Lecture 3
Artificial Intelligence

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Problem Solving by Searching

- Why search ?
- Early works of AI was mainly towards
  - proving theorems
  - solving puzzles
  - playing games
- All AI is search!
  - Not totally true (obviously) but more true than you might think.
- All life is problem solving !!
  - Finding a good/best solution to a problem amongst many possible solutions.

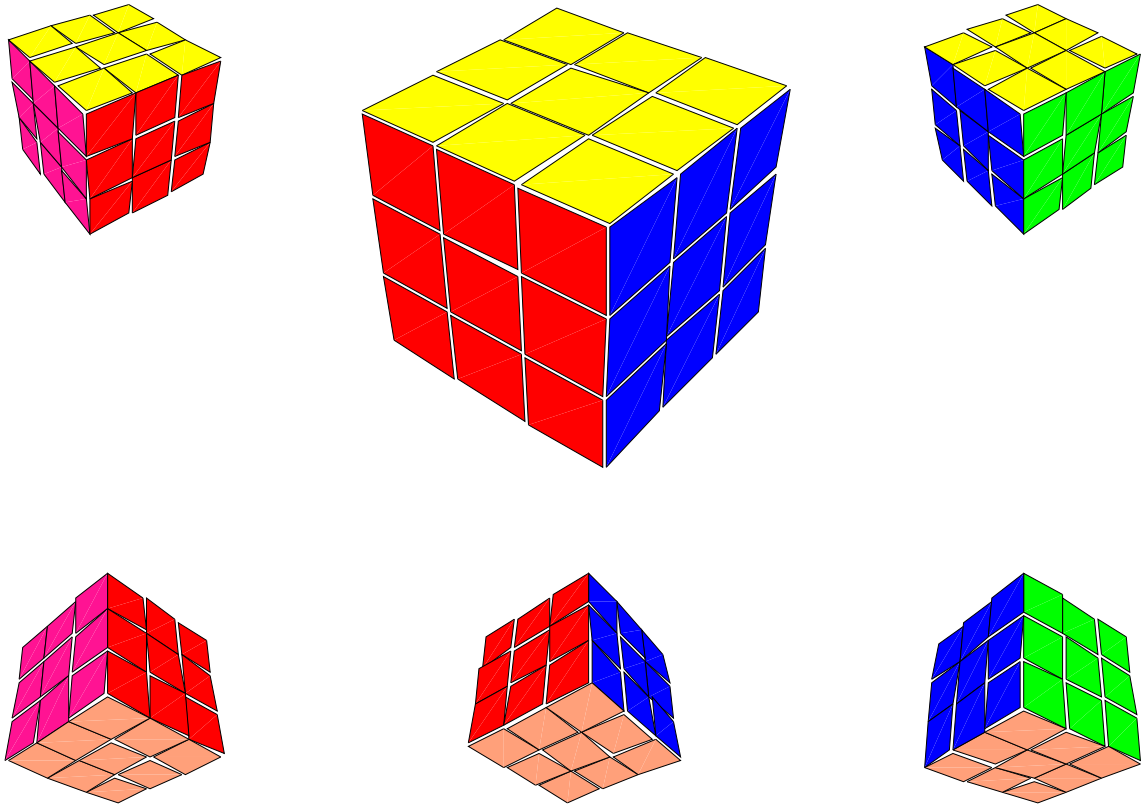
Credit: Khola Naseem

Problem Solving by Searching

- The simplest agents **Simple reflex agents**, which base their actions on a direct mapping from states to actions.
- Such agents cannot operate well in environments for which this mapping would be too large to store and would take too long to learn
- **Goal-based agents**, on the other hand, consider future actions and the desirability of their outcomes.
- Therefore, Goal-based agents is used

Classic AI Search Problems

- 3*3*3 Rubik's Cube



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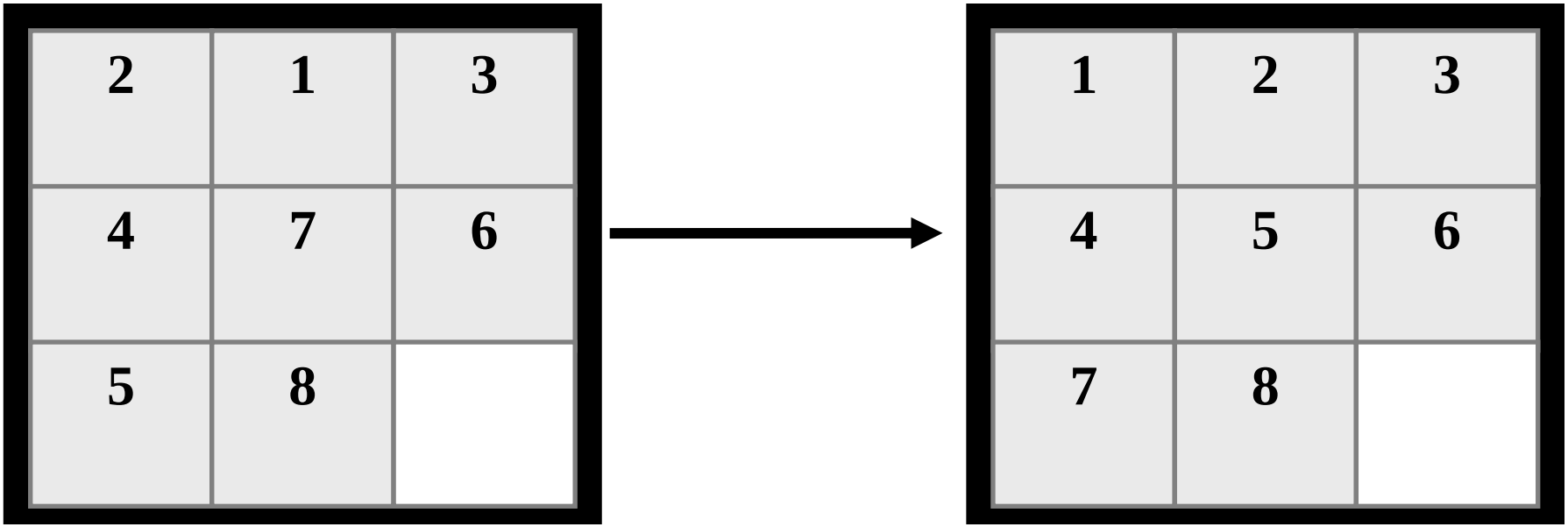
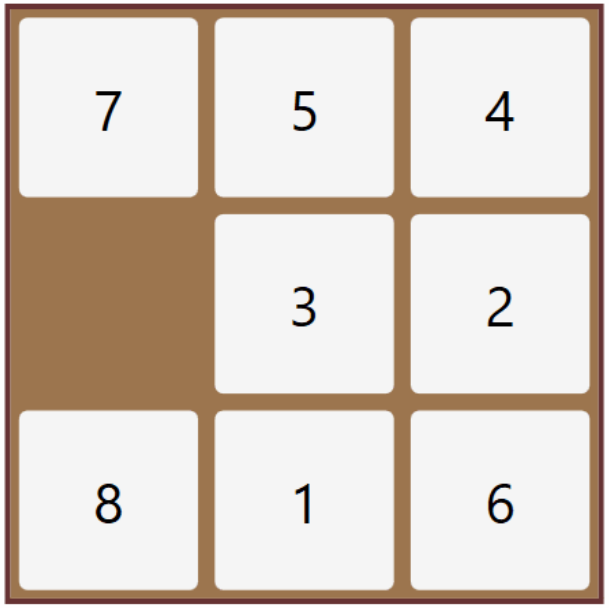
Classic AI Search Problems

- 8 Puzzle problem



Classic AI Search Problems

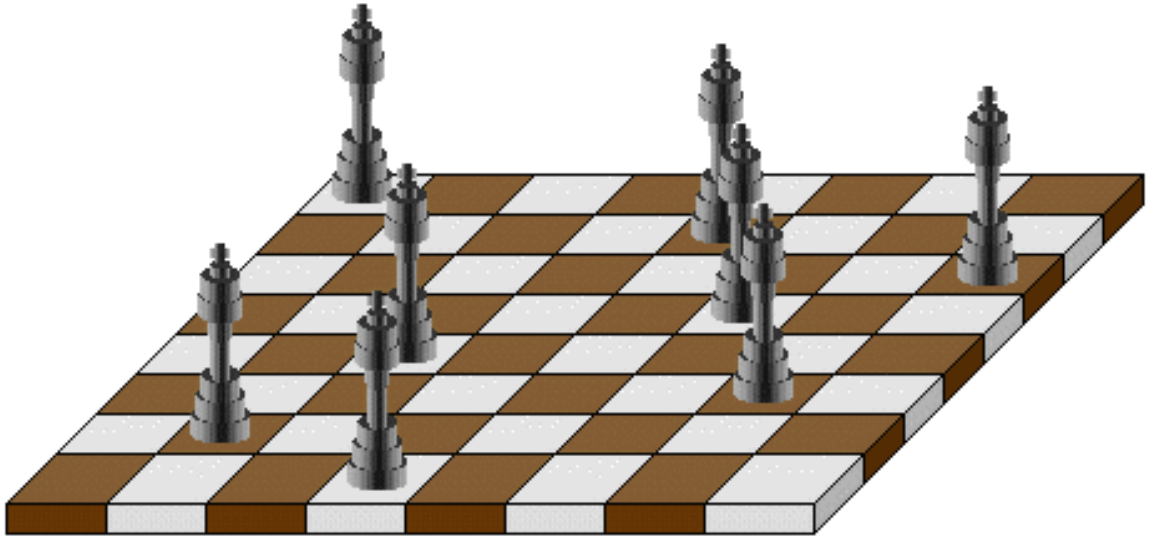
- 8 Puzzle problem



Credit: Khola Naseem

Classic AI Search Problems

- N-Queens:
- Problem of placing n chess queens on an n×n chessboard so that no two queens attack each other
- A solution requires that no two queens share the same row, column, or diagonal



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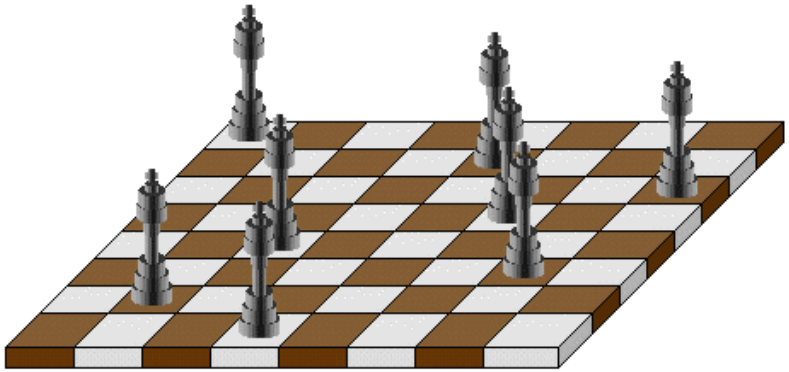
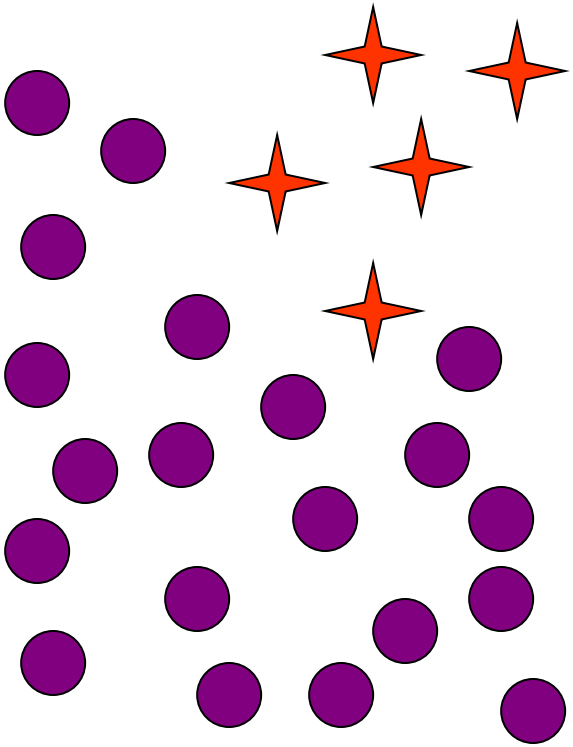
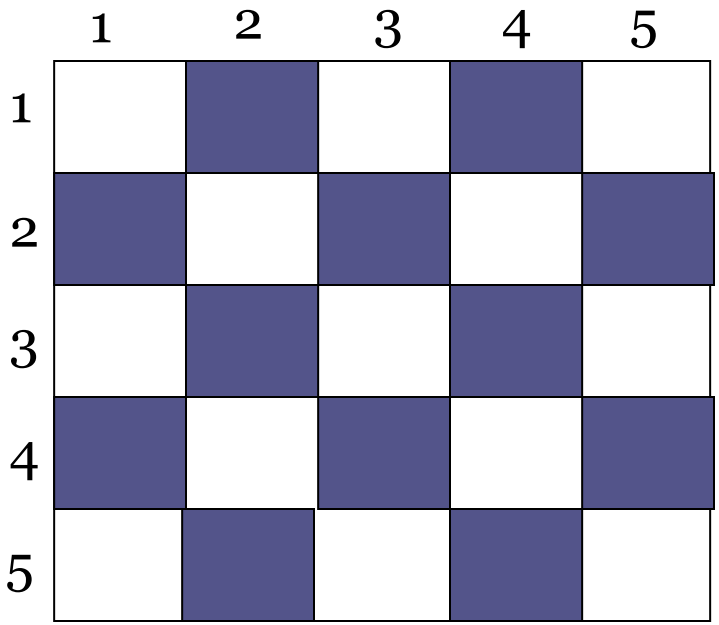
Classic AI Search Problems

- 5-Queens:







Classic AI Search Problems

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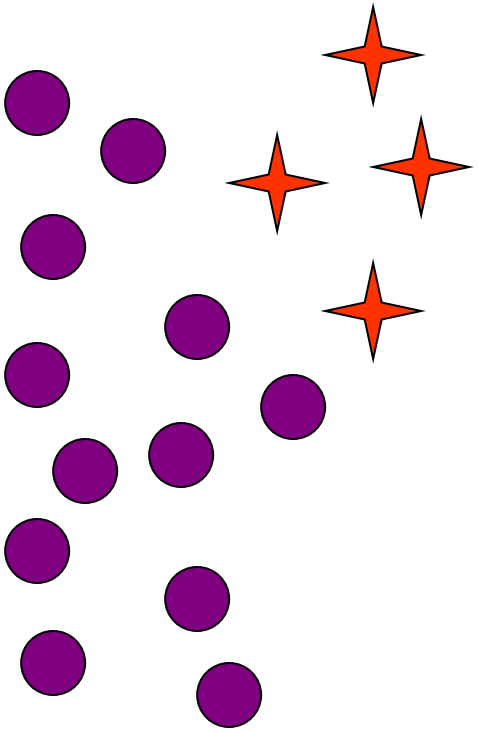

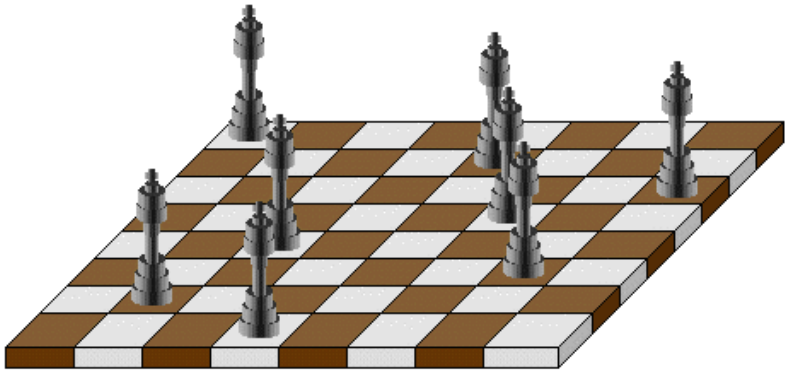

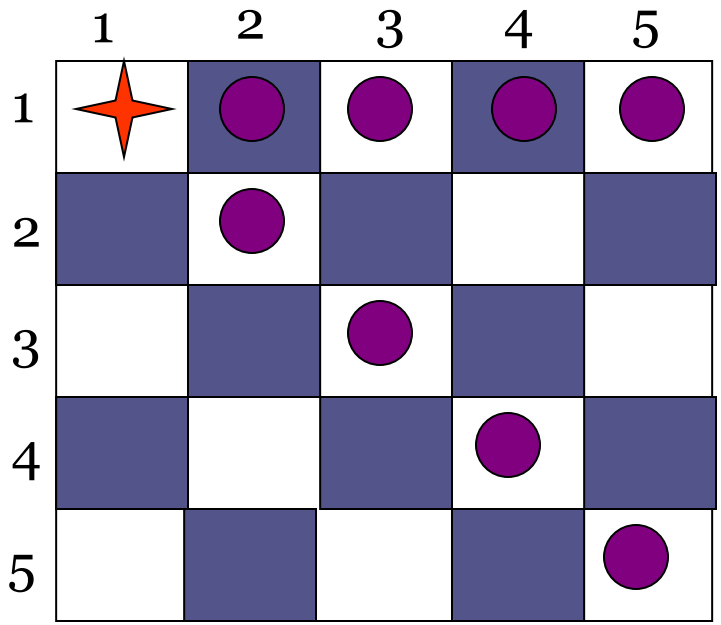

Classic AI Search Problems

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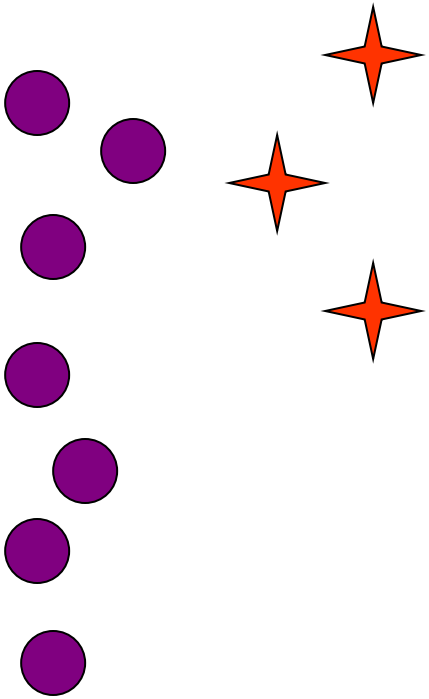

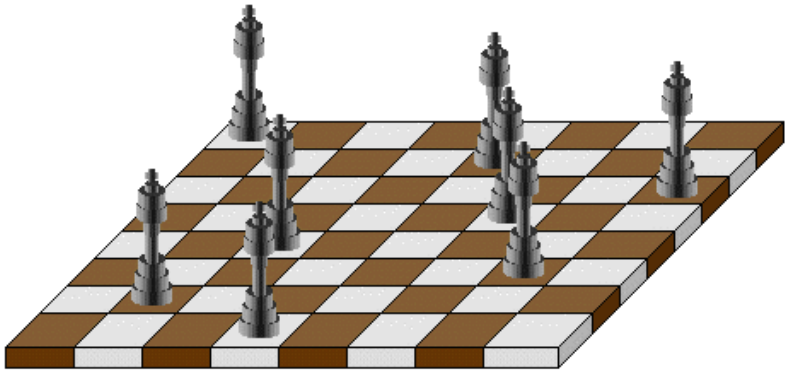

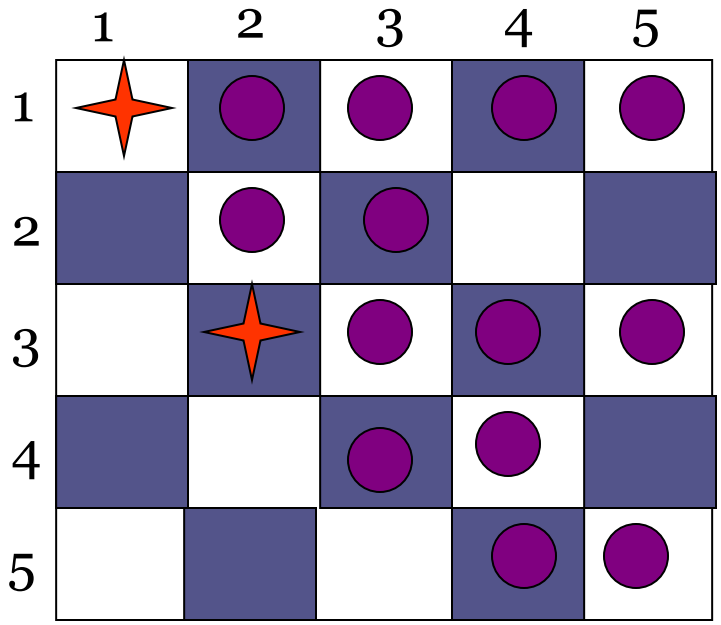

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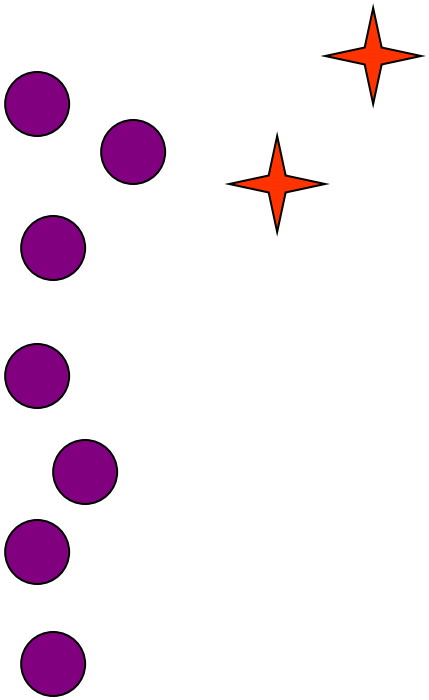

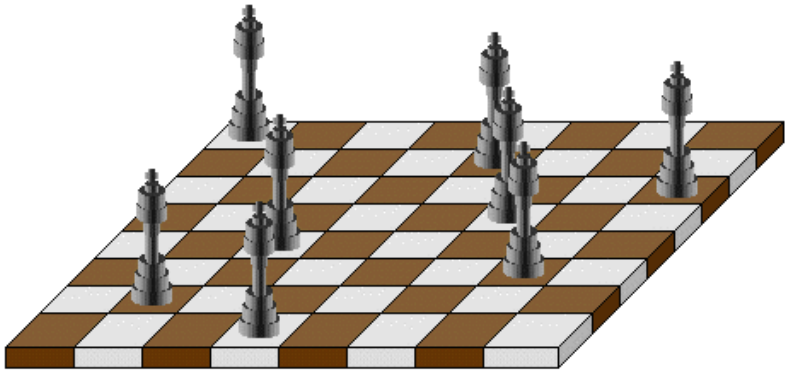

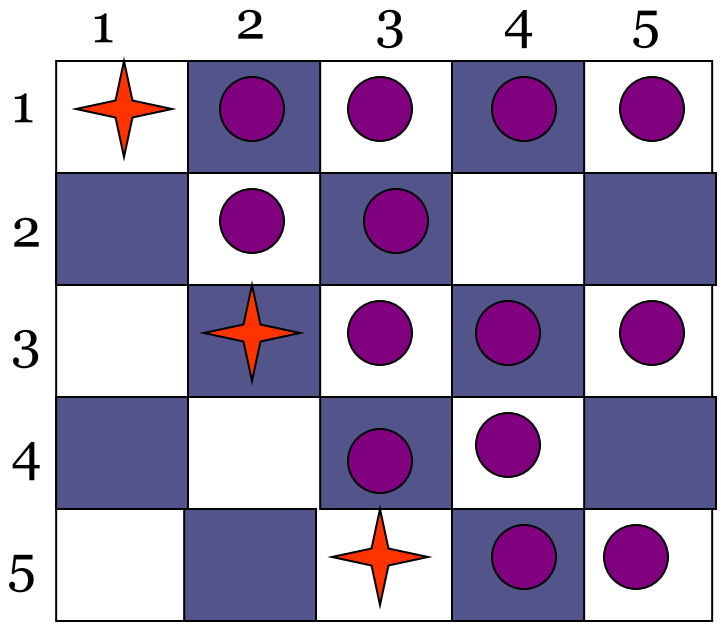

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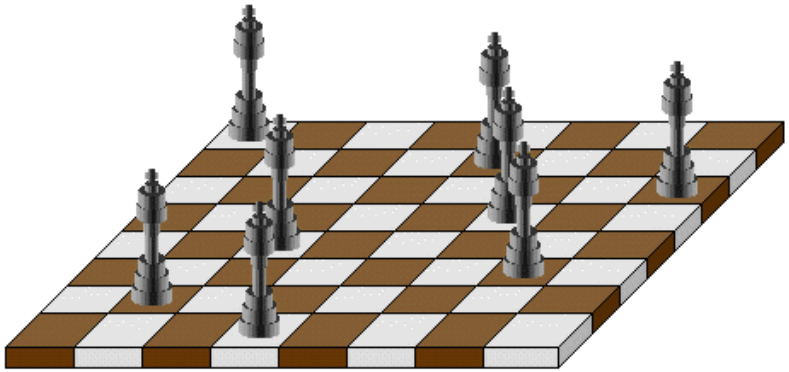

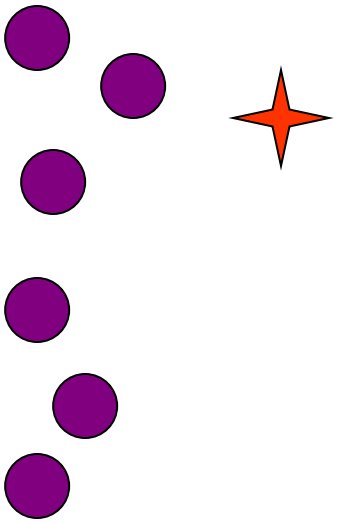

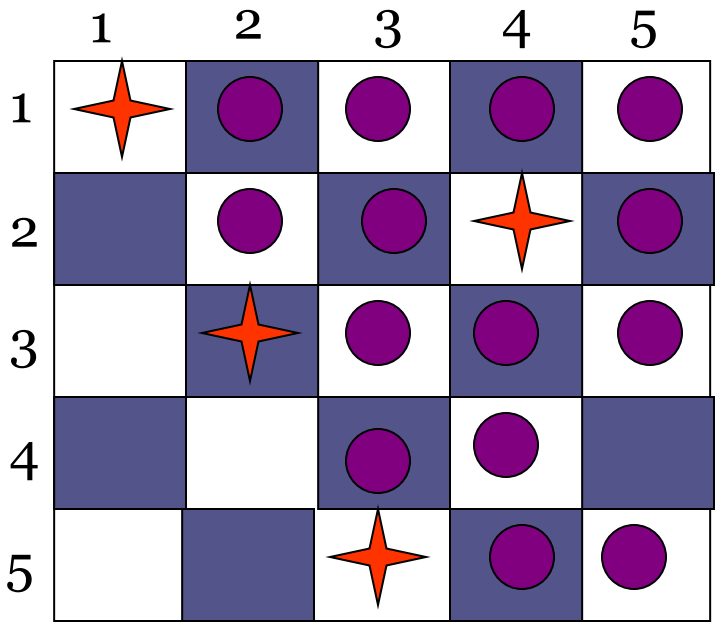

Classic AI Search Problems

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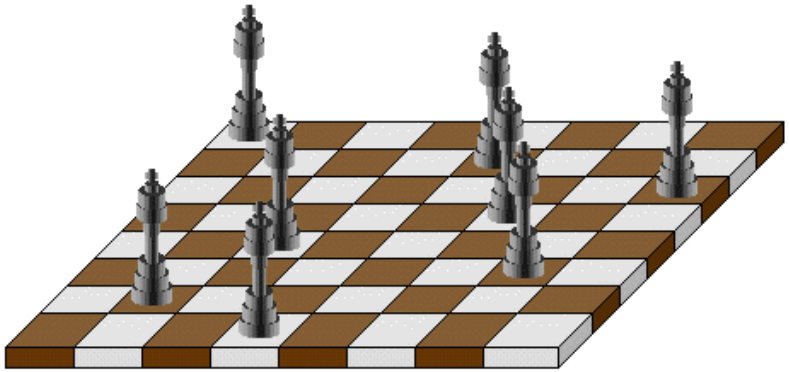
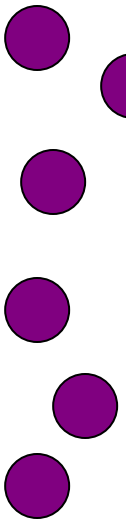
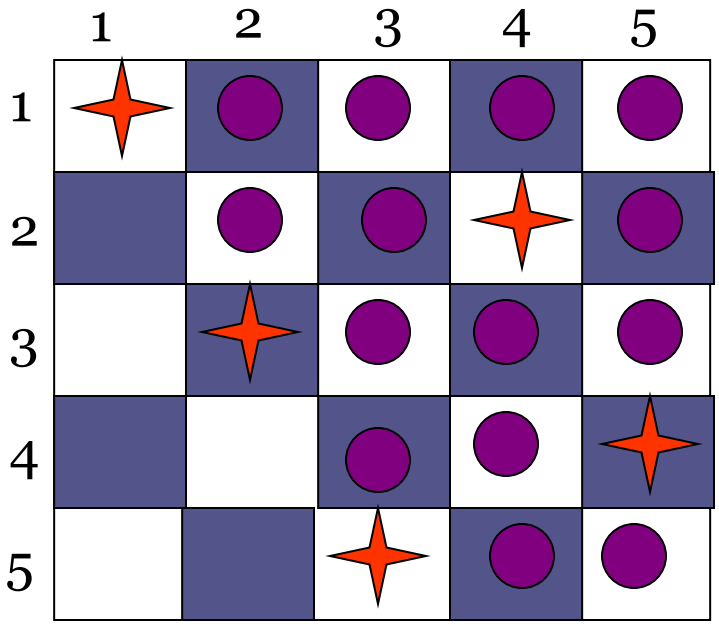




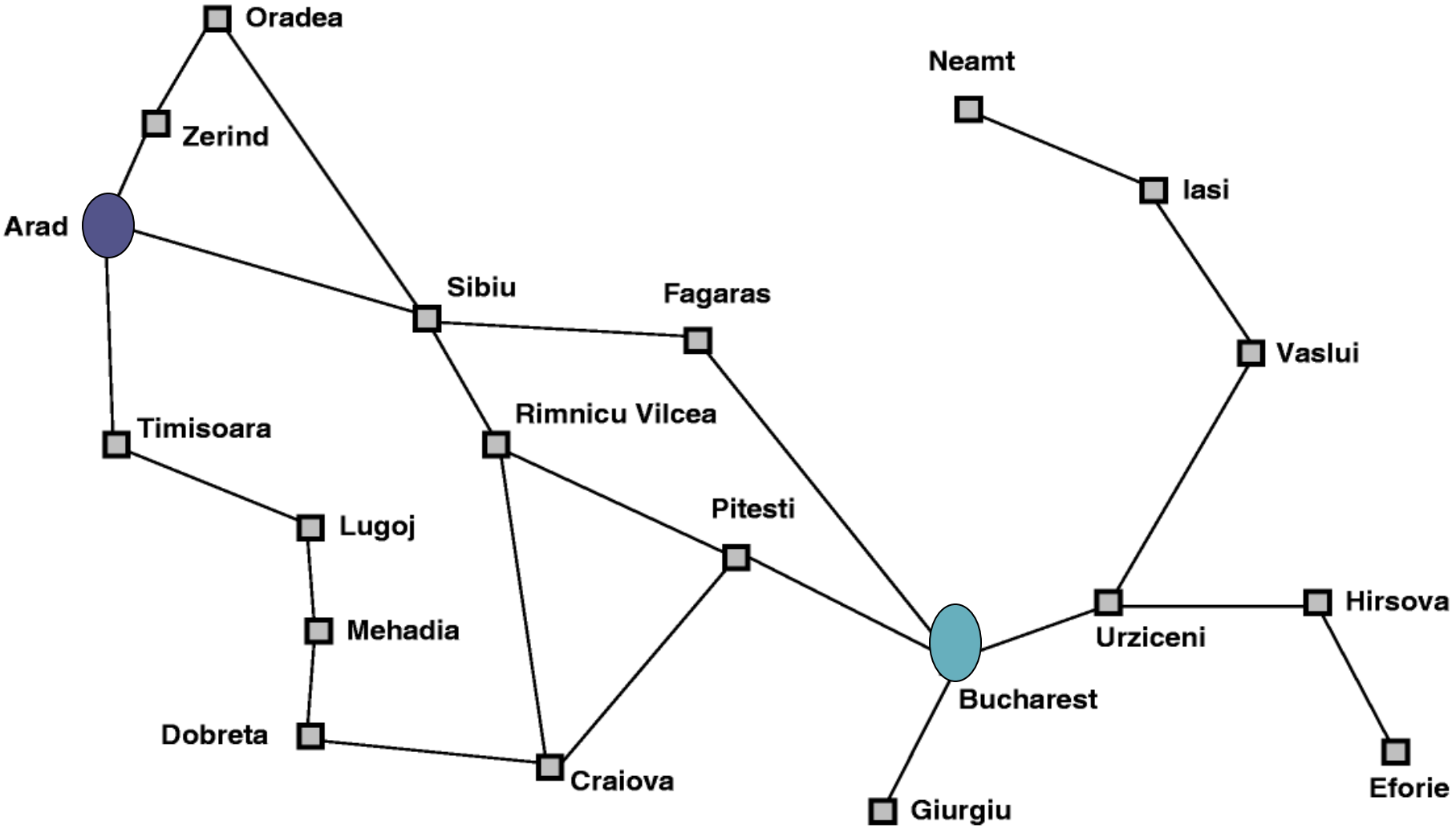
Solution !!

No Queen is under Attack



Classic AI Search Problems

- Map searching (navigation)



Problem Solving by Searching

- Problem-solving agent:
  - Is a kind of goal-based agent
- It solves problem by
  - finding sequences of actions that lead to desirable states (goals)
- To solve a problem,
  - the first step is the goal formulation, based on the current situation

Problem Solving by Searching

- The goal is formulated
  - as a set of world states, in which the goal is satisfied
- Reaching from initial state to goal state
- Actions are required
  - Actions are the operators
  - causing transitions between world states

Problem Solving by Searching

The Problem formulation

- The process of deciding
  - what actions and states to consider
- E.g., driving Main campus to Ksk
- in-between states and actions defined
- States: Some places between main campus & Ksk
- Actions: Turn left, Turn right, go straight, accelerate & brake, etc

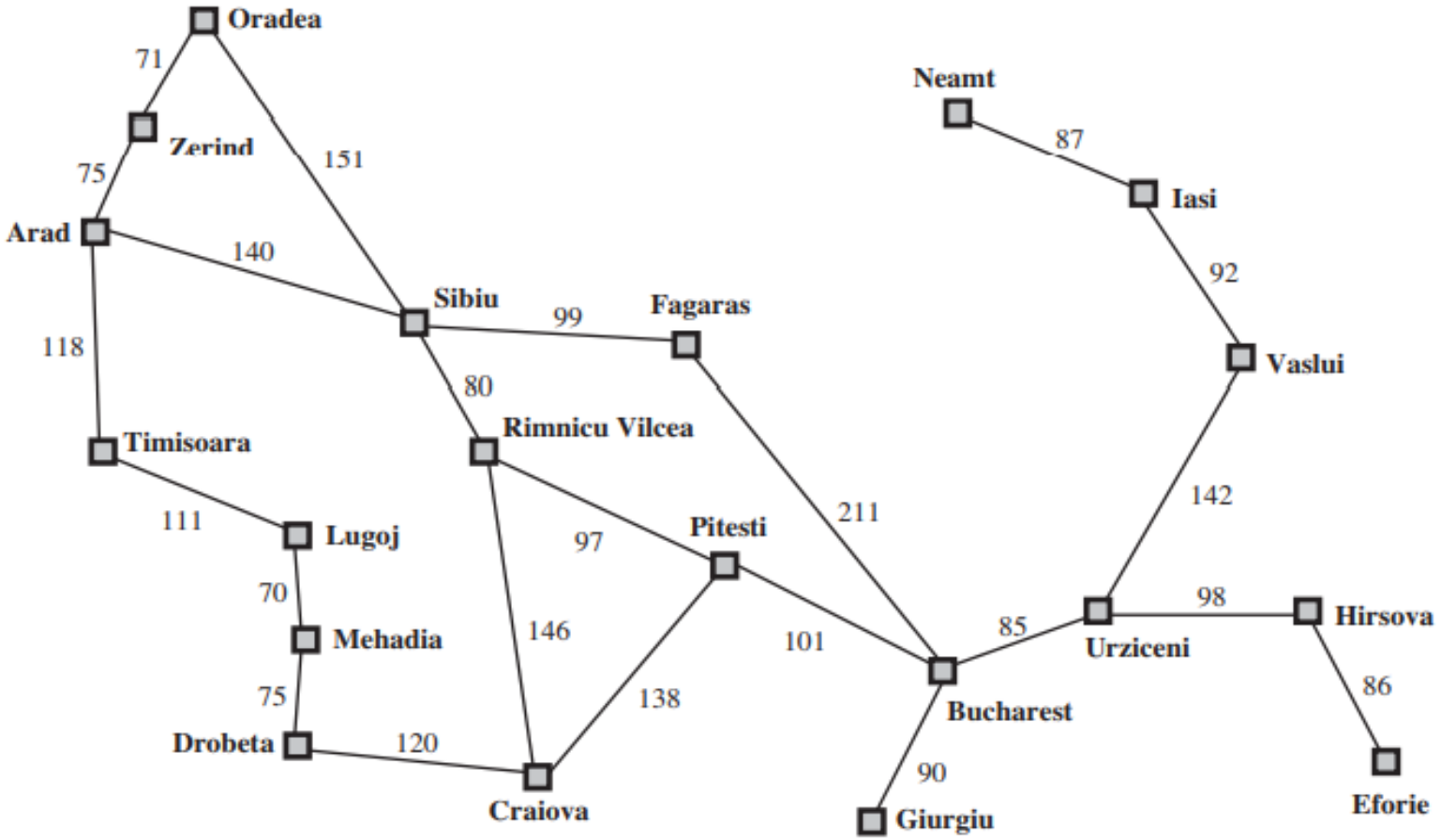
Problem Solving by Searching

Why searching is important:

- Because there are many ways to achieve the same goal
- the agent can examine different possible sequences of actions, and choose the best
- The process of looking for a sequence of actions that reaches the goal is called search
- The best sequence is then a list of actions, called solution
- Once a solution is found, the actions it recommends can be carried out. This EXECUTION is called the execution phase.

Problem Solving by Searching

- Example: Romania map
- Goal: Go to Bucharest from Arad



Credit: Khola Naseem

Well-defined problems and solutions:

- A problem can be defined formally by five components:
  - Initial state
  - Actions
  - Transition model or (Successor functions)
  - Goal Test
  - Path Cost

Well-defined problems and solutions:

- Initial state:
  - The initial state that the agent starts in. For example, the initial state for our agent in Romania might be described as In(Arad).
- Action:
  - A description of the possible actions available to the agent. Given a particular state s, ACTIONS(s) returns the set of actions that can be executed in s. We say that each of these actions is applicable in s.
  - For example, from the state In(Arad), the applicable actions are {Go(Sibiu), Go(Timisoara), Go(Zerind)}.

Well-defined problems and solutions:

- TRANSITION MODEL :
  - A description of what each action does; the formal name for this is the transition. TRANSITION MODEL model, specified by a function RESULT(s, a) that returns the state that results from SUCCESSOR doing action a in state s.
  - We also use the term successor to refer to any state reachable from a given state by a single action.
  - For example, we have RESULT(In(Arad),Go(Zerind)) = In(Zerind) .

Well-defined problems and solutions:

- State space :
  - Together, the initial state, actions, and transition model implicitly define the **state space** of the problem
  - the set of all states reachable from the initial state by any sequence of actions.
- Path:
  - A path in the state space is a sequence of states connected by a sequence of actions.

Credit: Khola Naseem

Well-defined problems and solutions:

Goal test

- The goal test, which determines whether a given state is a goal state.
- Sometimes there is an explicit set of possible goal states, and the test simply checks whether the given state is one of them.
- The agent's goal in Romania is the singleton set {In(Bucharest)}

Credit: Khola Naseem

Well-defined problems and solutions:

path cost:

- Is a function
- assigns a numeric cost to each path
- = performance measure
- denoted by g
- to distinguish the best path from others
- Usually the path cost is the sum of the step costs of the individual actions

Well-defined problems and solutions:

- Solution:
  - A solution to a problem is an action sequence that leads from the initial state to a goal state.
- OPTIMAL SOLUTION
  - Solution quality is measured by the OPTIMAL SOLUTION path cost function, and an optimal solution has the lowest path cost among all solutions

Well-defined problems and solutions:

On holiday in Romania; currently in Arad. Flight leaves tomorrow from Bucharest

- Formulate goal:
  - be in Bucharest
- Formulate problem:
  - states: various cities
  - actions: drive between cities
- Find solution:
  - sequence of cities, e.g., Arad, Sibiu, Fagaras, Bucharest

Credit: Khola Naseem

Well-defined problems and solutions:

- A simple problem-solving agent first formulates a goal and a problem, searches for a sequence of actions that would solve the problem, and then executes the actions one at a time. When this is complete, it formulates another goal and starts over.