Predictive Analytics

Semester III
2024-25

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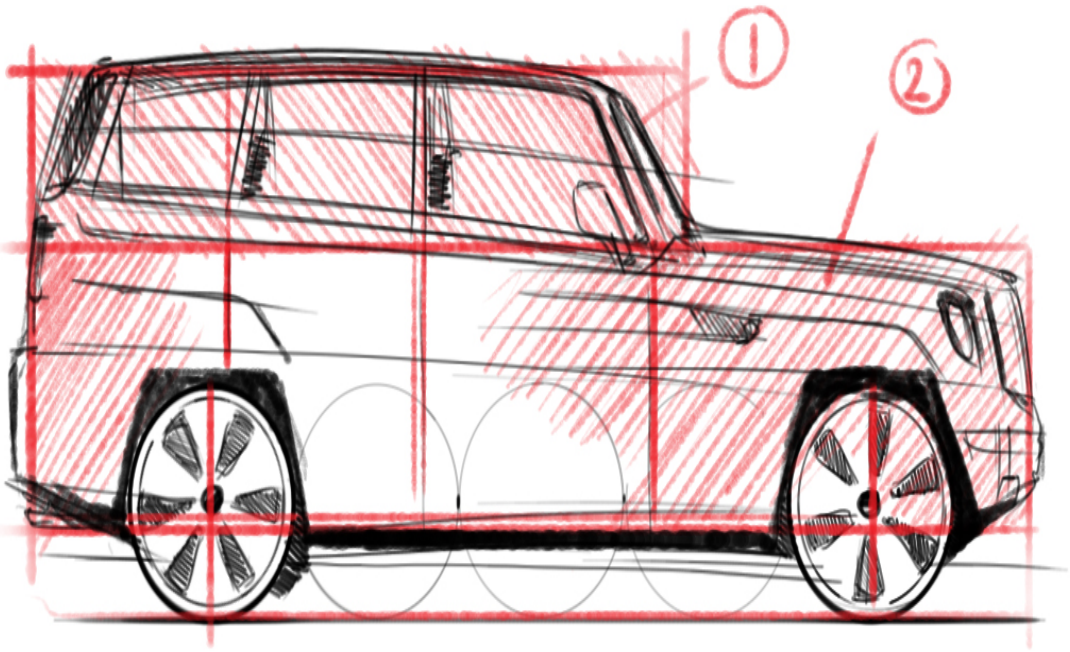
TARGET



Some Applications

- **Banking and Financial Services**

  Fraud and Risk Detection

  Analyze the probabilities of risk and defaults via customer profiling, past expenditures, and other essential variables.

  Marketing and Sales

  Push banking products based on customer's purchasing power.

- **Internet Search**

  Many search engines like Yahoo, Bing, Ask, AOL, and so on

  Data science algorithms are used to deliver the best result for the searched query in a fraction of seconds.

- **Targeted Advertising**

  Display banners on various websites to the digital billboards at the airports

  Digital ads get a lot higher CTR (Call-Through Rate) than traditional advertisements.

  Targeted based on a user's past behavior.

- **Delivery logistics**

  Logistic companies like DHL, FedEx, UPS, Delhivery

  Use data science to improve their operational efficiency

  Best routes to ship, the best suited time to deliver, the best mode of transport to choose

- **Recommendations**

  Internet giants like Amazon, Twitter, Google Play, Netflix,Linkedin

  Help in finding relevant products from billions of products available with them

  Promote their products in accordance with user's interest and relevance of information

- **Advanced Image Recognition**

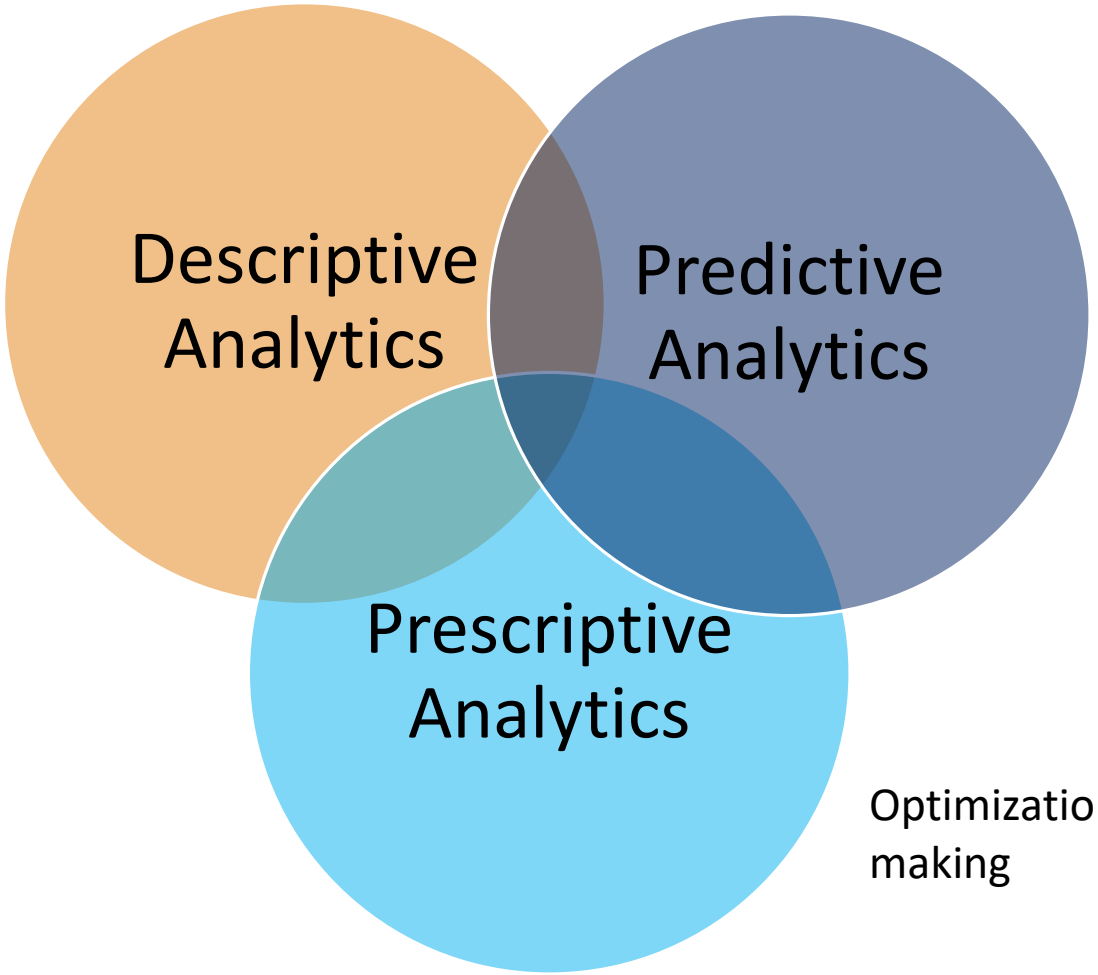
  Googlelens; Automatic Tag suggestions

- **Criminal Investigation and Counter Terrorism Activities**

Working With Data Set– Data Driven Decision Making

Components of Analytics

Data synthesis and Visualization



Predicting future/unknown events

Optimization and decision making

Descriptive Analytics	Predictive Analytics	Prescriptive Analytics
What Happened ?	What Will Happen ?	What Action to Take ?

ORG. VALUE ADD

Descriptive Analytics

Predictive Analytics

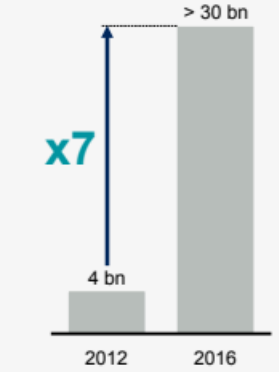
Prescriptive Analytics

Complexity

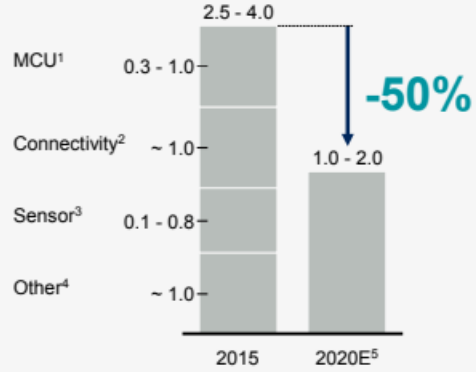
Exhibit 1

Falling IoT prices related to sensors and wireless device will drive the growth of available data

Increase in available data volume
Number of delivered sensors, globally



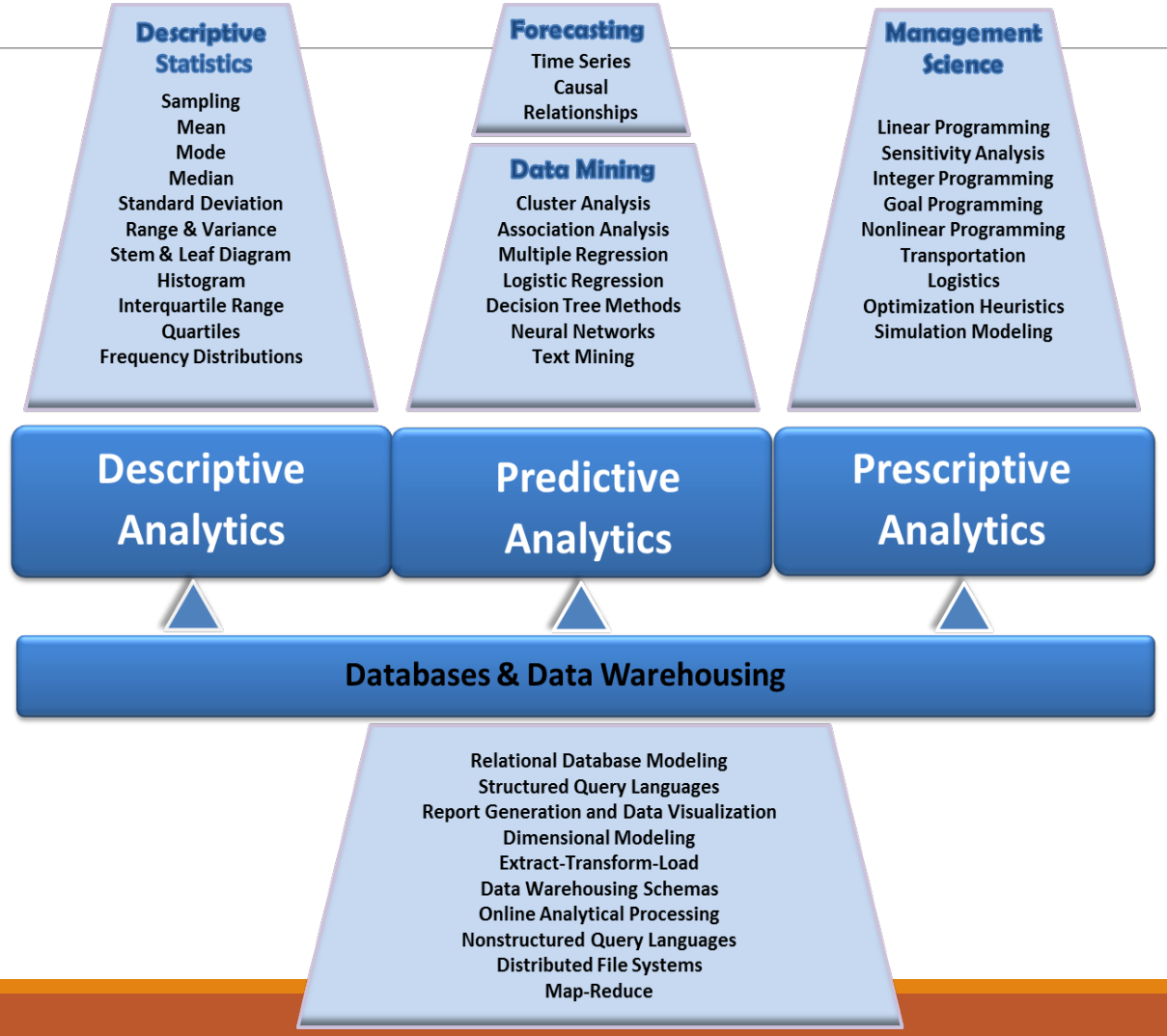
Expected development of cost for IoT nodes, 2016 - 20
Unit price, USD



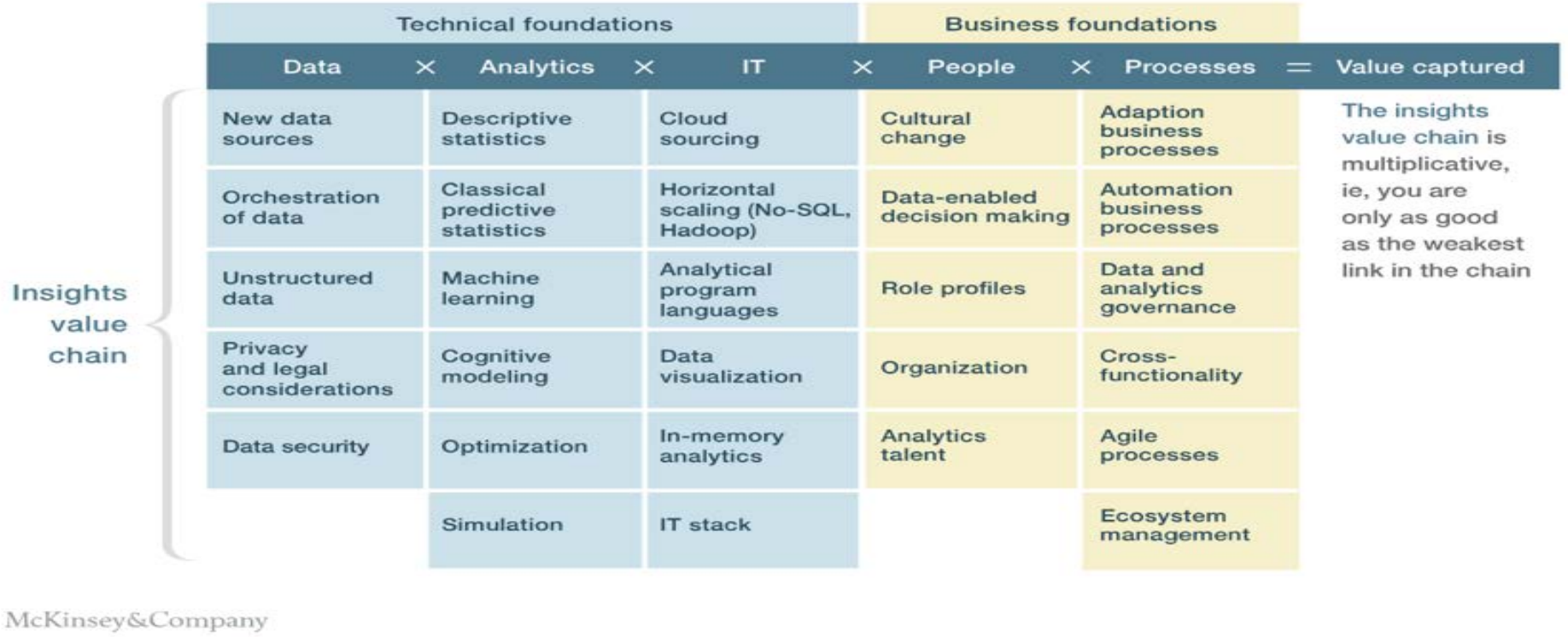
1 Current prices range from USD 0.3 (e.g., Cypress 32-bit) to USD 1.2 (e.g., TI 16-bit), dependent on speed, quality, and integrated memory size (ranges for larger order volumes)
2 Combination of filter transceiver and antenna – additional costs for switches and amplifiers not included
3 E.g., temperature, position, pressure, gyroscope
4 Additional components such as ADC converters, power management converters, capacitors, resistors, fuses, PCB (list not exhaustive)
5 2020 prices estimated by inflating current prices with a CAGR of -15% p.a.

SOURCE: Federal Statistical Office; Deutsche Bundesbank; Prognos; Digital Society Study; Thomas Nipperday; digikey.com; expert interviews; McKinsey

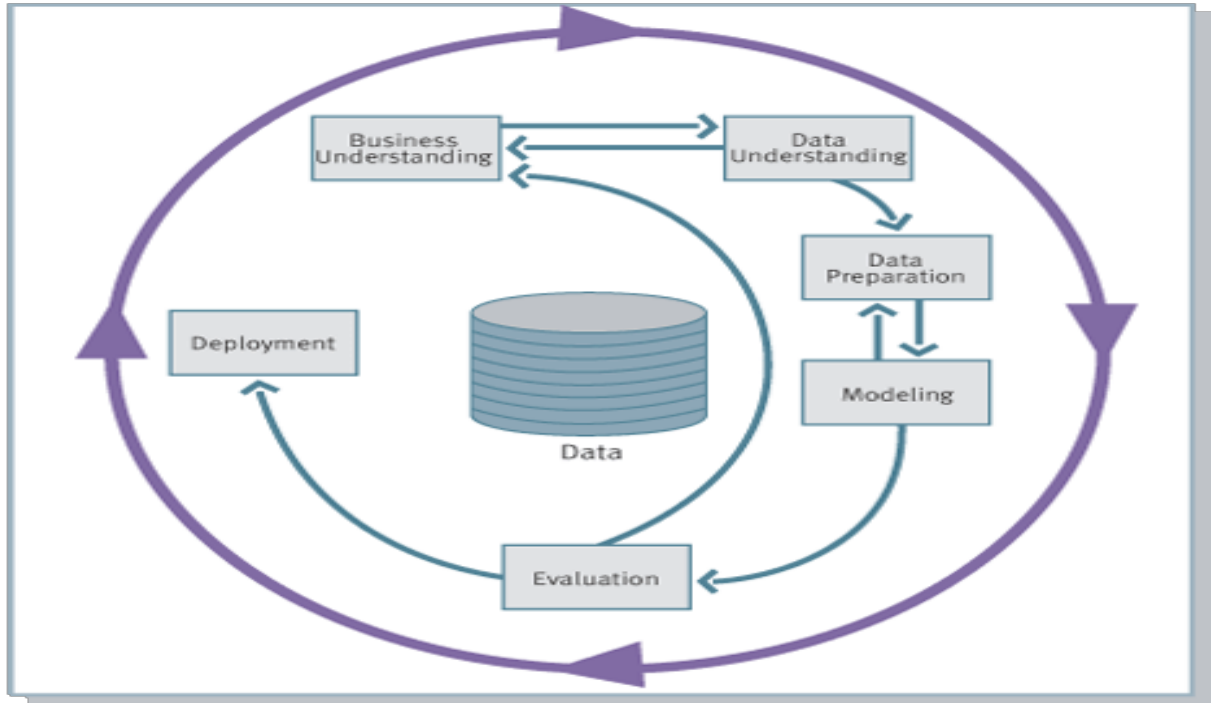
Business Analytics Domain



Data –Driven Insights Value Chain



Crisp DM framework



Data Mining Tasks:
Description
Estimation
Prediction
Classification
Clustering
Association

Cross Industry Standard Process: CRISP-DM (*cont'd*)

(1) Business/Research Understanding Phase

- Define project requirements and objectives
- Translate objectives into data mining problem definition
- Prepare preliminary strategy to meet objectives

(2) Data Understanding Phase

- Collect data
- Perform exploratory data analysis (EDA)
- Assess data quality
- Optionally, select interesting subsets

(3) Data Preparation Phase

- Prepares for modeling in subsequent phases
- Select cases and variables appropriate for analysis
- Cleanse and prepare data so it is ready for modeling tools
- Perform transformation of certain variables, if needed

Cross Industry Standard Process: CRISP-DM (*cont'd*)

(4) Modeling Phase

- Select and apply one or more modeling techniques
- Calibrate model settings to optimize results
- If necessary, additional data preparation may be required for supporting a particular technique

(5) Evaluation Phase

- Evaluate one or more models for effectiveness
- Determine whether defined objectives achieved
- Establish whether some important facet of the problem has not been sufficiently accounted for
- Make decision regarding data mining results before deploying to field

Cross Industry Standard Process: CRISP-DM (*cont'd*)

(6) Deployment Phase

- Make use of models created
- Simple deployment example: generate report
- Complex deployment example: implement parallel data mining effort in another department
- In businesses, customer often carries out deployment based on your model

Session Plan

Session no.	Module/Topic	Readings	Case Study
1,2	An introduction to R and Crisp DM framework		
3,4	Univariate and Multi-Variate Statistics	TB Chapter 5,6	Testing Marketing Hypotheses at WSES
5,6	Linear Regression	TB Chapter 8, 9	Package Pricing at Mission Hospital TK, Sriram; Grover, Shailaja; Hariharan, Satyabala; Unnikrishnan, Dinesh Kumar
7,8	Logistic Regression	TB Chapter 13	
9,10	Integration of Predictive and Prescriptive Analytics		Marketing Head's Conundrum by Maneesh Bhandari, Pramod Kumar Bagri, Dinesh Kumar Unnikrishnan
11,12	Model Evaluation Techniques	TB Chapter 15	
13,14	Regression Tree and Classification Trees	TB Chapter 11,18	
15,18	Ensemble Methods: Bagging and Boosting	TB Chapter 25	Predicting Customer Churn At Qwe Inc. by Ovchinnikov, Anton S.

Course evaluation

Assessment Tool	Percentage
Group Project/Assignment	20%
Quiz/ Individual Assignment	40%
End-term Exam	40%

Software

- Microsoft Excel or other spreadsheet programs like Google Sheets
- Proprietary Statistical Software: SAS, Stata or SPSS

Limitations:

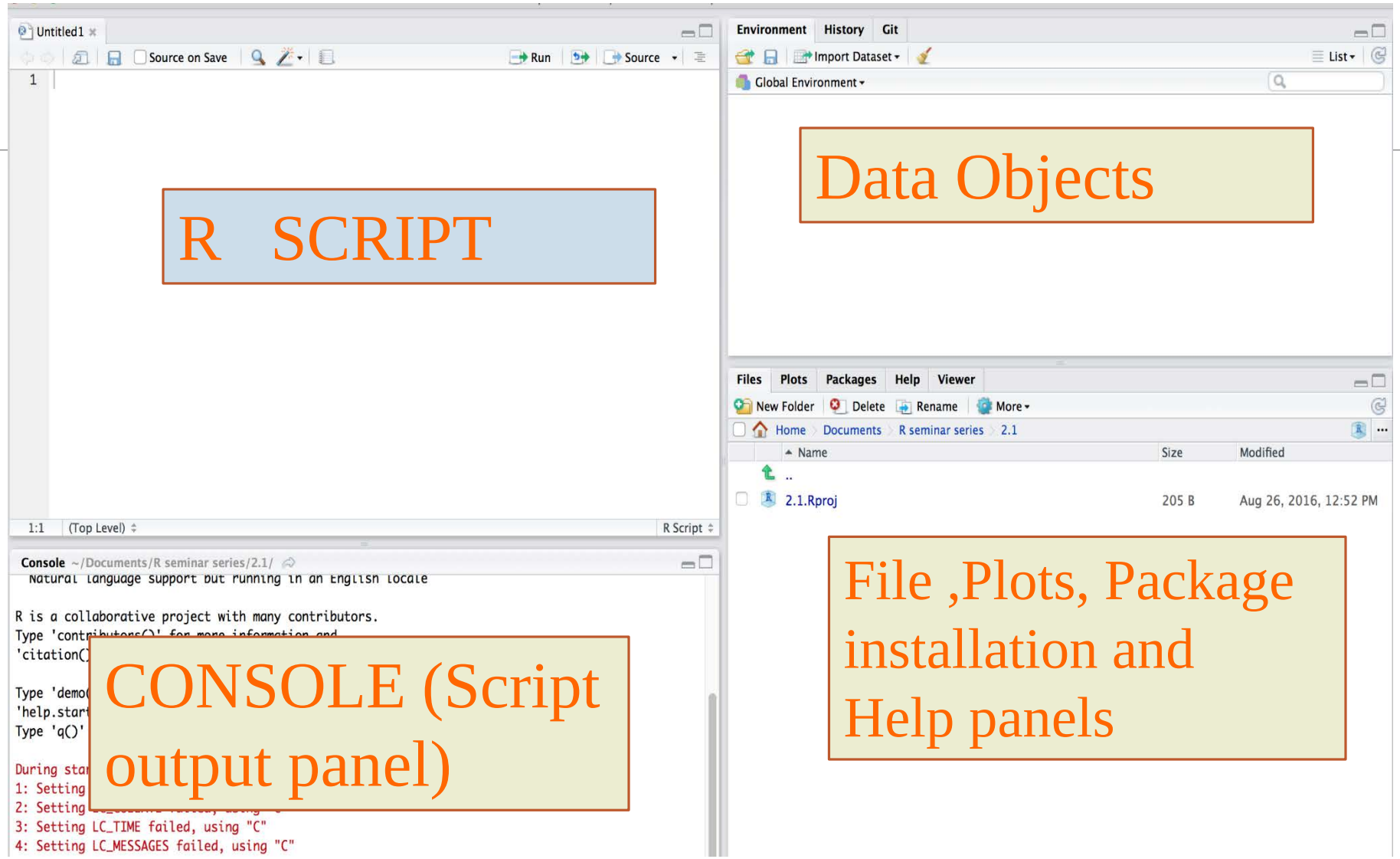
- Excel cannot handle datasets above a certain size.
- Reproducing previously conducted analyses on new datasets is challenging.
- Programs like SAS were developed for very specific uses.
- Don’t have a large community of contributors constantly adding new tools.

Next Step

R or Python

- Both are free and open source, and were developed in the early 1990s.
- R for statistical analysis and Python as a general-purpose programming language.
- But for data analysis, the differences between R and Python are starting to break down.
- https://www.guru99.com/r-vs-python.html

RStudio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Global Environment
Data Objects
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Console ~/Documents/R seminar series/2.1/
Natural language support but running in an English locale
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()
Type 'demo(
'help.start
Type 'q()'
During star
1: Setting
2: Setting
3: Setting LC_TIME failed, using "C"
4: Setting LC_MESSAGES failed, using "C"
CONSOLE (Script output panel)
File ,Plots, Package installation and Help panels

Some free online books in R

https://bookdown.org/rdpeng/rprogdatascience/

https://rstudio-education.github.io/hopr/r-notation.html

Name	Age	Occupation					
Mahima							
Rajan							
Vikas							

Get started with R

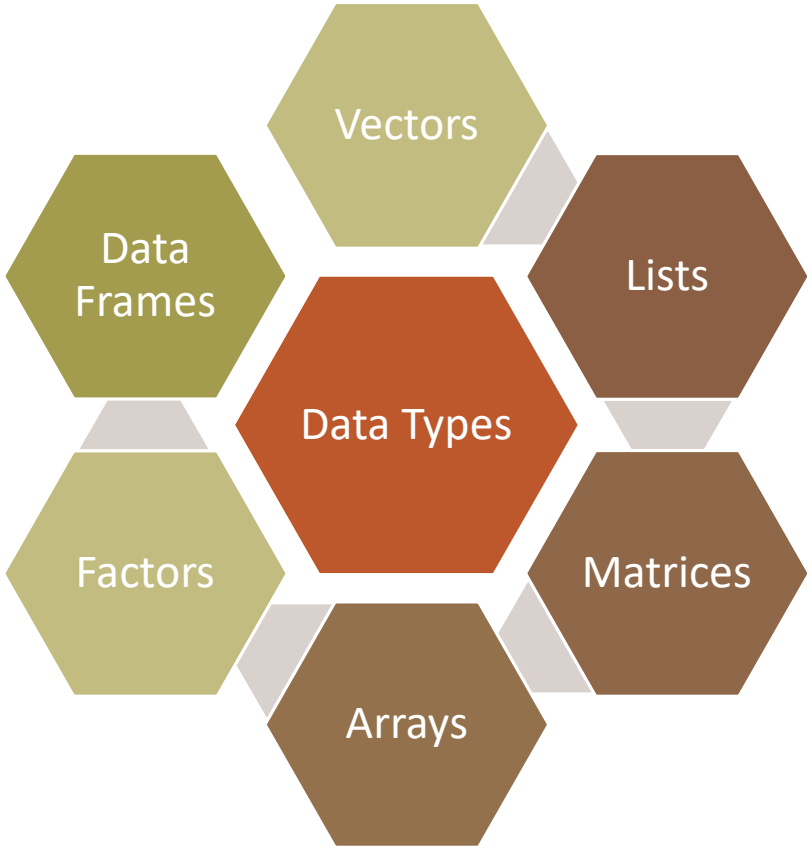
- Variables in R
- Operators in R
- Data Types in R
- Graphs in R

https://www.tutorialspoint.com/r/index.htm

Variables in R

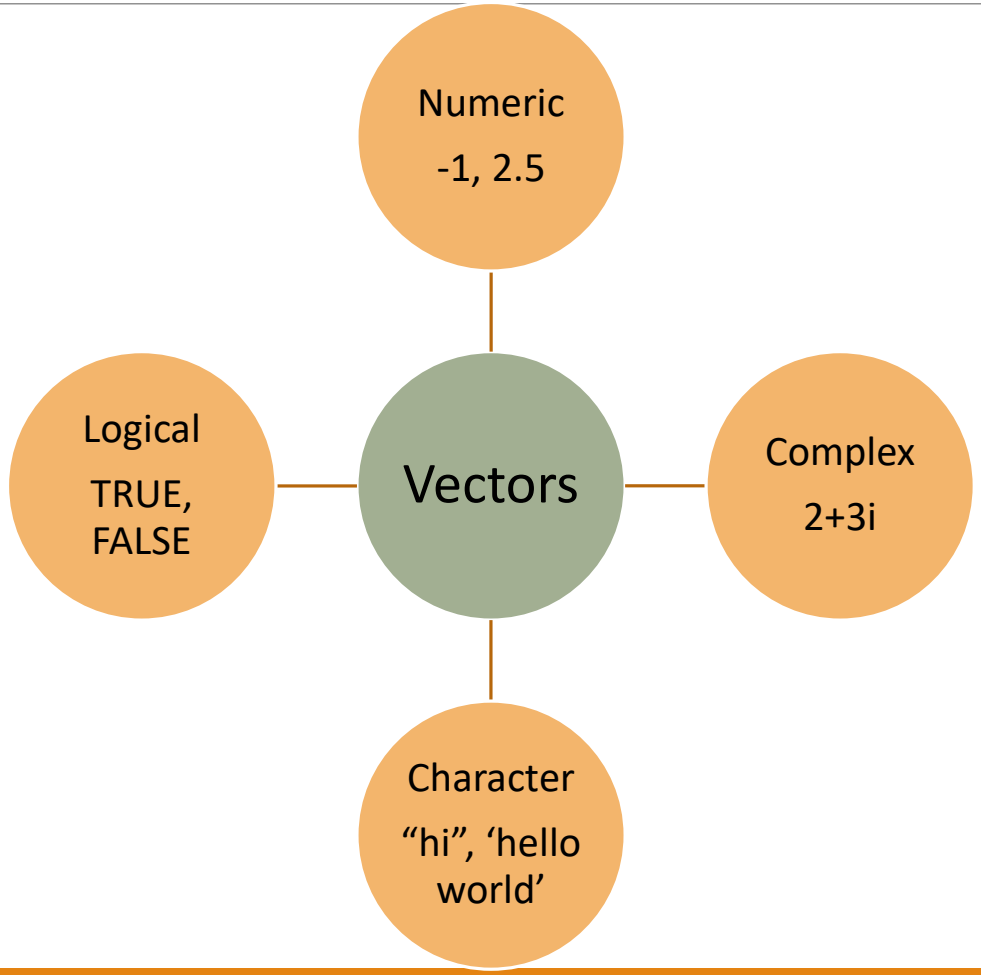
- Variables are reserved memory locations to store values.
- A valid variable name consists of letters, numbers and the dot or underline characters. The variable name starts with a letter or the dot not followed by a number.
- The variables can be assigned values using leftward (commonly used), rightward and equal to operator.
- Subject.1 <- “Maths”
- X_1 = 5
- TRUE -> .abc
- Some invalid names: .123, A%1,_class
- The variables are assigned with R-Objects and the data type of the R-object becomes the data type of the variable.

Data Types in R



Vectors

- A vector is a sequence of data elements of the same data type.
- Types of vectors: logical, numeric, complex, character
- If vector is defined of different basic types, the lower ranking type will be *coerced* into the higher ranking type.
- In general, The hierarchy for coercion is: logical < numeric < character
- Logicals are coerced a bit differently depending on what the highest data type is.



Operations in Vectors

Indexing

starts with 1; Accessed through []; Negative index is used for dropping the element

Age <- c(12,14,15,16)	Age [1] : 12	Age[-2]: 12, 15, 16
Age[Age>14]: 15, 16	Age[c(1,3)]: 12,15	Age[2:4]: 14, 15, 16

Replacing

Age[2] <- 16

Other functions

length, class

Operators in R

Arithmetic Operators	+ - * / ^ %%(Remainder) %/%(integer quotient)
Relational Operators	Give Boolean value as output < > == != >= <=
Logical Operators	&	! (Element wise) && || (first element comparison)
Assignment Operators	<- <<- > >>- =
Miscellaneous Operators	: (It creates the series of numbers in sequence for a vector)

https://excelquick.com/r-programming/assignment-operators-in-r/
https://renkun.me/2014/01/28/difference-between-assignment-operators-in-r/

Data Frames

- A data frame is a table or a two-dimensional array-like structure.
- Each column contains values of one variable.
- Each row contains one set of values from each column.
- The data stored in a data frame can be of numeric, factor or character type.
- Each column should contain same number of data items.

```
emp.data <- data.frame( emp_id = c (1:5), emp_name =
c("Rahul",“Rohan","Michelle","Ryan","Gaurav"), salary =
c(623.3,515.2,611.0,729.0,843.25))
```

- Some important commands : nrow(),ncol(),dim(),names(), rownames(),colnames(), head(), tail(), rbind(), cbind(), summary()

- Matrix : Same atomic type elements are arranged in a two-dimensional rectangular layout.

  A <- matrix(data, nrow, ncol)

  Indexing: A[1,2]; A[c(1,3),];A[c(1,3),-1]

- Arrays: Store data in more than two dimensions.

  vector1 <- rep(c(2,5),5) ; vector2 <- c(10,15,13,16,11,12)

  a<-array(c(vector1,vector2),dim=c(2,2,4))

- Lists contain elements of different types − numbers, strings, vectors and another list inside it.

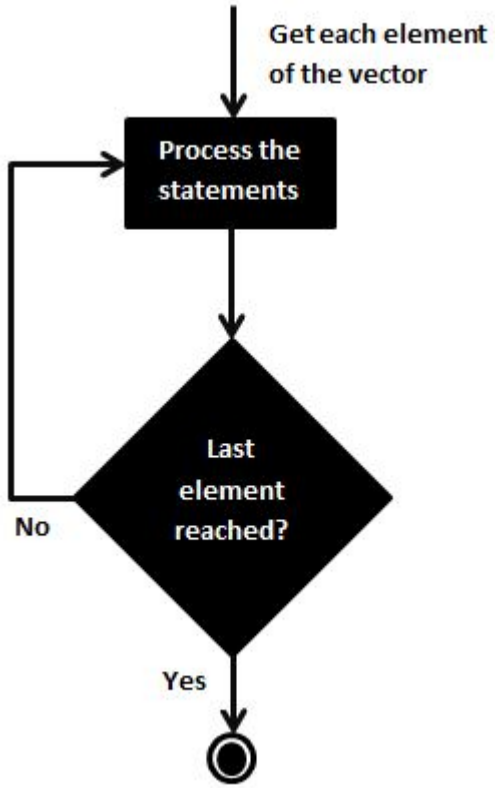
  Student <- list(c(“Arjun”, ”Ram”), 25, TRUE)

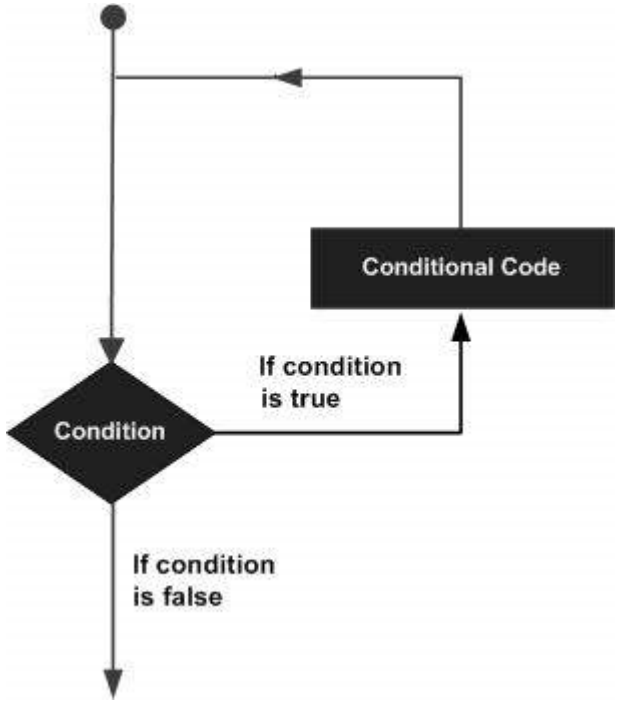
Factors

- Factors are used to categorize the data and store it as levels.
- They can store both strings and integers.
- They are useful in the columns which have a limited number of unique values. Like "Male, "Female" and True, False etc.
- They are useful in data analysis for statistical modeling.
- Factors are created using the **factor ()** function by taking a vector as input.

```
input. data <-
c("East","West","East","North","North","East","West","West","West","East","North")
factor_data <- factor(input.data)
```

Control structure in R





For loop

for (*variable* in *sequence*)
{ *expression expression expression* }

Example 1:

```
v <- c(1,2,3,4)
for ( i in v) {
  print(i)
}
```

```
for (j in 1:5) { print(j^2) }
```

If Loop

The keyword if

A single logical value between parentheses (or an expression that leads to a single logical value)

A block of code between braces that has to be executed when the logical value is TRUE

```
if(val %% 2 == 0) {count = count+1 }
```

```
# ignore the curls if it is only one statement

ifelse(test_expression, x, y)

a = c(5,7,2,9)

 ifelse(a %% 2 == 0,"even","odd")

[1] "odd" "odd" "even" "odd
```

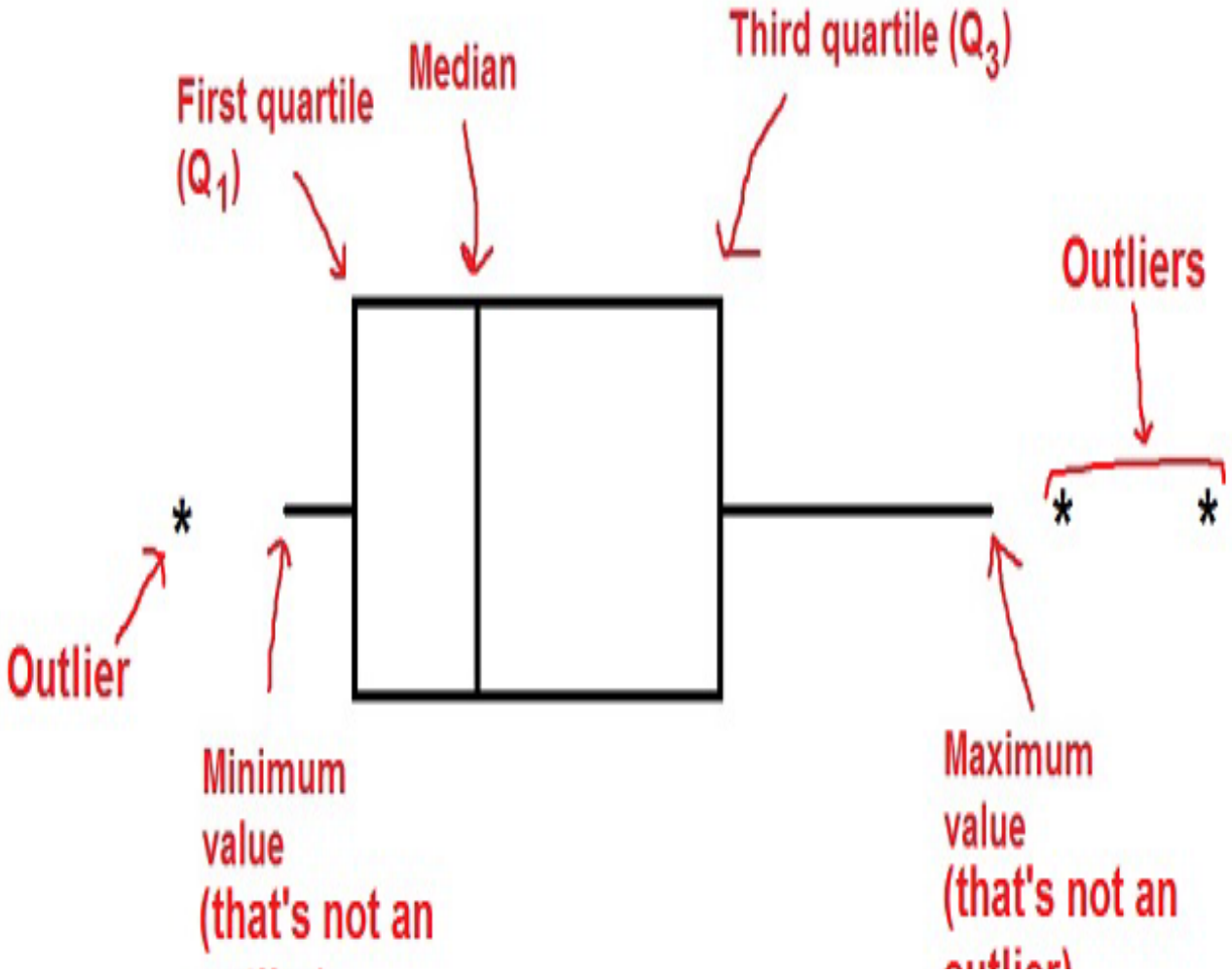
If else

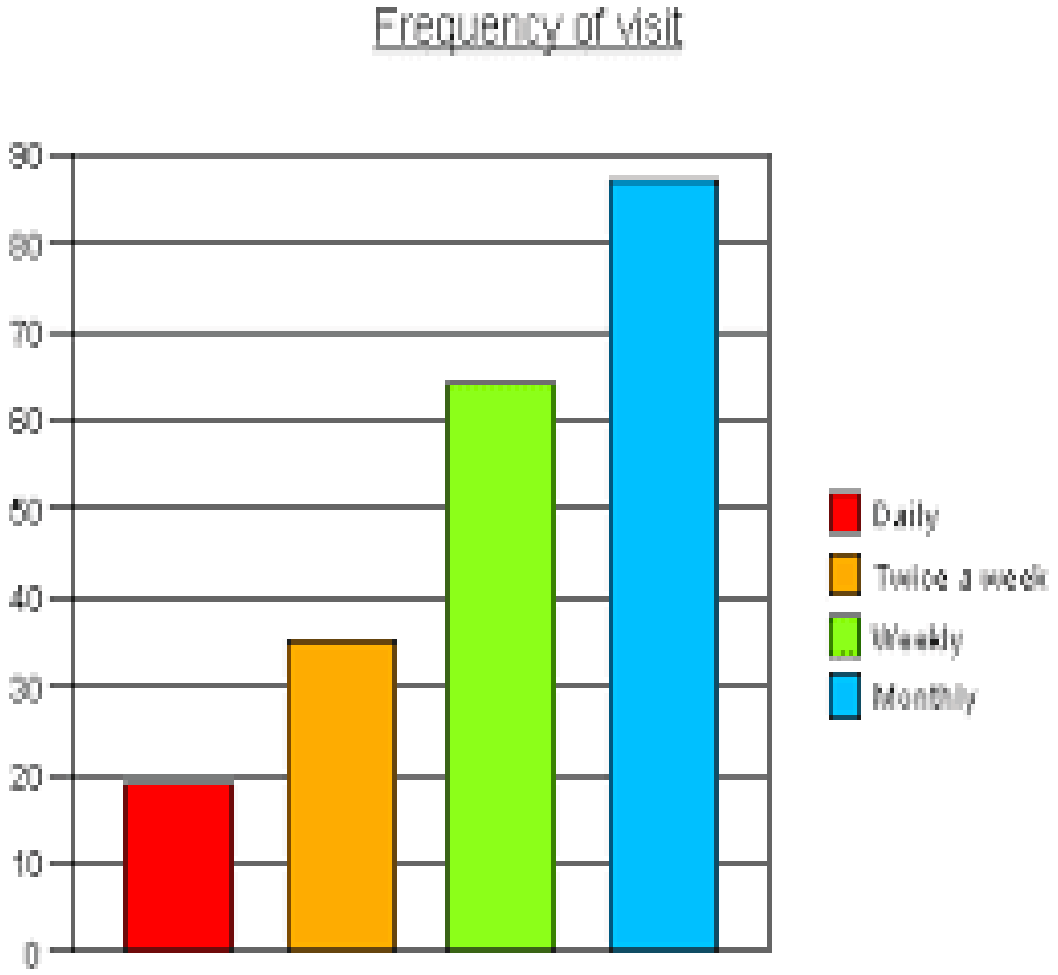
if(boolean_expression 1) { // Executes when the boolean expression 1 is true. }

else if(boolean_expression 2) { // Executes when the boolean expression 2 is true. }

else if(boolean_expression 3) { // Executes when the boolean expression 3 is true. }

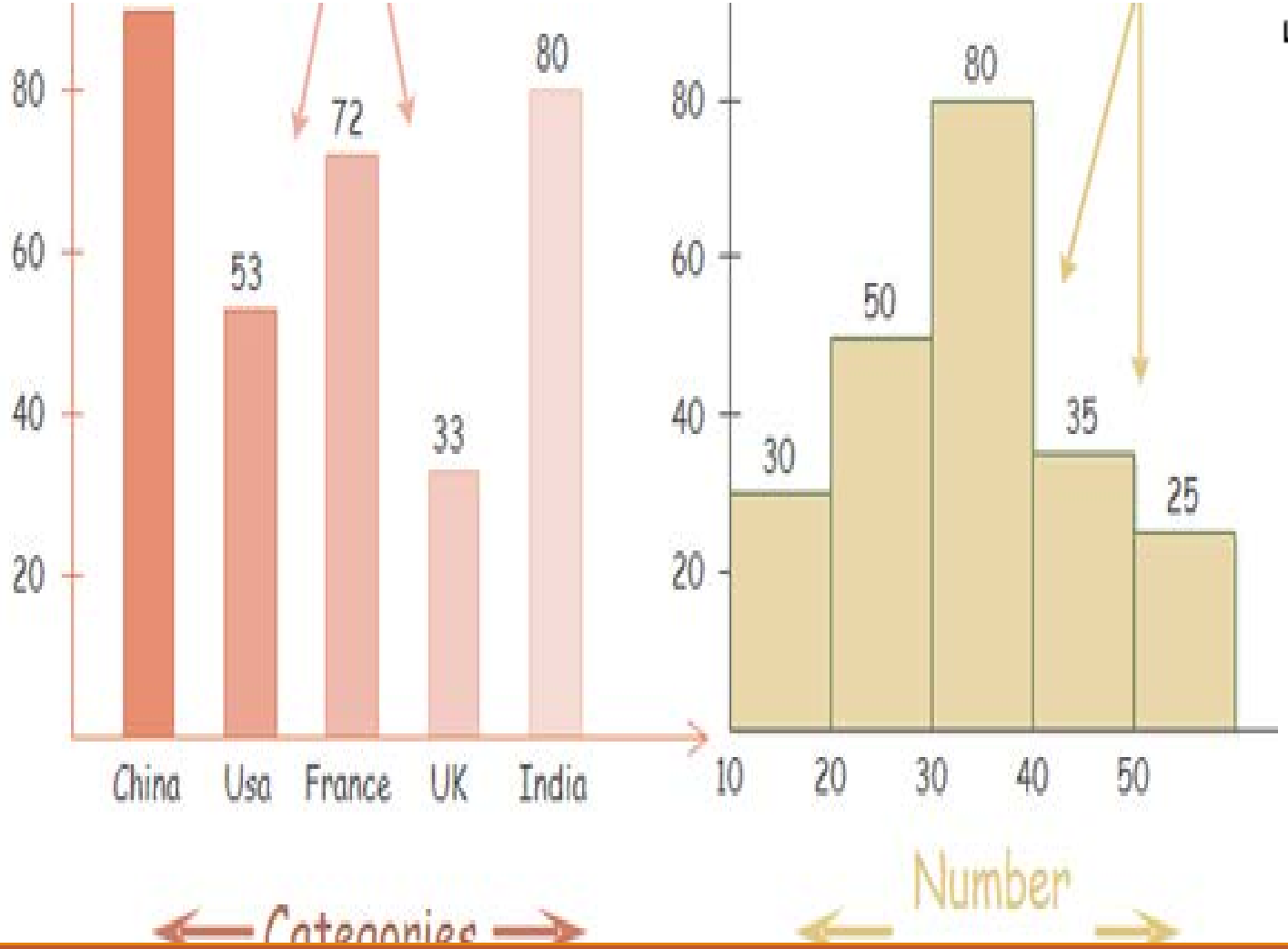
else { // executes when none of the above condition is true. }

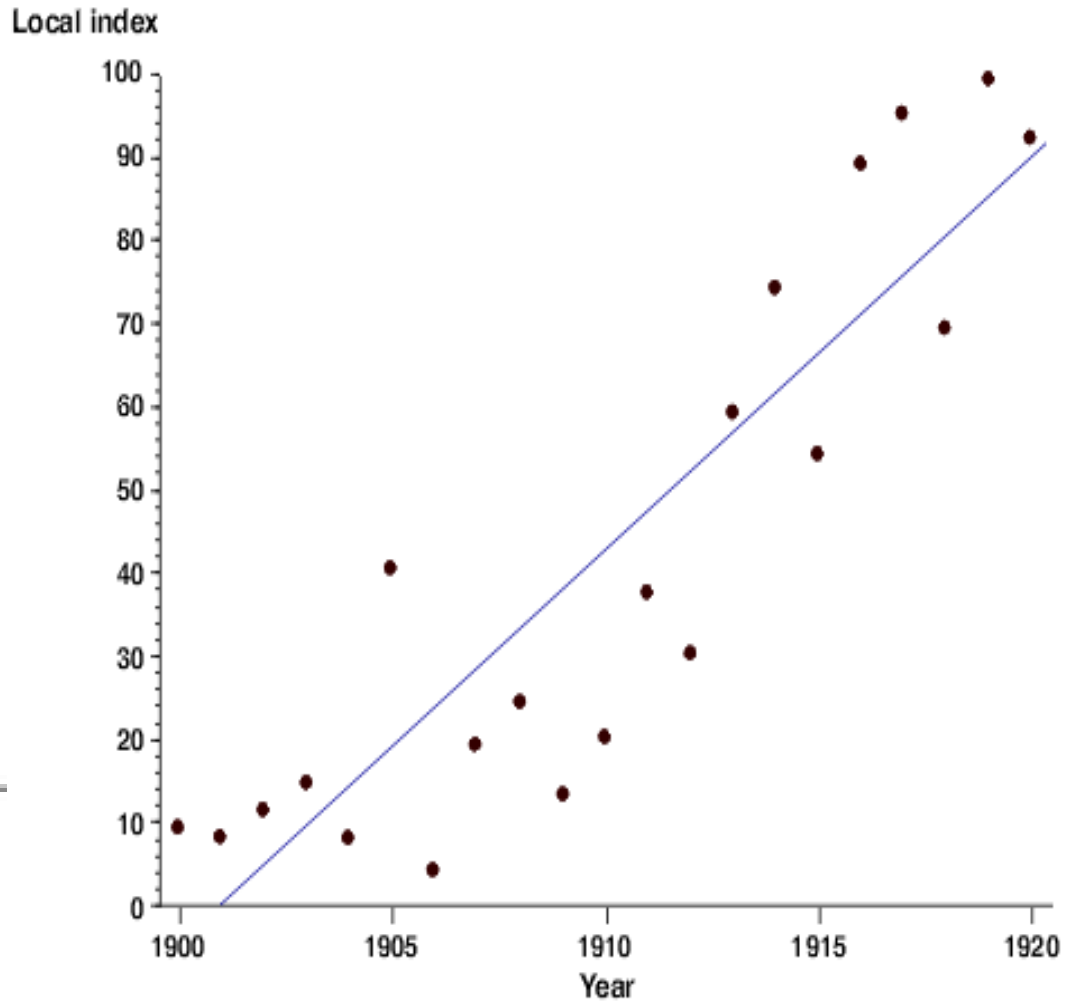




Data Visualization in R

Boxplot, Barchart





Data Visualization in R

Histogram, Line Graph, Scatterplot

What Tasks Can Data Mining Accomplish?

Six common data mining tasks

- Description
- Estimation
- Prediction
- Classification
- Clustering
- Association

What Tasks Can Data Mining Accomplish? (*cont'd*)

1. Description

- Describes patterns or trends in data
  - For example, pollster may uncover patterns suggesting those laid-off less likely to support incumbent
  - Descriptions of patterns, often suggest possible explanations
  - For example, those laid-off now less financially secure; therefore, prefer alternate candidate

- High-quality description accomplished using Exploratory Data Analysis (EDA)
  - Graphical method of exploring patterns and trends in data

What Tasks Can Data Mining Accomplish? (*cont'd*)

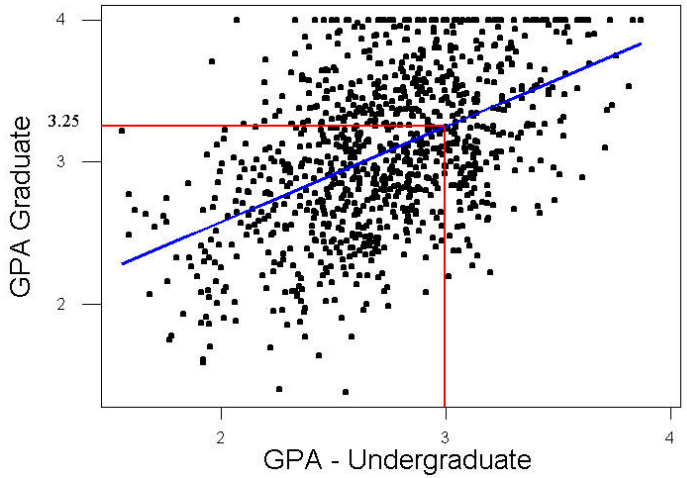
2. Estimation

- Example: Estimate a patient's systolic blood pressure, based on patient's age, gender, body-mass index, and sodium levels
  a) Use training data to develop model that estimates systolic blood pressure based on predictor variables
  b) Apply model to new cases, to obtain estimated systolic blood pressure

***Statistical Analysis* uses several estimation methods: point estimation, confidence interval estimation, linear regression and multiple regression**

What Tasks Can Data Mining Accomplish? (*cont'd*)

- Figure 1.2 shows scatter plot of graduate GPA against undergraduate GPA (1000 students)
- Linear regression finds line (blue) best approximating relationship between two variables



Regression line estimates student's graduate GPA based on their undergraduate GPA, resulting in the following model:

$$\hat{y} = 1.24 + 0.67x$$

For example, suppose student's undergraduate GPA = 3.0

According to estimation model, estimated student's graduate GPA = 1.24 + 0.67(3.0) = 3.25

Point ($x = 3.0$, $\hat{y} = 3.25$) lies on regression line

What Tasks Can Data Mining Accomplish? (*cont'd*)

3. Prediction

- Similar to estimation, except results lie in the future
- Methods used for classification and estimation applicable to prediction
  - Includes point estimation, confidence interval estimation, linear regression and correlation, multiple regression, k-nearest neighbor, decision trees and neural networks

- Example prediction tasks in business and research:

  - Predict price of stock 3 months into future, based on past performance
  - Predict percentage increase in traffic deaths next year, if speed limit increased
  - Predicting the winner of this fall's World Series, based on a comparison of the team statistics
  - Predict whether molecule in newly discovered drug leads to profitable pharmaceutical drug

What Tasks Can Data Mining Accomplish? (*cont'd*)

4. Classification

- Similar to Estimation task, except target variable is categorical
- Example: Classify the Income Bracket of an individual as Low, Middle or High based their Age, Gender and Occupation
  a) Use training data to develop model that classifies Income Bracket based on predictor variables
  b) Apply model to cases not currently in the database, to obtain estimated Income Bracket classification

What Tasks Can Data Mining Accomplish? (*cont'd*)

5. Clustering

- Refers to grouping records into classes of similar objects
- Cluster – a collection of records similar to one another, and dissimilar to records in other clusters
- Clustering algorithm seeks to segment data set into homogeneous subgroups
- Target variable not specified
  - Clustering does not try to classify/estimate/predict target variable

What Tasks Can Data Mining Accomplish? (*cont'd*)

6. Association

Find out which attributes "go together"

- Commonly used for Market Basket Analysis (Affinity Association)
- Quantify relationships between two or more attributes in the form of rules as:

  IF *antecedent* THEN *consequent*
- Rules measured using support and confidence

- Example: A particular supermarket might find that:
  - Thursday night 200 of 1,000 customers bought diapers, and of those buying diapers, 50 purchased beer
  - Association Rule: "IF buy diapers, THEN buy beer"
  - Support = 200/1,000 = 5%, and confidence = 50/200 = 25%