01201N
Smart Systems & Computational Intelligence

Prof. Mohamed Abdel Rahman

Course Outline
3cr. [2-0-2]

- Introduction to Computational Intelligence
- Nature- Inspired Algorithms (Evolutionary Computation)
  - Genetic Algorithms
  - Particle Swarm Optimization
  - Ant Colony Optimization
- Fuzzy Logic Systems
  - Fuzzification / Defuzzifiction
  - Membership functions
  - Fuzzy Controllers
- Artificial Neural Networks
- Neuro- Fuzzy Systems

Course Info

- INSTRUCTOR: PROF. MOHAMED ABDEL RAHMAN
  - Vice Dean of Informatics Research Institute
  - Professor of Computer Systems Engineering
  - AI and ML expert for more than 25 years

  Lecture: Thursday from 9:00 to 11:00
- Assistant: Ms. Tasneem Mohamed & Ms. Sara Sedhom
  - TA @ Computer Science, Alexandria University
  - MSc in Computer Science

  Practical: Tuesday from 9:00 to 11:00

Course Evaluation

- Mid Term: 20 Marks
- Practical work: 20 Marks
- Project: 10 Marks
- Final Exam: 50 Marks

Calendar

Week	Date	Lecture Title	Practical
Week1	5/10/2023	(OFF DAY)	Computational intelligence
Week 2	12/10/2023	Evolutionary Computation: GA	Assignment 1: Python Revision
Week 3	19/10/2023	Particle Swarm Optimization	Assignment 2: Python Syntax
Week 4	26/10/2023	Ant Colony Optimization	Assignment 3 GA (Knapsack Problem)
Week 5	2/11/2023	Fuzzy Logic: fuzzy inference system	Assignment 4 PSO
Week 6	9/11/2023	Fuzzy Logic: membership functions	Assignment 5 ACO (Travelling Salesman Problem)
Week 7	16/11/2023	Fuzzy systems (Examples and project)	Assignment 6 Fuzzy Inference Engine
Week 9	30/11/2023	Data Preprocessing for Int Sys	Assignment 7 Fuzzy (Tipping Problem)
Week 10	7/12/2023	Artificial Neural Networks	Assignment 8 Project
Week 11	14/12/2023	Network Design and Training	Assignment 9: ANN
Week 12	21/12/2023	Neuro-Fuzzy Systems	Assignment 9: ANN
Week 13	28/12/2023	Revision	Project Assessment
Week 14	4/1/2023	Practical Exam	

References & Textbooks

- "Machine Learning for Absolute Beginners," Oliver Theobald, 3rd edition, Scatterplot Press, 2021. BEST SELLER
- "Biomedical Engineering: Modified Methods for Medical Image Processing, Telemedicine, and Archiving," Mohamed Abdou, VDM publications, ISBN: 978-3-639-24018-4, Feb. 2010.
- "Fuzzy Logic with Engineering Applications," T.J. Ross, John Wiley & Sons, 3rd edition, 2010.

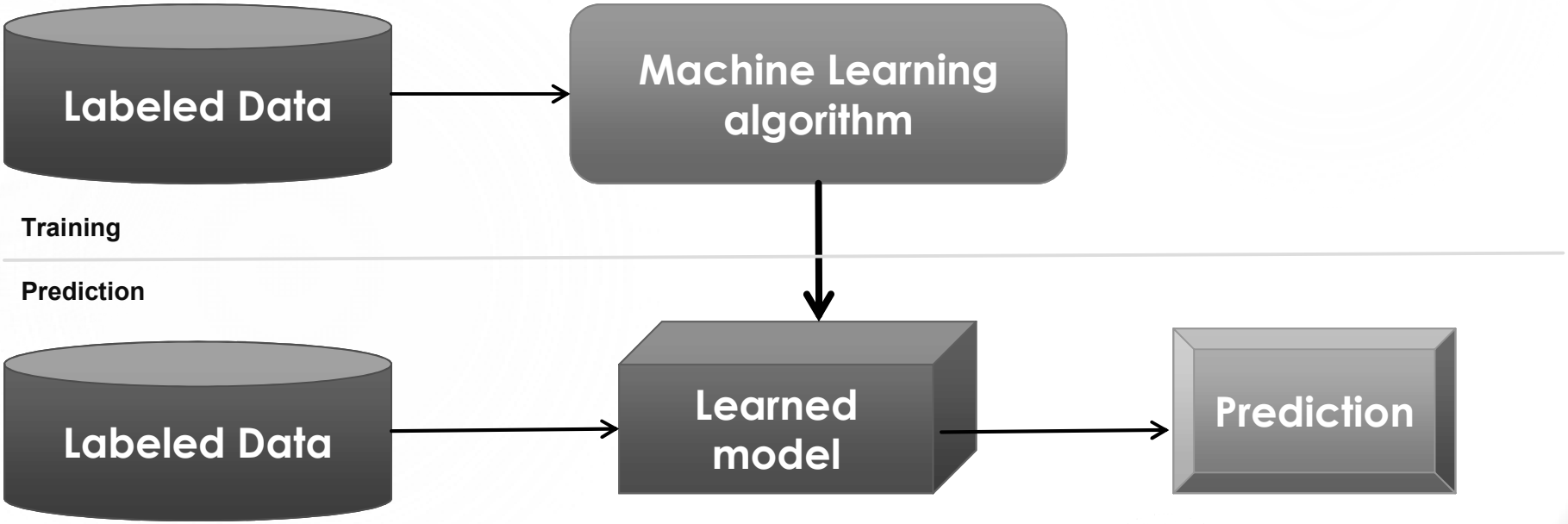
Machine Intelligence is the last invention that humanity will ever need to make …

Nick Bostrom
Professor Oxford University
Director, Future of Humanity Institute

Born	10 March 1973 (age 50), Sweden
Education	• University of Gothenburg (B.A.) • Stockholm University (M.A.) • King's College London (MSc) • London School of Economics (PhD)
Awards	• Professorial Distinction Award from University of Oxford • FP Top 100 Global Thinkers • Prospect Top World Thinker list

Machine Learning Basics

- ***Machine Learning*** is a branch of Artificial Intelligence, which focuses on methods that learn from data and make predictions on unseen data

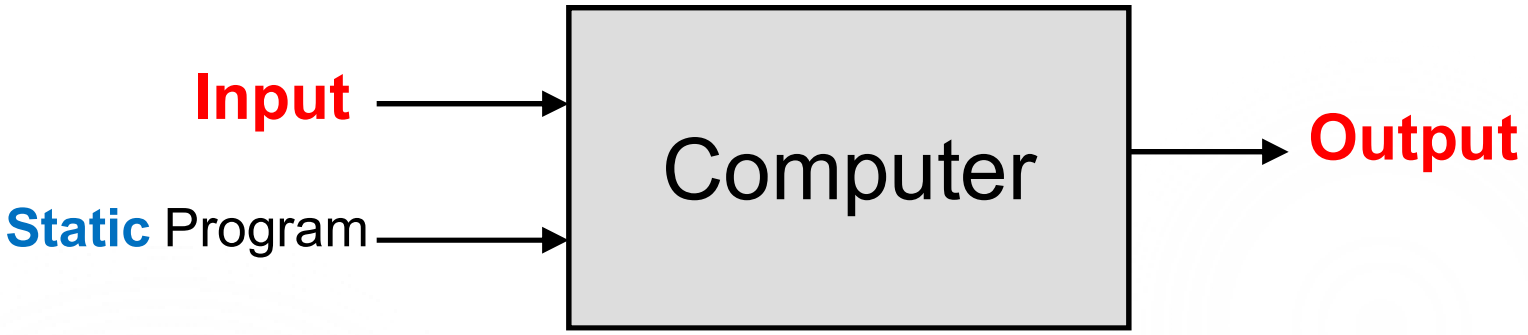


Why "Learn" ?

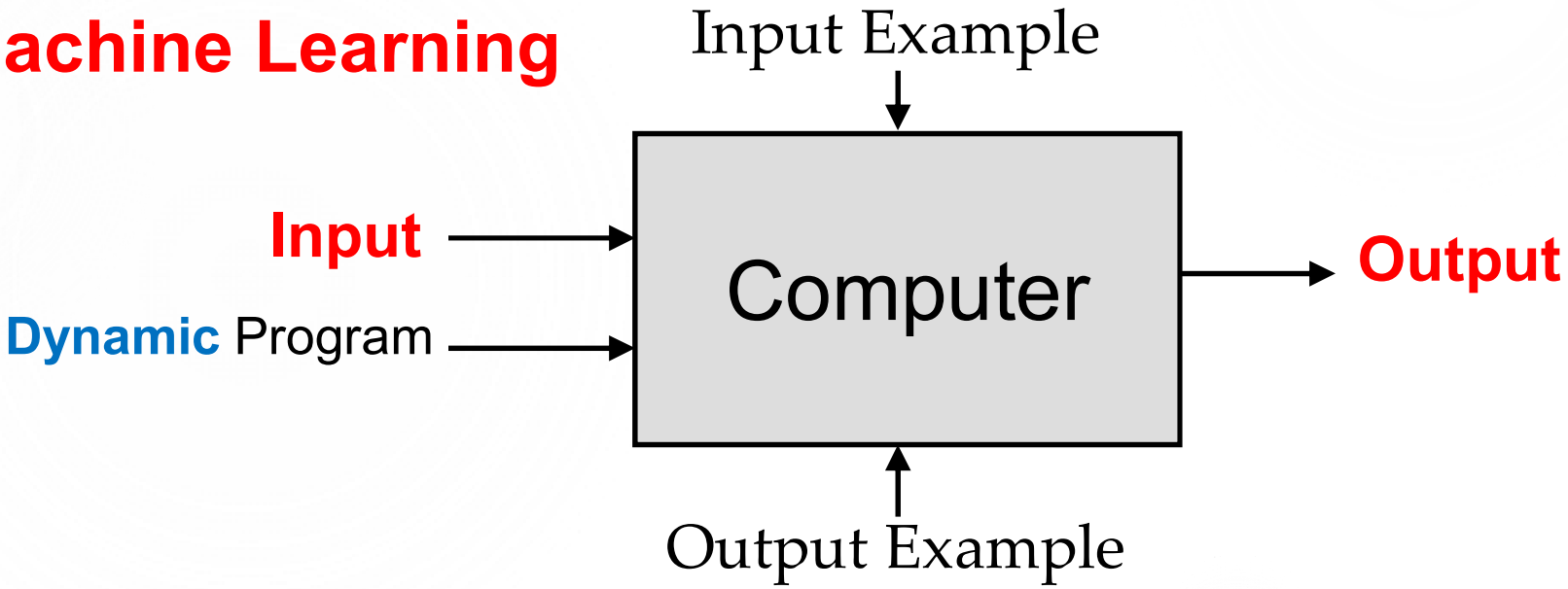
- Machine learning means programming computers to optimize a performance criterion using example data or past experience.

- Machine Learning is important when:
  - Human expertise does not exist (e.g. translators - CAD systems)
  - Humans are unable to handle huge data (e.g. social media analysis)
  - Solution changes in time (e.g. weather forecast)

Traditional Programming



Machine Learning



Intelligence

- Intelligence is the capability of a decision-making system to adapt its behavior to meet its goals in a range of environments.

Computational Intelligence

- The ability of a computer to learn a specific task from data or experimental observation.

Search Techniques

Search Techniques from Mathematics View

- Deterministic Search Techniques
  - Steepest Descent
  - Newton-Raphson
  - Simplex based Technique …

- Stochastic or Random Search Techniques
  - **Genetic Algorithm**
  - **Swarm Intelligence**
  - **Ant Colony**
  - Differential Evolution

How Search Techniques Works?

- Propose an initial solution
- Specify a search direction
- Update criteria
- Stopping criteria
- All above elements can be either
  - Deterministic or **Stochastic**
  - Single points or **population based**

Search Techniques from Computer Sc. View

Blind Search

- A blind (un-informed) doesn't have any specific knowledge about the problem and the solution

Heuristic Search

Metaheuristic Search

Search Techniques from Computer Sc. View

Heuristics

- A heuristic search has information about the problem and therefore uses logic in decision making.
- Heuristic algorithms aim to find a good solution (approximate) to a problem in a reasonable amount of computation time –with no guarantee of "efficiency".
- It is ***problem dependent***

Search Techniques from Computer Sc. View

Metaheuristics

- Metaheuristics are techniques for exploration and exploitation of a wider search space (compared to heuristic).
- They are ***problem independent*** techniques
- The most famous are "Evolutionary Algorithms"
  - Swarm Intelligence
  - Genetic Algorithm
  - Differential Evolution
  - Evolutionary programing
- You can start finding a solution for a problem using heuristic technique, then use metaheuristics to find better solution(s)

Example

- **Example:** Choosing the best between different brands of a special food at the grocery store.
- **Heuristic:** Many people often simplify the decision by going with the brand and type of food with which they've had the **best previous experience**

This could NOT be the best result

Metaheuristic: can take the previous solution as initial status, then search for the best using a specific criteria (price – expiry date – ingredients - …)

THANK YOU