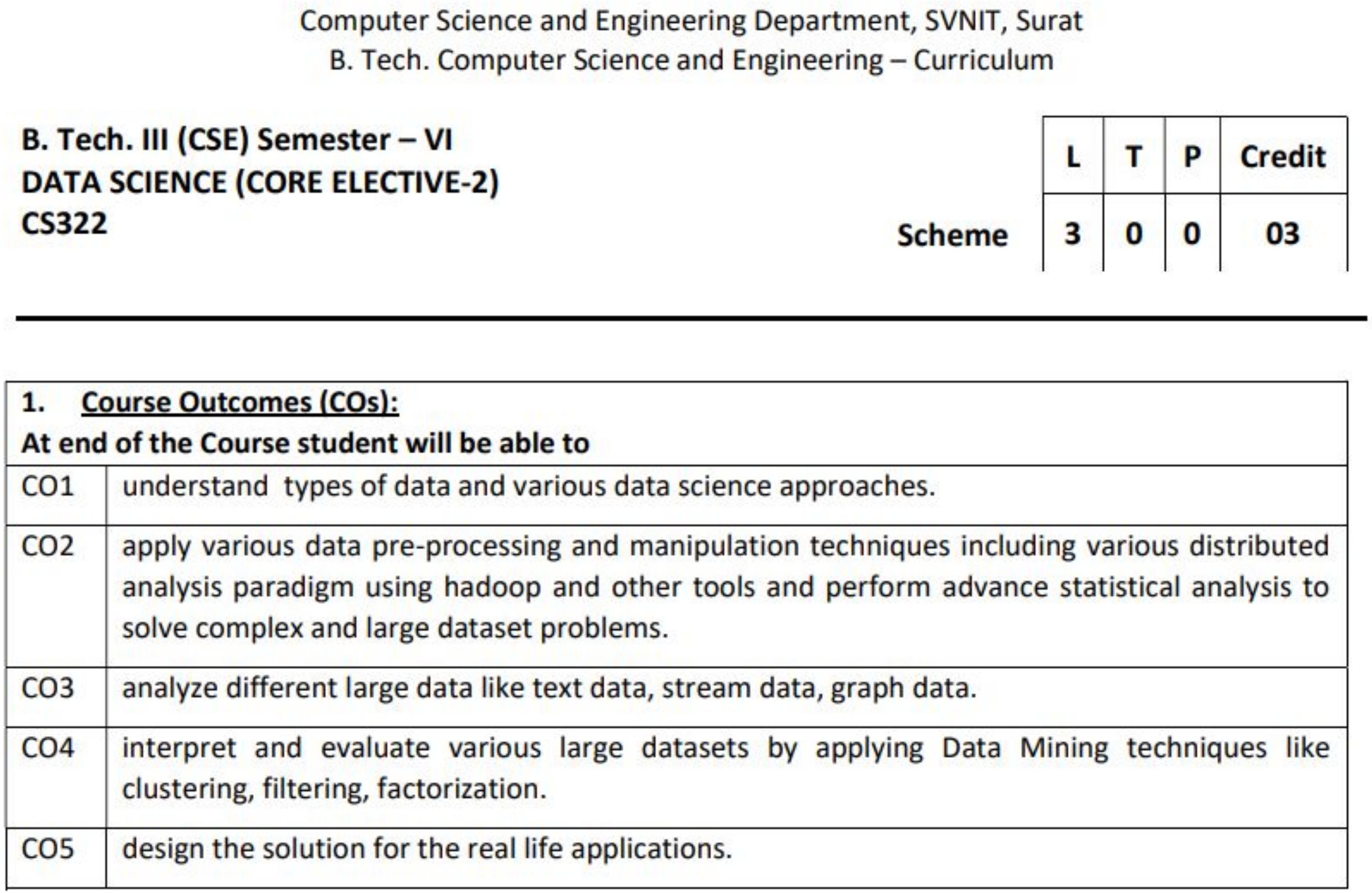
DATA SCIENCE

CS322

PARITA PATEL



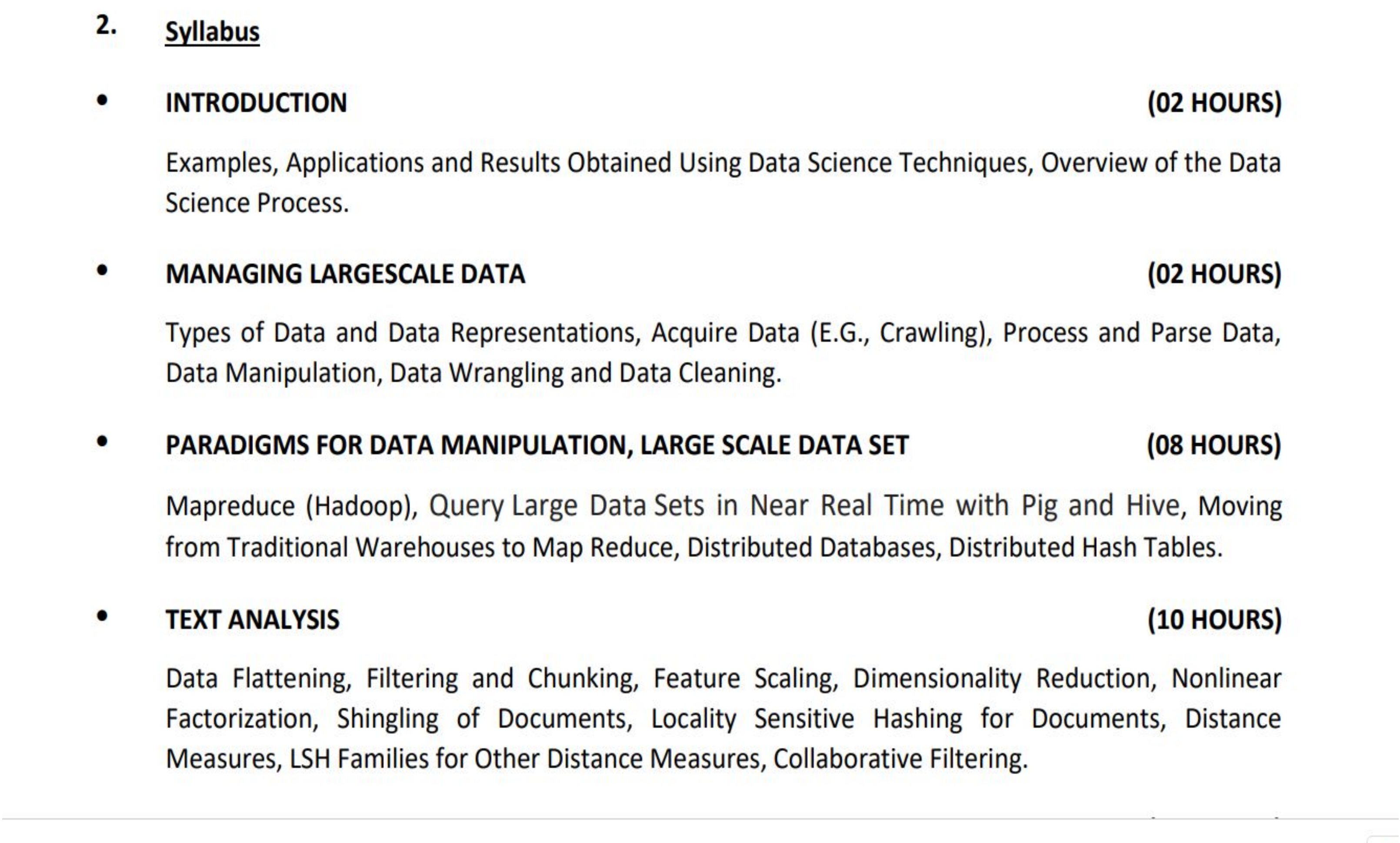
Computer Science and Engineering Department, SVNIT, Surat
B. Tech. Computer Science and Engineering – Curriculum

B. Tech. III (CSE) Semester – VI
DATA SCIENCE (CORE ELECTIVE-2)
CS322

	L	T	P	Credit
Scheme	3	0	0	03

1. <u>Course Outcomes (COs):</u>
At end of the Course student will be able to

CO1	understand types of data and various data science approaches.
CO2	apply various data pre-processing and manipulation techniques including various distributed analysis paradigm using hadoop and other tools and perform advance statistical analysis to solve complex and large dataset problems.
CO3	analyze different large data like text data, stream data, graph data.
CO4	interpret and evaluate various large datasets by applying Data Mining techniques like clustering, filtering, factorization.
CO5	design the solution for the real life applications.



2. Syllabus

- **INTRODUCTION** **(02 HOURS)**

  Examples, Applications and Results Obtained Using Data Science Techniques, Overview of the Data Science Process.

- **MANAGING LARGESCALE DATA** **(02 HOURS)**

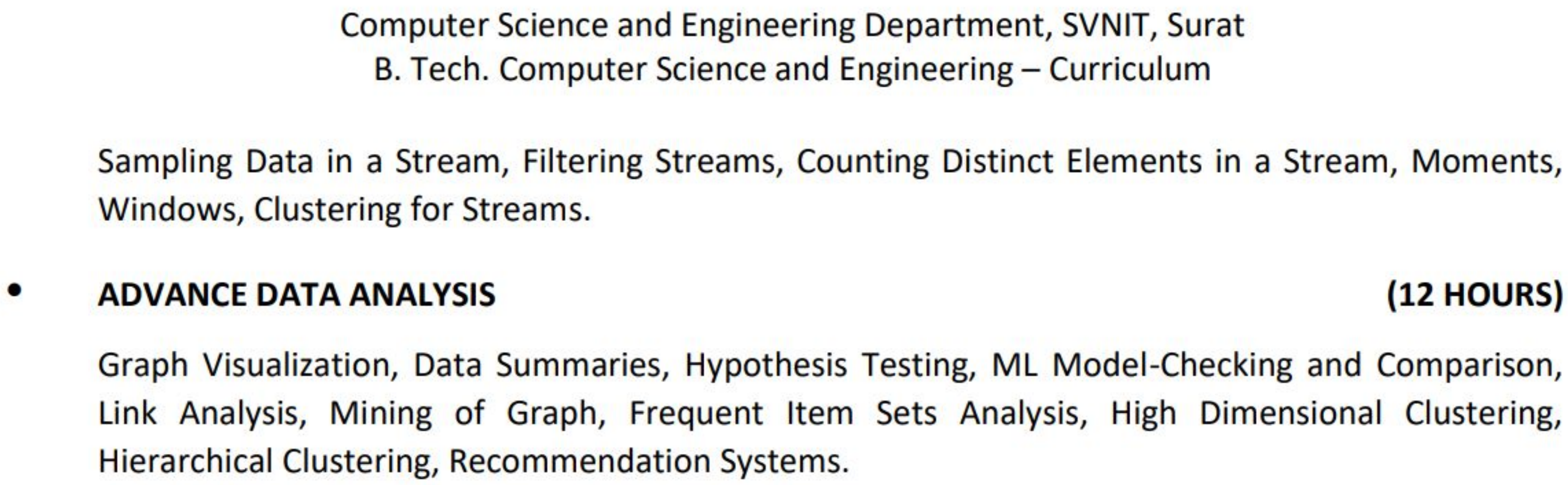
  Types of Data and Data Representations, Acquire Data (E.G., Crawling), Process and Parse Data, Data Manipulation, Data Wrangling and Data Cleaning.

- **PARADIGMS FOR DATA MANIPULATION, LARGE SCALE DATA SET** **(08 HOURS)**

  Mapreduce (Hadoop), Query Large Data Sets in Near Real Time with Pig and Hive, Moving from Traditional Warehouses to Map Reduce, Distributed Databases, Distributed Hash Tables.

- **TEXT ANALYSIS** **(10 HOURS)**

  Data Flattening, Filtering and Chunking, Feature Scaling, Dimensionality Reduction, Nonlinear Factorization, Shingling of Documents, Locality Sensitive Hashing for Documents, Distance Measures, LSH Families for Other Distance Measures, Collaborative Filtering.

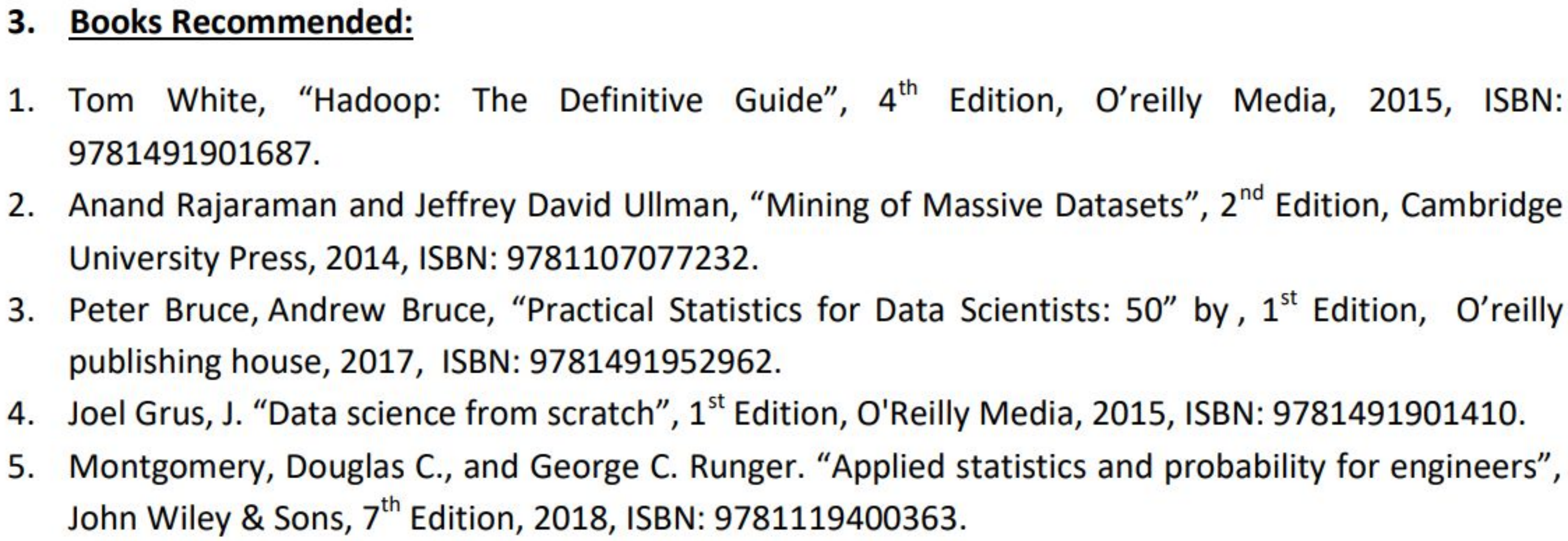


Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Moments, Windows, Clustering for Streams.

- **ADVANCE DATA ANALYSIS** **(12 HOURS)**

Graph Visualization, Data Summaries, Hypothesis Testing, ML Model-Checking and Comparison, Link Analysis, Mining of Graph, Frequent Item Sets Analysis, High Dimensional Clustering, Hierarchical Clustering, Recommendation Systems.

Books:



3. Books Recommended:

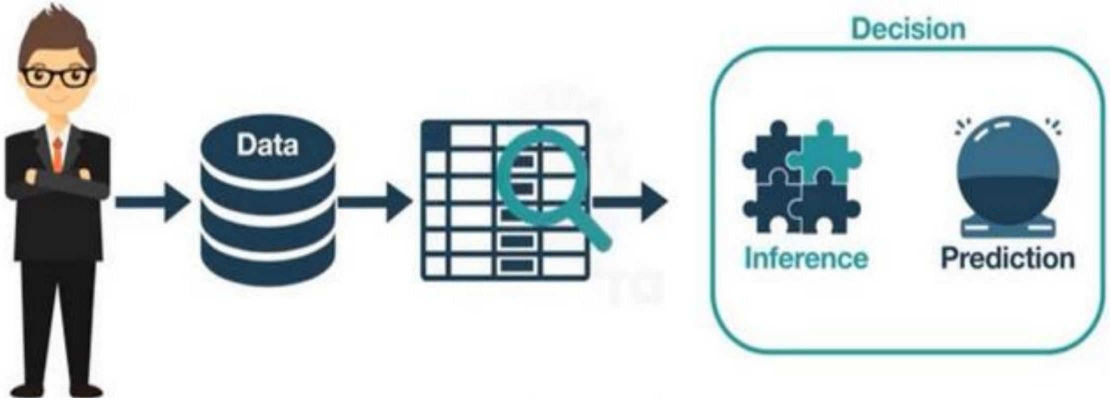
1. Tom White, “Hadoop: The Definitive Guide”, 4th Edition, O’reilly Media, 2015, ISBN: 9781491901687.
2. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, 2nd Edition, Cambridge University Press, 2014, ISBN: 9781107077232.
3. Peter Bruce, Andrew Bruce, “Practical Statistics for Data Scientists: 50” by , 1st Edition, O’reilly publishing house, 2017, ISBN: 9781491952962.
4. Joel Grus, J. “Data science from scratch”, 1st Edition, O'Reilly Media, 2015, ISBN: 9781491901410.
5. Montgomery, Douglas C., and George C. Runger. “Applied statistics and probability for engineers”, John Wiley & Sons, 7th Edition, 2018, ISBN: 9781119400363.

UNIT -1

INTRODUCTION

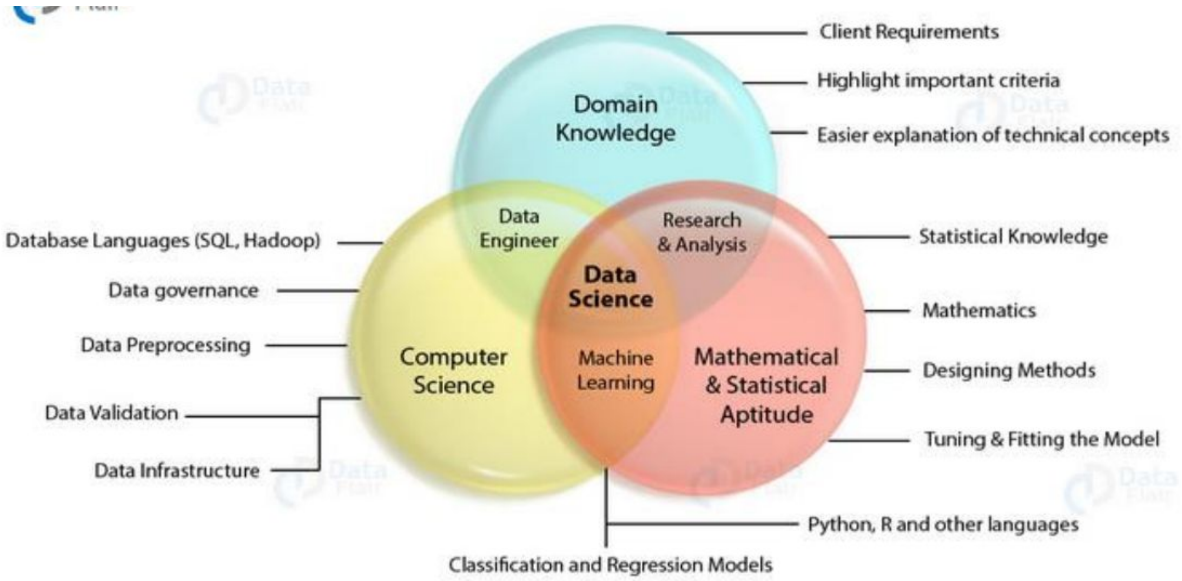
Introduction to Data Science

- Data science is the domain of study that deals with vast volumes of data using modern tools and techniques to find unseen patterns, derive meaningful information, and make business decisions
- Data Science is a comprehensive process that involves preprocessing, analysis, visualization and prediction.
- Data science is about finding hidden patterns in the data.



Introduction to Data Science

- Data science involves various underlying fields like statistics, mathematics, computer science, predictive analytics, machine learning algorithm development, and new technologies to gain insights from big data.



Why Data Science ?

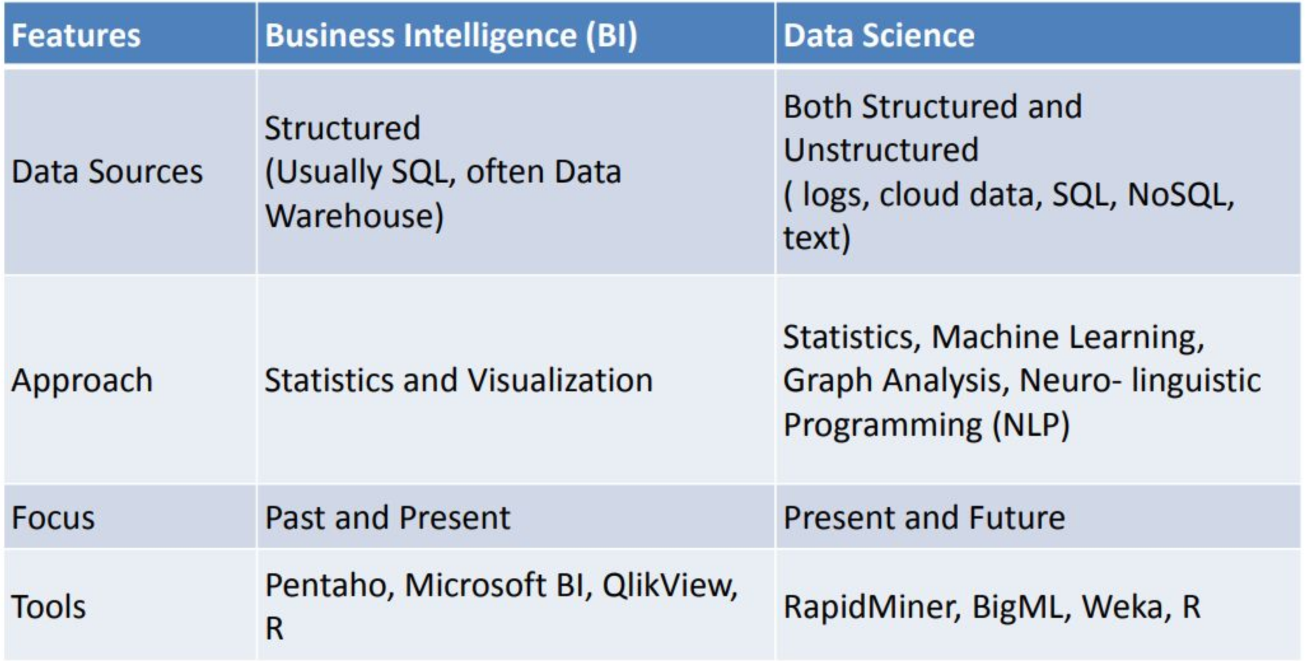
- Traditionally, the data that we had was mostly ***structured and small*** in size, which could be analyzed by using simple ***BI tools***. Unlike data in the traditional systems which was mostly structured, today most of the data is ***unstructured*** or ***semi-structured.***
- Year 2020 survey shows that, more than 80 % of the data will be unstructured. This data is generated from different sources like financial logs, text files, multimedia forms, sensors, and instruments. Simple BI tools are not capable of processing this huge volume and variety of data.
- This is why we need more complex and advanced analytical tools and algorithms for processing, analyzing and drawing meaningful insights out of it.

Why Data Science ?

- Data science or data-driven science enables better decision making, predictive analysis, and pattern discovery.
- Allows companies to increase efficiencies, manage costs, identify new market opportunities, and boost their market advantage.
- Data Science has helped to create smarter systems that can take autonomous decisions based on historical datasets.

BI vs Data Science

Difference Between BI and Data Science



Features	Business Intelligence (BI)	Data Science
Data Sources	Structured (Usually SQL, often Data Warehouse)	Both Structured and Unstructured (logs, cloud data, SQL, NoSQL, text)
Approach	Statistics and Visualization	Statistics, Machine Learning, Graph Analysis, Neuro- linguistic Programming (NLP)
Focus	Past and Present	Present and Future
Tools	Pentaho, Microsoft BI, QlikView, R	RapidMiner, BigML, Weka, R

Types of data scientists

❑ Type A Data Scientists

- The A here stands for Analysis. This is a more static approach towards analysis of data or gaining insights from it. The work of a Type A data scientist is more closely related to that of a statistician.
- A Type A Data Scientist is well versed with data cleaning, working with large data-sets, data visualization, domain knowledge, etc.

Types of data scientists

❑ Type B Data Scientists

- The B here stands Building. While Type B Data Scientists share their background in statistics with Type A Data Scientists, they are well versed in coding and fundamentals of software engineering. They are responsible for building data products that directly interact with the user.
- This helps them to craft products that provide recommendations and other forms of interactive results to the user.

Application

Examples

- Gmail filters your emails in the spam and non-spam categories

➔ Before Google/Gmail decides to segregate the emails into spam or not spam category, before it arrives to your mailbox, hundreds of rules apply to those email in the data centres.

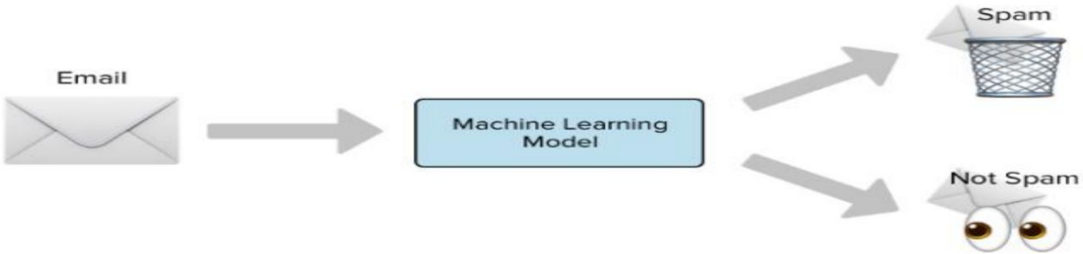
➔ These rules describe the properties of a spam email. There are common types of spam filters which are used by Gmail/Google —Blatant Blocking, Bulk Email Filter, Category Filters, Null Sender Disposition, Null Sender Header Tag Validation.

➔ There are ways to avoid spam filtering and send your emails straight to the inbox.

Application

Examples

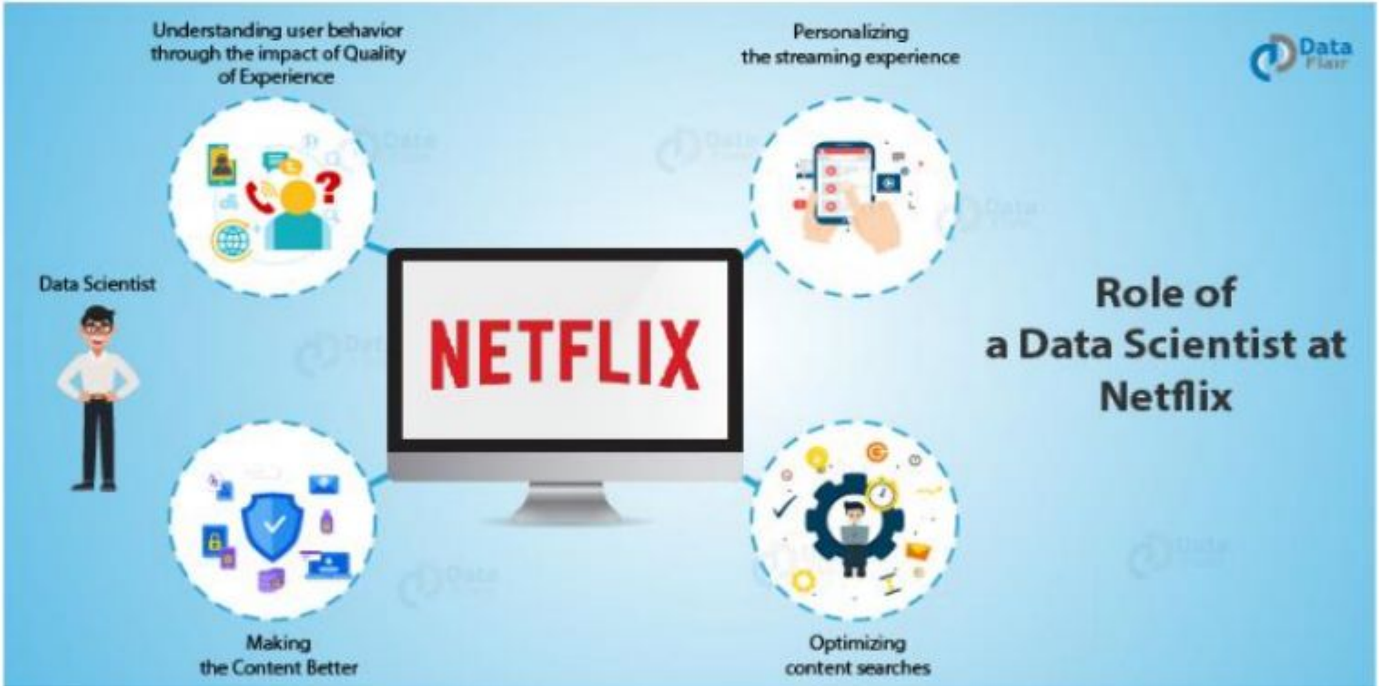
- Gmail filters your emails in the spam and non-spam categories



➔ Spam detection is a supervised machine learning problem. This means you must provide your machine learning model with a set of examples of spam and ham messages and let it find the relevant patterns that separate the two different categories. Most email providers have their own vast data sets of labelled emails.

Case Study

- How Netflix Used Data Science to Improve its Recommendation System?


Understanding user behavior through the impact of Quality of Experience
Personalizing the streaming experience
Data Flair
Data Scientist
NETFLIX
Role of a Data Scientist at Netflix
Making the Content Better
Optimizing content searches

Case Study

- How Netflix Used Data Science to Improve its Recommendation System?

➔ In order to make this happen, Netflix invested in a lot of algorithms to provide a flawless movie experience to its users. One of such algorithms is the ***recommendation system*** that is used by Netflix to provide suggestions to the users

➔ A recommendation system ***understands the needs of the users*** and provides suggestions of the various cinematographic products. System takes the information about the user as an input.

➔ This information can be in the form of the ***past usage of product or the ratings*** that were provided to the product. It then processes this information to predict how much the user would rate or prefer the product. A recommendation system makes use of a variety of machine learning algorithms.

Case Study

- How Netflix Used Data Science to Improve its Recommendation System?

➔ Another important role that a recommendation system plays today is to ***search for similarity*** between different products. In the case of Netflix, the recommendation system searches for movies that are similar to the ones you have watched or have liked previously.

➔ Therefore, based on the movies that are watched, Netflix provides recommendations of the films that share a degree of similarity.

➔ Now a days Netflix uses Hybrid Recommendation System (Content + Collaborative filtering) for suggesting content to its users.

Recommendation System

There are two main types of Recommendation Systems –

- **Content-based recommendation systems**

➔ In a content-based recommendation system, the background knowledge of the products and customer information are taken into consideration. Based on the content that you have viewed on Netflix, it provides you with similar suggestions.

➔ For example, if you have watched a film that has a sci-fi genre, the content-based recommendation system will provide you with suggestions for similar films that have the same genre.

Recommendation System

There are two main types of Recommendation Systems –

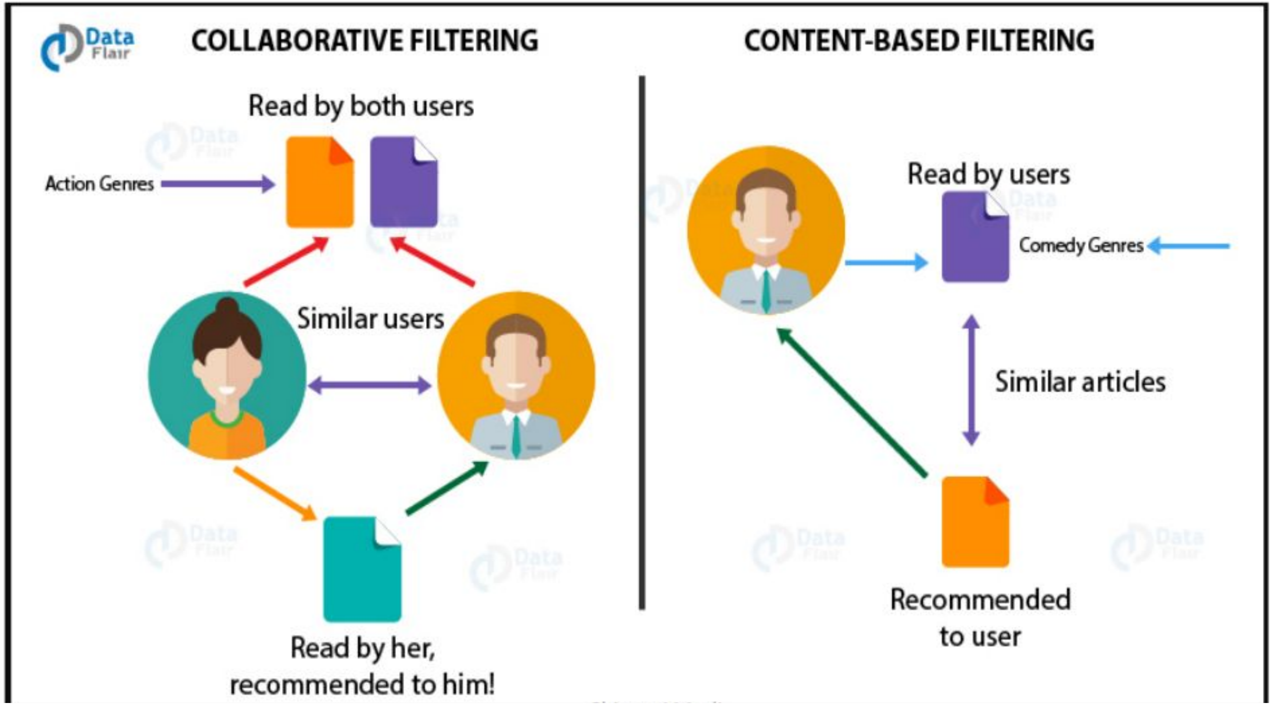
- **Collaborative recommendation systems**

➔ Unlike the content based filtering that provided recommendations of similar products, Collaborative Filtering provides recommendations based on the ***similar profiles of its users***. One key advantage of collaborative filtering is that it is independent of the product knowledge.

➔ Rather, it relies on the users with a basic assumption that what the users liked in the past will also like in the future. ***For example***, if a person A watches crime, sci-fi and thriller genres and B watches sci-fi, thriller and action genres then A will also like action and B will like crime genre.

Recommendation System

There are two main types of Recommendation Systems –



Applications

Examples

- Companies like Google and Amazon are using Data Science to develop powerful recommendation systems for their users.
- Various financial companies are using predictive analytics and forecasting methods to predict stock prices.
- Asking a personal assistant like Alexa or Siri for a recommendation

Applications

- Data science is all about using data to solve problems.

➢ **Decision making:** The problem could be decision making such as identifying which email is spam and which is not. OR understand the precise requirements of your customers from the existing data like the customer's past browsing history, purchase history, age and income.

➢ **Product recommendation:** product recommendation such as which movie to watch?

➢ **Predictive analytics:** Predicting the outcome such as who will be the next President of the USA?

➢ So, the core job of a data scientist is to ***understand*** the data, ***extract*** useful information out of it and ***apply*** this in solving the problems

Applications

- Data science is all about using data to solve problems.

➢ **Self-driving car**: self-driving cars collect live data from sensors, including radars, cameras, and lasers to create a map of its surroundings. Based on this data, it takes decisions like when to speed up, when to speed down, when to overtake, where to take a turn – making use of advanced machine learning algorithms

➢ **Weather forecasting:** Data from ships, aircraft, radars, satellites can be collected and analyzed to build models. These models will not only forecast the weather but also help in predicting the occurrence of any natural calamities. It will help you to take appropriate measures beforehand and save many precious lives.

➢ **Interest based search engine**

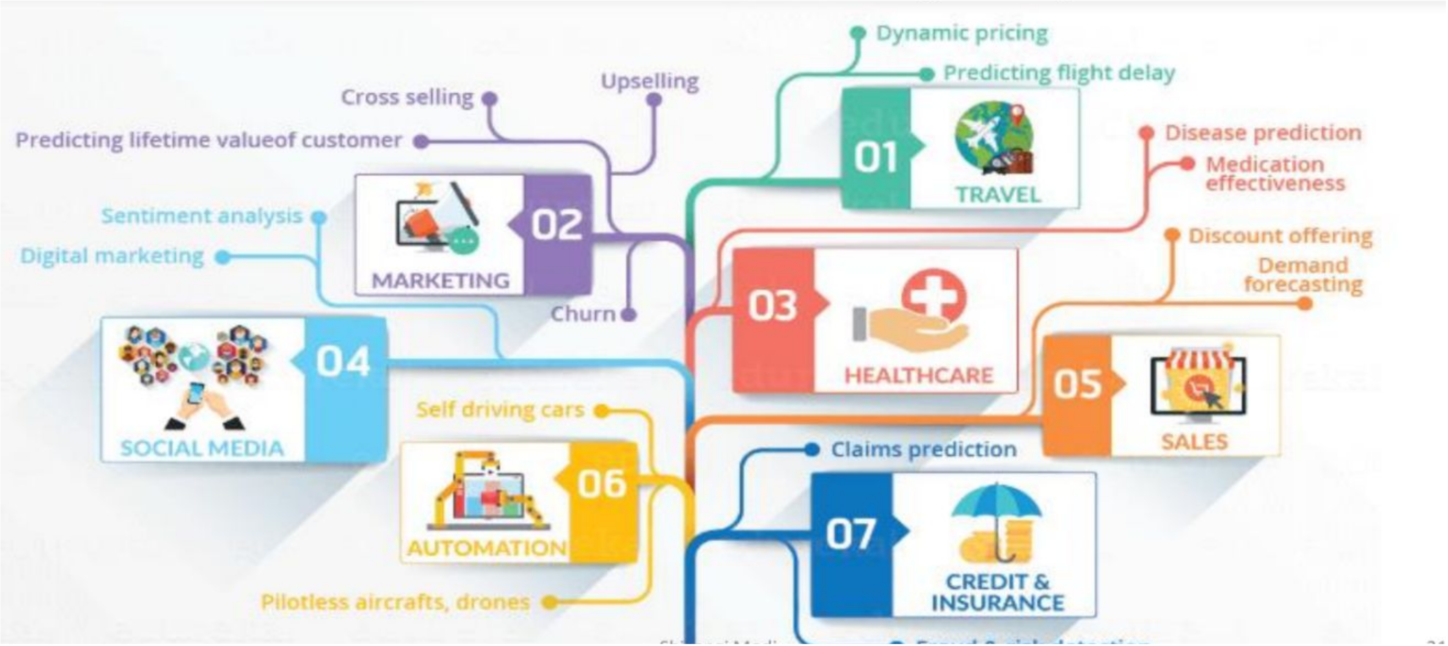
➢ **Talking to a Chabot for customer service**

Applications

- With the help of data science, Airlines can optimize operations in many ways, including:
  - Plan routes and decide whether to schedule direct or connecting flights
  - Build predictive analytics models to forecast flight delays
  - Offer personalized promotional offers based on customers booking patterns
  - Decide which class of planes to purchase for better overall performance
- To choose insurance plan
- To find restaurant
- To select internet plan
- To create marketing campaign
- To choose next destination for vacation

Applications

➢ **All the domains where Data Science is creating its impression.**



Applications

- **Data Science in Healthcare**

□ With the help of classification algorithms, doctors are able to detect cancer and tumors at an early stage using Image Recognition software.

□ Genetic Industries use Data Science for analyzing and classifying patterns of genomic sequences. Various virtual assistants are also helping patients to resolve their physical and mental ailments.

□ Drug Discovery with Data Science

□ Predictive Analytics in Healthcare: Finds various correlations and association of symptoms, finds habits, diseases and then makes meaningful predictions.

□ Monitoring Patient Health

Applications

- **Data Science in E-commerce**

Amazon uses a recommendation system that recommends users various products based on their historical purchase. Data Scientists have developed recommendation systems predict user preferences using Machine Learning.

- **Data Science in Manufacturing**

Industrial robots have made taken over mundane and repetitive roles required in the manufacturing unit. These industrial robots are autonomous in nature and use Data Science technologies such as Reinforcement Learning and Image Recognition.

Applications

- **Data Science as Conversational Agents**

Amazon’s Alexa and Siri by Apple use Speech Recognition to understand users. Data Scientists develop this speech recognition system, that converts human speech into textual data. Also, it uses various Machine Learning algorithms to classify user queries and provide an appropriate response.

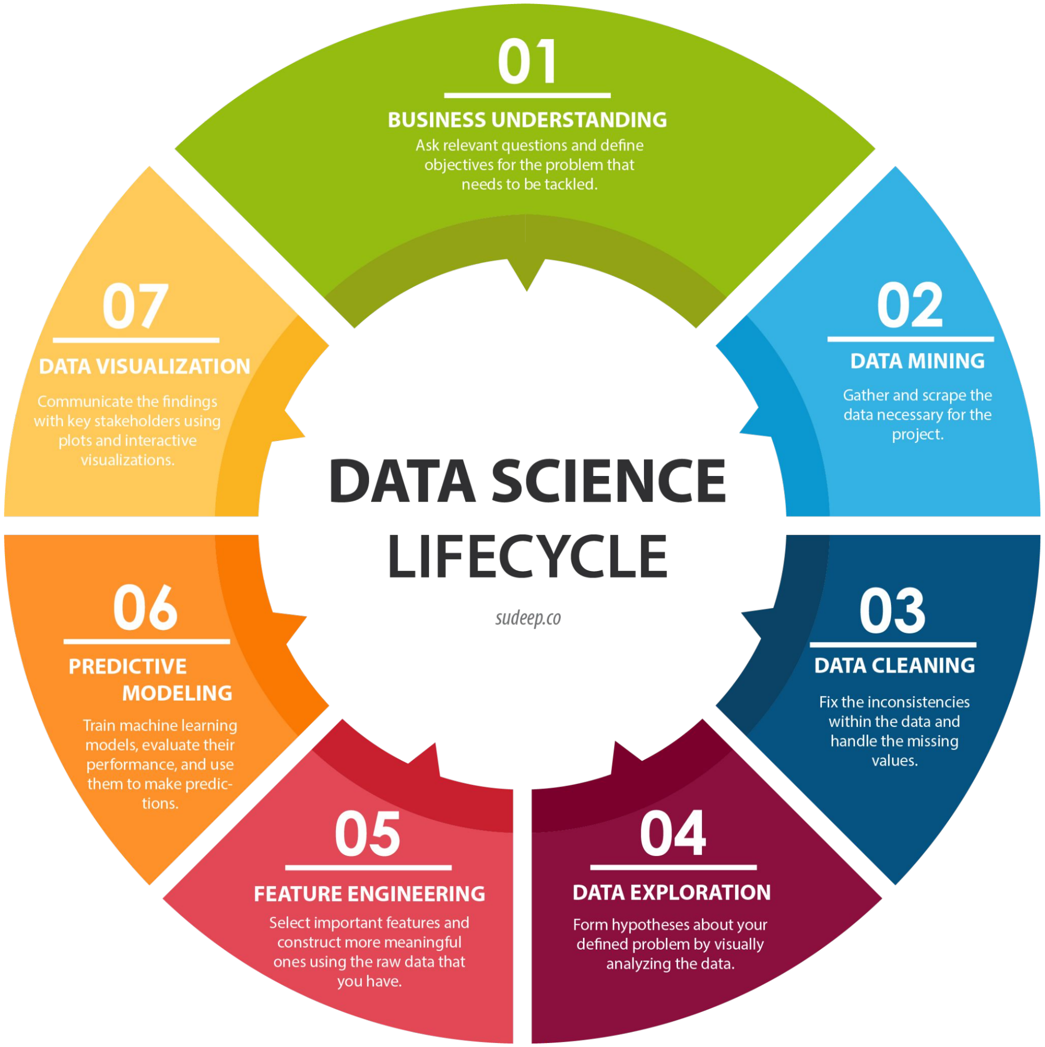
Applications

- **Data Science in Transport**

Self Driving Cars use autonomous agents that utilize Reinforcement Learning and Detection algorithms. Self-Driving Cars are no longer fiction due to advancements in Data Science.

LOGISTICS COMPANIES LIKE DHL, FEDEX HAVE
DISCOVERED THE BEST TIME AND ROUTES TO SHIP
ROUTE B
BEST TIME:
12:00PM
FEDX
Shivangi Modi

Data Science Life Cycle



DATA SCIENCE LIFECYCLE

sudeep.co

01

BUSINESS UNDERSTANDING

Ask relevant questions and define objectives for the problem that needs to be tackled.

02

DATA MINING

Gather and scrape the data necessary for the project.

03

DATA CLEANING

Fix the inconsistencies within the data and handle the missing values.

04

DATA EXPLORATION

Form hypotheses about your defined problem by visually analyzing the data.

05

FEATURE ENGINEERING

Select important features and construct more meaningful ones using the raw data that you have.

06

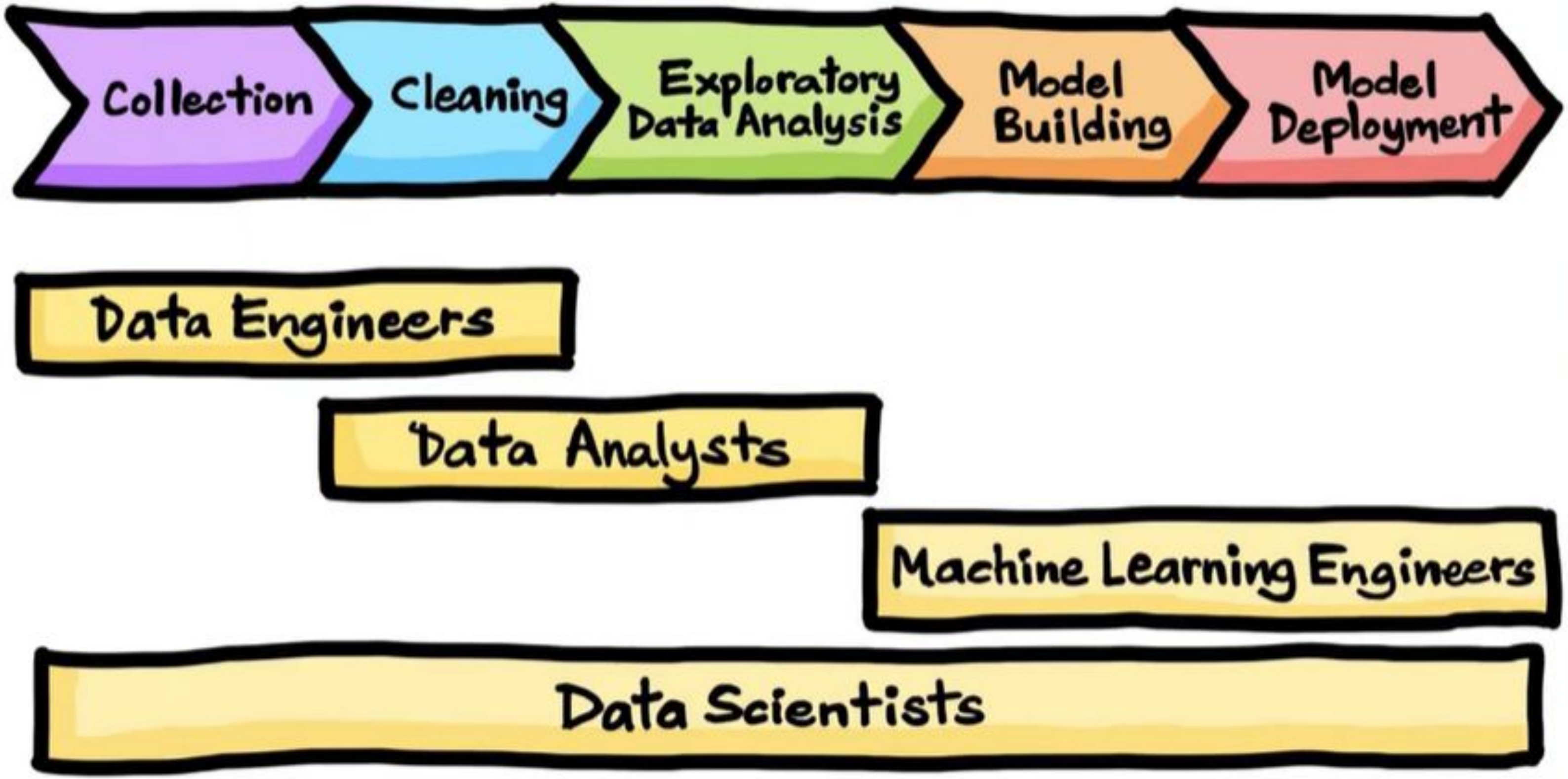
PREDICTIVE MODELING

Train machine learning models, evaluate their performance, and use them to make predictions.

07

DATA VISUALIZATION

Communicate the findings with key stakeholders using plots and interactive visualizations.


Collection
Cleaning
Exploratory Data Analysis
Model Building
Model Deployment
Data Engineers
Data Analysts
Machine Learning Engineers
Data Scientists

Data Science Life Cycle

Step 1: Define Problem Statement

- ➢ Creating a well-defined problem statement is a first and critical step in data science. It is a brief description of the problem that you are going to solve.

why do we need a well-defined problem statement?

- ➢ Most of the times, these initial set of a problem shared with you is vague and ambiguous.
- ➢ For example, the problem statement: “I want to increase the revenue”, doesn’t tell you how much to increase the revenue such as 20% or 30%, for which products to increase revenue and what is the time frame to increase the revenue.
- ➢ You have to make the problem statement clear, goal-oriented and measurable. This can be achieved by asking the right set of questions.

Data Science Life Cycle

Step 2: Data Collection

- ➢ Data collection is a systematic approach to gather relevant information from a variety of sources.
- ➢ Depending on the problem statement, the data collection method is broadly classified into two categories.

- Primary data collection

- Secondary data collection

Primary data collection: When we have some unique problem and no related research is done on the subject. Then, we need to collect new data. This method is called as **primary data collection.**

For **example**, we want information on the average time that employees spend in a cafeteria across companies. There is no public data available of these. But we can collect the data through various methods such as surveys, interviews of employees and by monitoring the time spent by employees in cafeteria. This method is time-consuming.

Data Science Life Cycle

Step 2: Data Collection

- **Secondary data collection**: To use the data which is readily available or collected by someone else. These data can be found on the internet, news articles, government census, magazines and so on. This method is called as s**econdary data collection.**

This method is less time-consuming than the primary method.

Data Science Life Cycle

Step 3: Data Preparation

Since raw data may not be usable, data preparation is the most crucial aspect of the data science lifecycle. A data scientist must first examine the data to identify any gaps or data that do not add any value. During this process, you must go through several steps, including:

- **Data Integration:** Resolve any conflicts in the dataset and eliminate redundancies

- **Data Transformation:** Normalize, transform and aggregate data using ETL (extract, transform, load) methods

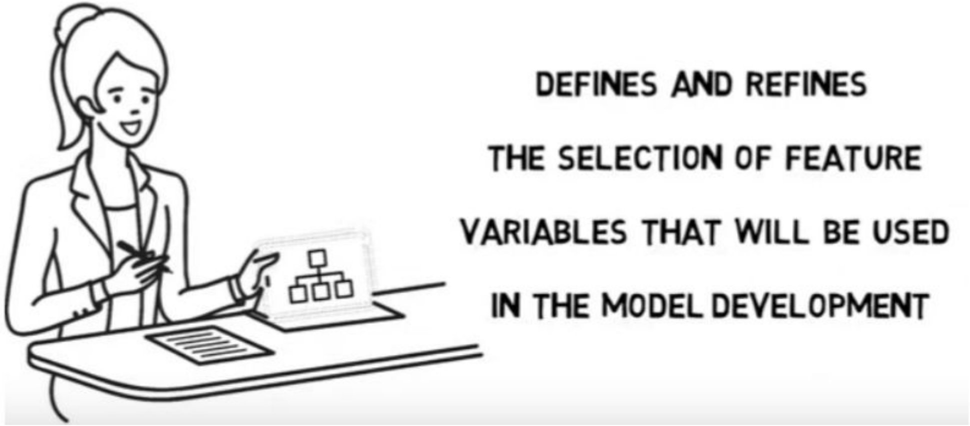
- **Data Reduction:** Using various strategies, reduce the size of data without impacting the quality or outcome

- **Data Cleaning:** Correct inconsistent data by filling out missing values and smoothing out noisy data

Data Science Life Cycle

Step 4: Exploratory Data Analysis

- ➢ it’s important to analyze the data. It is the most exciting step as it helps you to build familiarity with the data and extract useful insights.
- ➢ If you skip this step then you might end up generating inaccurate models and choosing the insignificant variables in your model.



DEFINES AND REFINES THE SELECTION OF FEATURE VARIABLES THAT WILL BE USED IN THE MODEL DEVELOPMENT

Data Science Life Cycle

Step 4: Exploratory Data Analysis

➢ A Data Scientist analyzes the data through various statistical procedures.

In particular, two types of procedures used are:

- Descriptive Statistics
- Inferential Statistics

➢ Assume that you are a Data Scientist working for a company that manufactures cell phones. You have to analyze customers using the mobile phones of your company. In order to do so, you will first take a thorough look at the data and understand various trends and patterns involved.

➢ In the end, you will summarize the data and present it in the form of a graph or a chart. You therefore, apply **Descriptive Statistics** to solve the problem.

Data Science Life Cycle

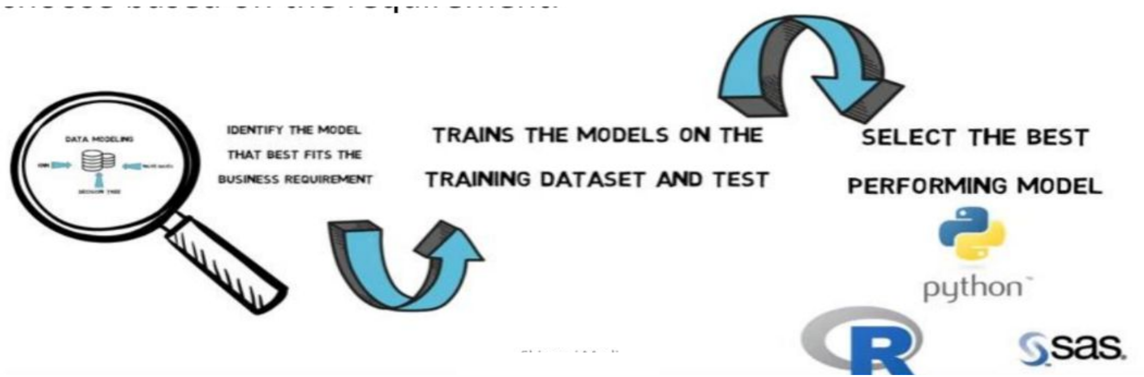
Step 4: Exploratory Data Analysis

- You will then draw ‘inferences’ or conclusions from the data. To understand inferential statistics through the following example – Assume that you wish to find out a number of defects that occurred during manufacturing.
- However, individual testing of mobile phones can take time. Therefore, you will consider a sample of the given phones and make a generalization about the number of defective phones in the total sample.

Data Science Life Cycle

Step 5: Data Modeling

- ➢ Modeling means formulating every step and gather the techniques required to achieve the solution.
- ➢ The important factor is how to perform the calculations. There are various techniques under Statistics and Machine Learning that you can choose based on the requirement.


DATA MODELING
DECISION TREE
IDENTIFY THE MODEL THAT BEST FITS THE BUSINESS REQUIREMENT
TRAINS THE MODELS ON THE TRAINING DATASET AND TEST
SELECT THE BEST PERFORMING MODEL
python
R
sas

Data Science Life Cycle

Step 6: Communicate Results: Data reporting, Data visualization,

Business Intelligence, Decision making

- ➢ This is the final step where you present the results from your analysis to the stakeholders. You explain to them how you came to a specific conclusion and your critical findings.
- ➢ Uses tools like tableau, Power BI, QlikView to create powerful reports and dashboards.

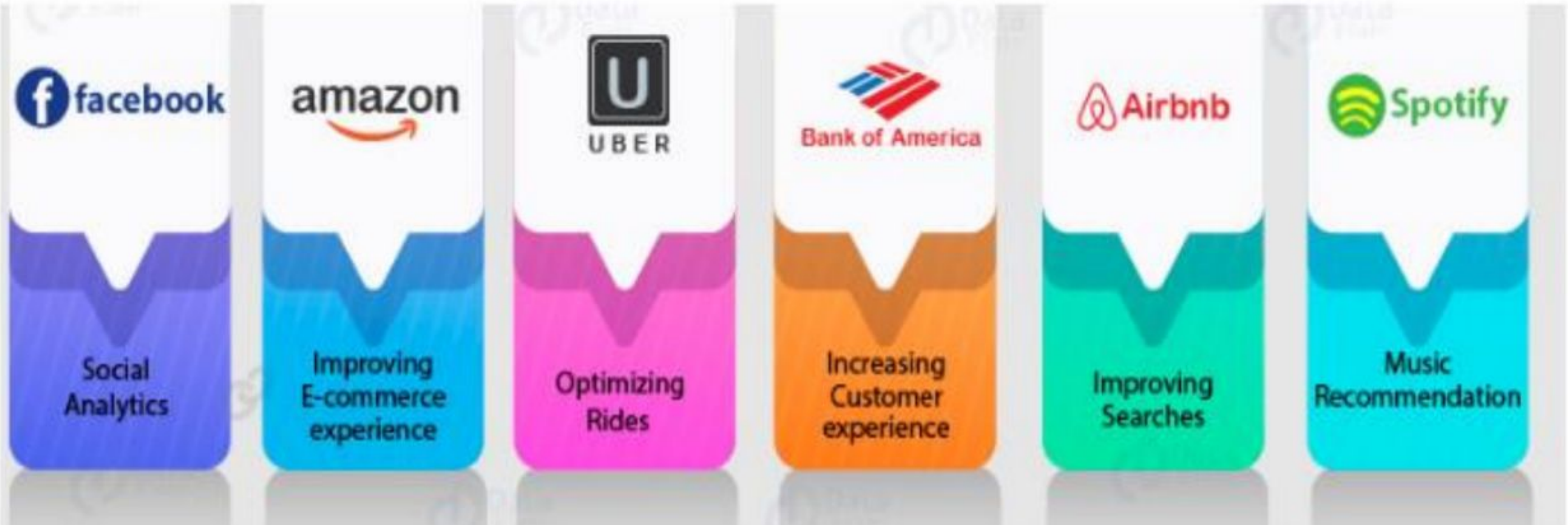
Data Science Life Cycle

Step 7: Deploys and maintains

- ➢ This is the final step where you present the results from your analysis to the stakeholders. You explain to them how you came to a specific conclusion and your critical findings.
- ➢ Test the selective model in a pre production environment before deploying in production environment.
- ➢ After successfully deployment, uses reports and dashboards to get real time analytics.
- ➢ Further monitor and maintain project performance

Data Science Use Cases

Big companies are using data science for different purposes.



Data Science Use Cases

- **Facebook – Using Data to Revolutionize Social Networking & Advertising**

➢ Facebook using advanced techniques like deep learning in data science to study user behaviour and gain insights to improve their product.

➢ Using deep learning, Facebook makes use of facial recognition and text analysis.

➢ In facial recognition, Facebook uses powerful neural networks to classify faces in the photographs. It uses its own text understanding engine called “DeepText” to understand user sentences.

➢ It also uses Deep Text to understand people’s interest and aligning photographs with texts.

Data Science Use Cases

- **Facebook – Using Data to Revolutionize Social Networking & Advertising**

➢ Facebook uses deep learning for targeted advertising. Using this, it decides what kind of advertisements the users should view.

➢ It uses the insights gained from the data to cluster users based on their preferences and provides them with the advertisements that appeal to them.

Data Science Use Cases

- **Uber – Using Data to Make Rides Better**

➢ Uber is a popular smartphone application that allows you to book a cab.

➢ Uber makes extensive use of Big Data because Uber has to maintain a large database of drivers, customers, and several other records.

➢ Uber contains a database of drivers. Therefore, whenever you hail for a cab, Uber matches your profile with the most suitable driver. What differentiates Uber from other cab companies is that Uber charges you based on the time it takes to cover the distance and not the distance itself.

➢ It calculates the time taken through various algorithms that also make use of data related to traffic density and weather conditions.

Data Science Use Cases

- **Bank of America – Using Data to Leverage Customer Experience**

➢ Using data science, banking industries are able to detect frauds in payments and customer information. It also prevents frauds regarding insurances, credit cards, and accounting.

➢ In order to minimize the losses, a bank needs to detect fraud sooner. In order to carry this out, banks employ data scientists to use their quantitative knowledge where they apply algorithms like association, clustering, forecasting, and classification.

Data Science Use Cases

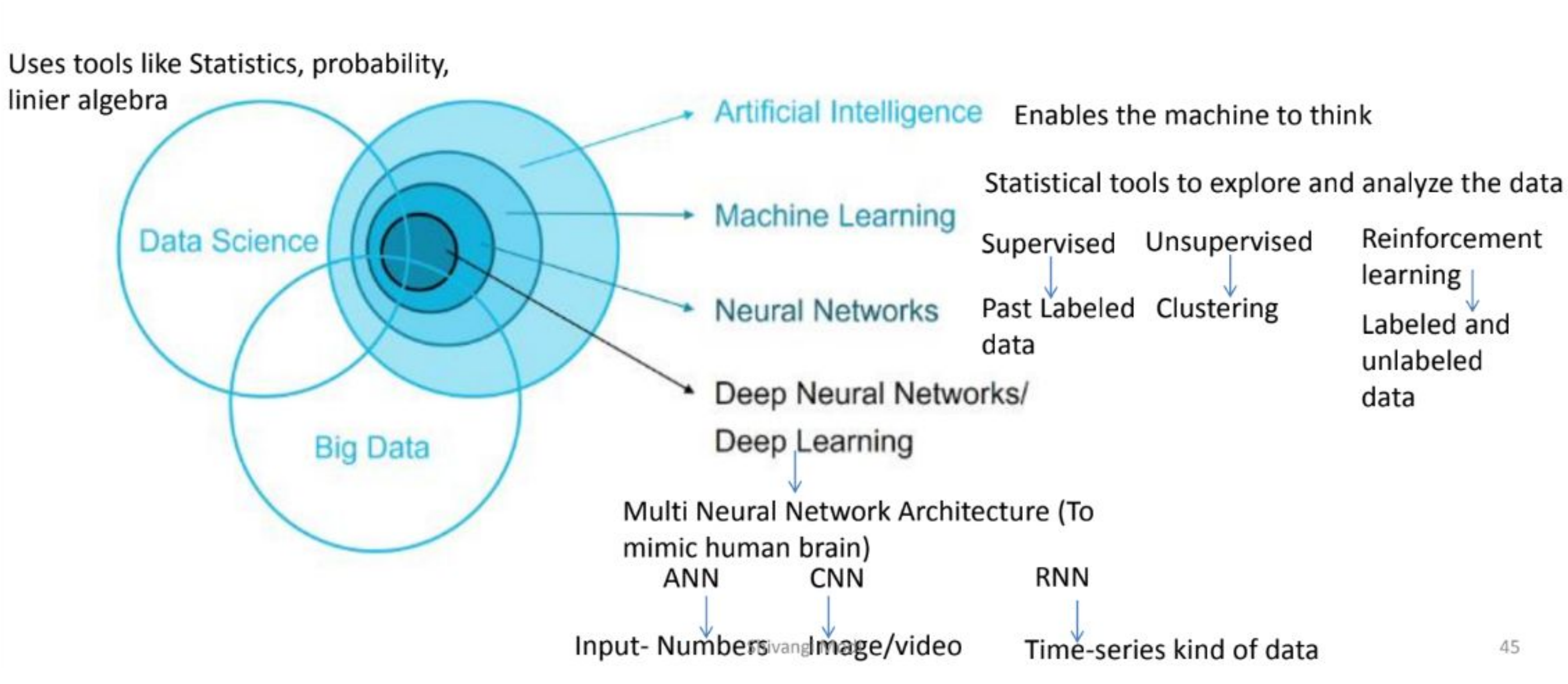
- **Spotify – Revolutionizing Music Streaming**

➢ It is an online music streaming giant that uses Data Science for providing personalized music recommendations

➢ Spotify is a data-driven company that leverages big data to provide personalized playlists to its users.

➢ In the year 2017, Spotify used data science to gain insights about which universities had the highest percentage of party playlists and which ones spent the most time on it. It publishes its findings on their page “Spotify Insights” to provide information about the on-going trends in the music.

AI vs ML vs DL vs Data science



Uses tools like Statistics, probability, linier algebra

Artificial Intelligence — Enables the machine to think

Statistical tools to explore and analyze the data

Machine Learning

Supervised → Past Labeled data

Unsupervised → Clustering

Reinforcement learning → Labeled and unlabeled data

Neural Networks

Deep Neural Networks/ Deep Learning → Multi Neural Network Architecture (To mimic human brain)

ANN → Input- Numbers

CNN → Image/video

RNN → Time-series kind of data

Tools and Libraries

Programming language

- R
- Python
- Java

Machine learning Algorithms

- Classification and clustering
- Regression
- Reinforcement
- Deep learning
- Dimensionality reduction

IDE (Integrated development environment)

- Pycharm
- Jupyter
- Spyder
- R Studio

Tools and Libraries

Web Scraping

- Beautiful soup library
- Scrapy tool
- URLLib library

Math

- Statistics
- Linear Algebra
- Differential Calculus

Data Visualization tools

- Tableau
- Power BI

Matplotlib library

- Data analysis
- Feature engineering
- Data Wrangling
- Exploratory data analysis

THANK YOU