Introduction

Smart Analytics for Big Data

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30/09/2020

Plan and Organisation of the lesson

Today

1. Introduction (45min)
2. Reproducible research (45min)
   - *in-class*: introduction & demo
   - *out-of-class*: reading
3. Case Study (1h30min)
   - Team work on Data Visualizations
   - Discussion

Introduction

Context

- Industry 4.0, Digital Factory, Internet of Things, Digital Economy
- Assessing the relevance of data and selecting the **right data for business decisions** is a key strategic capability.
- Analysis of complex and **big data**, **temporal** and **spatial** data
  - needs **specific skills** to search and to extract the relevant information
  - to **analyze** them accordingly with their specific dimensions.

Some definitions

Many notions

For examples *"AT&T business" offers*

Data science solutions for IoT including Artificial Intelligence and machine learning

Big Data

- most cited definition of big data includes the 3Vs (**Volume, Variety, and Velocity**) *Laney (2001)*
- big data should include '**Value**' *(Gantz et al., 2011)*
- big data should also have '**Veracity**' *(Zikopoulos et al., 2013)*

Data Sciences

- Data Manager
- Data Miner
- Data Analyst
- Data Scientist

Tools

Data Science, Machine Learning, Statistics, AI, etc

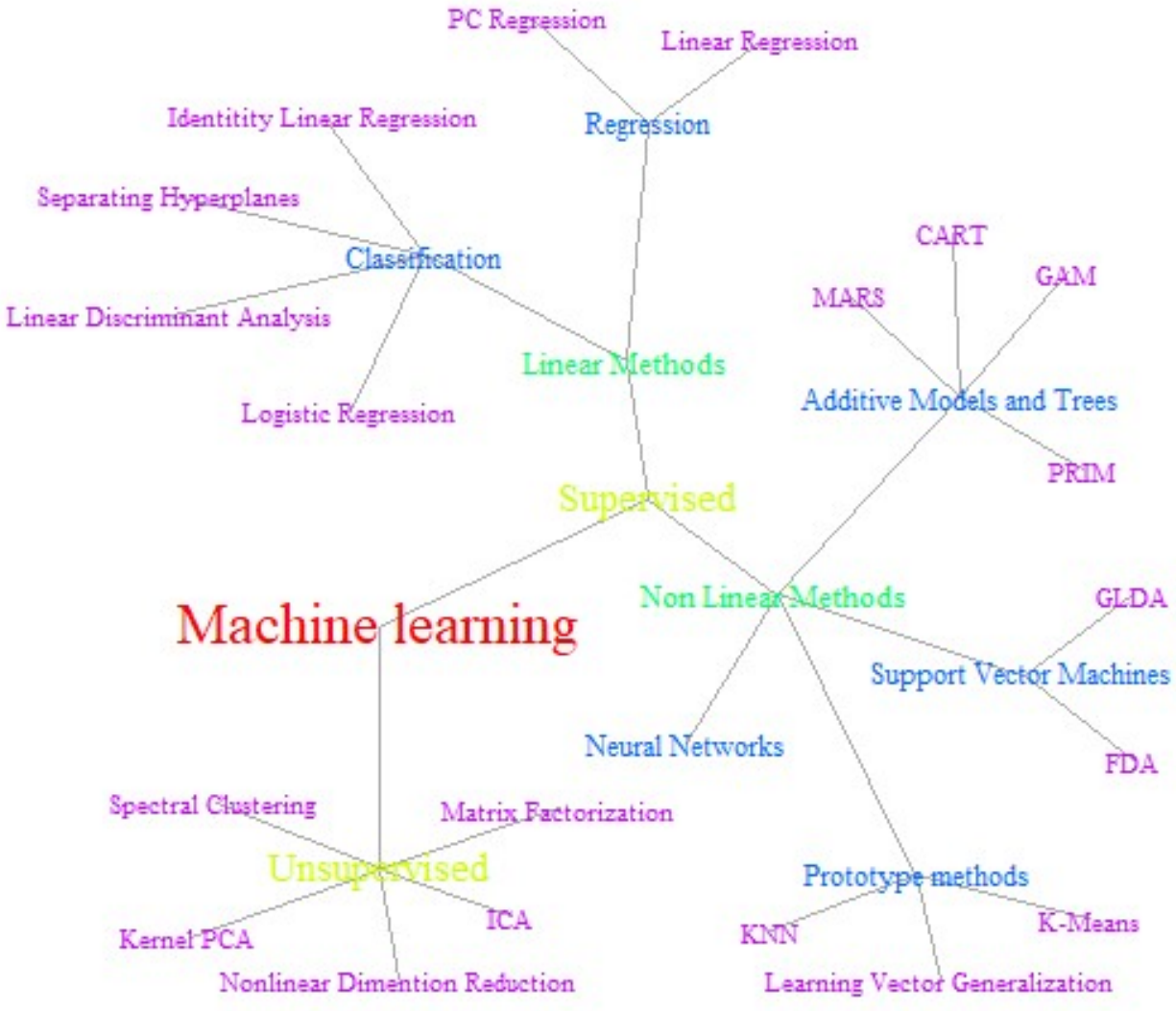
More than 30 models and families

- Generalized Additive Model
- Generalized Linear Model
- Generalized Non-Linear Model
- Multinomial Logistic Regression
- Multinomial Probit
- Linear Model
- Indicator (Identity) Linear Model
- Logistic Regression
- Probability (Unit) Regression
- Cumulative Logistic Regression
- Cumulative Probability (Unit) Regression
- Complementary Log-Log Model
- Continuation-Ratio Logistic Regression
- Hierarchical Logistic Regression
- Poisson Log-Log Regression
- Negative Binomial Regression
- Conditional Regression Model
- Mixed Logistic Regression
- Linear Discriminant Analysis
- Quadratic Discriminant Analysis
- Support Vector Machines
- Order Support Vector Machines
- Support Vector Ordinal Regression
- K Nearest Neighbours
- Classification And Regression Trees
- Separating Hyperplanes
- Neural Networks
- Feed-Forward Neural Networks
- Bayesian Neural Networks
- Markov Chains
- Markov Chains Monte Carlo
- Deep Neural Networks

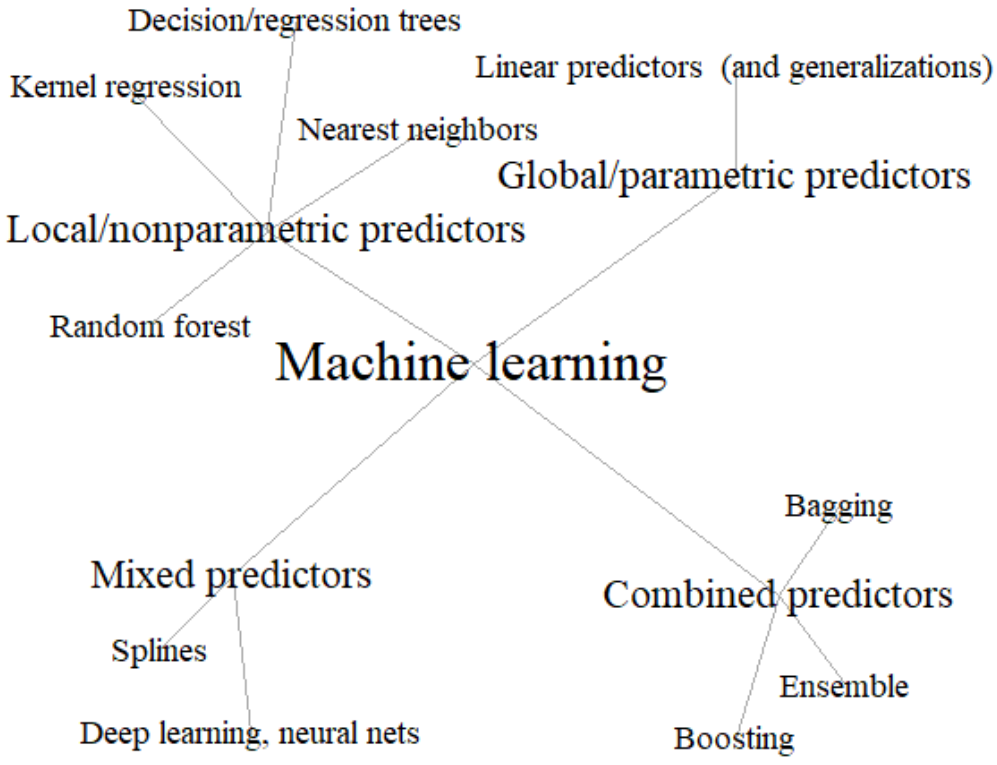
Several criterias differenciating the methods

- Supervised
- Unsupervised
- Additive
  - Linear
  - Non-linear
- Generative
- Discriminative
- Parametric
- Semi-parametric
- Non-parametric
- Classification
- Regression
- Binary data
- Multinomial data
- Ordinal data
- Count data
- Continuous data
- Explicative
- Data driven

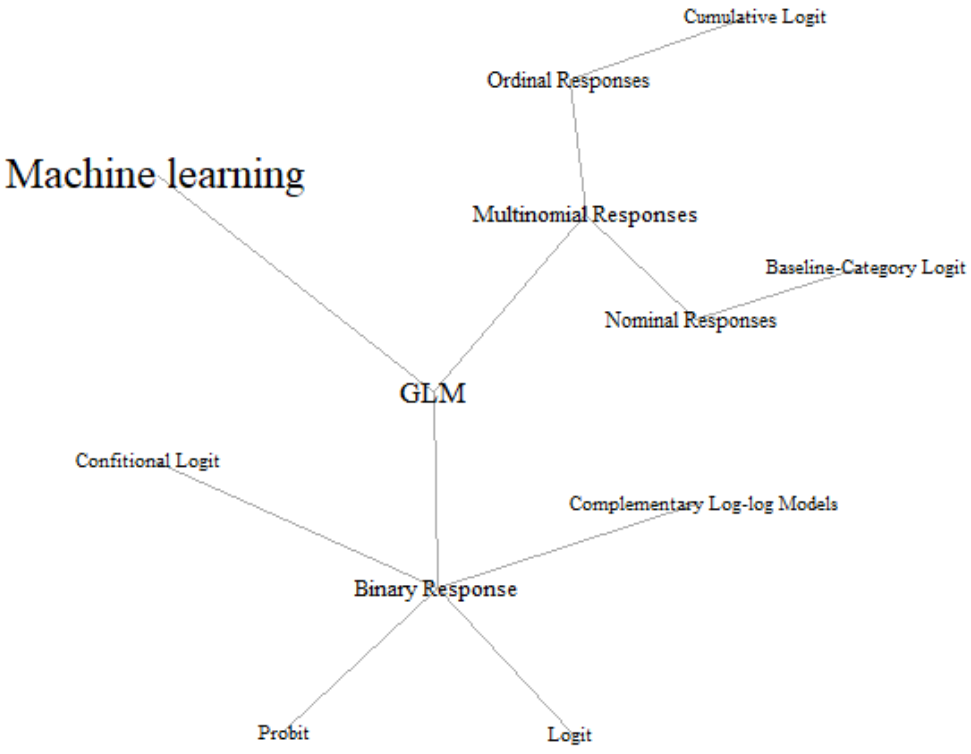
Hastie, Tibshirani, and Friedman (2009) *reference*



Mullainathan and Spiess (2017) *reference*



Agresti (2007) *reference*



Artificial Intelligence (AI)

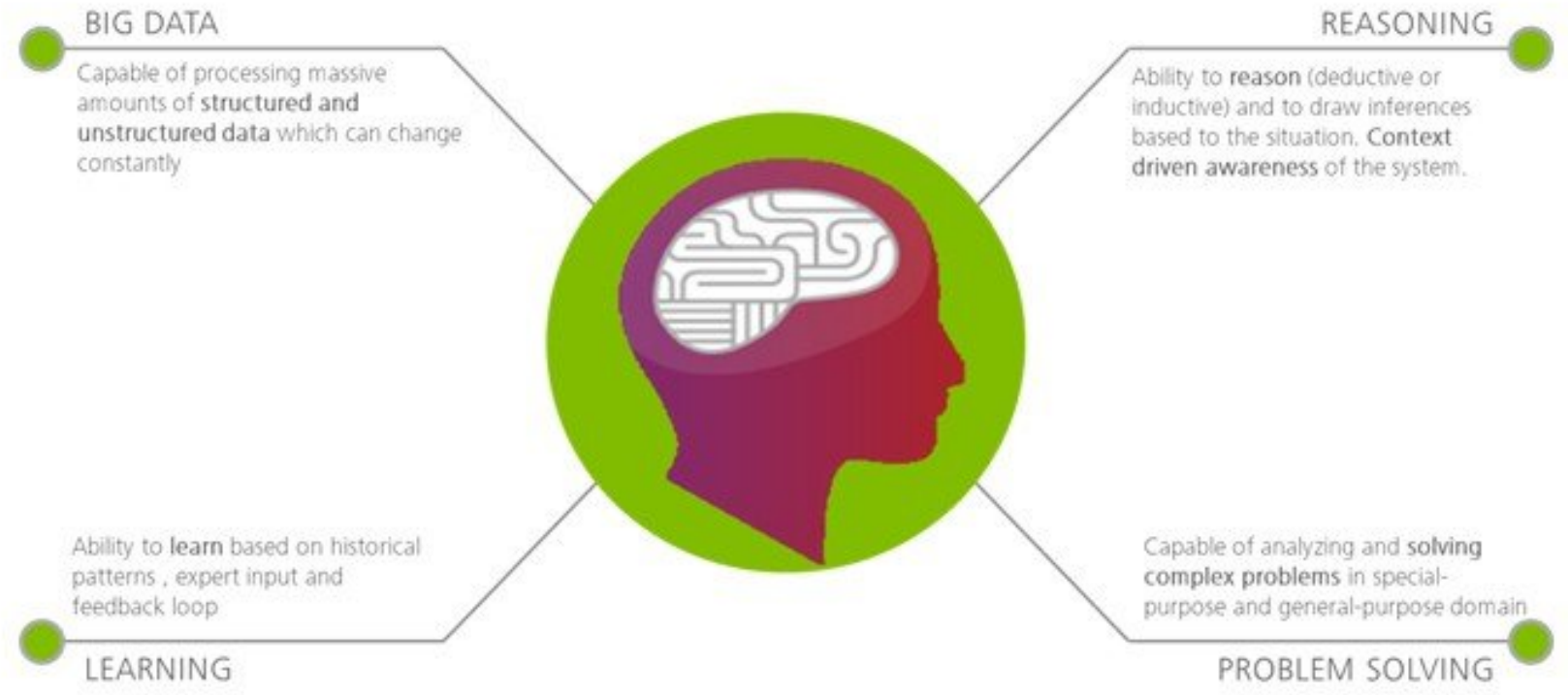


Figure 1: AI schema

Industrial issues

Smart Analytics in Industry 4.0

Lee, Kao, and Yang (2014) identify that

- self-learning machines are still far from implementation in current industries
- advances are expected in 5 distinct categories:

1. *Manager and Operator Interaction*: machine control and schedule design have to include machines health
2. *Machine fleet*: prognostic and health management methods have to consider the fleet of machines

1. *Product and Process Quality*: product quality informs on the process quality
2. *Big Data and Cloud*: Data management and distribution in Big Data environment
3. *Sensor and Controller Network*: decision-making algorithms depend on wrong and inaccurate readings

Smart Machine Maintenance

- Machine health awareness analytics with self-learning knowledge base
- Decision support analytics for self-maintenance

Servitization

- to shift from selling products, to selling an integrated product and service offering that delivers value in use (Martinez et al. (2010))

Product-Service System (PSS)

- system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers' needs, and have a lower environmental impact than traditional business models (Mont (2004))
- Market goal of manufacturers:
  - is not one-time product selling, but
  - continuous profit from customers by total service solution, which can satisfy unmet customers' needs.

Industrial big data environment

Industry 4.0 with *Smart Machine Maintenance*, *servitization* and *PSS* imply:

- different units of observation, analyse and decision
  - from 'human-related data' to 'machine generated data' (machine, controllers, sensors, manufacturing systems, etc.)
  - sales prediction, user relationship mining and clustering, recommendation systems, opinion mining, etc.

- SI networks. From the sensor to the dashboard and decision
  - compatibility and standard issue
  - vibration, pressure, etc. are added to historical data
  - this aggregation is called “Big Data”
- not a one shot process: dynamic workflow
  - integrated platform, predictive analytics, and visualization tools

Conclusion

Challenges are to switch:

- from Data Analytics
- to DS projects, including
  - BD dimension
  - DM
  - DA
  - OR

DS and OR : the new challenges

Class organisation

Goals

Be DM, DA and DS supervisor in the Big Data context

Teachers and Industrial Contributors

GI and Ensimag:

- *Christophe Bobineau*, MCF, Grenoble INP ENSIMAG
- *Iragaël Joly*,[1] MCF HDR, Grenoble INP Génie industriel
- *Pierre Lemaire*, MCF, Grenoble INP Génie industriel
- *Genoveva Vargas Solar*, DR, CNRS, LIG, HADAS Group

Invited Teachers:

- *Bruno Agard*, PR, Laboratoire en Intelligence des Données (LID), Département de Mathématiques et de Génie Industriel, École Polytechnique de Montréal

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Organisation of the course

- Data supply-chain: from data collection and production, storage and organization, management, exploitation and analysis, and communication.
- Big data and dynamic process of analysis needs transparent, repeatable and reproducible technics.
- Backward presentation: from needs to solutions

Three +1 parts

1. **Big-Data Management**
2) **Exploration of complex data with high dimensionality**
3) **Analysis of complex data with temporal and / or spatial dimensions**
4) **Visualization and communication**

Planning

Date	Semaine	Horaire	Intervenants	Thème	Horaire	Intervenants	Thème	Horaire	Intervenants	Thème
01/10/2020	S41	08h00			9h30	I. Joly	Intro	11h00	I. Joly	Intro - appli (Rmd)
08/10/2020	S42	08h00	I. Joly	Vizu + GIS	9h30	I. Joly	Vizu + GIS	11h00	I. Joly	Vizu + GIS - appli
15/10/2020	S43	08h00			9h30	C.Bobineau	Intro : Distributed data management and transa	11h00	C.Bobineau	Intro : Distributed data managemen
22/10/2020	S44	08h00	G Vargas	Map-Reduce	9h30	G Vargas	NoSQL/MongoDB	11h00	C Bobineau	HO1: Getting acquinted with Mongo
29/10/2020	S45	TOUSSAINT								
05/11/2020	S46	08h00	C.Bobineau	HO1: Getting acquinted wi	9h30	G Vargas	HO2 : Sharding with Mongo	11h00	G Vargas	Project
12/11/2020	S47	08h00		Projet Introduction ?	9h30	G Vargas	Data Analytics	11h00	G Vargas	Data processing & Analytics
19/11/2020	S48	13h30	B Agard		15h00	B Agard		16h30	B Agard	
26/11/2020	S49	13h30	B Agard		15h00	B Agard		16h30	B Agard	
03/12/2020	S50	13h30	B Agard		15h00	B Agard		16h30	B Agard	
10/12/2020	S51	08h00	I. Joly	TP Projet Mobilité	9h30	I. Joly	TP Projet Mobilité	11h00	I. Joly	TP Projet Mobilité
	S52	NOEL								
		NOEL								
07-janv	S01	08h00	I. Joly	Categorical Data Analysis	9h30	I. Joly	Categorical Data Analysis	11h00	I. Joly	Categorical Data Analysis
14-janv	S02	08h00	I. Joly	Survival analysis	9h30	I. Joly	Survival analysis	11h00	I. Joly	Survival analysis
21-janv	S03	08h00			9h30		Exam	11h00		Exam

Figure 2: Planning 2020 - Version sept

Tools

- RStudio = R + Rmarkdown
- Other tools for DM: MongoDB, ...

Evaluation

- Individual evaluation, e.g. in-class work (TP), multiple choice questions or closed-formed quizzes and **exam**
- Application Project realized in group: **Mobility project**

Conclusion

DS Workflow

From the class

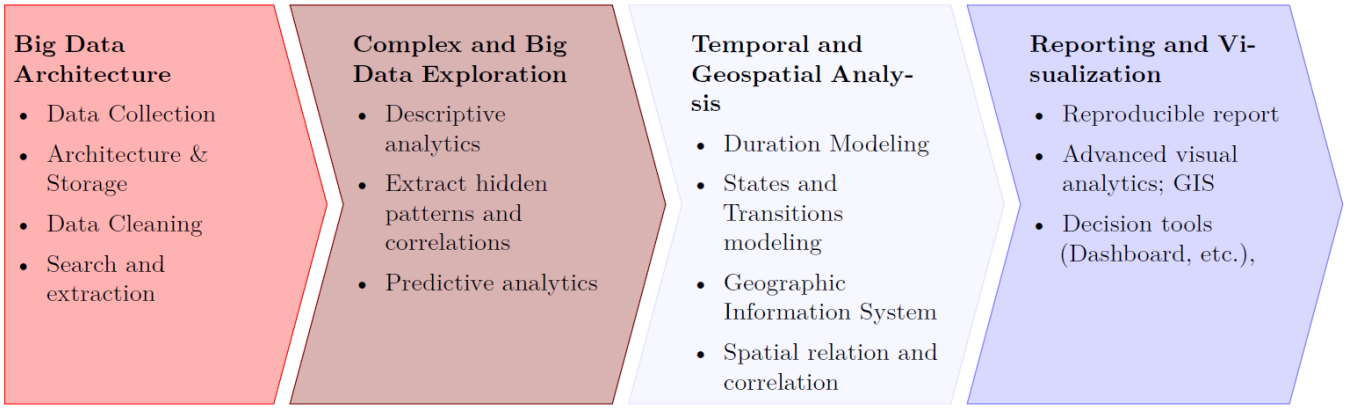
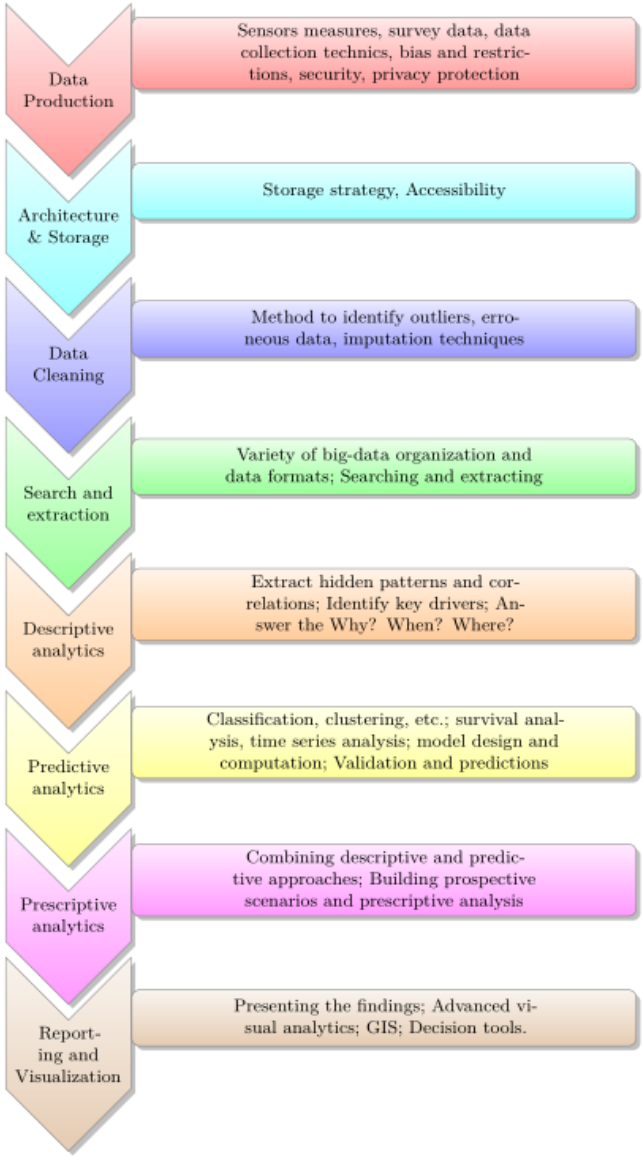


Figure 3: Data processing and analytics

To


Data Production
Sensors measures, survey data, data collection technics, bias and restrictions, security, privacy protection
Architecture & Storage
Storage strategy, Accessibility
Data Cleaning
Method to identify outliers, erroneous data, imputation techniques
Search and extraction
Variety of big-data organization and data formats; Searching and extracting
Descriptive analytics
Extract hidden patterns and correlations; Identify key drivers; Answer the Why? When? Where?
Predictive analytics
Classification, clustering, etc.; survival analysis, time series analysis; model design and computation; Validation and predictions
Prescriptive analytics
Combining descriptive and predictive approaches; Building prospective scenarios and prescriptive analysis
Reporting and Visualization
Presenting the findings; Advanced visual analytics; GIS; Decision tools.

References