	51
hydroxide,electrolytic,eletrolysi,electrolysis,sodium,calcium,electrlyte	50
regression,guage,mile,mole,customary,are,correlation,error,correlat,var	49

A data analyst needs to identify the most frequently cited words in the documentation and classify them into groups.

Which method should the analyst use for classification?

Clustering

A data analyst wants to reduce the dimensionality of the text from a set of web pages.

Which method should the data analyst apply to the dataset?

Kohonen Maps

Use the given dataset to answer the following question:

id	name	location	income	gender	satisfaction
1	Alice	Alpharetta, GA	80,000	F	low
2	Bob	Boston, MA	110,000	M	low
3	Carol	Chicago, IL	70,000	F	low
4	David	Dallas, TX		M	low
5	Edward		500,000	M	high
6	Frank	Fort Laramie, CO	30,000	F	low

Which statement is valid in describing a method and the data it needs to perform data mining?

If no values are missing, linear regression may be performed using an “income” column

Match each data mining method to its characteristics of processing heterogeneous or incomplete data.

Answer options may be used more than once or not at all. Select your answer from the pull-down list.

		YOUR ANSWER	CORRECT ANSWER
✔	Neural networks perceptrons.	The variables in ϵ [0,1] must be transformed.	The variables in ϵ [0,1] must be transformed.
✔	Radial basis function networks.	The variables in ϵ [0,1] must be transformed.	The variables in ϵ [0,1] must be transformed.
✔	Neural networks (Kohonen).	The variables in ϵ [0,1] must be transformed.	The variables in ϵ [0,1] must be transformed.
	Linear regression.	The variables in ϵ [0,1] must be transformed.	Numerical variables and variables without missing values.
	Moving centres method and its variants.	The variables in ϵ [0,1] must be transformed.	Numerical variables and variables without missing values.

In a recent poll, the responses of the respondents were mapped with the census data available on a government portal.

Which type of predictive data mining algorithm is this?

Correspondence Analysis (CA)

Answer options may be used more than once or not at all. Select your answer from the pull-down list.

		YOUR ANSWER	CORRECT ANSWER
✔	Detects the two-way interactions between tables	Decision tree	Decision tree

		YOUR ANSWER	CORRECT ANSWER
	Identifies hidden interconnected relationships	Cluster analysis	Neural networks
	Large volumes of data distilled into homogeneous group	Decision tree	Cluster analysis
	Marriage between lexicometry and data mining	Cluster analysis	Text mining

Which two modeling algorithms are used in data mining?

Neural networks perceptrons

Decision trees

A client requests an analysis of the reviews posted for one of the IT products that was launched last year. Data for all of the client's products was downloaded in Excel, and each word was separated. Sentiment categories were designed based on word counts. However, the sentiment model is not working on new data.

What could be the reason for this failure?

Grouping of words was not performed

A company that creates English speech recognition software would like to create automatic completion functionality for healthcare professionals.

Which two tools are required for this application?

Semantic dictionary

Syntactic analyzer

Which two sources of data are suitable for the purpose of providing a more personalized online experience?

Personal identification of user

Website cookies

A data analyst wants to determine what percentage of users that visit a web page for a new movie also view the movie stars' web pages.

What are two disadvantages of using cookies to retrieve the data in this study?

Privacy settings may block data transmission.

This method identifies the computer, but not unique users.