ABC's of Systemic Approach to Machine Learning

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1. **INTRODUCTION**

According to the father of Artificial Intelligence (AI), John McCarthy, AI is “The science and engineering of making intelligent machines, especially intelligent computer programs”. An AI framework is made out of an agent and its environment. The agents act in their environment. The environment may contain different agents. Machine Learning is a sub-set of artificial intelligence where computer algorithms are used to autonomously learn from data and information. In machine learning computers don’t have to be explicitly programmed but can change and improve their algorithms by themselves. In this whitepaper, we are focusing about introduction about intelligence, artificial intelligence, agent and its environment and types of agent program. The concept of machine learning is aroused from learning agent.

2. **INTRODUCTION TO INTELLIGENCE**

Intelligence is a “functional property and completely independent of any physical embodiment”. Alternative less-symbolic paradigms are neural networks and evolutionary computation. Languages that support symbolic programming include: wolfram languages (multi-paradigm programming language), LISP and Prolog.

Reasoning
Reasoning is a “set of processes that enables us to provide basis for judgement, making decisions, and prediction”.
There are two types of reasoning: −

(a) Inductive Reasoning – It conducts specific observations to makes broad general statements.
Example:

Nita is a teacher. All teachers are studious. Therefore, Nita is studious."

(b) Deductive Reasoning – It starts with a general statement and examines the possibilities to reach a specific, logical conclusion.
Example:

All women of age above 60 years are grandmothers. Shalini is 65 years.Therefore, Shalini is a grandmother.

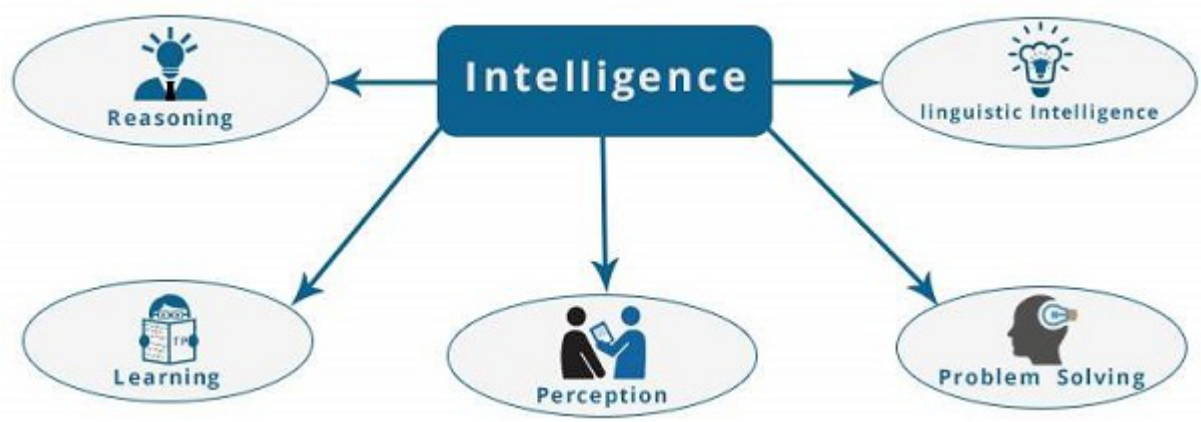


Figure 1: Components of Intelligence

Learning
Learning is an activity of gaining knowledge or skill by studying, practicing, being taught, or experiencing something. Learning enhances the awareness of the subjects of the study.

Problem Solving
Problem Solving is the process in which one perceives and tries to arrive at a desired solution from a present situation by taking some path, which is blocked by known or unknown hurdles. Problem solving also includes decision making.

Perception
It is the process of acquiring, interpreting, selecting, and organizing sensory information. Perception presumes sensing.

Linguistic Intelligence
Linguistic Intelligence is one's ability to use, comprehend, speak, and write the verbal and written language. It is important in interpersonal communication.

1. **Intelligence vs Artificial Intelligence**

   Intelligence is a property/ability attributed to people, such as to know, to think, to talk, to learn.

   Intelligence = Knowledge + ability to perceive, feel, comprehend, process, communicate, judge, learn.

   Artificial Intelligence is an "interdisciplinary field aiming at developing techniques and tools for solving problems that people at good at".

3. **INTRODUCTION TO ARTIFICIAL INTELLIGENCE**

Existing definitions advocate everything from replicating human intelligence to simply solving knowledge-intensive tasks.
Example:

“Artificial Intelligence is the design, study and construction of computer programs that behave intelligently.” -- Tom Dean.

“Artificial Intelligence is the enterprise of constructing a physical symbol system that can reliably pass the Turing test.” -- Matt Ginsberg.

In textbook, AI is defined as an experimental discipline utilizing the ideas and the methods of computation.

1. **Goals of Artificial Intelligence**
   - Scientific goal: understand the mechanism behind human intelligence.
   - Engineering goal: develop concepts and tools for building intelligent agents capable of solving real world problems. Examples:
     - Knowledge-based systems: capture expert knowledge and apply them to solve problems in a limited domain.
     - Common sense reasoning systems: capture and process knowledge that people commonly hold which is not explicitly communicated.
     - Learning systems: posses the ability to expend their knowledge based on the accumulated experience.
     - Natural language understanding systems.
     - Intelligent robots.
     - Speech and vision recognition systems.
     - Game playing (IBM’s Deep Blue)

4. **INTRODUCTION TO AGENT**

Agents are used to provide a consistent viewpoint on various topics in the field of AI. Agents require essential skills to perform tasks that require intelligence. Intelligent agents use methods and techniques from the field of AI.

1. **Objectives of an Agent**
   - Introduce the essential concepts of intelligent agents.
   - Define some basic requirements for the behavior and structure of agents.
   - Establish mechanisms for agents to interact with their environment.
2. **What is an Agent?**

   In general, Agent is an “entity that interacts with its environment, perception through sensors and actions through effectors or actuators”.

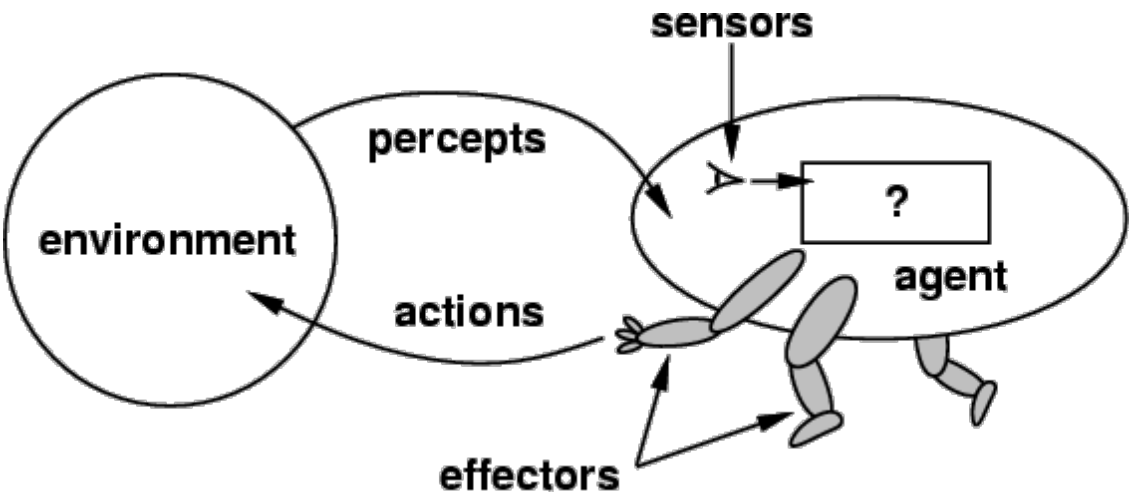


Figure 2: Structure of Agent

Examples of Agents:

(i) human agent

- eyes, ears, skin, taste buds, etc. - sensors
- hands, fingers, legs, mouth, etc. - actuators
- powered by muscles

(ii) robot

- camera, infrared, bumper, etc. - sensors
- grippers, wheels, lights, speakers, etc. - actuators
- often powered by motors

(iii) software agent

- functions as sensors
- information provided as input to functions in the form of encoded bit strings or symbols
- functions as actuators - results deliver the output

3. **Structure of Intelligent Agents**

Agent = Architecture + Program

Architecture is nothing but operating platform of the agent. It may be computer system,

specific hardware, possibly OS functions. Program is nothing but function that implements the mapping from percepts to actions. It is closely related to software agent.

4. **Agents and Environment**

   Environment is used to determine to a large degree the interaction between the “outside world” and the agent. The “outside world” is not necessarily the “real world” as we perceive it. It may be a real or virtual environment the agent lives in. In many cases, environments are implemented within computers. They may or may not have a close correspondence to the “real world”.

   1. **Environment Properties**
      i. Fully observable vs. partially observable
         - If sensors capture all relevant information from the environment it is fully observable; otherwise partially observable.

      ii. Deterministic vs. stochastic (non-deterministic)
         - If the changes in the environment are predictable then the environment is deterministic otherwise stochastic (non-deterministic).

      iii. Episodic vs. sequential (non-episodic)
         - In an episodic environment, independent perceiving-acting episodes are possible. If not so, it is sequential.

      iv. Static vs. dynamic
         - If the environment does not change while the agent is “thinking” then it is static. Otherwise it is dynamic

      v. Discrete vs. continuous
         - If limited number of distinct percepts/actions then it is discrete. Otherwise it is continuous

      vi. Single vs. multiple agents
         - interaction and collaboration among agents
         - competitive, cooperative

      The real world is partially observable, stochastic, sequential, dynamic, continuous, multi-agent.

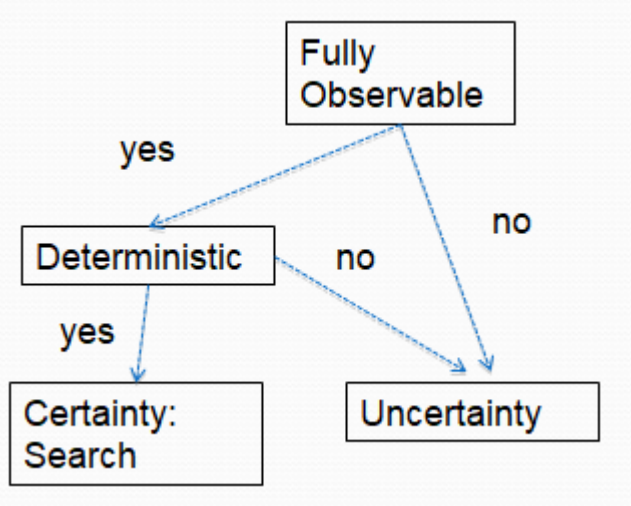


Figure 3: Choice under (Un)certainty

5. **Software Agents**

   Software agent also referred to as “softbots”. It is an autonomous computer program that carries out tasks on behalf of users. It lives in artificial environments where computers and networks provide the infrastructure. It may be very complex with strong requirements on the agent example: World Wide Web, real-time constraints. In some cases, natural and artificial environments may be merged for user interaction. Sensors and actuators in the real world are camera, temperature, arms, wheels, etc.

5. **TYPES OF AGENT PROGRAM**

Types of agent program are different ways of achieving the mapping from percepts to actions. The different levels of complexity

- simple reflex agents
  - respond immediately to percepts
- model-based agents
  - maintain internal state to track aspects of the world
- goal-based agents
  - work towards a goal
- utility-based agents
  - try to maximize their own “happiness."
- learning agents

1. **Simple Reflex Agent**

   In simple reflex agent, instead of specifying inpidual mappings in an explicit table, common input-output associations are recorded. It requires processing of percepts to achieve some abstraction. The frequent method of specification is through condition-action rules

   - if percept then action

It is similar to innate reflexes or learned responses in humans. The advantage of this type is efficient implementation and easily runs into infinite loops. The disadvantage is limited power and the environment must be fully observable.

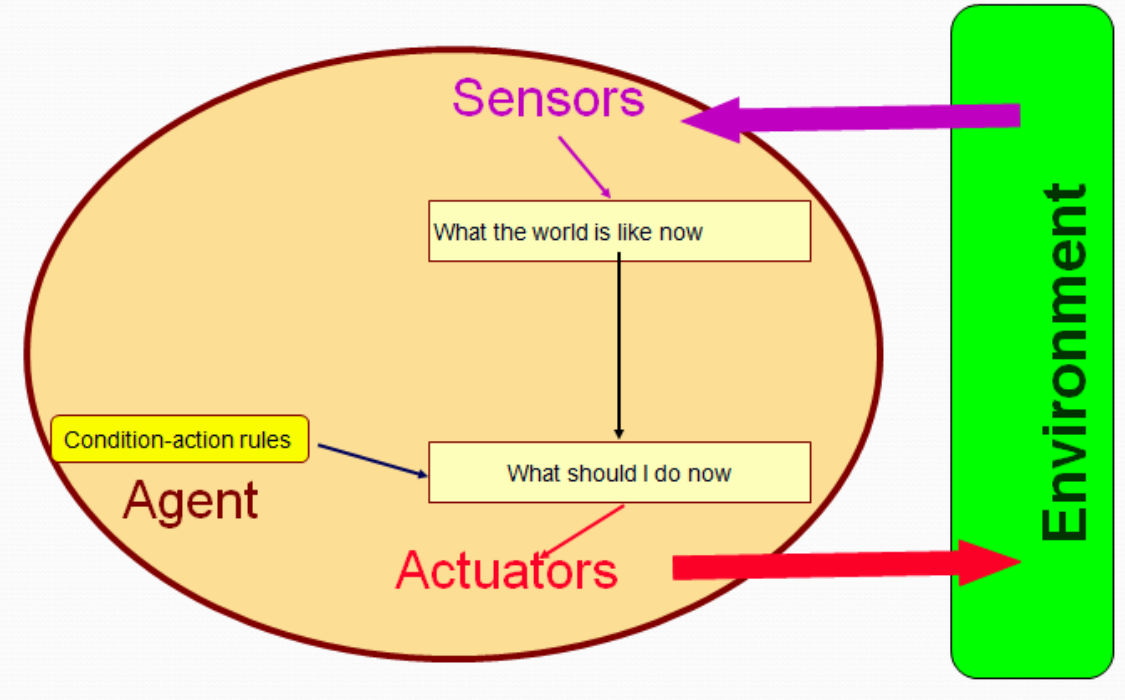
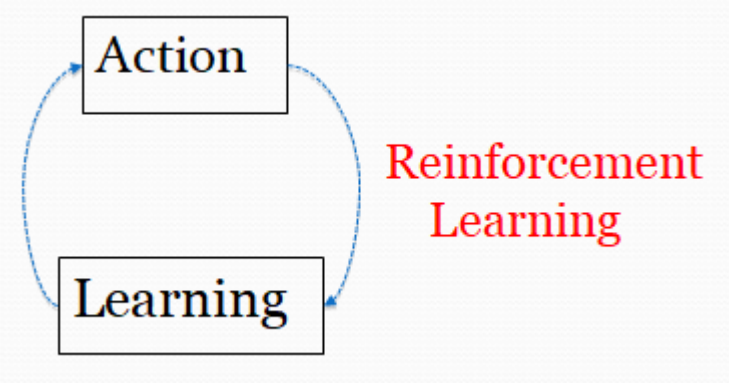


Figure 4: Simple Reflex Agent

The picture for Reflex-Based Agents,



This model Studied in AI, Cybernetics, Control Theory, Biology, Psychology.

2. **Model-Based Reflex Agent**

Its internal state maintains important information from previous percepts. Sensors only provide a partial picture of the environment and helps with some partially observable environments. The internal states reflects the agent's knowledge about the world, this knowledge is called a model. It may contain information about changes in the world (two kinds of knowledge). And it is caused by actions of the action and independent of the agent's behavior.

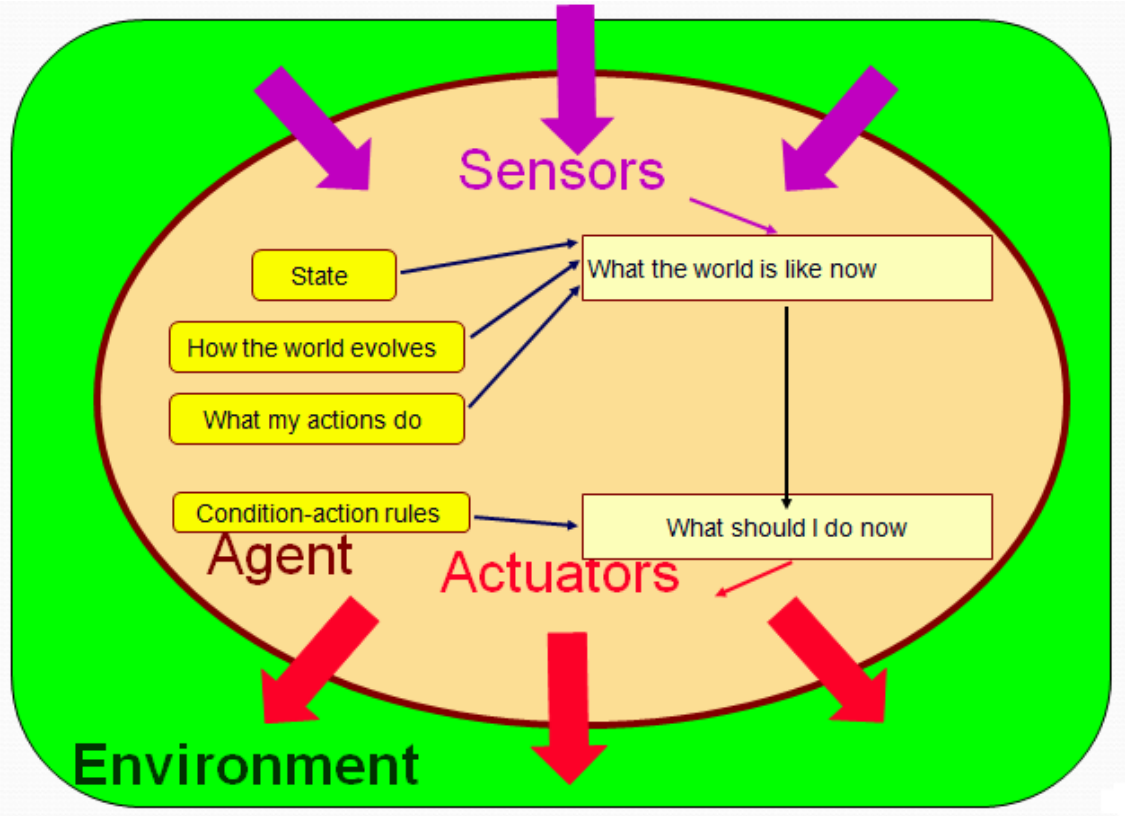
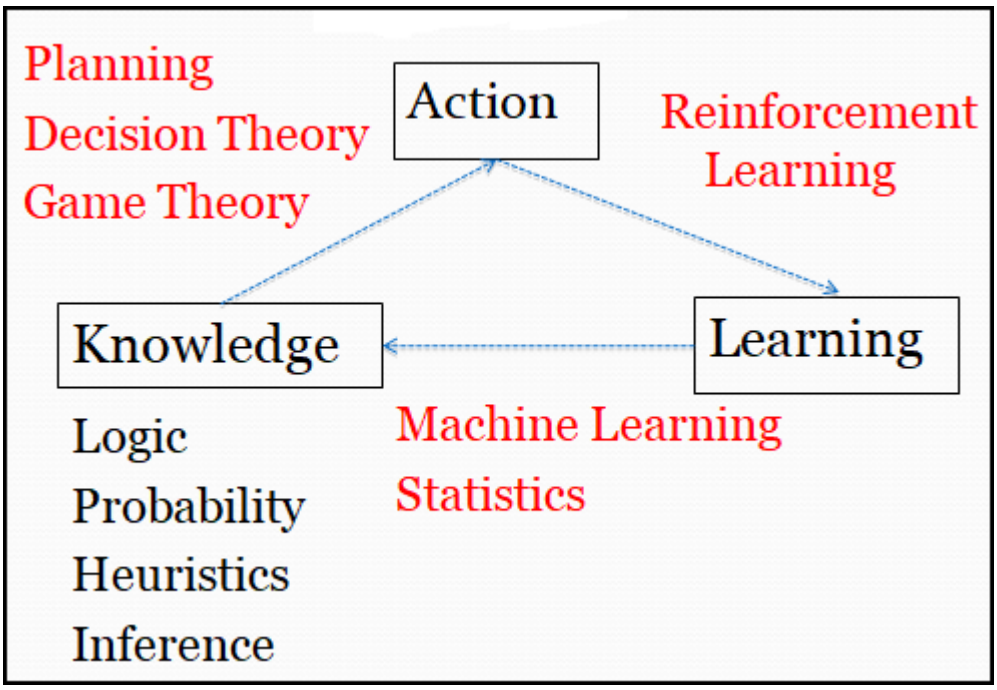


Figure 5: Model-Based Reflex Agent Diagram

The Big Picture: AI for Model-Based Agents is as follows:



3. **Learning Agent**

   We have described so far agent programs with various methods for selecting actions. We have not, so far, explained how the agent programs come into being. All agents can improve their performance through learning. Learning in intelligent agents is essential for dealing with unknown environments (i.e., compensating for the designer's lack of omniscience about the agent's environment). Learning is also essential for building agents with a reasonable amount of effort (i.e., compensating for the designer's laziness, or lack of time).

   Components of learning agent:

   - performance standard
     - selects actions based on percepts, internal state, background knowledge
     - can be one of the previously described agents
   - learning element
     - identifies improvements
   - critic
     - provides feedback about the performance of the agent
     - can be external; sometimes part of the environment
   - problem generator
     - suggests actions
     - required for novel solutions (creativity)

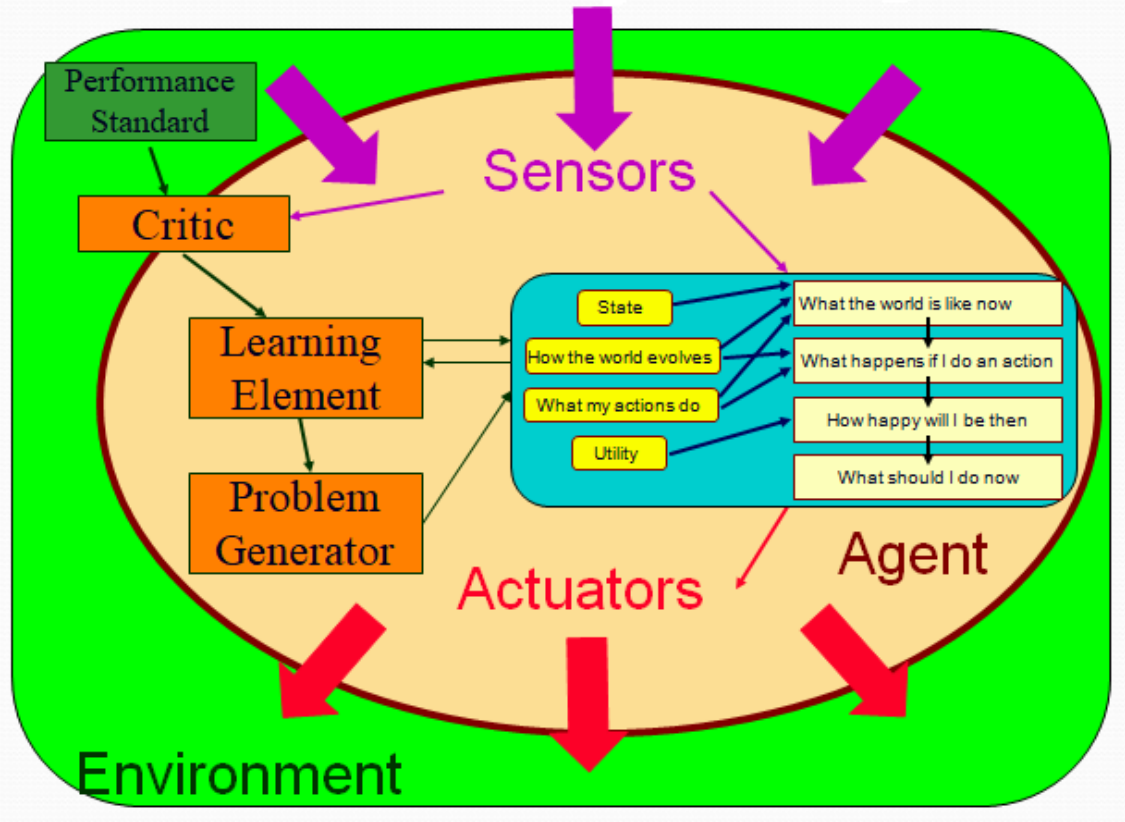


Figure 6: Learning Agent

6. **CONCLUSION**

Thus the learning agent concept is the base for machine learning. It is proved based on the following definitions given by different authors. Ethem Alpaydin said that “Machine learning is programming computers to optimize a performance criterion using example data or past experience”. In Wikipedia, “Machine learning, a branch of artificial intelligence, concerns the construction and study of systems that can learn from data”.

ABOUT THE AUTHOR

Dr.S.Balakrishnan is a Professor and Head, Department of Computer Science and Business Systems at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India. He has 17 years of experience in teaching, research and administration. He has published over 15 books, 3 Book Chapters, 13 Technical articles in CSI Communications Magazine, 1 article in Electronics for You (EFY) magazine, 3 articles in Open Source for You Magazine and over 100 publications in highly cited Journals and Conferences. Some of his professional awards include: Contributors Competition Winner July 2019 and August 2019, by DataScience Foundation, with cash prize of £100, 100 Inspiring Authors of India, Deloitte Innovation Award - Cash Prize Rs.10,000/- from Deloittee for Smart India Hackathon 2018, Patent Published Award, Impactful Author of the Year 2017-18. His research interests are Artificial Intelligence, Cloud Computing and IoT. He has delivered several guest lectures, seminars and chaired a session for

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