Feb – Jun 2023
IT258

Data Science – Introduction and Basics

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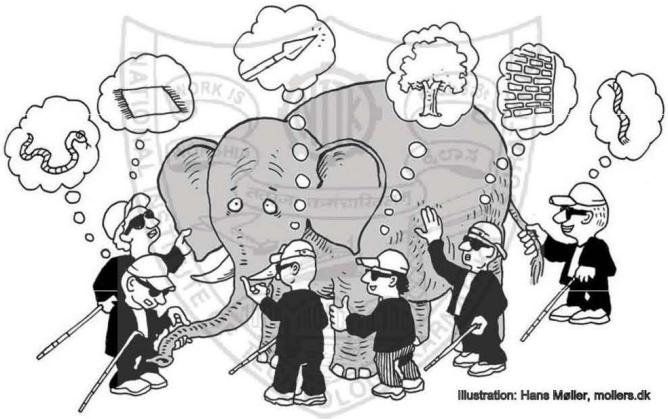
What is Data Science?



What is Data Science?

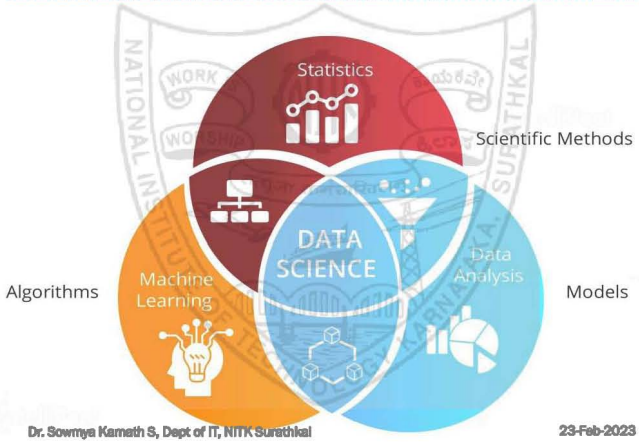
"the application of **computational** and **statistical** techniques to address or gain **insight** into some problem in the real world"

What is Data Science?

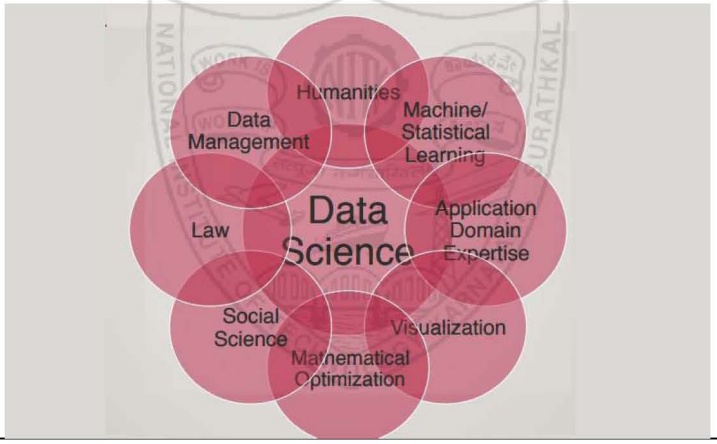
"is an interdisciplinary field of scientific methods, processes, algorithms and systems to extract **knowledge** or insights **from data** in various forms, either **structured or unstructured**."

Data science = statistics +
data processing +
data modeling +
visualization +
machine learning +
analytics +
big data + …

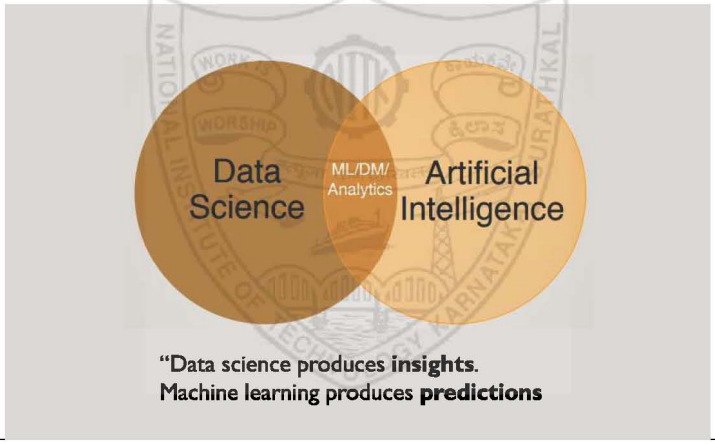
Data Science



The Data Science Confluence



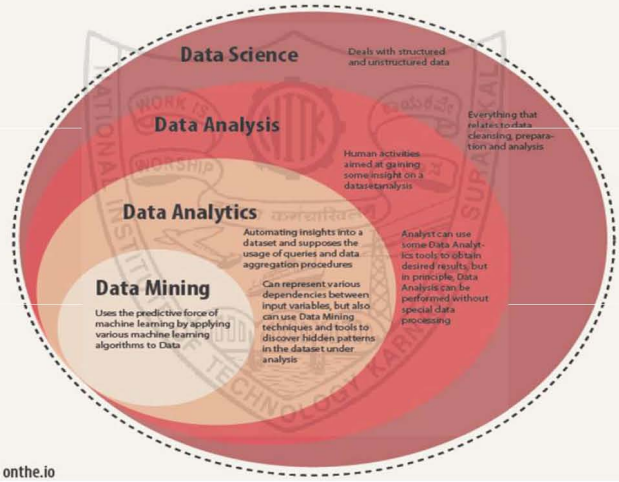
Data Science and AI



Data related disciplines..

- **Data Mining**
- **Data Analytics**
- **Data Analysis**
- **Data Science**

What is the difference between Data Science, Data Analysis, Data Analytics and Data Mining ?



Source: onthe.io

Data related disciplines..

- **Data Mining**

Given lots of data,

Discover patterns and models that are:

Valid: some findings on new data with some certainty
Useful: should be possible to act on the item
Unexpected: non-obvious to the system
Understandable: humans should be able to interpret the pattern

Data related disciplines..

- **Data Mining**
  - **Descriptive methods**
    - Find human-interpretable patterns that describe the data
    - **Example:** Clustering
  - **Predictive methods**
    - Use some variables to predict unknown or future values of other variables
    - **Example:** Recommender systems

Data related disciplines..

- **Data Analytics**
  - applying a computational/algorithmic process to derive meaningful, previously unknown insights into the various aspects of the dataset.
  - E.g. Predictive analytics, preventive analytics
- **Data Analysis**
  - the process of compiling and analyzing data to support decision making.
  - E.g. For exploratory data analysis, data mining etc..

Data related disciplines..

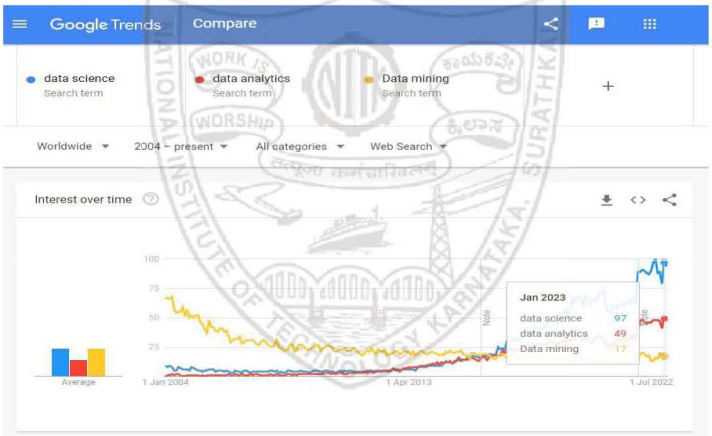
- **Data Science**

  the ability to look at things 'differently' using a combination of
  - mathematics,
  - statistics,
  - programming,
  - in the context of the problem being solved,

  +

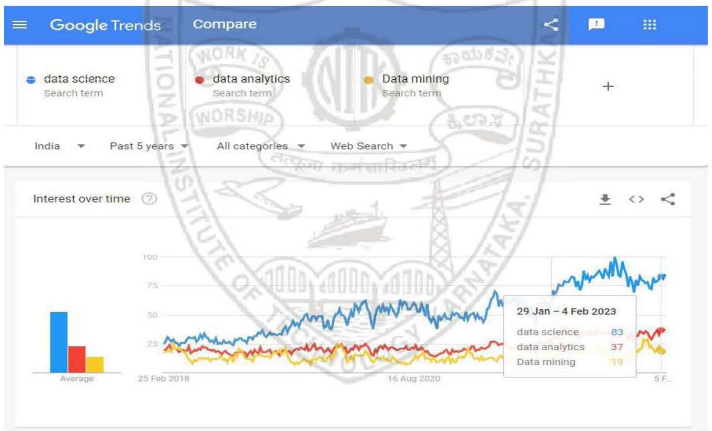
  the activities of cleansing, preparing and aligning the data.

Comparing Interest in Data-related disciplines
(Worldwide, All time)



Comparing Interest in Data-related disciplines
(Worldwide, Last 5 years)

Comparing Interest in Data-related disciplines
(India, last 5 years)



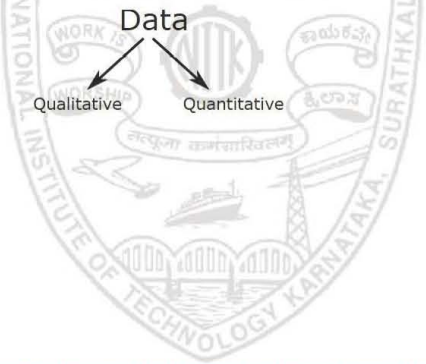
The most fundamental question...

What is data???

Trying to define data ...

- "facts and statistics collected together for reference or analysis."
- "things known or assumed as facts, forming the basis for reasoning or calculation."
- "used to describe things by assigning a value to them."

What is data?



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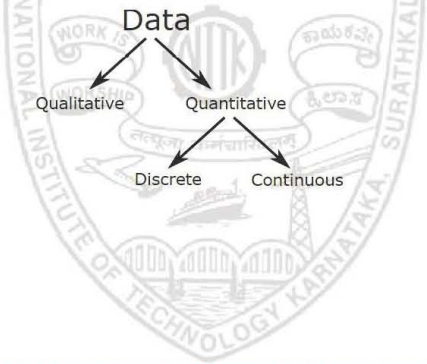
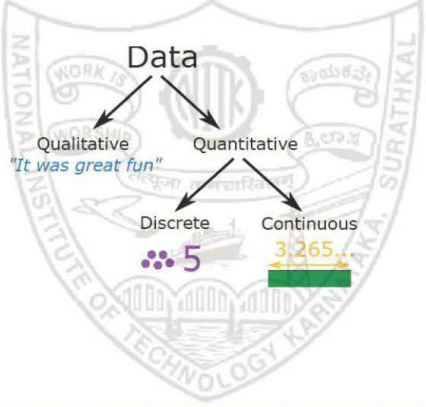


What is data?

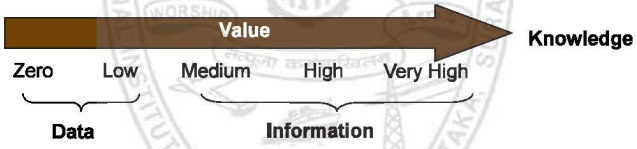


Data v/s. Information

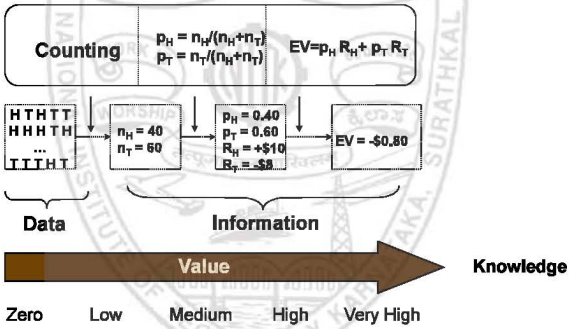
- **Data**: a set of facts.
- **Information**: data that are processed to useful; provides answers to "who", "what", "where", and "when" questions
- **Knowledge**: application of data and information; answers "how" questions.
- **Understanding**: an appreciation of "why"
- **Wisdom**: evaluated understanding.

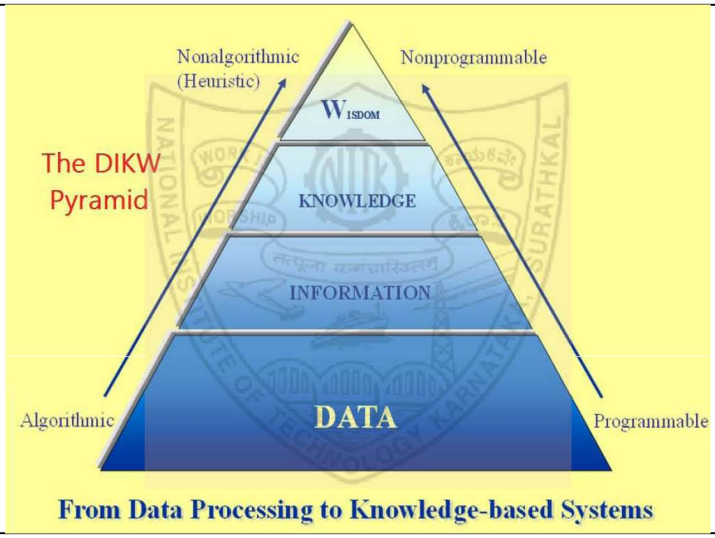
Ref: Ackoff, "From Data to Wisdom", 1989

Relationship between D, I and K



DIKW in data analysis...

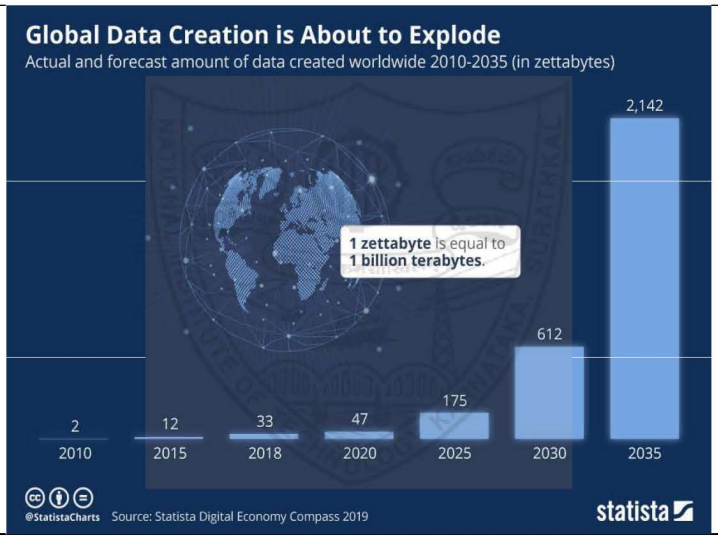




From Data to Knowledge and beyond...

"Datafication"

- "Datafication"
  - taking all typical aspects of life and turning them into data.
  - Term coined by Kenneth Cukier and Victor Mayer-Schöenberger in 2013.

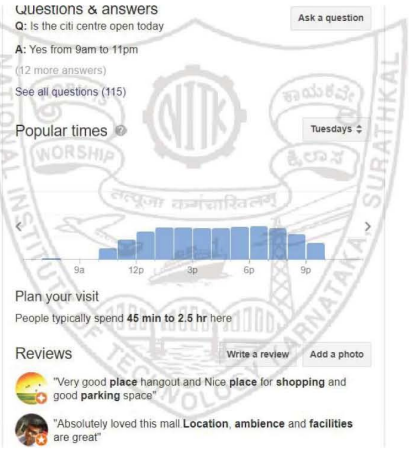


Datafication (contd.)

- Data examples →
  - What you like/enjoy has been turned into a stream of your "likes"
  - What you read and share is considered your opinion on certain topics (particularly in politics)
  - Datafying cities, workplaces, traffic systems, processes, ….

Datafying cities

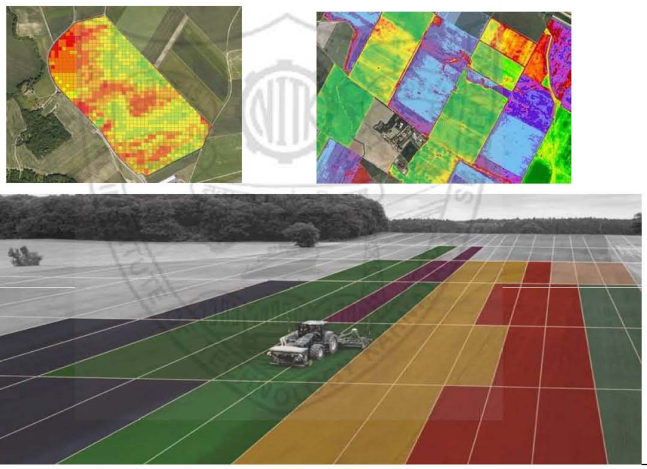
Datafying public spaces



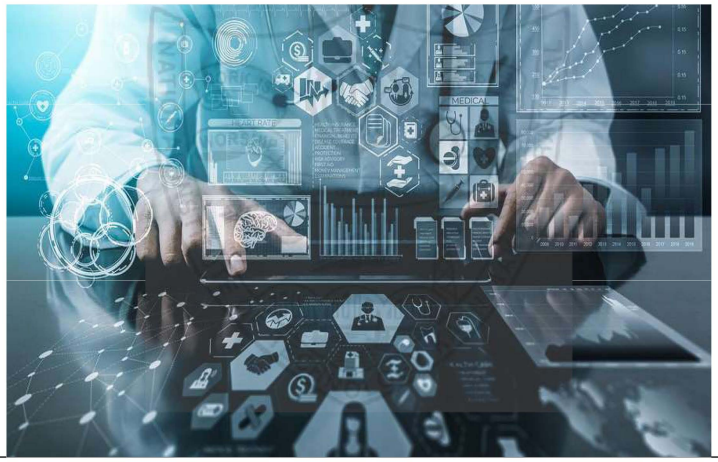
Datafying systems

Datafying processes

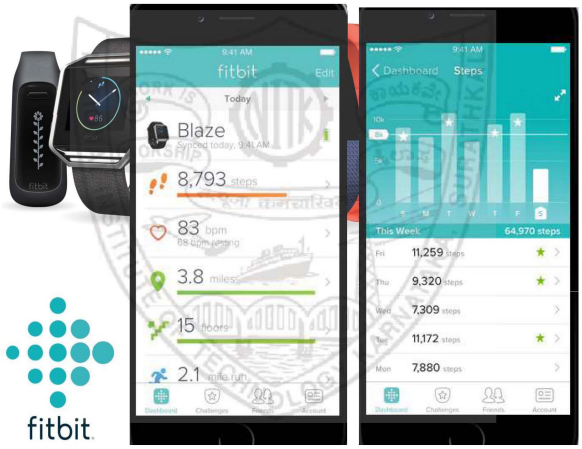
Datafying processes



Datafying domains



Datafying activities



amazon

Customers who bought this item also bought

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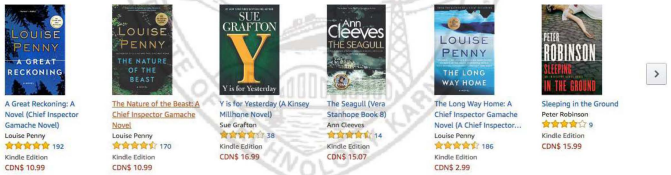
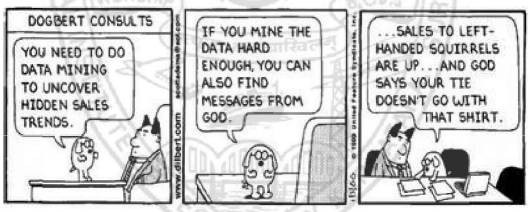


So, is DATA all we need?

Is Data all we need?

- **Meaningfulness** of Analytical Answers is important!
  - Significant risk of "**discovering**" patterns that are **meaningless**.



Is Data all we need?

- **Bonferroni's principle:**

  "… if you look for interesting patterns in more places than your amount of data will support, you are bound to find crap!"

Is Data all we need?

- **Bonferroni's principle:**
  - a statistical method for accounting for random events.
  - Process:
    - determine the number of expected random events of interest in the dataset
    - if the observed number is significantly greater than this number, the chances of *any* observations providing useful insight are almost nonexistent.

Example: Michael Drosnin's bestseller book

Proposed that purportedly meaningful messages can be extracted using the *Equidistant Letter Sequence* (ELS) method, where, letters are selected based on a starting point and counting every nth letter based on a given 'skip number' in a given direction.

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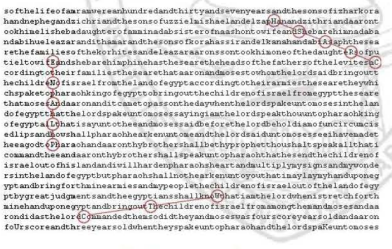
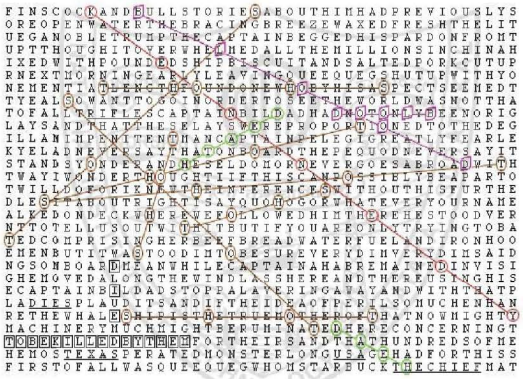


"WTC plane crash"

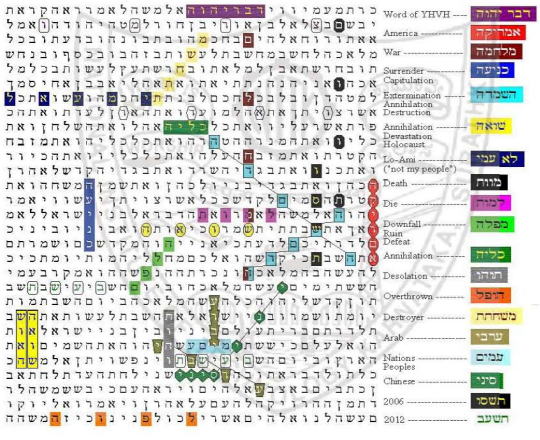
"Kennedy shot"

Reaction to Michael Drosnin's hidden codes book



Ref: Assassinations Foretold in Moby Dick! https://users.cecs.anu.edu.au/~bdm/dilugim/moby.html

Reaction to Michael Drosnin's hidden codes book

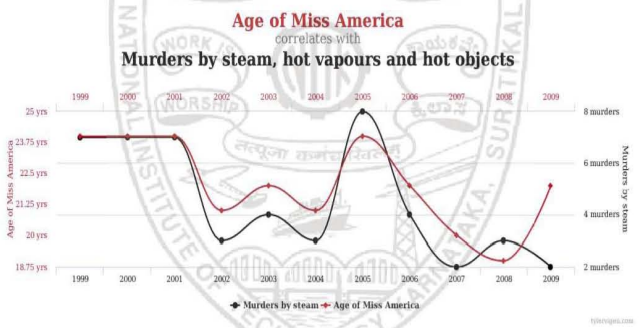


Reaction to Michael Drosnin's hidden codes book

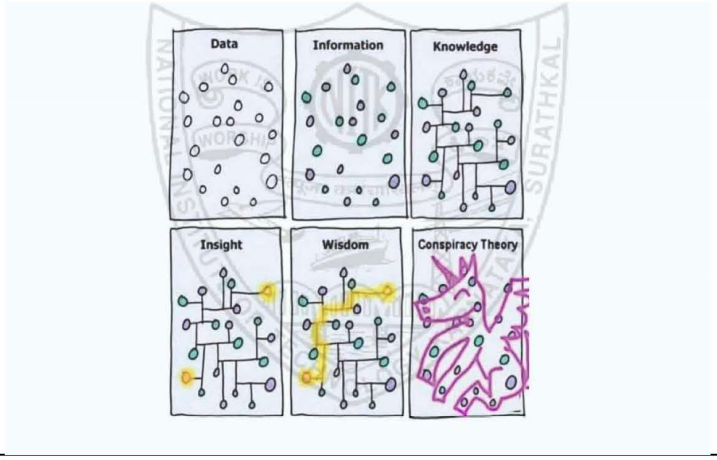
The Demise of Drosnin: A **shocking discovery** has been made deep within the text of **Moby Dick**.

Ref: https://users.cecs.anu.edu.au/~bdm/dilugim/drosnin.html

Bonferroni's Principle - example



DIKW exploited to the extreme ?



Rhine Paradox

Joseph Banks Rhine (September 29, 1895 – February 20, 1980), usually known as **J. B. Rhine**, was an American botanist who founded parapsychology as a branch of psychology, founding the parapsychology lab at Duke University, the *Journal of Parapsychology*, the Foundation for Research on the Nature of Man, and the Parapsychological Association. Rhine wrote the books *Extrasensory Perception* and *Parapsychology: Frontier Science of the Mind*.

Parapsychology is the study of alleged psychic phenomena (extrasensory perception, telepathy, precognition, clairvoyance, psychokinesis (also called telekinesis), and psychometry) and other paranormal claims, for example, those related to near-death experiences, synchronicity, apparitional experiences, etc.[1]

Joseph Banks Rhine; https://en.wikipedia.org/wiki/Joseph_Banks_Rhine

Rhine Paradox

- Joseph Rhine's Extra-sensory Perception experiments.
  - a great example of how not to conduct scientific research!

Total Information Awareness

- Four states of Information Awareness -
  - KNOW WHAT YOU KNOW
  - DON'T KNOW WHAT YOU KNOW
  - KNOW WHAT YOU DON'T KNOW
  - DON'T KNOW WHAT YOU DON'T KNOW

Total Information Awareness

- Four states of Information Awareness -
  - KNOW WHAT YOU KNOW—*Information you **know** and **have**.*
  - DON'T KNOW WHAT YOU KNOW—*Information you **don't know** you **have***
  - KNOW WHAT YOU DON'T KNOW—*Information **you know you need** but **don't have.***
  - DON'T KNOW WHAT YOU DON'T KNOW—*Information you **don't even know exists**.*

Total Information Awareness

- TIA - More of an desire than a reality
  - Impossible to achieve as we cannot know everything, in every context.

Total Information Awareness

- TIA - More of an desire than a reality
  - Impossible to achieve as we cannot know everything, in every context.
  - If you are looking for so many vague connections, then you will find things that were bogus.
    - Violation of innocents' privacy or worse!

Is Data all we need?

- It is easy to find "interesting" patterns where none exist!
- How should we judge whether a "pattern" is interesting?
- When should we worry about falsely labeling patterns "interesting"? (E.g. Google mistranslates a sentence vs. incorrect cancer diagnosis. . .)
- ....

Is data all we need?

- Major Challenges –
  - How to store data?
  - How to process this data?
  - How to analyse this data?
  - How to model this data?
  - .....
  - How to transform into **interesting** and **meaningful actionable** insights / knowledge?

Data + __?__ = value + insights = profits/power/upper hand!

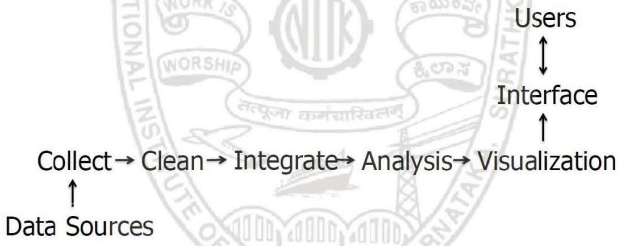
Goal of Data Science

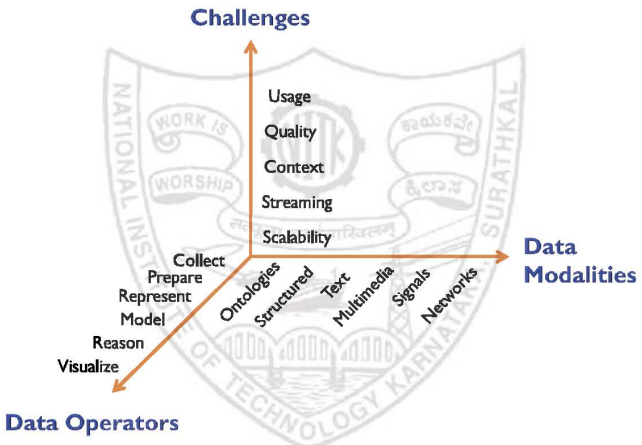
Turn raw data into data products

Data to Data products....

- Transaction Databases → *Fraud Detection, purchase trend analysis ..*
- Wireless Sensor Data → *Smart Home, automated monitoring ..*
- Text Data, Social Media Data → *Opinion Mining, Product Reviews, Consumer Satisfaction*
- Software Log Data → *Automatic Troubleshooting, Bug tracking ..*
- Genotype and Phenotype Data → *Disease prediction, new treatments, patient modeling …*

The Life of Data





Data Scientist/Analyst - Responsibilities

- Data Management
  - Data collection, storage, cleaning, filtering, integration …
- Large-scale Parallel Data Processing
  - Parallel computing, incremental processing…
- Statistics and Machine Learning
  - Data modeling, inference, prediction, pattern recognition …
- Interface and Data Visualization
  - HCI design, visualization, story-telling…

More reading...

- Bell, Gordon, Tony Hey, and Alex Szalay. "*Beyond the data deluge.*" *Science* 323.5919 (2009): 1297-1298.
- O'Neil, Cathy, and Rachel Schutt. *Doing data science: Straight talk from the frontline.* " O'Reilly Media, Inc.", 2013.
- Baesens, B. (2014). *Analytics in a big data world: The essential guide to data science and its applications*. John Wiley & Sons.