

# Search Problems

CS5491: Artificial Intelligence  
ZHICHAO LU

Content Credits: **Prof. Wei**'s CS4486 Course  
and **Prof. Boddeti**'s AI Course

# TODAY

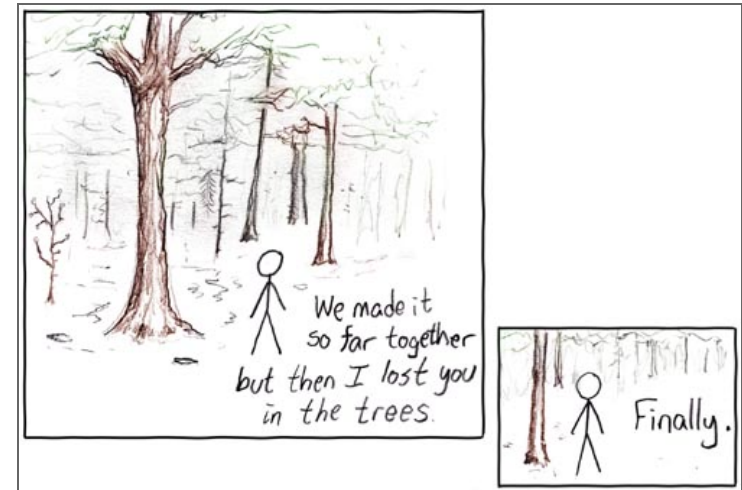
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## Agents that Plan Ahead

## Search Problems

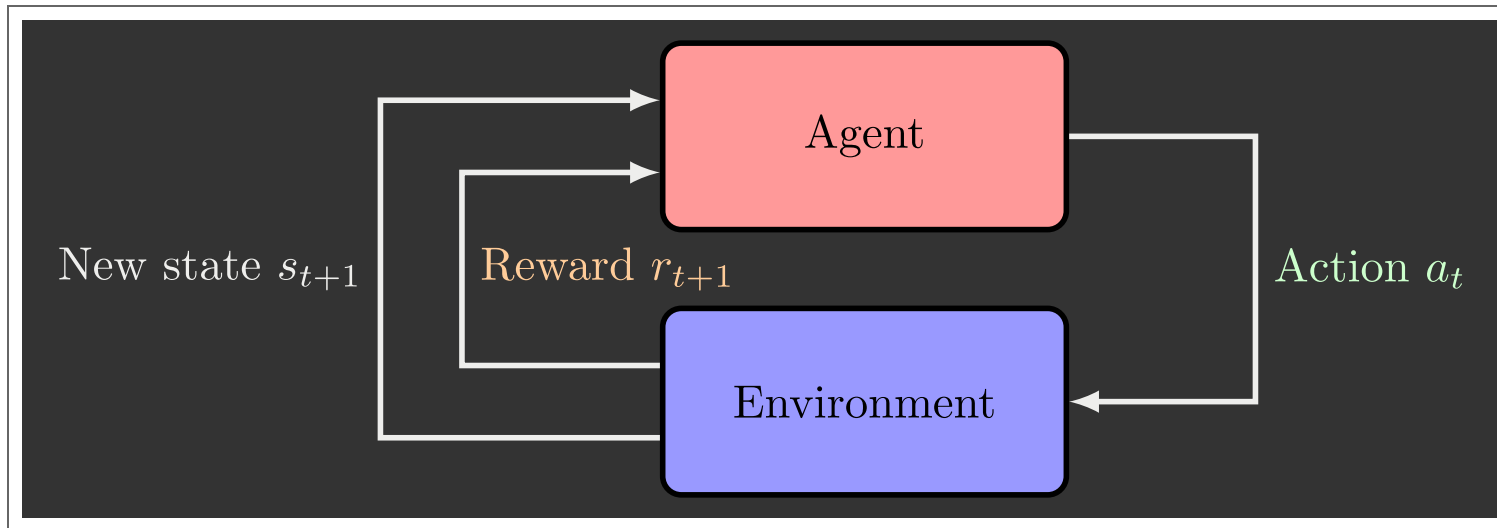
## Reading

- Today's Lecture: RN Chapter 3.1-3.4
- Next Lecture: RN Chapter 3.1-3.4



**XKCD**

## REMINDER: RATIONAL AGENTS



An **agent** is an entity that *perceives* and *acts*.

A **rational agent** selects actions that maximize its (expected) **utility**.

Characteristics of the **percepts**, **environment**, and **action space** dictate techniques for selecting rational actions.

# RATIONAL AGENTS

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Are rational agents **omniscient**?

- No - they are limited by what they can perceive

Are rational agents **clairvoyant**?

- No - they lack knowledge of environment dynamics

Do rational agents **explore** and **learn**?

- Yes - essential qualities required in unknown environments

So, rational agents are not necessarily successful, but they are **autonomous**.

# RATIONAL AGENTS

## Performance Measure

- -1 per time step; +10 food; +500 win; -500 die; +200 hit scared ghost

## Environment

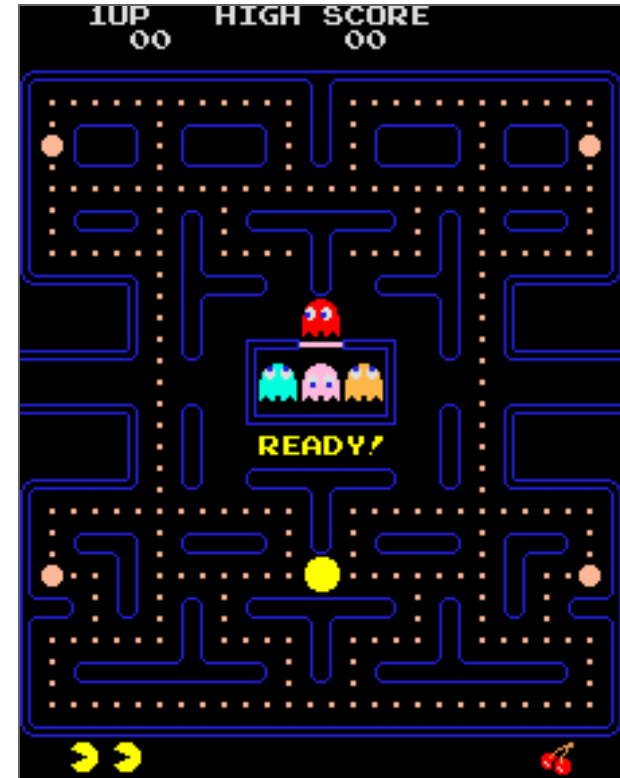
- Pacman dynamics + ghost behavior

## Actuators

- North, West, East, South, Stop (idle)

## Sensors

- entire state is visible



# ROBOTAXI - PEAS

## Performance Measure

- income, happy customer, vehicle costs, fines, car, insurance

## Environment

- streets, other drivers, customers, etc.

## Actuators

- steering, brake, gas, display/speaker

## Sensors

- cameras, lidar, radar, ultrasonic, accelerometer, mechanical sensors, microphone, etc.



# ENVIRONMENT CATEGORIZATION

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	Pacman	Robotaxi
Fully or Partially Observable	fully	partial
Single or Multi Agent	multi	multi
Deterministic or Stochastic	deterministic	stochastic
Static or Dynamic	static	dynamic
Discrete or Continuous	discrete	continuous

# ENVIRONMENT CATEGORIZATION

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Reflex agents:

- Choose actions based on current observation (and maybe memory)
- May have memory or a model of the world's current state.
- Do not consider future consequences of actions
- Consider how the world IS as opposed to how it would be.

Can a reflex agent be rational?

# AGENTS THAT PLAN AHEAD

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## Planning Agents:

- Decision based on **predicted consequences** of actions
- Must have a **transition model** : how the world evolves in responses to actions
- Must formulate a goal
- **Consider how the world WOULD BE as opposed to how it is**

## Spectrum of Deliberativeness:

- Generate complete, optimal plan offline, then execute
- Generate simple, greedy plan, start executing, replan if necessary

# SEARCH PROBLEMS

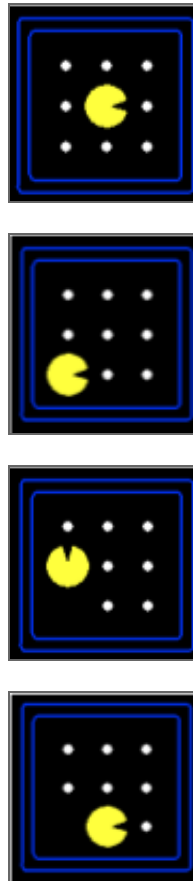
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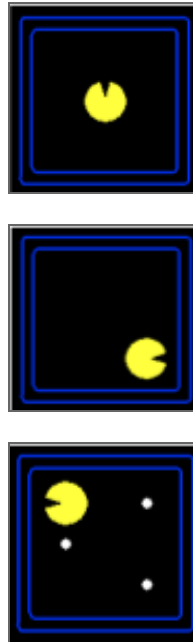
# WHAT ARE SEARCH PROBLEMS?

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A **search problem** consists of:

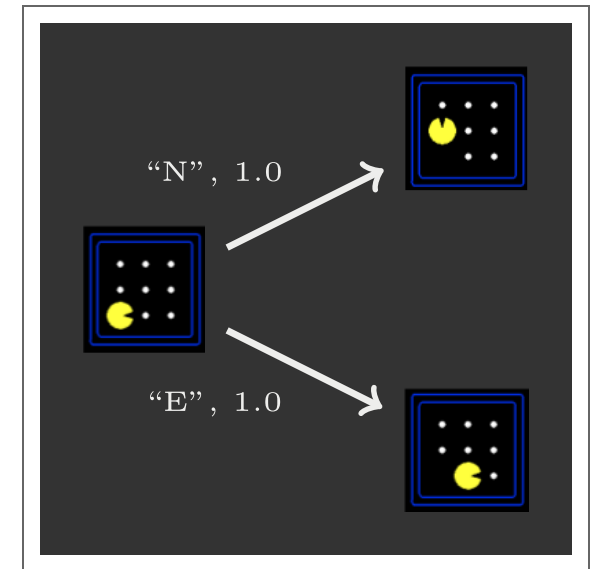
- A state space:





- A successor function (actions, costs):
- A start state and goal test

A **solution** is a sequence of actions (a plan) which transforms the start state to the goal test.

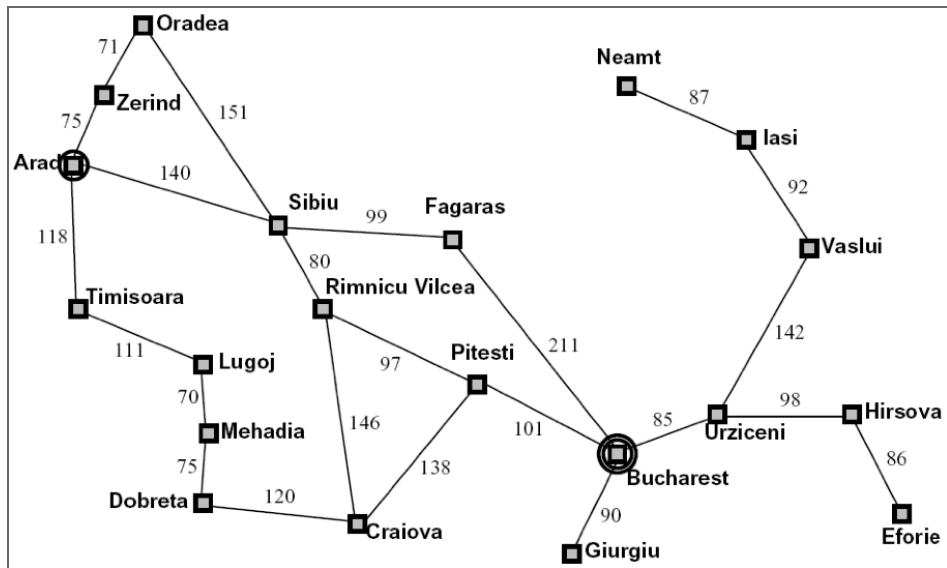


# SEARCH PROBLEMS ARE MODELS

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# EXAMPLE: TRAVELING IN ROMANIA



## State Space:

- Cities

## Successor Function:

- Roads: travel to adjacent city with cost=distance

## Start Space:

- Arad

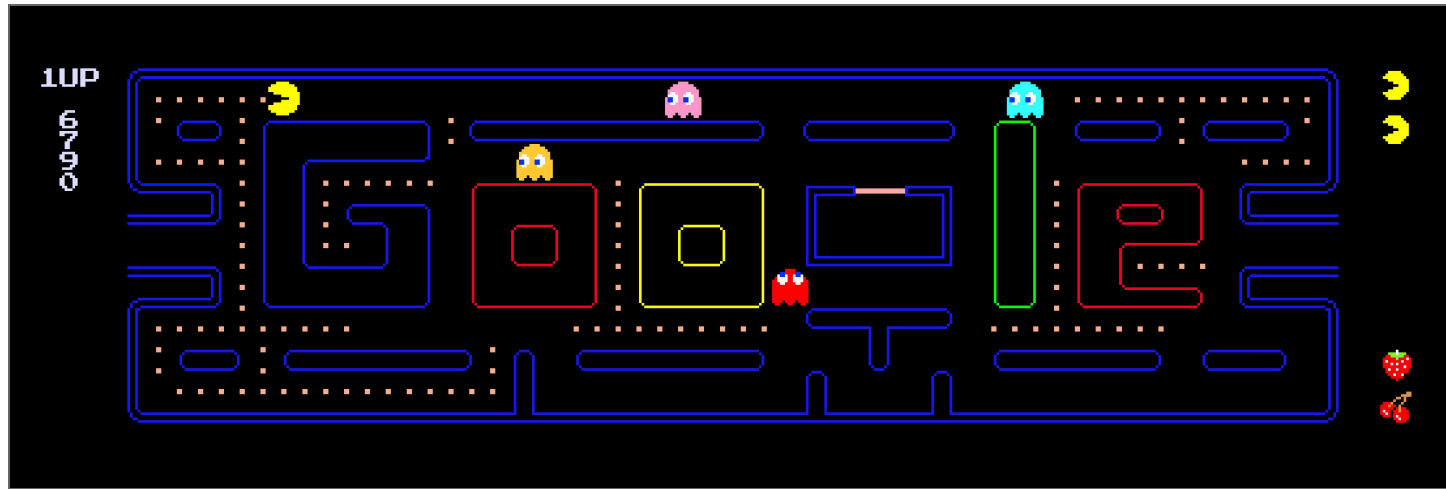
## Goal Test:

- Is state == Bucharest?

## Solution?

# WHAT IS IN A STATE SPACE?

World State: Includes every last detail of the environment



Search State: Keeps only details necessary for planning

Problem: Pathing

- States: (x,y) position
- Actions: NEWS
- Successor: update location

Problem: Eat-All-Dots

- States: (x,y), boolean for each dot
- Actions: NEWS
- Successor: update location, boolean for dots

- Goal Test: Is  $(x,y) == \text{END}$
- Goal Test: All dot booleans are false

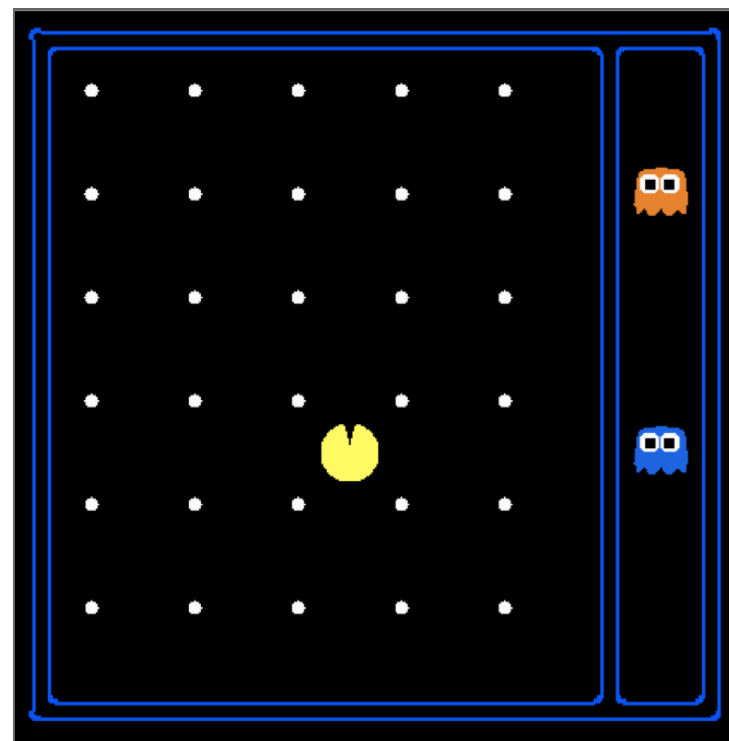
## SEARCH SPACE SIZE

### World State

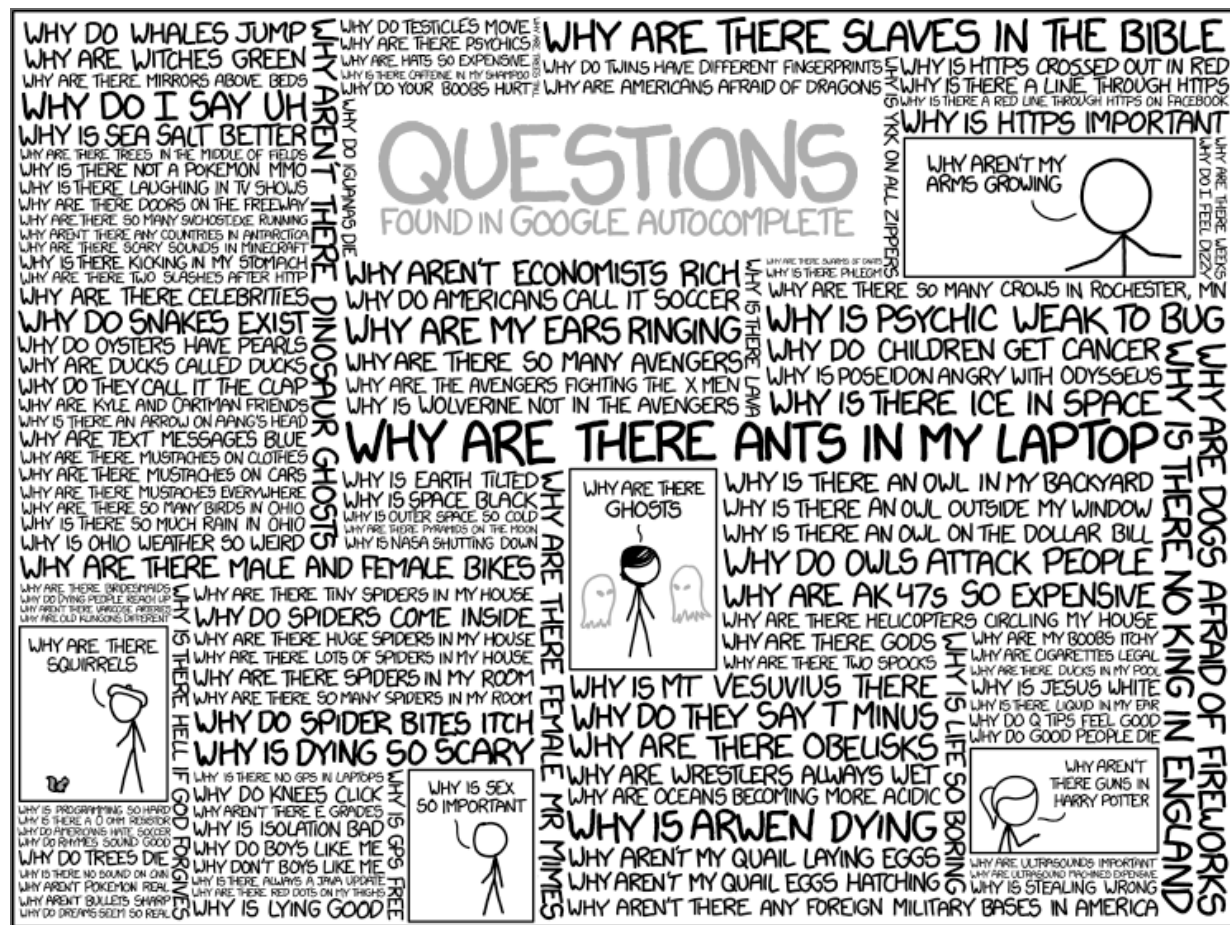
- Agent Positions: 120
- Food Count: 30
- Ghost Positions: 12
- Agent Orientation: NEWS

### Size

- World States:  $120 \times 2^{30} \times 12^2 \times 4$
- States for Pathing: 120
- States for Eat-All-Dots:  $120 \times 2^{30}$



# Q & A



**XKCD**







## Speaker notes

