G51FAI
Fundamentals of AI

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Overview


Objectives

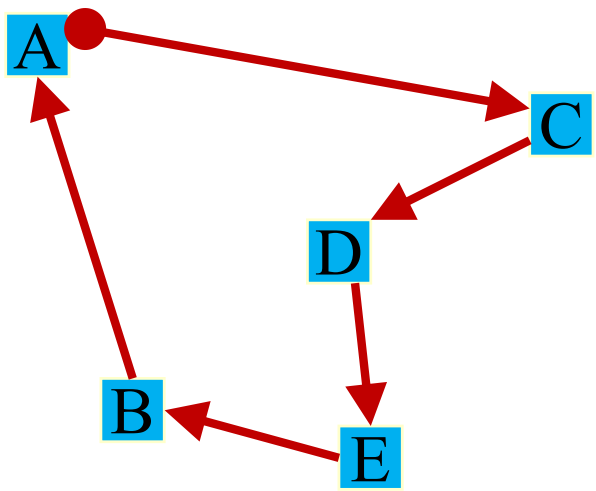
- The need for AI study
- Combinatorial Explosion & Example Problems
- Brief history of AI
- Introduce some important AI tests and terminologies

Questions

Why do we need AI anyway?

The Travelling Salesman Problem (TSP)

- A salesperson has to visit a number of cities
- (S)He can start at any city and must finish at that same city
- The salesperson must visit each city only once
  - for examples, with 5 cities a possible tour is:



- Solving the TSP means finding the minimum cost solution:
  - given a set of cities and distances between them, the optimal tour is the one with the shortest total distance

The Travelling Salesman Problem (TSP)

- Suppose we have n cities
  - for 1st city we have n choices
  - for 2nd city we have (n-1) choices….
  - possible number of routes is thus

    $$n*(n-1)*(n-2)*\ldots.*1$$

  - Hence, we have n! sequences
- Note: If reversed sequence is considered the same tour, n!/2 possible tours

Combinatorial Explosion

A 10 city TSP has around $1.8*10^6$ possible solutions.

50 City TSP has $1.52*10^{64}$ possible solutions

Age of the universe is about $45 * 10^{16}$ seconds

A 10GHz computer might do 10^9 tours per second

Running since start of universe, it would still only have done 10^{26} tours

Not even close to evaluating all tours!

Need to be clever about how to solve such search problems!

Scaling Properties

- Big Oh notation: **O(*f*(*n*))**
  - ***n*** is a **measure** of **problem size or runtime**
  - **Function *f*(*n*)** is an **upper bound** on the **asymptotic behavior** (as n gets very large)
  - E.g. $(5n^2 + 4n)$ is $O(n^2)$
  - "Polynomial" means $O(n^k)$ for some fixed k
    - e.g., $O(n^2)$
  - "Exponential" means $O(2^{an})$ for some fixed a
    - e.g., $O(2^{n/20})$

Scaling Properties

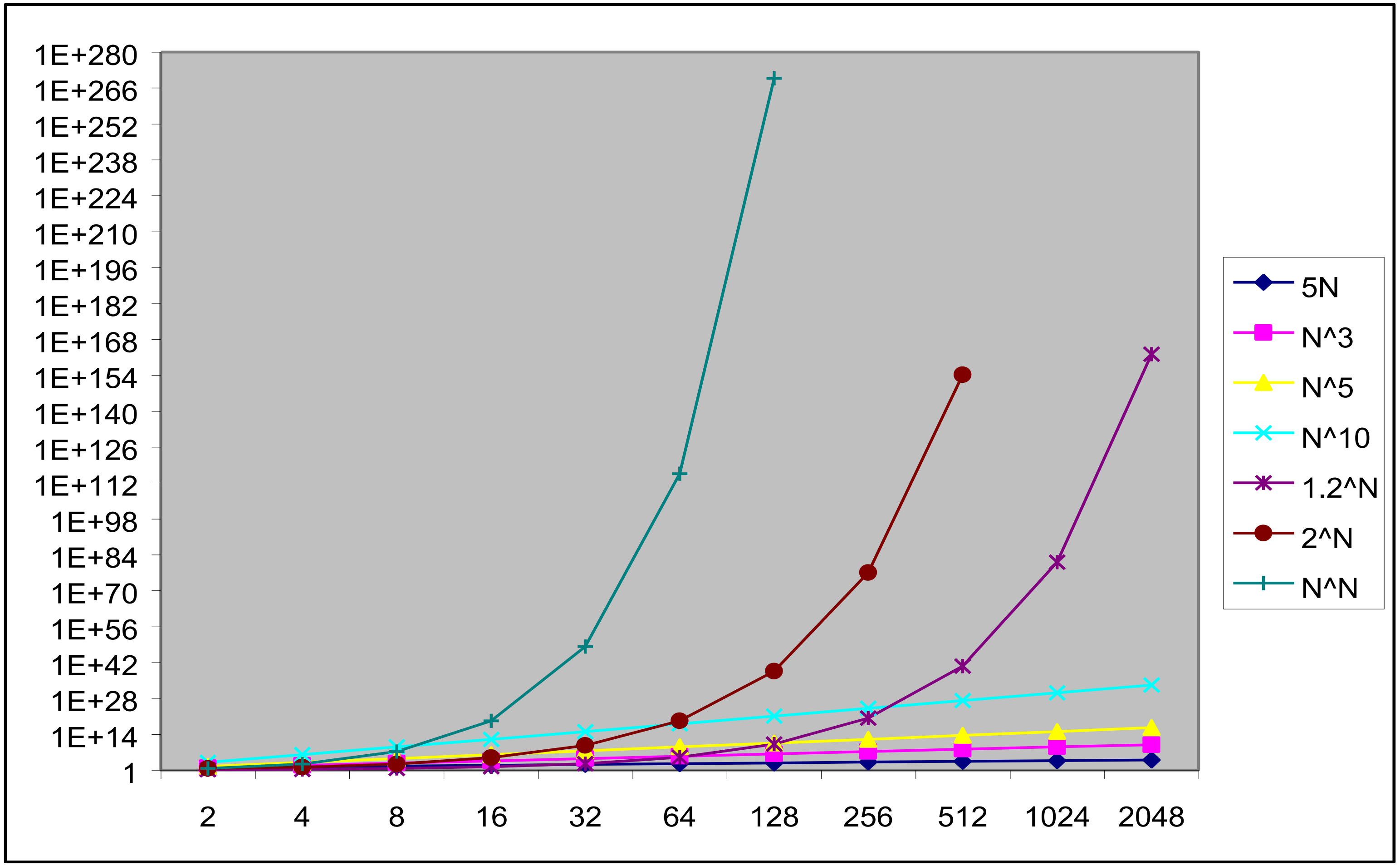
- Why is exponential so much worse than polynomial?

- Let's say we have two problems A and B with scaling properties for the runtimes of the best algorithms:
  - A: $O(n^2)$ polynomial (quadratic)
  - B: $O(2^{n/20})$ exponential

- Suppose that currently, for A and B, can manage to solve problems of size n=1000 in 10 mins

- Now, suppose we need to solve n=1100
  - A: will take $(1100/1000)^2 * 10 = 12.1$ mins
  - B: will take $(2^{1100/20}/2^{1000/20}) * 10 = 2^{100/20} * 10 = 320$ mins

Combinatorial Explosion



Combinatorial Explosion

Running on a computer capable of 1 million instructions/second

	10	20	50	100	200
N^2	1/10,000 second	1/2500 second	1/400 second	1/100 second	1/25 second
N^5	1/10 second	3.2 seconds	5.2 minutes	2.8 hours	3.7 days
2^N	1/1000 second	1 second	35.7 years	> 400 trillion centuries	45 digit no. of centuries
N^N	2.8 hours	3.3 trillion years	70 digit no. of centuries	185 digit no. of centuries	445 digit no. of centuries

Ref : Harel, D. 2000. Computer Ltd. : What they really can't do, Oxford University Press

One of the main thrusts of AI is to find ways to control or circumvent this fundamental issue of combinatorial explosion

A Brief History of AI

- The gestation of AI (1943 - 1956):
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence", Shannon's seminal paper on computer Chess ~ 10^{120}
  - 1956: McCarthy's name "Artificial Intelligence" adopted

- Early enthusiasm, great expectations (1952 - 1969):
  - Early successful AI programs: Samuel's checkers, Newell & Simon's General Problem Solver, Gelernter's Geometry Theorem Prover
  - 1958: McCarthy's AI programming language LISP
  - 1965: Robinson's complete algorithm for logical reasoning, Zadeh publish his famous paper "Fuzzy Sets"

A Brief History of AI

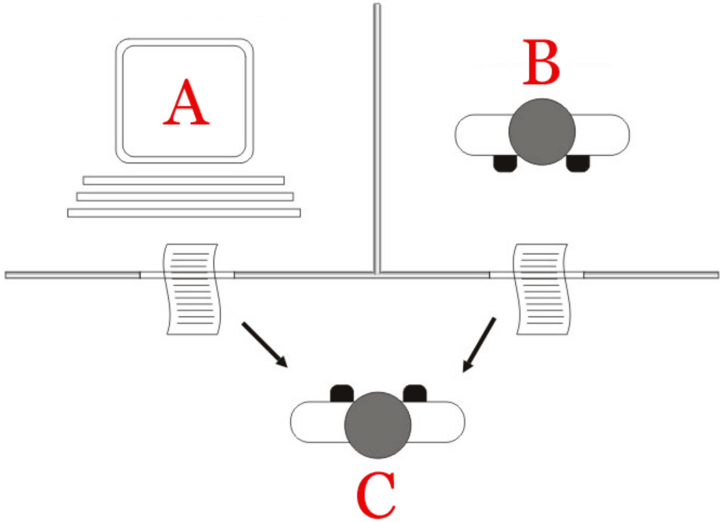
- A dose of reality (1966 - 1974):
  - AI discovered computational complexity
  - Early experiments in machine evolution (now genetic algorithms)

- Knowledge-based systems (1969 - 1988):
  - Intelligence needs knowledge (strong as opposed to weak methods)
  - 1976: MYCIN by Shortliffe (blood infection diagnosis)
  - Expert systems industry booms

A Brief History of AI

- The return of NNs and novel AI (1986 onward):
  - Mid 80’s: Back-propagation learning algorithm reinvented
  - Expert systems industry busts
  - 1988: Novel AI (ALife, GAs, Soft Computing, …)
  - Split in AI approaches: neat vs scruffy
  - Emergence of intelligent agents

The Turing Test



Source: Juan Alberto Sánchez Margallo - https://commons.wikimedia.org/wiki/File:Test_de_Turing.jpg

- The interrogator C only knows the person and machine as A and B, i.e., **C cannot see A and B**.
- Using a teletype, the interrogator, can ask A and B any question he/she wishes. The aim of the interrogator is to determine which is the person and machine.
- If the machine succeeds in fooling the interrogator into thinking that it is a person, the machine is deemed intelligent.
- https://www.youtube.com/watch?v=IFIW8KphZo0

The Chinese Room

- In 1980 John Searle devised a thought experiment which he called the Chinese Room (Searle, 1980)
  - Searle, J.R. 1980. Minds, Brains and Programs. *Behavioural and Brain Sciences*, 3: 417-457, 1980

The Chinese Room

- The system comprises:
  - a human, who only understands English
  - a rule book, written in English
  - two stacks of paper.
    - One stack of paper is blank.
    - The other has indecipherable symbols on them.
  - In computing terms
  - the human is the CPU
  - the rule book is the program
  - the two stacks of paper are storage devices.
- The system is housed in a room that is totally sealed with the exception of a small opening

Chinese Room: Process

- The human sits inside the room waiting for pieces of paper to be pushed through the opening.
- The pieces of paper have indecipherable symbols written upon them.

- The human has the task of matching the symbols from the "outside" with the rule book.
- Once the symbol has been found the instructions in the rule book are followed.
  - may involve writing new symbols on blank pieces of paper,
  - or looking up symbols in the stack of supplied symbols.

- Eventually, the human will write some symbols onto one of the blank pieces of paper and pass these out through the opening.

Searle's Claim

- We have a system that is capable of passing the Turing Test and is therefore intelligent according to Turing.
- ***But the system does not understand Chinese as it just comprises a rule book and stacks of paper which do not understand Chinese***.

Summary

- Understand what is meant by combinatorial explosion (esp. w.r.t. TSP).

- The Turing Test and Chinese Room

  - Read the papers, and AIMA section 26.1, 26.2 and understand their relationship

- Read section 1.1, 1.3, 1.4 of AIMA

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