COSC 4368 Fundamentals of Artificial Intelligence

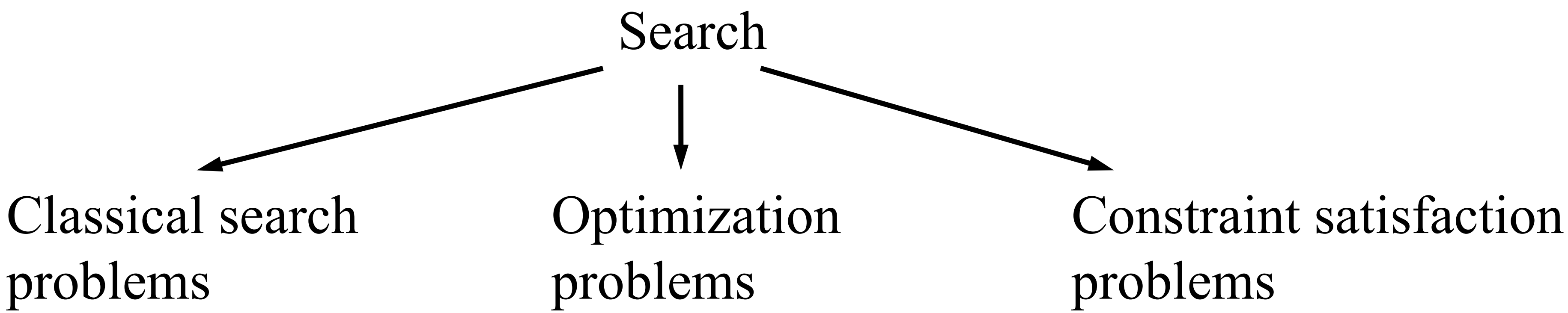
Lecture 2: Search
August 23st, 2023

Teaching Plan on Part I (Search)

- Search1: Classification of Search Problems, Terminology, and Overview (only partially covered in the textbook)
- Search2: Problem Solving Agents
- Search3: Heuristic Search and Exploration
- Search4: Randomized Hill Climbing and Backtracking (not covered in the textbook)
- Search5: Games (will cover this topic quite quickly)
- Search6: Constraint Satisfaction Problems
- Search7: Greedy Search and A* Search
- Search8: Introduction to Evolutionary Computing (EC)
- Search9: Using EC to solve Travelling Salesman Problems

Classification of Search Problems

- Depending on the nature of problems, search problems can be divided into multiple categories:



Search

Classical search problems

Optimization problems

Constraint satisfaction problems

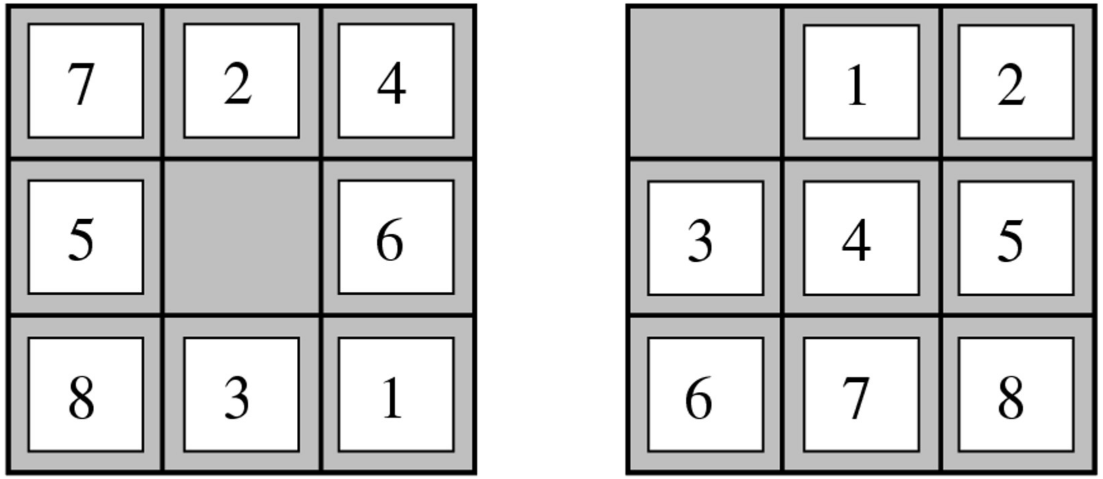
Observable, deterministic, known environment

The solution matters, but how you get it doesn't

The state is not a black box or indivisible, but it can be represented as a set of variables

When these assumptions do not hold, the problem becomes more difficult

Classical Search Problem – the 8-Puzzle



7	2	4
5		6
8	3	1

Start State

	1	2
3	4	5
6	7	8

Goal State

- Consists of a 3*3 board with eight number tiles and a blank space
- A tile adjacent to the blank space can slide into the space
- State: specifies the location of the tiles and the blank space
- Action: movements of the blank space, *Left, Right, Up, Down*
- Goal: find a sequence of actions that leads from a start state to a specified goal state

A Search Tree for the 8-Puzzle

Global search

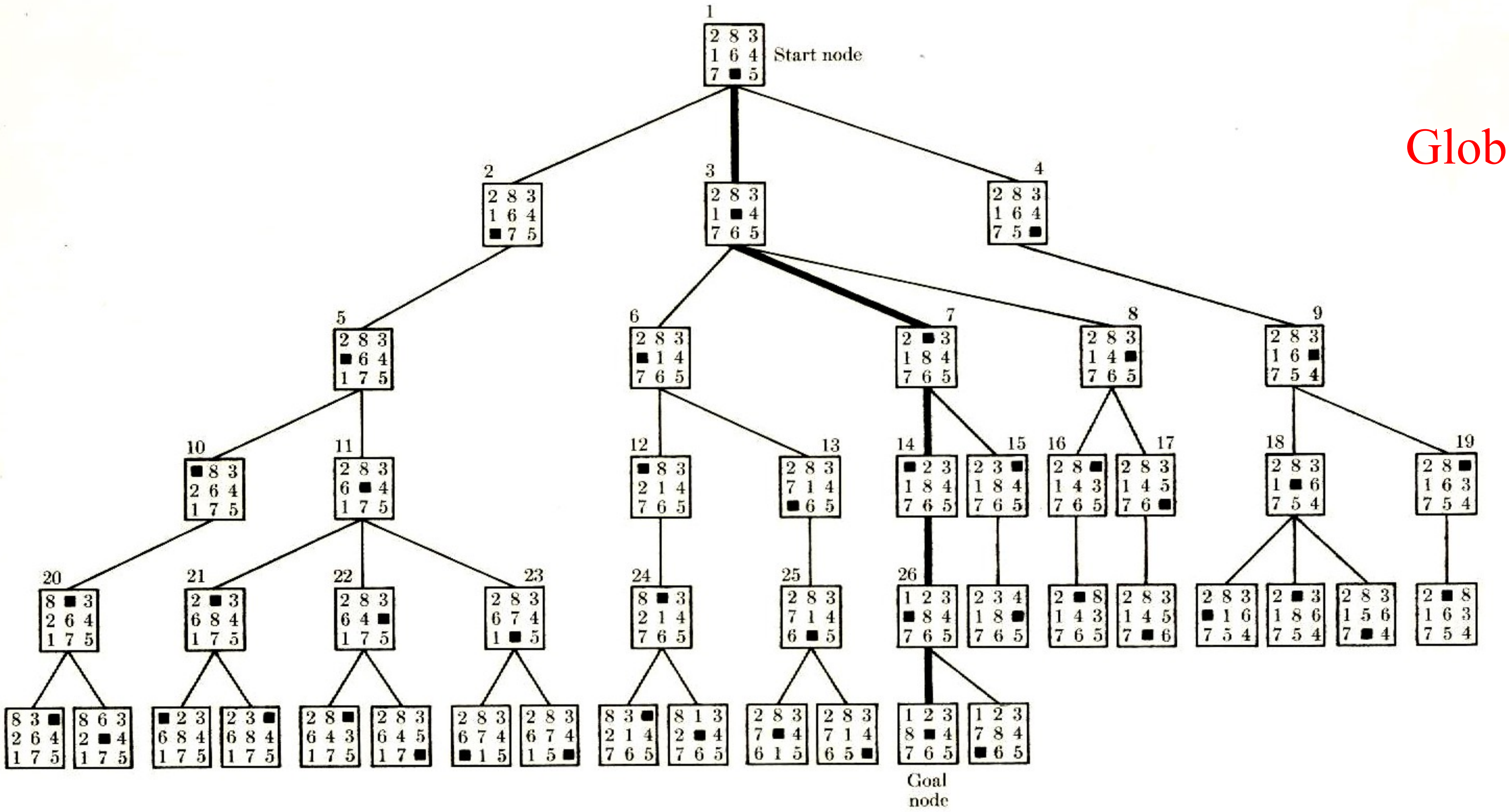
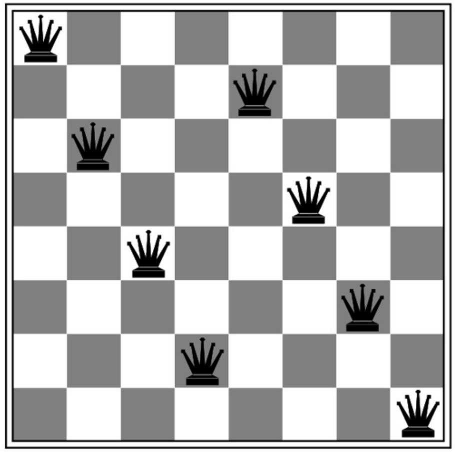


FIG. 3-2 *The tree produced by a breadth-first search.*

Optimization Problem

- Find the best state according to an objective function, while the path followed by the search is not important



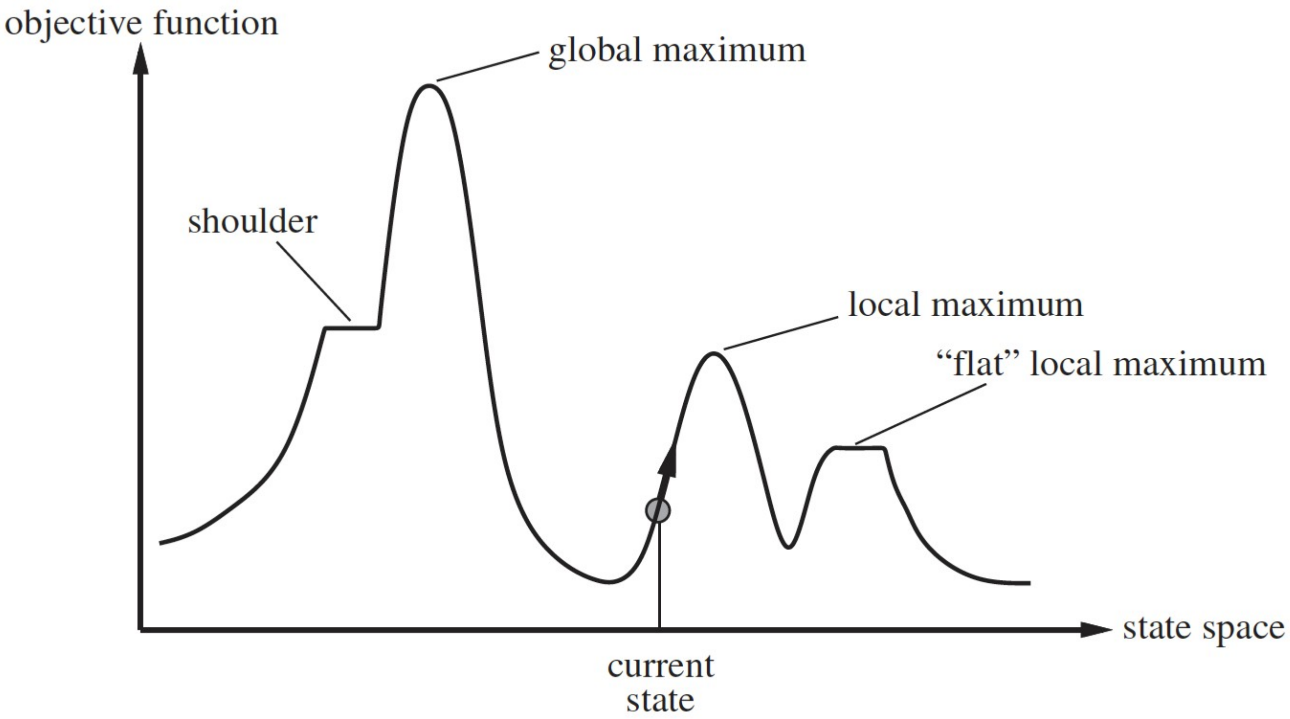
The 8-queens problem:

- place eight queens on a chessboard such that no queen attacks any other
- what matters in the final configuration of queens, not the order in which they are added

- Can be solved by using local search: only evaluate and modify the current states, not systematically exploring paths from an initial state

Optimization Problem

- General optimization problem:
  - Denote state value as S
  - An objective function f(S) which evaluates the value of the state S
  - Objective: find the state S with the largest value f(S)

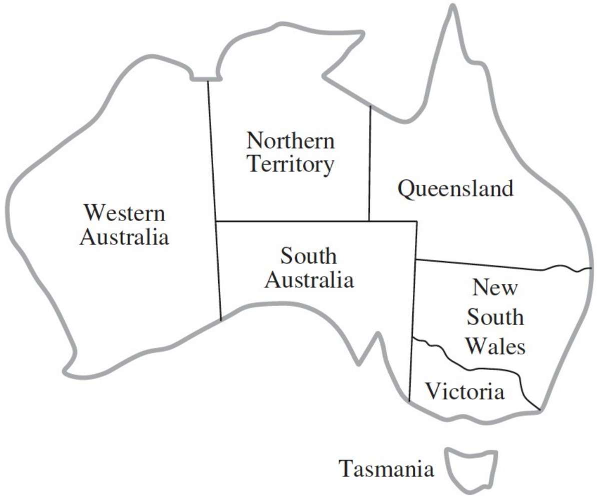


One-dimensional state-space example

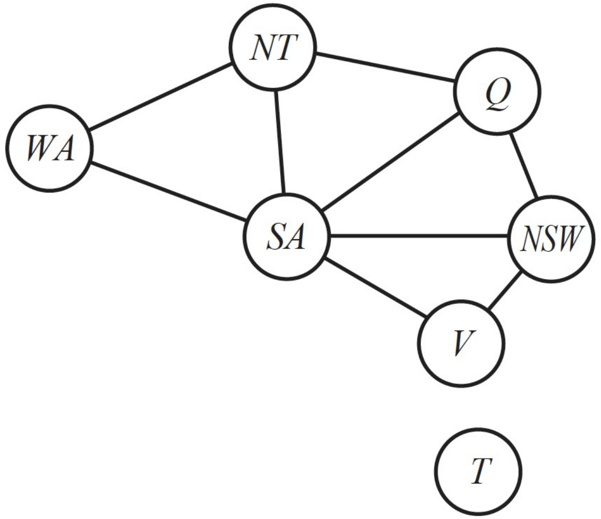
Basic local search:
modify the current state to its neighbor which has a larger value

Constraint Satisfaction Problem

- Each state can be represented as a set of variables
- A problem is solved when each variable has a value that satisfies all the constraints on this variable (corresponds to some goal state)
- Example: map coloring
  - Coloring each region either red, blue, or green, in such a way that no neighboring regions have the same color



(a)

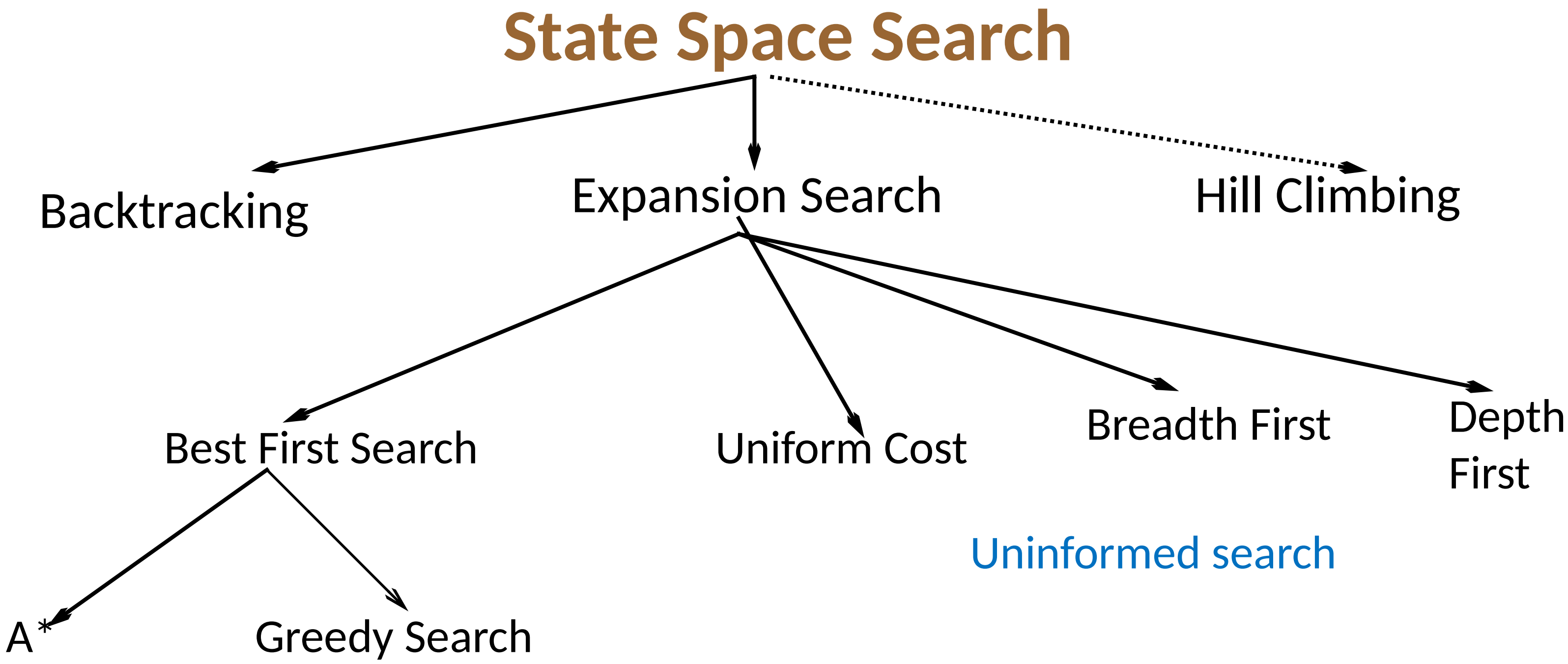


(b)

State={WA, NT, SA, Q, NSW, V, T}
Domain of each variable={red, blue, green}
Constraints={WASA, WANT,...... }

Constraints can significantly reduce the state search space by identifying the values that violate the constraints (combined with global state space search)

Classification of Search Algorithms



State Space Search

Backtracking

Expansion Search

Hill Climbing

Best First Search

Uniform Cost

Breadth First

Depth First

A*

Greedy Search

Uninformed search

Informed search with domain knowledge (heuristic function)

Remark: Many other search algorithms exist that do not appear above

Classification of Search Algorithms

Reading List:

- Chapter 3: mandatory: 63-92, 96-102, 104-106; optional: 92-96, 102-104
- Chapter 4: mandatory: 110-115, 141 optional: 116-119 (EC will be covered separately later), 119-122
- Chapter 5: mandatory: 146-158, 174-175 optional: 159-161, 164-168
- Chapter 6: mandatory: 180-193(skip 6.1.2) optional: 194-199
- There are some additional slides, discussing categories of search algorithms, backtracking, randomized hill climbing which are not covered in the textbook!

Remark: all page numbers refer to the 4th Edition from 2021…