# The Fundamentals: Introduction to Artificial Intelligence and its impact on Education

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# Research everywhere, Data Everywhere, Solutions- old and new

If you look around, everywhere you will find research that has been previously done

Starting from our cloths, the stitches of our cloths, the tables and chairs, the pens and pencils, computers, cell phones, networks, writing boards, building itself, electricity and lights, refrigerators, fans, supplies and distributions, internet,  packaging, wrappers and  bags, spectacles, ornaments, perfumes, medicines, materials, processed food, chemical processes, software production pipelines, electronics and IC chips, cars, oil and minerals, artifacts, sports equipments, travel and tourism, finance and taxes, legal matters, logistics, resource planning from small to large, agriculture, education, arts and culture, music, cinema, sound systems, employment, forecasting, media, water management.. diverse fields

… name a topic and you may even find phd thesis or research articles connecting to them!

# What was research yesterday may not be research today

Newton’s laws

Kirchoff’s laws

Ohm’s law

The laws of thermodynamics

Value of gravitational constants

Principles of electricity generation

Laws of optics

Steam engine

…. Today we use them, and do further research

# Example Key Ideas that lead to tremendous technology impact on the humanity

Mechanics

Steam Engine

Electricity and Electronics

Communication on wires and wireless frequencies

Material science

Organic and inorganic chemistry

The Computer and Programming

# A few Modern Challenges

Non-conventional sources of Energy

Waste-management and recycling

Rapid construction and engineering

Satellite technologies

Efficient engineering- power transmission, power conversion and utilization

Compact storage for information

Fail safe systems

Stable Economies

Welfare and sustainability

Use of Computers for better Living

# A Quest from the Known into the Unknown

**Ideas**: Set theory, the Biological Evolution Tree, Big Bang Theory, String Theory

**Theorems**: Pythagoras Theorem, Pumping Lemma

**Laws**: Ohm's Law, Newton's laws, interchangeability of mass and energy

**Techniques**: Proof by induction, making plastic from crude oil, making steel

**Algorithm**: Shortest Path Algorithm, Searching and Sorting, AI algorithms

**Structural organization**: Composition of Atom, Structure of a DNA, Periodic table

**Dynamic behavior**: Celestial motions-N body problem, Electromagnetic induction, IC Engine, PN junction, electronic gates, flip-flops, circuits, electricity distribution

**Natural Processes**: formation of a black hole, nuclear fusion in the Sun, fertilization of life, birth process, process of digestion, body metabolism processes, seasons

# Science vs. mathematics and Logic

Science is about the physical universe

Maths can be used to model ideas in science

Maths can be done independently

Maths is an axiomatic system, which gives rise to an artificial universe

We map real life behaviors to Mathematical models

If that works,  then can we analyse, understand, and utilize the models for our use

Logic is part of Mathematics, and it is its foundation too

# Scientific method of Enquiry

Observe, Note

Hypothesize, Fit a mathematical model

Experiment and Validate with variations - repeatability

Concretize theories

# Mathematical method of Discovery

Axiomatize

Create a little universe, Observe properties

Hypothesize, Conjecture

Prove

# The Role of Statistics

Data is at the core of statistics

Statistics tries to generate information from Data, making sense out of data

E.g. Census, Minerals, Water Supplies, Gender Rations, Literacy, Legal cases pending, Employment, Electricity and water Consumption, Rainfall,

Works of Prof. Mahalanobis and colleagues in statistics, planning commission of India and the surveys- for resource allocation and planning

Random variables, Distributions and statistical properties

Queuing theory, Markov models, stochastic processes

Use statistics as models to explain phenomena

Statistics is relevant everywhere today- from planning to data science

# Data Science Foundations

Collect Data

Analyze Data

Find patterns and behaviors

Model fitting

Predict the unknown

Run simulations

- For example, given maths and language subject marks, can science marks be predicted?
- Given energy consumption trends, can the needs be predicted?
- Given generation of waste, can pollution and AQI be predicted?
- Given production of grains and crops, can availability and prices be predicted?
- Statistics and data science can be applied to any disciple that generates data

# Logic Foundations

Truth and Contradiction: T, F

Logical Operations: AND, OR, EXOR, NOT, Implication

Deduction and Inference Process

Apply logic to real world situations: Beginning of AI

- Logic Programming
- Expert Systems

# Ontology and Linguistic Foundations

Concepts and Words

Morphologis and Grammar

Syntax and Semantics

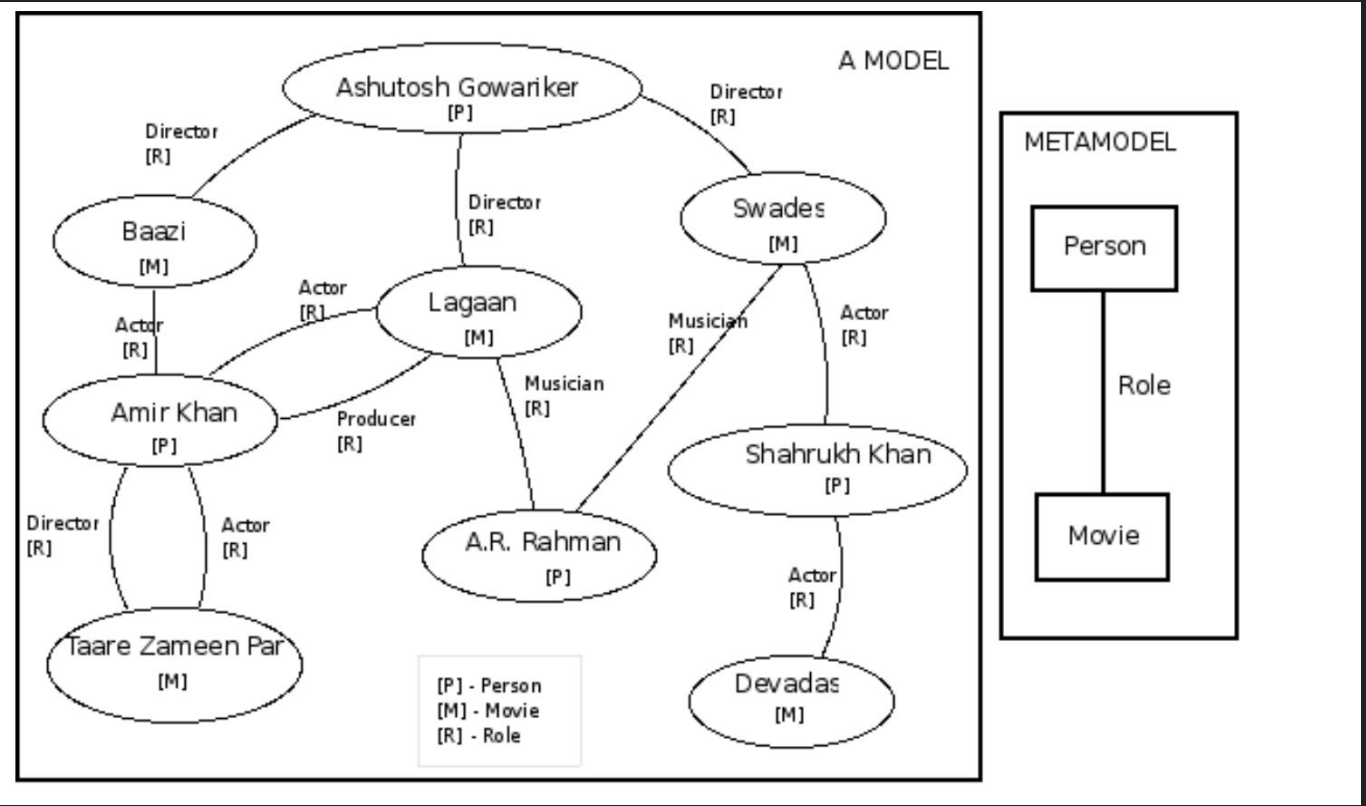
Ambiguities and Context

Ontology Categories and Network of Words

Linguistic and Cognitive Processes:

- Comprehension, Summarization, Generation, Rewriting etc.

# Knowledge Graphs




An image from our project website at iitb.

# Media Foundations: Audio and Visual Information

Representation of Audio, Speech in terms of raw signal

Representation of Visual Information in terms of Pixel Values

Representation of Video in terms of sequences of Frames

Mixed Media (multi-media)

Multi-media is packed with information

# Programming Foundations

Functions, Member Functions, Procedures, Loops, Recursion

Variables, Data structures, Types and Classes

Declarative Specifications

Algorithms

Memory Representations

Storage Representations

Networking and Distributed Computing

# The Culmination into AI

Statistics + Logic + Programming + Linguistics and Ontologies + Media + Hardware ⇒ Modern AI

# Artificial Intelligence: Approximating Intelligence

Early AI involved Knowledge Graphs, Search techniques, Logic

Modern AI involves model building using gigantic data sources

Then the trained models are used to perform tasks

There are a huge collection of new AI algorithms and techniques

Success of AI over past few decades, more surprisingly the LLMs and generative AI has created lots of new opportunities

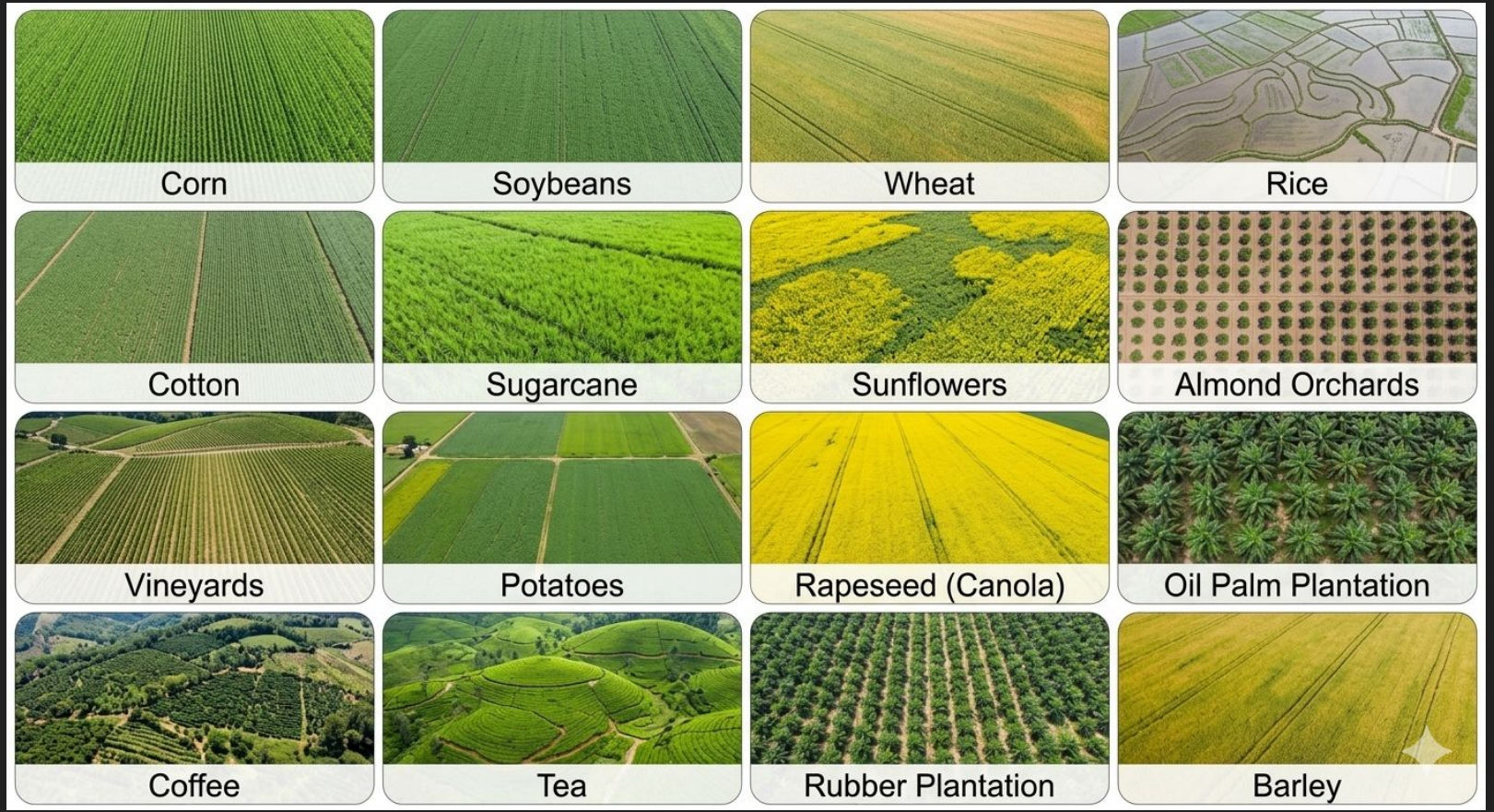
Pervasive Nature for applications and sensory domains=> **Involving tasks which do not have exact algorithms or very fast algorithms**

# The Turing Test for AI:

*Will a human being be able to tell the difference between a human and a computer?*

# Satellite Image Recognition Task

image generated from Gemini AI



# Face Recognition Task

Face Recognition
- Now available on devices too


image generated from Gemini AI

# Stock Market Predictions

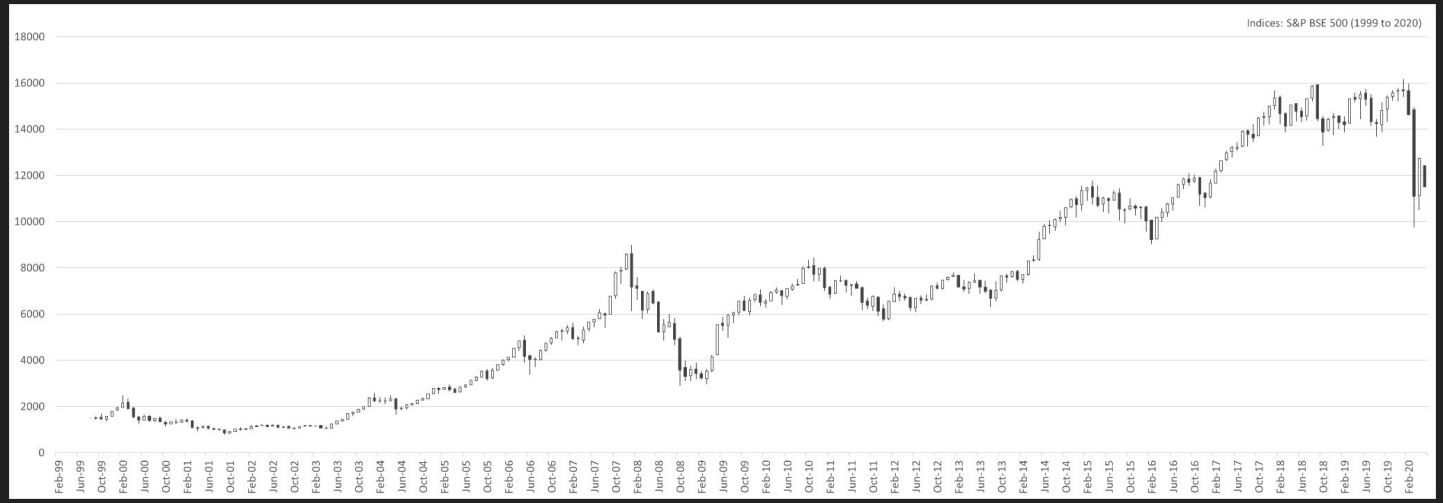



image from wikipedia

# Energy Consumption Prediction

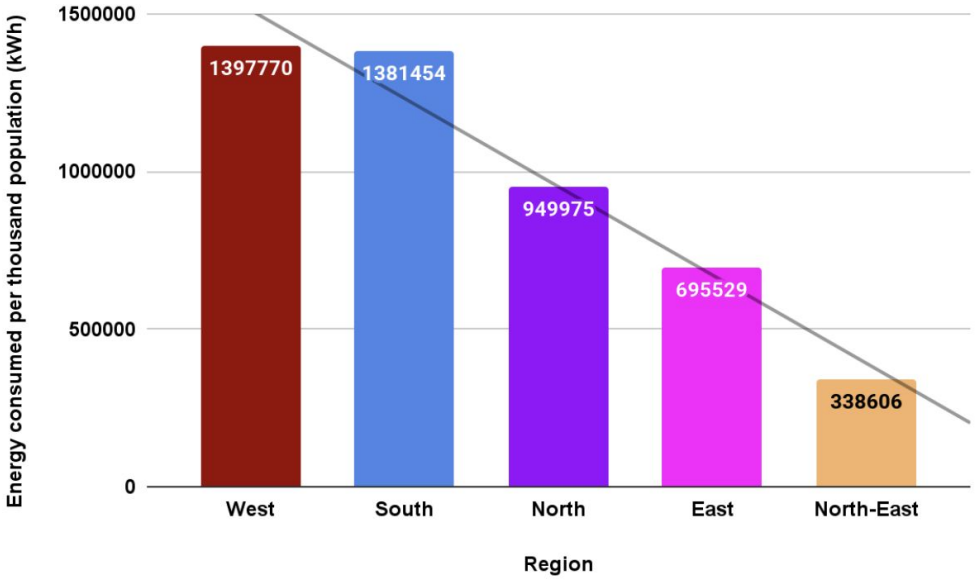



*Image 1: Region Wise electricity consumption in India* | Data Source: CEA

# Monsoon Prediction

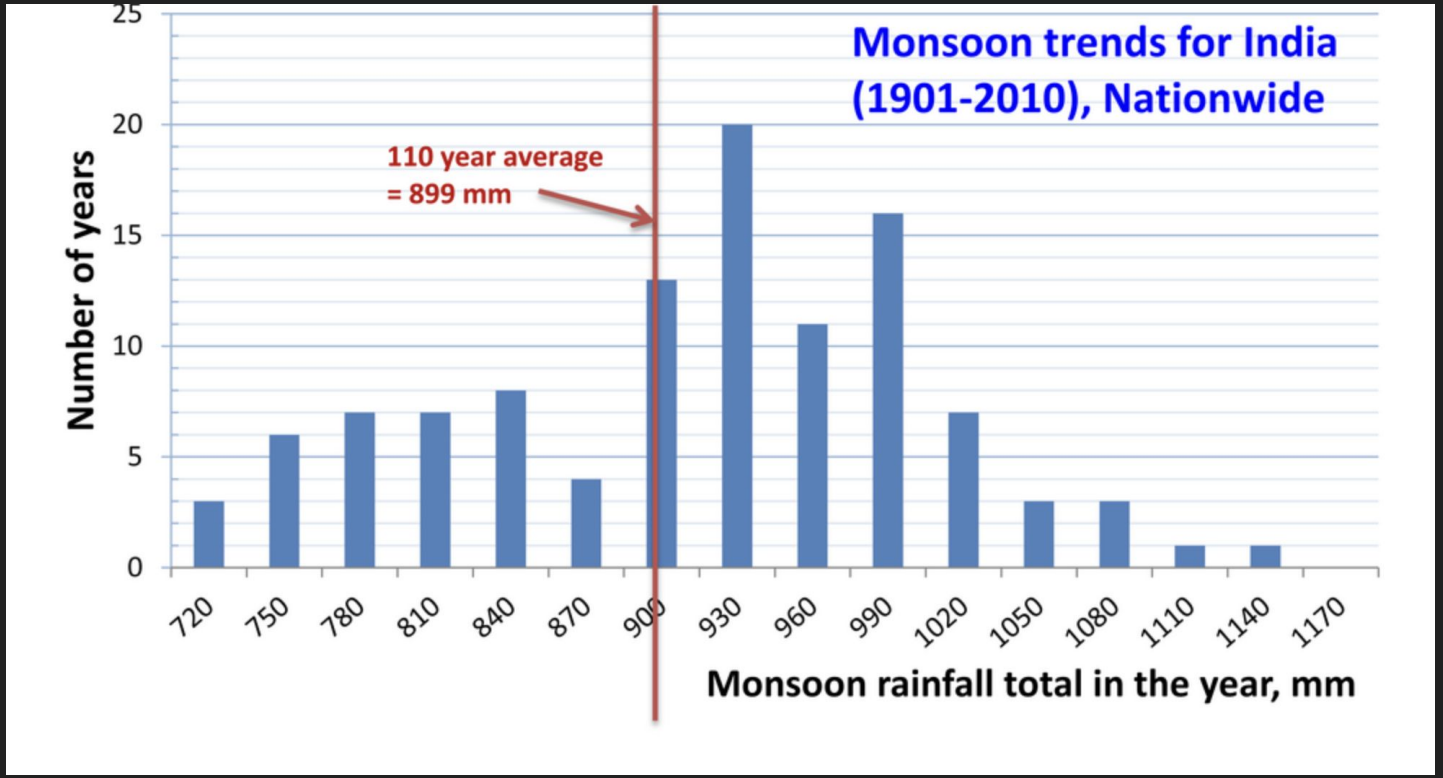



image from wikipedia

# How Do you evaluate Performance? .. The core ideas through an Example

There are 60 apples and 40 oranges shipped to a customer

Photographs are taken by a computer of the customer, and the computer AI is counting the numbers to check if the items are as per the order

The computer converges on 50 items as apples and 50 as oranges.

How do you measure the success of this decision?

# Recall and Precision

Let’s take the case of Apples

Out of 50 apples predicted, 30 happen to be actually apples

So we got only 50% of the apples correctly identified out of 60 apples (50% recall)

But we got 30 out of 50 apples predictions correct (60% precision for our prediction)

We can calculate these figures for oranges, and for the whole set of predictions

# False Positive, True Positive, False Negative, True Negative

See Apple as Apple

See Apple as not Apple

See not Apple as Apple

See Not apple as Not Apple


image generated by Gemini AI giving such a prompt to generate it

# Precision Vs. Recall

Precision

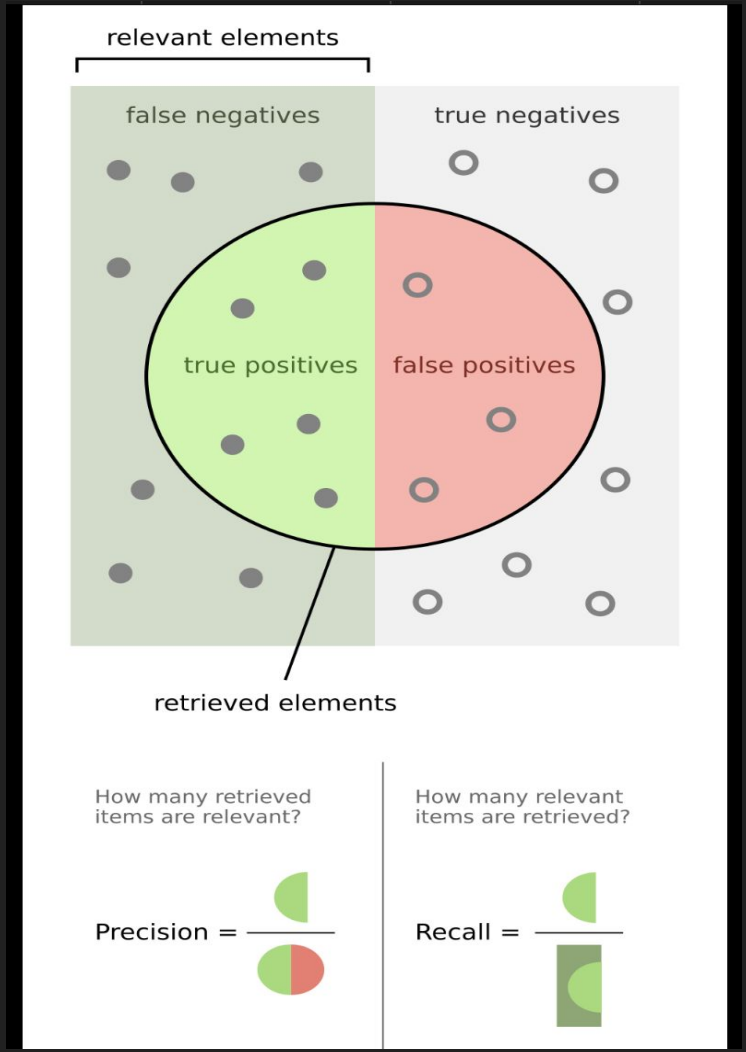
How many correct from among my predictions?

= TP / TP + FP

Recall

How many correct did I get from among all correct?

= TP / TP + FN

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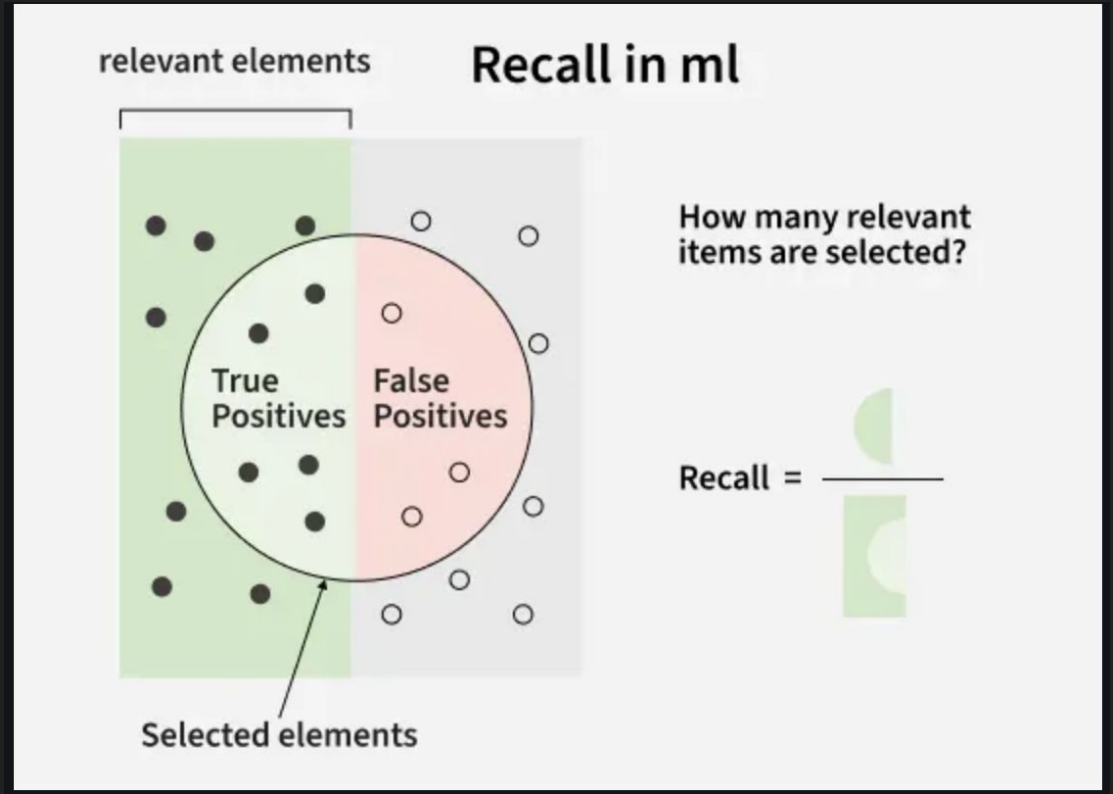


image from “geeks for geeks”

# Subtleties of Logic

“If you solve a problem, I will give you a chocolate”; you didn’t solve it, but I still give you a chocolate. Am I violating the rule?

“If you don’t eat this, I will not talk to you”; you eat this, but I am not going to talk to you;

Is this violating the rule?!

# Subtleties of Logic

Example:

People found to have followed some bad practice spoke a particular language, so all people speaking that language are the followers of that bad practice

Is this correct ?

# Subtleties of Logic

Example:

A teacher says “All students in my class know the Pythagoras theorem”. Someone finds one student who cannot mention what the theorem is.

Does that  disprove the teacher?

# Subtleties of Logic

Example:

A teacher says “I have one student in my class who can solve any trigonometric problem in Loni’s book of problems.”, another teacher finds one student who cannot do that, and then claims that the first teacher is wrong.

Is this correct?

# Subtleties of Logic

Example:

A teacher says “I have one student in my class who can solve any trigonometric problem in Loni’s book of problems.”, another teacher drops by on a random day and finds no student who could solve one particular problem that he picked, and then he claims that the first teacher is wrong.

Is this correct?

# Subtleties of Logic

Example:

A teacher says “I have one student in my class who can solve any trigonometric problem in Loni’s book of problems.”, another teacher drops by on a random day and finds that no student who could solve one particular problem that he picked, and then he claims that the first teacher is wrong.

Is this correct?  –well that student in the claim could have been absent- so the second teacher needs to do the same test on some other day to cover the whole class!

# Golden Rules of Logic to Remember in Research

Implication is not equivalence

Correlation or co-occurrence is not causality

Absence of Proof is not Proof of Absence

Example does not prove Generalization

Counterexample disproves a “for all” Generalization

# Different ways AI may get used in Education

Students use AI to learn new topics

They may use AI  to complete homework assignments

Teachers may use AI to generate possible lesson plans, examples, questions

AI may be used to automatically evaluate written answer sheets

AI may be used to detect possible plagiarism through AI tools

AI may be used to detect possible  use of unfair means

AI may be used to correct writing and polish it up

AI may be used to translate from one language to another

AI can be used as a conversing agent

# The Warnings: AI Hallucinates

AI: It may give an answer, which may not be correct

Imagine a child being asked questions which the child does not really understand, the child may give answers based on what it “knows”, hallucinating the solutions

# The Warnings: AI has False Positives and False Negatives

In identification, AI may miss the correct picks,

and it may also pick the wrong items

# The Warnings: AI may learn a Bias

For example, AI does not understand laws of equality and inclusions. They need to be explicitly added.

# The Warnings: AI may work on incomplete or incorrect data

If trained on incomplete or incorrect data, the results can be flawed

# The Warnings: AI may do better than human beings for certain tasks

For example, it is long since AI showed its prowess in Chess- the impact is not yet fully known; still a learning curve!

There will be new jobs such as testing and data analysis, verification of AI, human intelligence integration with AI, new ideas in application domains, if used for welfare, sustainability, quality of life, reduced costs, it can be quite helpful like any other newly introduced technology. AI has been there for years, but now it has become a large scale AI with the advancements in technology and computational and communication powers

# The Warnings: AI Model may become obsolete or repetitive

As human intelligence evolves and new data becomes available, if not revised, an old AI trained model may become obsolete, or even sound repetitive

# The Warnings: Privacy

AI is heavily data-driven. There could be concerns for privacy of data

# Lab Exercise-1

1) Download a public statistics/report in your domain: Social, Education, Engineering, Law, Commerce and Finance, Agriculture, Manufacturing,

2) Propose a couple of goals which can be solved by algorithm

3) Proposal a couple of goals which can be solved by AI

4) Make a small presentation in groups of 2 or 3.

# Lab Exercise-2

Given the data sheet, find out a model manually, and predict the unknown values. Tell us how you predicted the values; that is to say, how did you learn the knowledge hidden inside the sheet? When can it go wrong?

# Lab Exercise-3

Write  a paragraph about AI based on the discussions that we had today in this venue. Send it through an AI agent to rewrite to make it better in grammar, create image using AI to suit the paragraph you wrote and make a document puting the  two together. At the end of it, write your critical evaluation comparing

- did AI generate anything new which was not in your original paragraph?
- did AI miss anything  that was in your original paragraph?
- did I misunderstood you?
- what was the reason for the misunderstand and the misses
- Give an overall score

# Lab Exercise-4 Knowledge Graph

- Make a Knowledge Graph for the following piece of text, identifying your entity types and relation types:

A store has many branches. Each branch must be managed by a manager. The branch sells many products. Product is sold by many branches. Branch employs many workers. The worker may process at most 10 sales. Each Product includes code, name, size, cost. A branch is uniquely identified by number. Branch has name, address and number. Worker is identified by id.

# Lab Exercise-5 Integration of AI into Education and Policies about the integration

Make a point-wise proposal on how AI can be added in the syllabus, mention a couple of examples, topics, identify the level-introductory, intermediate, advanced & research.

Mention policy matters