What is A.I.?

- Computers can manipulate symbols as well as numbers.

- Thinking can be functionally/computationally modeled as a symbol-processing system (this is called the **PSSH** - Physical Symbol System Hypothesis, of Newell & Simon).

- **Goal:** To Build Machinery (Hardware & Software), which performs actions that are considered to be evidence of intelligence when performed by humans.

- **Early Work** in the field focused on formal tasks such as game playing and mathematical theorem proving.
Areas of Research in A.I.

- Mundane Tasks
  - Perception (Vision, Speech)
  - Natural Language (Understanding, Generation, Translation)
  - Robotics

- Formal Tasks
  - Games (chess, Checkers)
  - Mathematics (Geometry, Logic)

- Expert Tasks
  - Engineering (Design, Manufacturing)
  - Medical Diagnosis.
  - Financial Analysis.
An Example of AI Techniques?

**Search in Formal Systems**

A formal systems like games consists of the following components:

1. Set of valid States.
2. Set of valid Operators.
3. Start State.
4. Goal State.

Example: 8-puzzel Problem

*A typical state of the problem:*

<table>
<thead>
<tr>
<th>1</th>
<th>3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

*Valid Operators: (move the blank tile to left, right, up and down)*

*Goal State:*

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>8</td>
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<tr>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
**Winning Strategy**

A sequence of operations applied to starting state, which will end in the goal state:
Types of Search Strategy:

I: Depth-First Search

**Depth First Strategy:**
- Expand the current hypothesis as far (Deep) as possible before considering other hypotheses.
- When a cutoff level or dead-end is reached, backtrack to most recent viable hypothesis.
Example Search-Tree:
The Eights Puzzle

Be careful of Loops!!!

And so on (possibly ad finitum!)
Types of Search Strategy:

II: Breadth-First Search

Breadth First Strategy:

- Expand all competing hypothesis at a given depth in parallel (no favoritism!)
- Move down through search tree an entire level at a time.
- When the goal is found, the pathway followed is guaranteed to be the shortest!
- Unlike Depth-First search, Loops are not a problem.
Types of Search Strategy:

**IV: Bi-Directional (Wave) Search**

- **Bi-Directional (Intersecting Wave) Search:**
  - Perform a search from the Start Node downwards (iterative depth-first or breadth-first).
  - Perform a parallel search from Goal node upwards (iterative depth-first or breadth-first). Where the search waves meet is the halfway point.
  - Join the path from Start to halfway point to the reverse of the path from Goal to halfway point.

![Diagram of Bi-Directional (Intersecting Wave) Search](image-url)
How to Impart Intelligence to Algorithm?

Some configurations are better than others because they are closer to goal state.

Define an “evaluations function” for any given configuration that estimates how far from a goal you are.

Take note for number of moves you have made so far and include this in evaluation function in order to find shortest path to goal.

- In 8-Puzzel:

  \[ f(\text{state}) = \# \text{ of tiles in wrong place (not including blank space)} + \# \text{ of moves made so far}. \]
Machine Learning:

How can algorithms be designed which will learn to improve itself with experience?

1. (Samuel 1958)- Checkers
   • Program vs. Human
   • Program vs. "Book Game"
     • Evaluation Function

\[
f(\text{board}) = w_1 f_1(\text{board}) + \ldots + w_n f_n(\text{board})
\]

• Program vs. Program

Idea:
Adjust the values \(\{w_1, \ldots, w_n\}\) with experience for continuous improvements.

2. Neural Approach