Artificial Intelligence

Main Reference:

Elaine Rich
Kevin Knight
SB Nair
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Artificial Intelligence

McGraw-Hill, 2015

Definition:

Study of how to make computers do things at which, at the moment, people are better

Intelligence: “Ability to learn, understand and think”

Examples: Speech recognition, Smell, Face, Object, Intuition, Inferencing, Learning new skills, Decision making, Abstract thinking

What About Things that People Do Easily?

- Common sense: Reasoning

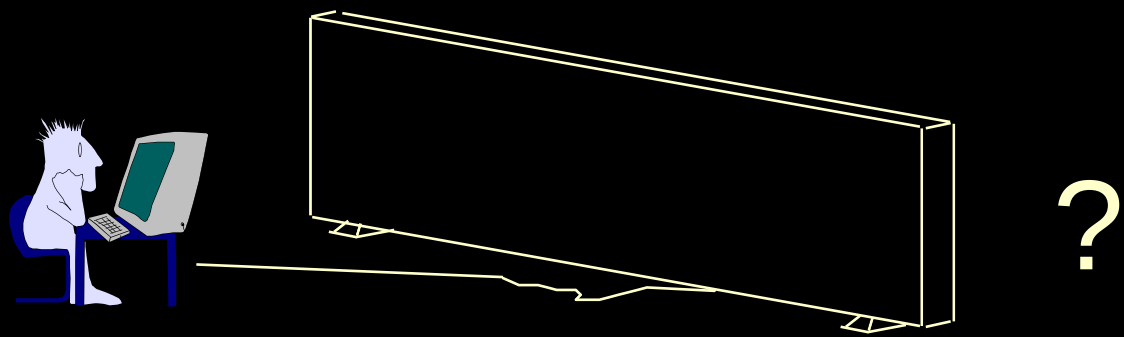
- Moving Around : perception of world around us like animals are less intelligent but having better visual perception.

- Language: to communicate like NLP

What is AI?

	HUMAN	RATIONAL
THOUGHT	**Thinking Humanly**	**Thinking rationally**
BEHAVIOUR	Acting Humanly	Acting rationally

Acting Humanly: System that acts like human



- You enter a room which has a computer terminal. You have a fixed period of time to type what you want into the terminal, and study the replies. At the other end of the line is either a human being or a computer system.
- If it is a computer system, and at the end of the period you cannot reliably determine whether it is a system or a human, then the system is deemed to be intelligent.

Acting Humanly: System that acts like human

- The Turing Test approach
  - a human questioner cannot tell if
    - there is a computer or a human answering his question, via teletype (remote communication)
  - The computer must behave intelligently
- Intelligent behavior
  - to achieve human-level performance in all cognitive tasks

Systems that acts like humans

- These cognitive tasks include:
  - *Natural language processing*
    - for communication with human
  - *Knowledge representation*
    - to store information effectively & efficiently
  - *Automated reasoning*
    - to retrieve & answer questions using the stored information
  - *Machine learning*
    - to adapt to new circumstances

Systems that think like humans:Cognitive Modeling

- Humans as observed from ‘inside’
- How do we know how humans think?
  - Introspection vs. psychological experiments
- Cognitive Science
- “The exciting new effort to make computers think … machines with *minds* in the full and literal sense” (Haugeland)
- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …” (Bellman)

Systems that think ‘rationally’ "laws of thought"

- Humans are not always ‘rational’
- Rational - defined in terms of logic?
- Logic can’t express everything (e.g. uncertainty)
- Logical approach is often not feasible in terms of computation time (needs ‘guidance’)
- “The study of mental facilities through the use of computational models” (Charniak and McDermott)
- “The study of the computations that make it possible to perceive, reason, and act” (Winston)

Systems that act rationally: "Rational agent"

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Giving answers to questions is 'acting'.
- I don't care whether a system:
  - replicates human thought processes
  - makes the same decisions as humans
  - uses purely logical reasoning

Systems that act rationally

- Logic → only *part* of a rational agent, not *all* of rationality
  - Sometimes logic cannot reason a correct conclusion
  - At that time, some ***specific (in domain) human knowledge*** or information is used
- Thus, it covers more generally different situations of problems
  - Compensate the incorrectly reasoned conclusion

Systems that act rationally

- Study AI as rational agent –

2 advantages:

  - It is more general than using logic only
    - Because: LOGIC + Domain knowledge
  - It allows extension of the approach with more scientific methodologies

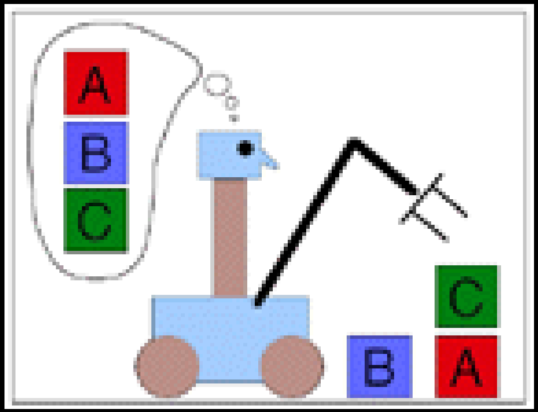
AI

From the above two definitions, we can see that AI has two major roles:

- Study the intelligent part concerned with humans.
- Represent those actions using computers.

Goals of AI

- To make computers more useful by letting them take over dangerous or tedious tasks from human
- Understand principles of human intelligence



Foundation of AI

- ***Philosophy***
  - At that time, the study of human intelligence began with no formal expression
  - Initiate the idea of mind as a machine and its internal operations

Foundations of AI

- Mathematics formalizes the three main area of AI: *computation*, *logic*, and *probability*
  - Computation leads to analysis of the problems that can be computed
    - *complexity theory*
  - Probability contributes the "*degree of belief*" to handle *uncertainty* in AI
  - *Decision theory* combines *probability theory* and *utility theory* (bias)

Foundations of AI

- Psychology
  - How do humans think and act?
  - The study of human reasoning and acting
  - Provides reasoning models for AI
  - Strengthen the ideas
    - humans and other animals can be considered as information processing machines

Foundations of AI

- Computer Engineering
  - How to build an efficient computer?
  - Provides the artifact that makes AI application possible
  - The power of computer makes computation of large and difficult problems more easily
  - AI has also contributed its own work to computer science, including: time-sharing, the linked list data type, OOP, etc.

Foundations of AI

- Linguistics
  - For understanding natural languages
    - different approaches has been adopted from the linguistic work
  - Formal languages
  - Syntactic and semantic analysis
  - Knowledge representation

Advantages of AI

- more powerful and more useful computers
- new and improved interfaces
- solving new problems
- better handling of information
- relieves information overload
- conversion of information into knowledge

Disadvantages of AI

- increased costs
- difficulty with software development - slow and expensive
- few experienced programmers

Topics of AI

Learning systems

"Learning is any process by which a system improves performance from experience"

- If a system is going to act truly appropriately, then it must be able to change its actions in the light of experience:
  - how do we generate new facts from old ?
  - how do we generate new concepts ?
  - how do we learn to distinguish different situations in new environments ?

Topics of AI

Knowledge representation and reasoning

- The <u>second</u> most important concept in AI
- If we are going to act rationally in our environment, then we must have some way of describing that environment and drawing inferences from that representation.
  - how do we describe what we know about the world ?
  - how do we describe it *concisely* ?
  - how do we describe it so that we can get hold of the right piece of knowledge when we need it ?
  - how do we generate new pieces of knowledge ?
  - how do we deal with *uncertain* knowledge ?

Topics of AI

Knowledge representation techniques

- *Production rules*
- *Predicate logic*
- *Frames*
- *Filler*
- *Slots*
- *Semantic nets*

Selection of knowledge depends on nature of application and choice of user

Knowledge

Declarative

Procedural

- Declarative knowledge deals with factoid questions (what is the capital of India? Etc.)
- Procedural knowledge deals with “How”
- Procedural knowledge can be embedded in declarative knowledge

Topics of AI

Planning

"determination of methodology from which a successful result can be achieved from known initial state"

Given a set of goals, construct a sequence of actions that achieves those goals:

- often very large search space
- but most parts of the world are independent of most other parts
- often start with goals and connect them to actions
- what happens if the world changes as we execute the plan and/or our actions don't produce the expected results?

Topics of AI

Planning

Major component of planning system include *heuristic functions, set of rules in the problem state and a deduction process.*

Topics of AI

Knowledge Acquisition

- *Making new pieces of knowledge from a given knowledge network*
- *Setting active structure for existing knowledge*
- *Learning knowledge from the environment*
- *Fine tuning of knowledge*

Topics of AI

Intelligent Search

- *Search* is the fundamental technique of AI.
  - Possible answers, decisions or courses of action are structured into an abstract space, which we then search.
- Search is either "blind" or “uninformed":
  - Blind (deterministic nature)
    - we move through the space without worrying about what is coming next, but recognising the answer if we see it
  - Informed (heuristic search/non deterministic)
    - we guess what is ahead, and use that information to decide where to look next.
- We may want to search for the first answer that satisfies our goal, or we may want to keep searching until we find the best answer.

Topics of AI

Logic Programming

PROLOG, LISP

- PROLOG(PROgramming in LOGic) to handle complex real world situations of propositions, predicate logic and first order logic.
- LISP(LISt Processor) another AI language that can handle strings

Topics of AI

Soft Computing

"Techniques that made effort to mimic the intelligence found in nature"

- *Statistical learning*
- *Fuzzy logic methods*
- *Genetic or evolutionary algorithms*
- *Probabilistic reasoning*
- *Chaos theories*

- These tools/techniques are used separately as well as jointly depending on the type of domain of application

Topics of AI

Management of Imprecision and Uncertainty

Techniques/ tools for reasoning under incomplete data and knowledge

- *Fuzzy*
- *Stochastic*
- *Belief networks*

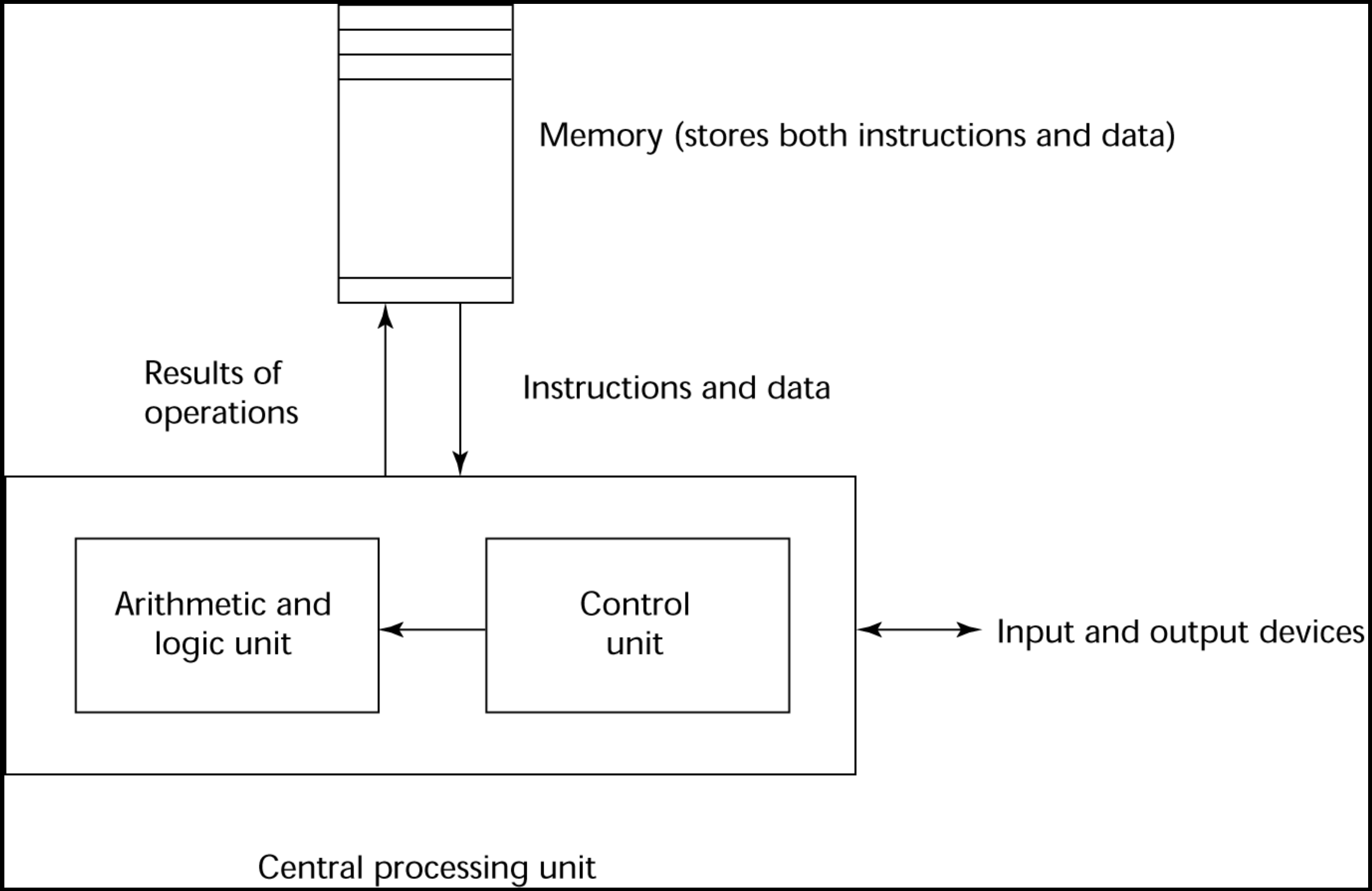
Interacting with the Environment

- In order to enable intelligent behaviour, we will have to interact with our environment.
- Properly intelligent systems may be expected to:
  - accept sensory input
    - vision, sound, …
  - interact with humans
    - understand language, recognise speech, generate text, speech and graphics, …
  - modify the environment
    - robotics

History of AI

- AI has a long history
  - Ancient Greece
    - Aristotle
  - Historical Figures Contributed
    - Ramon Lull
    - Al Khowarazmi
    - Leonardo da Vinci
    - David Hume
    - George Boole
    - Charles Babbage
    - John von Neuman
  - As old as electronic computers themselves (c1940)

The ‘von Neuman’ Architecture



History of AI

- Origins
  - The Dartmouth conference: 1956
    - John McCarthy (Stanford)
    - Marvin Minsky (MIT)
    - Herbert Simon (CMU)
    - Allen Newell (CMU)
    - Arthur Samuel (IBM)
- The Turing Test (1950)
- “Machines who Think”
  - By Pamela McCorckindale

Periods in AI

- Early period - 1950’s & 60’s
  - Game playing
    - brute force (calculate your way out)
  - Theorem proving
    - symbol manipulation
  - Biological models
    - neural nets
- Symbolic application period - 70’s
  - Early expert systems, use of knowledge
- Commercial period - 80’s
  - boom in knowledge/ rule bases

Periods in AI cont'd

- period - 90's and New Millenium
- Real-world applications, modelling, better evidence, use of theory, ...?
- Topics: data mining, formal models, GA's, fuzzy logic, agents, neural nets, autonomous systems
- Applications
  - visual recognition of traffic
  - medical diagnosis
  - directory enquiries
  - power plant control
  - automatic cars

The Origins of AI

1950 Alan Turing’s paper, *Computing Machinery and Intelligence*, described what is now called “The Turing Test”.

Turing predicted that in about fifty years "an average interrogator will not have more than a 70 percent chance of making the right identification after five minutes of questioning".

1957 Newell and Simon predicted that "Within ten years a computer will be the world's chess champion, unless the rules bar it from competition."

The Origins of AI

Birth of AI occurred when Marvin Minsky & John McCarthy organized the Dartmouth Conference in 1956

- brought together researchers interested in "intelligent machines"
- for next 20 years, virtually all advances in AI were by attendees
  - Minsky (MIT), McCarthy (MIT/Stanford), Newell & Simon (Carnegie),…

John McCarthy

Marvin Minsky

Fashions in AI

Progress goes in stages, following funding booms and crises: Some examples:

1. Machine translation of languages

    1950's to 1966 - Syntactic translators

    1980 - commercial translators available

2. Neural Networks

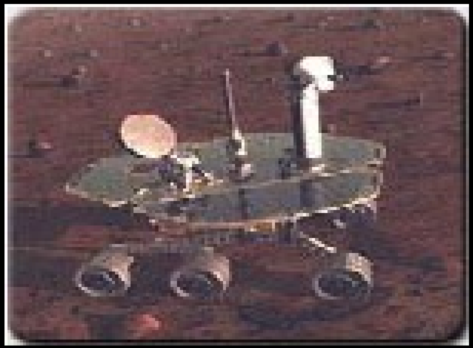
    1943 - first AI work by McCulloch & Pitts

    1950's & 60's - Minsky's book on "Perceptrons" stops nearly all work on nets

    1986 - rediscovery of solutions leads to massive growth in neural nets research

AI Applications

- Autonomous Planning & Scheduling:
  - Autonomous rovers.

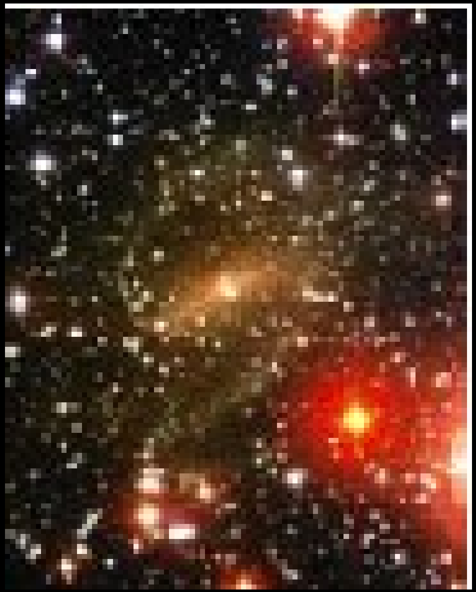


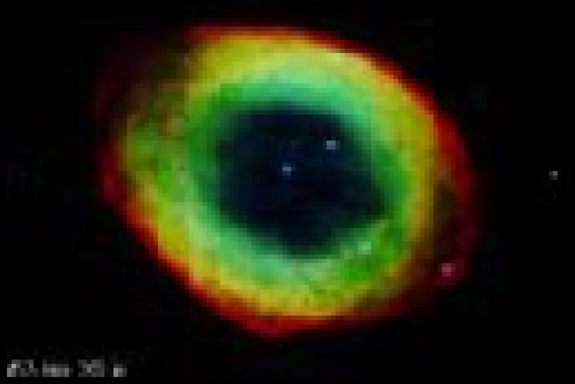
AI Applications

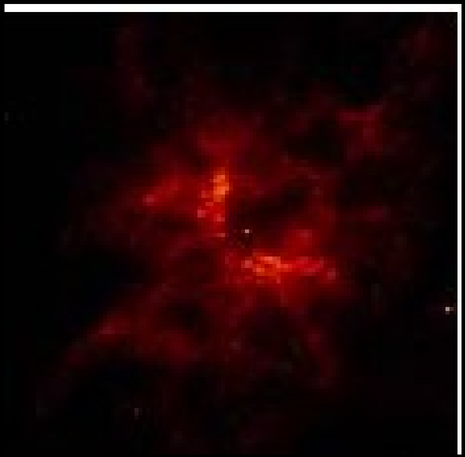
- Autonomous Planning & Scheduling:
  - Telescope scheduling

AI Applications

- Autonomous Planning & Scheduling:
  - Analysis of data:

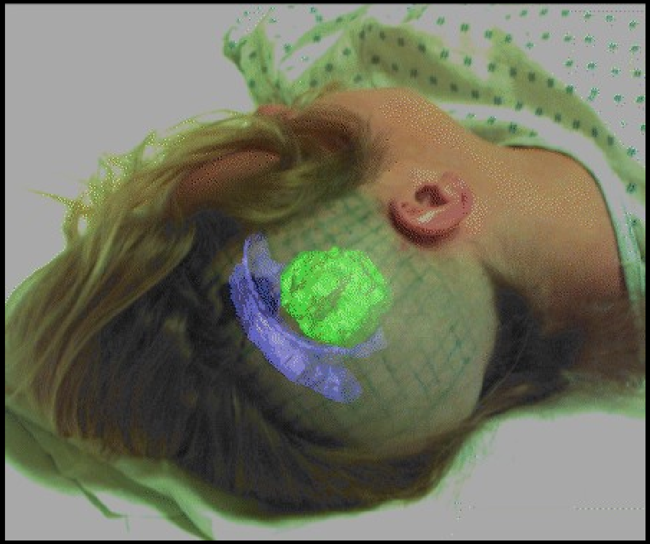


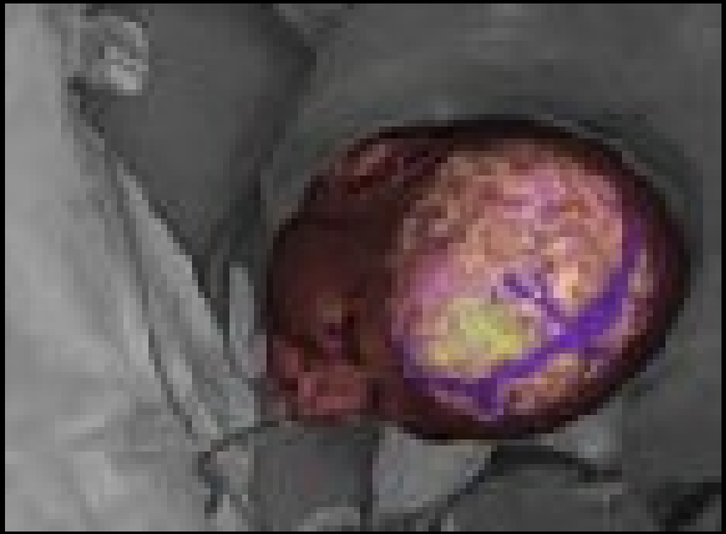




AI Applications

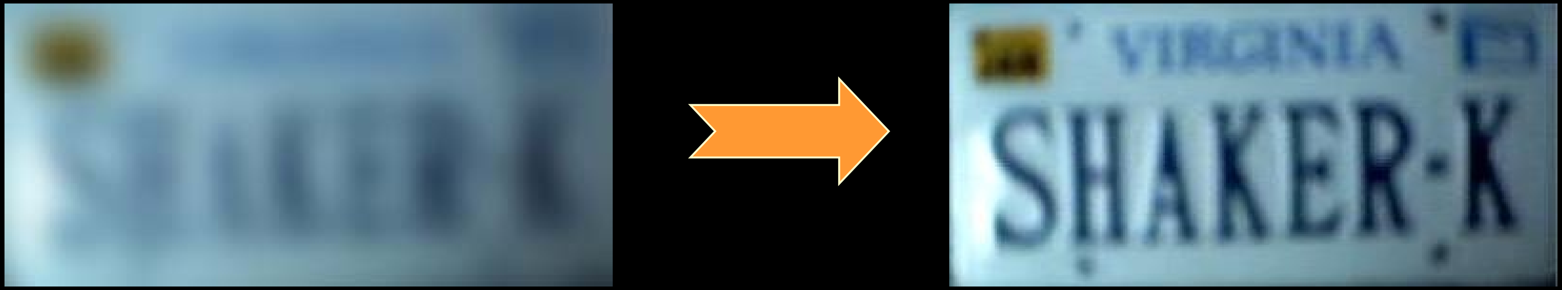
- **Medicine**:
  - Image guided surgery

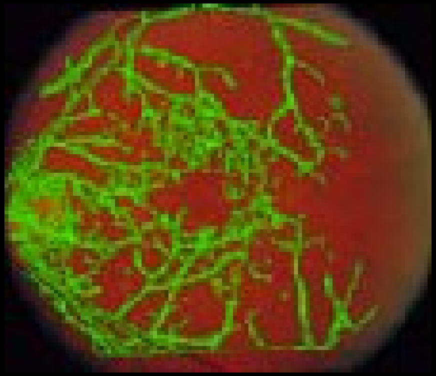


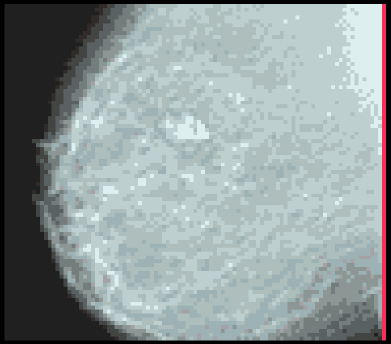


AI Applications

- **Medicine**:
  - Image analysis and enhancement





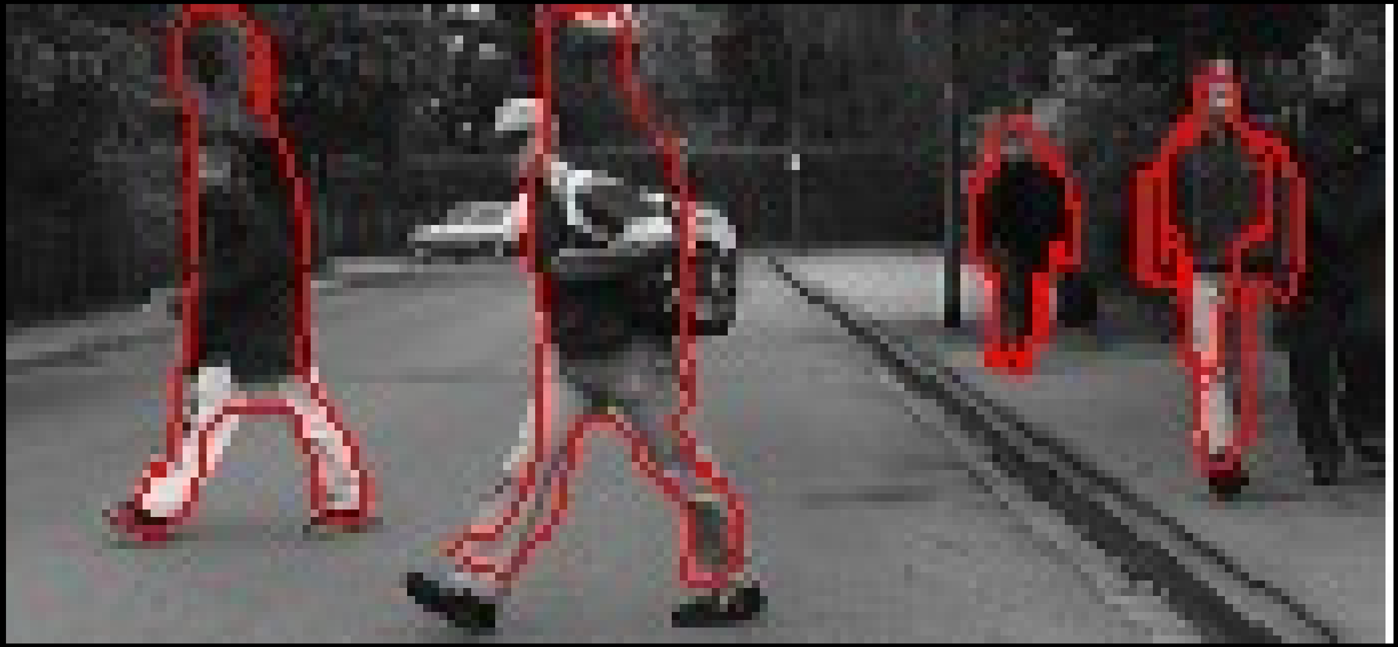


AI Applications

- **Transportation**:
  - **Autonomous vehicle control:**

AI Applications

- **Transportation**:
  - **Pedestrian detection:**

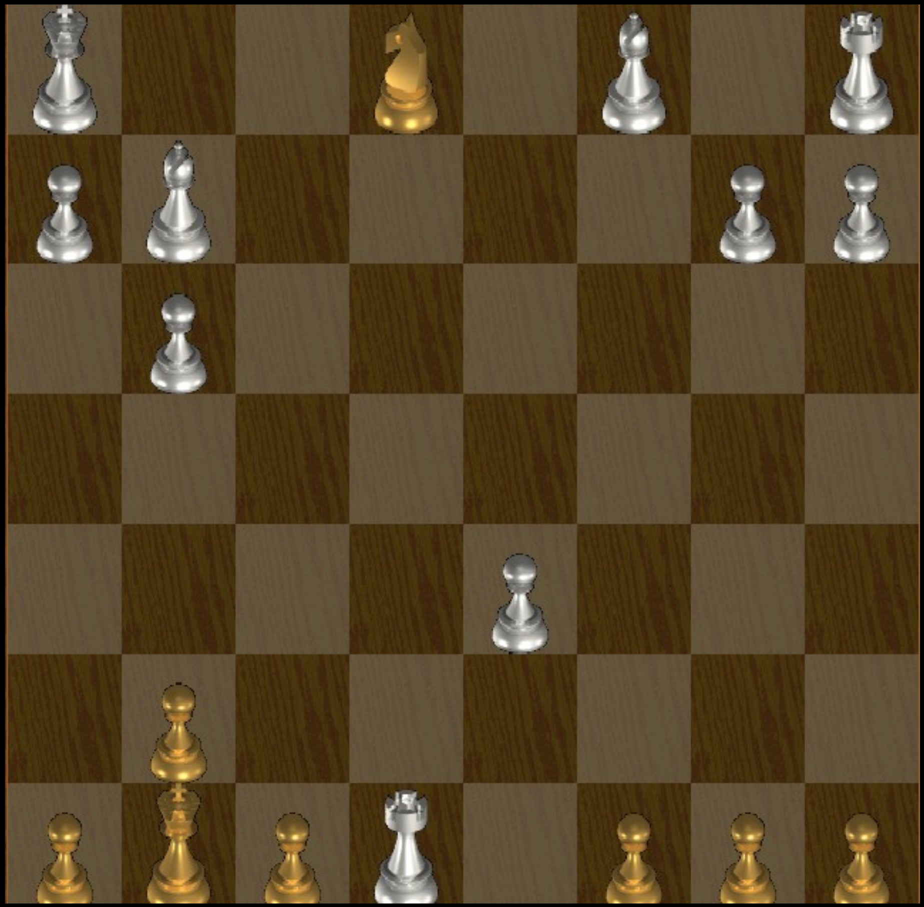


AI Applications

Games:

AI Applications

- **Games**:



AI Applications

- **Robotic toys**:

AI Applications

Other application areas:

- **Bioinformatics:**
  - Gene expression data analysis
  - Prediction of protein structure
- **Text classification, document sortin**g:
  - Web pages, e-mails
  - Articles in the news
- **Video, image classification**
- **Music composition, picture drawing**
- **Natural Language Processing** .
- **Perception.**

4 questions

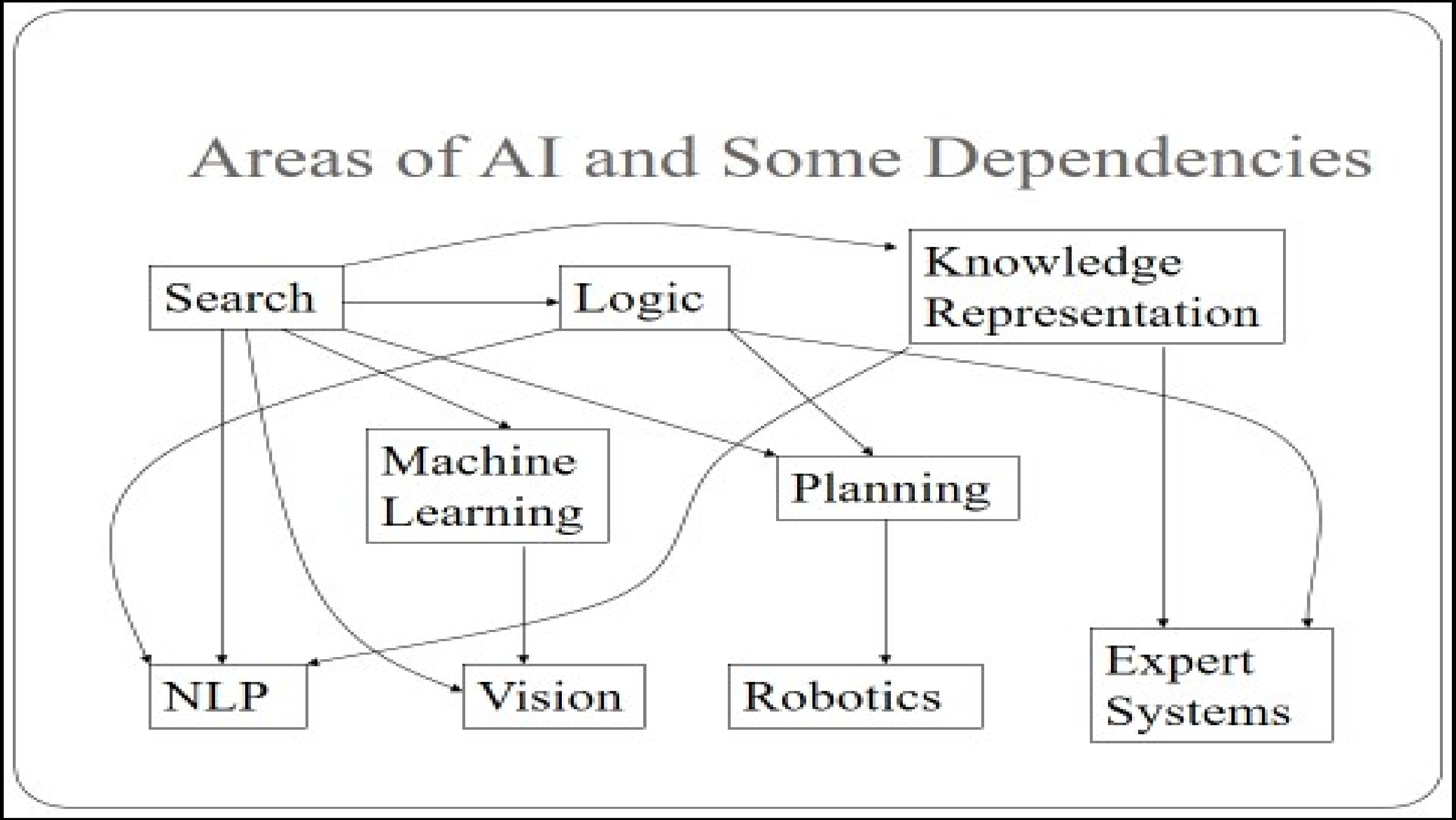
- What are our underlying assumptions about intelligence?
- What kinds of techniques will be useful for solving AI problems?
- At what level of detail are we trying to model human intelligence?
- How will we know when we have succeeded in building an intelligent program?

What is an AI Technique?

- Intelligence requires knowledge

  (less desirable properties)
  - voluminous
  - hard to characterize accurately
  - constantly changing
  - differ from data by being organized in a way that corresponds to the ways it will be used

Areas of AI and some dependency



Knowledge Representation

- Generalizations
- Understood by people
- Easily modified
- Used in a great many situations
- Can be used to reduce the possibilities that must be considered

Example: Tic-Tac-Toe program

- complexity
- use of generalizations
- clarity of knowledge
- extensibility

1	2	3
4	5	6
7	8	9

Program 1

- Board: 9-element vector

  0 : blank, 1 : X , 2 : O
- Move table: 3^9 Rows of 9-element vectors
- Algorithm:

  1. transform board vector from base 3 to 10
  2. use (1) as the move table index
  3. change the board by using the vector from (2)

Move Table

It is a vector of 3^9 elements, each element of which is a nine element vector representing board position.

Total of 3^9(19683) elements in move table

Move Table

Index	Current Board position	New Board position
0	000000000	000010000
1	000000001	020000001
2	000000002	000100002
3	000000010	002000010

Comments:

- Advantages:
  efficient in terms of time,
  optimal game of tic-tac-toe in theory
- Disadvantages:
  space - move table space
  work - move table
  error prone - move table
  three dimension - 3^{27}, no longer work at all

Program 2

- Board: program1
  2 : blank, 3 : X, 5 : O
- Turn: game moves 1,2,3,.....
  odd-numbered move : x
  even-numbered move : o

Algorithm : *3 sub procedures*

Make2: Board[5] or Board [2, 4, 6, or 8],

Posswin (p): 18 (3*3*2) for p = X

50 (5*5*2) for p = O

- Go (n) : Move to Board [n]

Sterategy

- Turn=1 Go (1)
- Turn=2 Go (5) or Go (1)
- Turn=3 Go (9) or Go (3)
- Turn=4 Go(Posswin(X)) or Go(Make2)
- Turn=5 Go(Posswin(X)), or Go(Posswin(O)), or Go(7), or Go(3) [fork]
- …

Comments:

- Less efficient than Program 1 (time)
- More efficient (space)
- More clarity (strategy)
- Easier to change (strategy)

- Cannot extend to three dimension

Program 2'

- program 2 board
- magic square 15
- possible win check:

  S = sum of two paired owned by a player

  D = 15 – S

  if 0 < D < 10 and Board [D] is empty then the player can win

8	3	4
1	5	9
6	7	2

Q How is Tic-Tac-Toe solved using

Magic Square Method ?

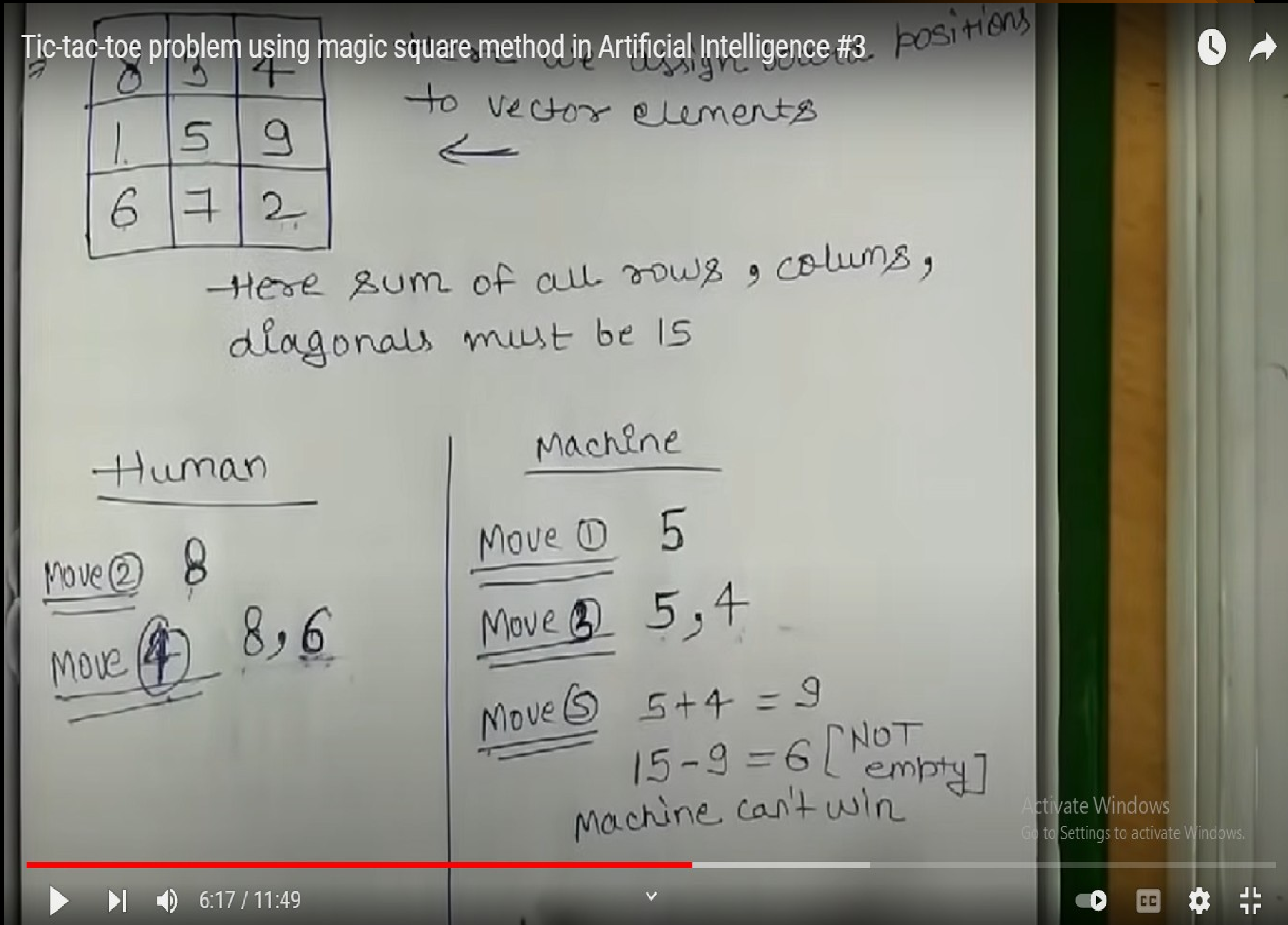
⇒

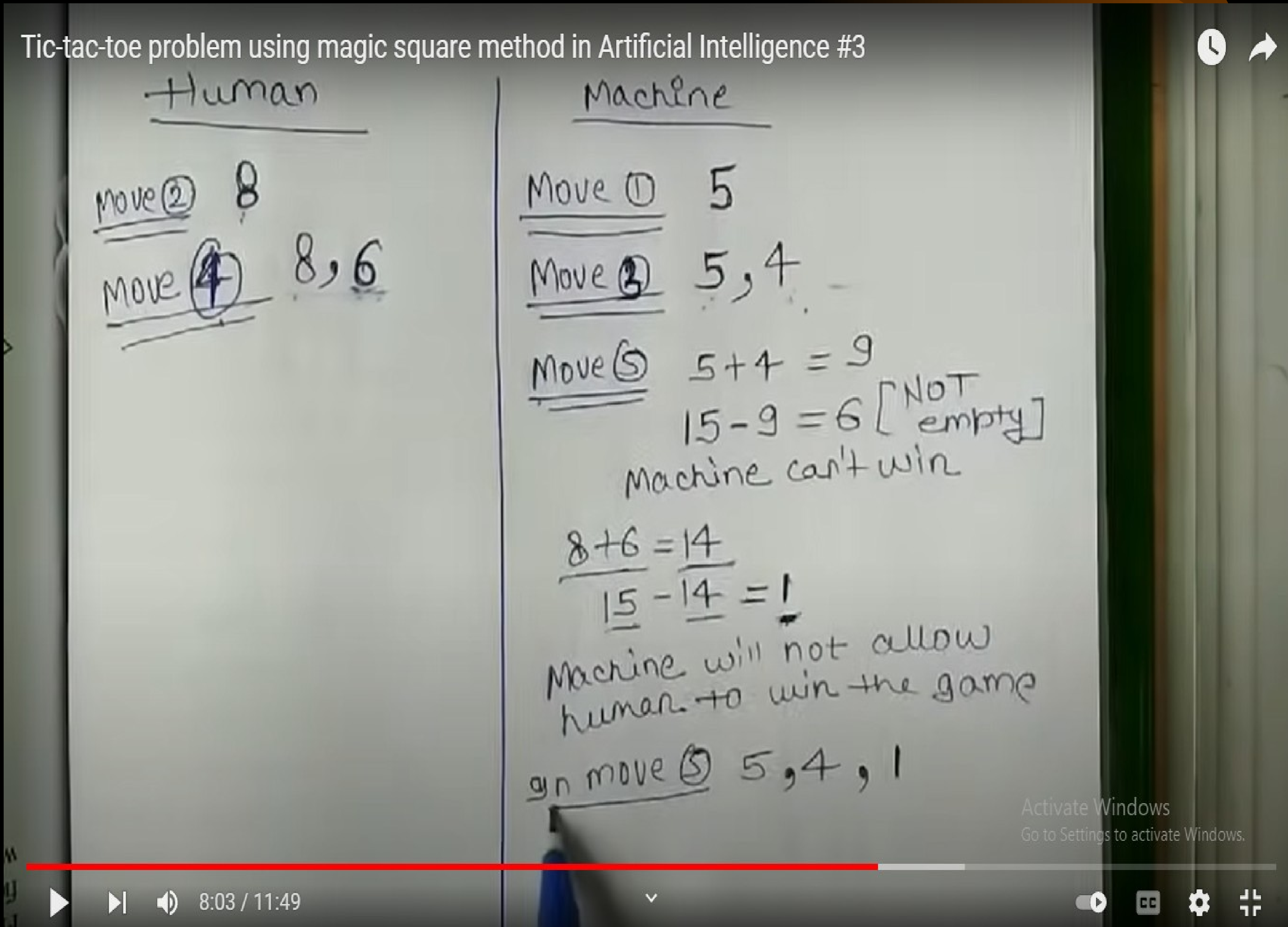
8	3	4
1	5	9
6	7	2

Here we assign board positions to vector elements ⟵

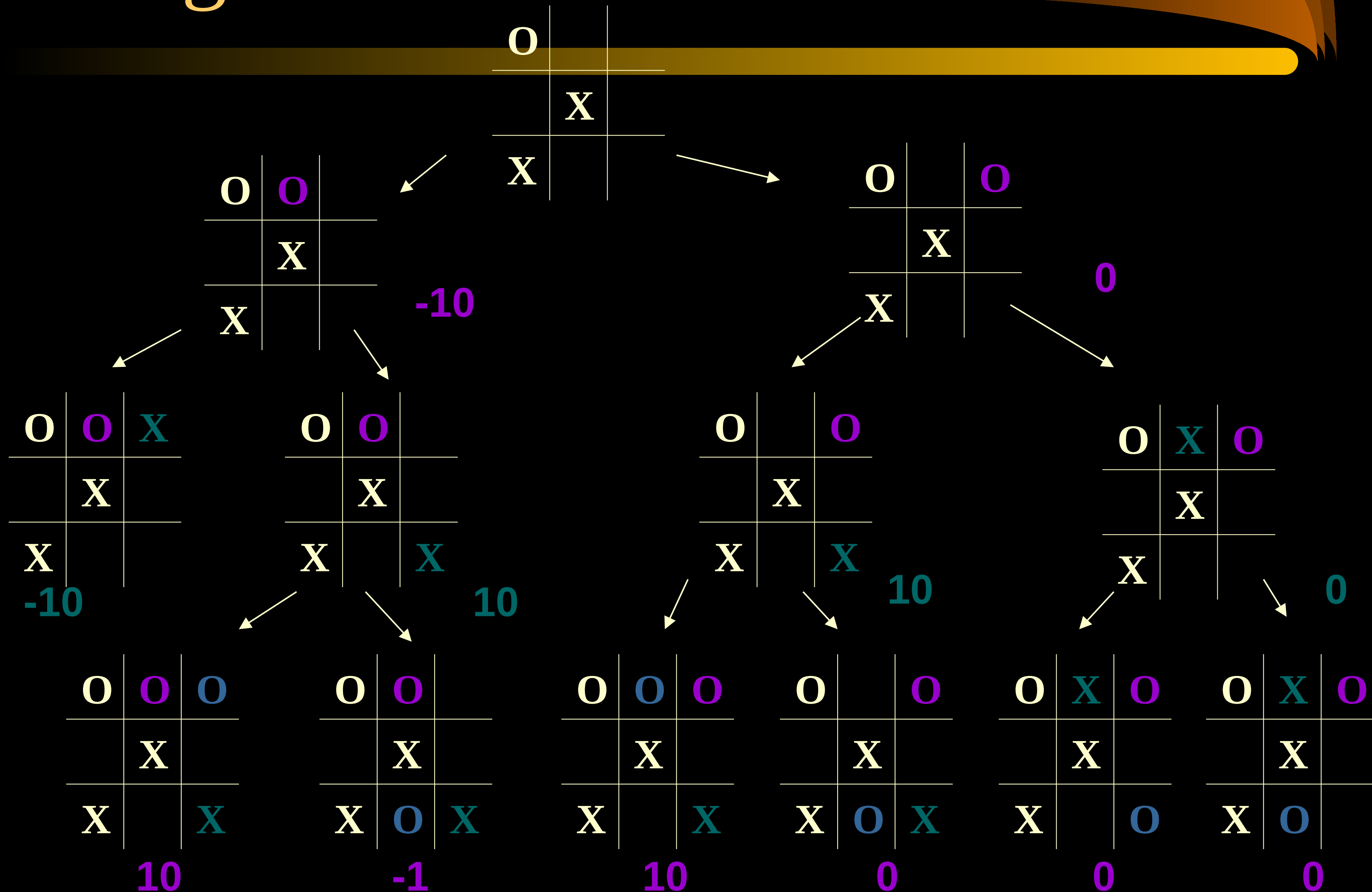
Here sum of all rows, colums, diagonals must be 15

Human	Machine
	Move 1 5
Move 2 8	
	Move 3 5, 4
Move 4 8, 6	


Tic-tac-toe problem using magic square method in Artificial Intelligence #3
positions
to vector elements
8 3 4
1 5 9
6 7 2
Here sum of all rows, colums,
diagonals must be 15
Human
Machine
Move 1 5
Move 2 8
Move 3 5,4
Move 4 8,6
Move 5 5+4 = 9
15-9 = 6 [NOT empty]
Machine can't win
Activate Windows
Go to Settings to activate Windows.
6:17 / 11:49


Tic-tac-toe problem using magic square method in Artificial Intelligence #3
Human
Machine
Move 2 8
Move 4 8, 6
Move 1 5
Move 3 5, 4
Move 5 5+4 = 9
15-9 = 6 [NOT empty]
Machine can't win
8+6 = 14
15 - 14 = 1
Machine will not allow human to win the game
on move 5 5, 4, 1
8:03 / 11:49
Activate Windows
Go to Settings to activate Windows.

Program 3 : *minimax*



Comments

- much more complex (time and space)
- Extendable
- AI technique