

# Representational Dimensions

Computer Science cpsc322, Lecture 2

*(Textbook Chpt1)*

January, 6, 2010



## Department of Computer Science Undergraduate Events

### Events this week

#### How to Prepare for the Tech Career Fair

Date: Wed. Jan 6  
Time: 5 – 6:30 pm  
Location: DMP 110

#### Resume Writing Workshop (for non-coop students)

Date: Thurs. Jan 7  
Time: 12:30 – 2 pm  
Location: DMP 201

#### CSSS Movie Night

Date: Thurs. Jan 7  
Time: 6 – 10 pm  
Location: DMP 310  
Movies: “Up” & “The Hangover”  
(Free Popcorn & Pop)

#### Drop-In Resume Edition Session

Date: Mon. Jan 11  
Time: 11 am – 2 pm  
Location: Rm 255, ICICS/CS Bldg

#### Industry Panel

Speakers: Managers from Google, IBM, Microsoft, TELUS, etc.

Date: Tues. Jan 12  
Time: Panel: 5:15 – 6:15 pm;  
Networking: 6:15 – 7:15 pm  
Location: Panel: DMP 110;  
Networking: X-wing Undergrad Lounge

#### Tech Career Fair

Date: Wed. Jan 13  
Time: 10 am – 4 pm  
Location: SUB Ballroom

# Lecture Overview

- **Recap from last lecture**
- Representation and Reasoning
- An Overview of This Course
- Further Dimensions of Representational Complexity

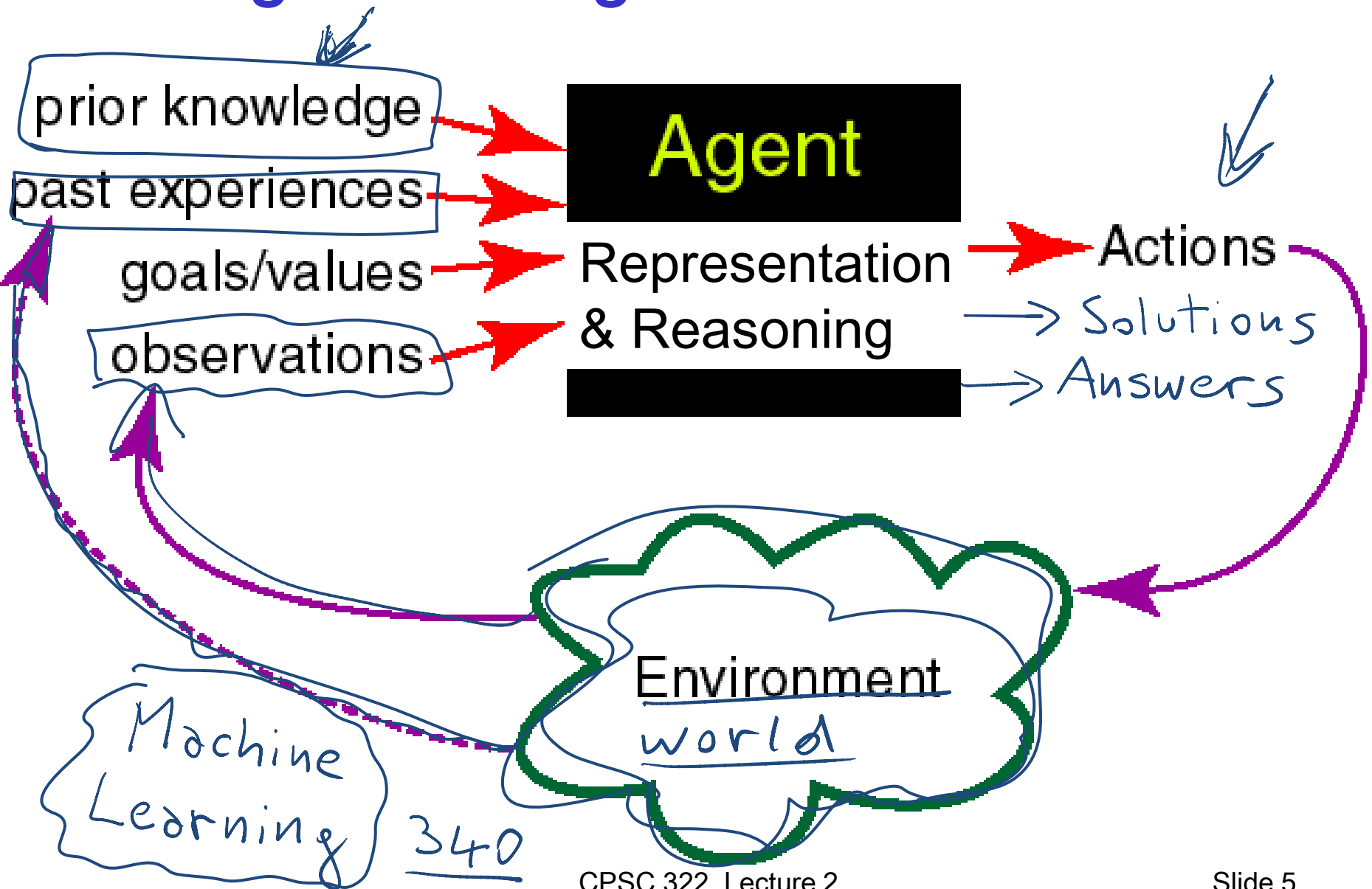
# Course Essentials

- **Course web-page** : CHECK IT OFTEN!
- **Textbook**: Available online and pdf on WebCT
  - We will cover at least Chapters: 1, 3, 4, 5, 6, 8, 9
- **WebCT**: used for textbook, discussion board....
- **Aispace** : online tools for learning Artificial Intelligence  
<http://aispace.org/>
- **Lecture slides...**
- Midterm exam, Wed, Mar 10 (1.5 hours, regular room)



Any conflict?

# Agents acting in an environment



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# What do we need to represent ?

- **The environment /world** : What different configurations (**states / possible worlds**) can the world be in, and how do we denote them?

Chessboard, Info about a patient, Robot Location

- **How the world works** (*we will focus on*)
  - **Constraints:** *electric circuit* sum of current into a node = 0
  - **Causal:** *medicine* what are the causes and the effects of brain disorders?
  - **Actions** preconditions and effects: *when can I press this button? What happens if I press it?*

# Corresponding Reasoning Tasks / Problems

- **Constraint Satisfaction** – Find state that satisfies set of constraints. *E.g.* ↪ *What is a feasible schedule for final exams?*
- **Answering Query** – Is a given proposition true/likely given what is known? *E.g.*, *Does this patient suffers from viral hepatitis?* ↪
- **Planning** – Find sequence of actions to reach a goal state / maximize utility. *E.g.*, *Navigate through and environment to reach a particular location*



# Representation and Reasoning System

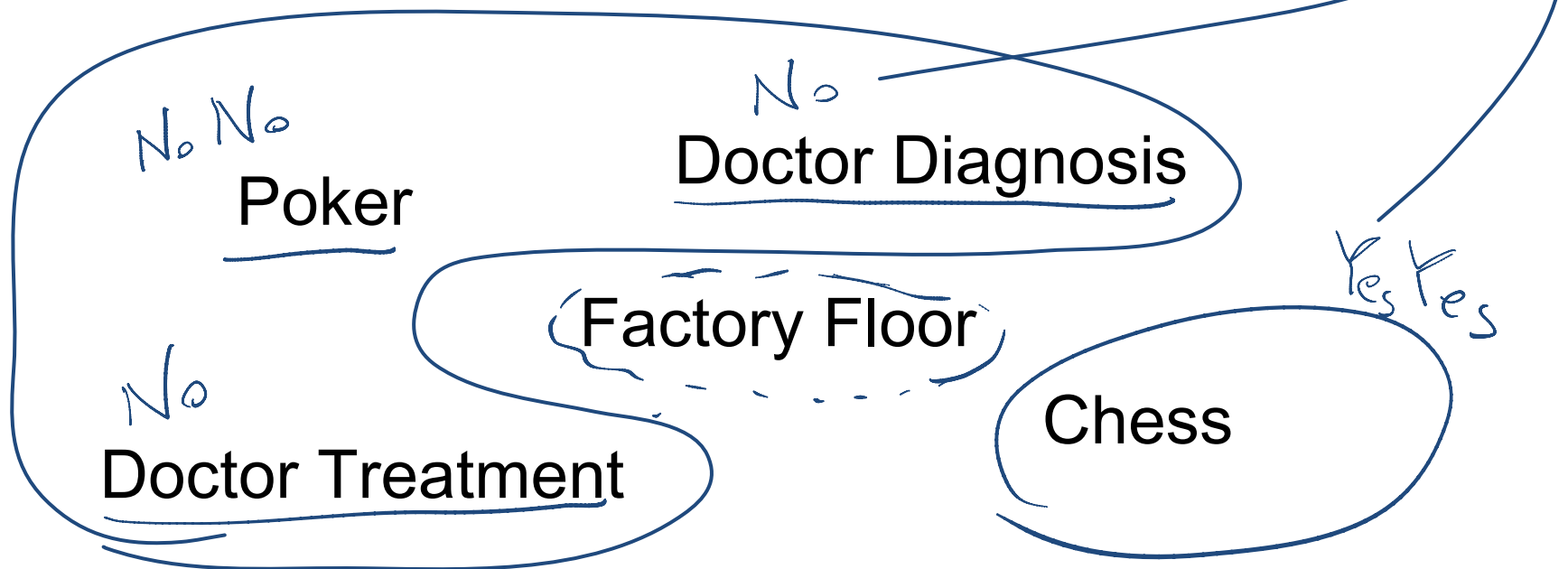
- A **(representation) language** in which the environment and how it works can be described
- Computational **(reasoning) procedures** to compute a solution to a problem in that environment (an answer, a sequence of actions)



**But** the choice of an appropriate R&R system depends on a key property of the environment and of the agent's knowledge

# Deterministic vs. Stochastic (Uncertain) Domains

- Sensing Uncertainty: Can the agent fully observe the current state of the world?
- Effect Uncertainty: Does the agent know for sure what the effects of its actions are?



# Deterministic vs. Stochastic Domains

Historically, AI has been divided into two camps:  
those who prefer representations based on **logic**  
and those who prefer **probability**.

A few years ago, CPSC 322 covered logic, while  
CPSC 422 introduced probability:

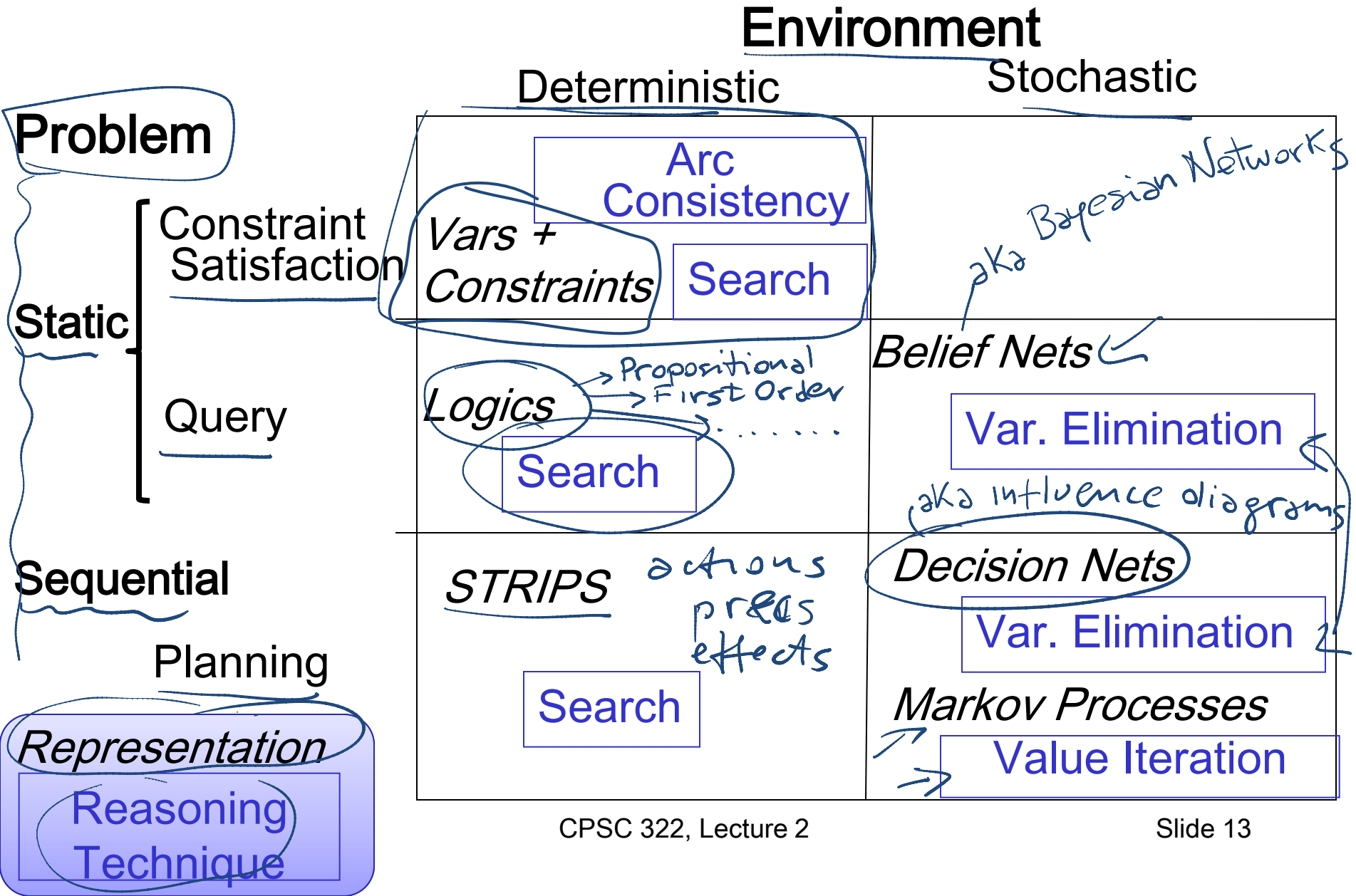
- now we introduce both representational families in 322, and 422 goes into more depth
- this should give you a better idea of what's included in AI

**Note:** Some of the most exciting current research in AI is actually building bridges between these camps.

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- **An Overview of This Course**
- Further Dimensions of Representational Complexity

# Modules we'll cover in this course: R&Rsys



# Lecture Overview

- Recap from last lecture
- Representation
- An Overview of This Course
- **Further Dimensions of Representational Complexity**

# Dimensions of Representational Complexity

We've already discussed:

- Reasoning tasks (**Static** vs. **Sequential** )
- **Deterministic** versus **stochastic** domains

Some other important dimensions of complexity:

- Explicit state or <sup>features</sup> (propositions) or relations ←
- Flat or hierarchical — are binary features
- Knowledge given versus knowledge learned from experience
- Goals versus complex preferences
- Single-agent vs. multi-agent

# Explicit State or propositions

How do we model the environment?

- You can enumerate the **states** of the world. *S<sub>1</sub> S<sub>2</sub> S<sub>3</sub> ... efficiency*
- A state can be described in terms of **features** *much more concise*
  - Often it is more natural to describe states in terms of assignments of values to features (variables).
  - 30 binary features (also called propositions) can represent  $2^{30} = 1,073,741,824$  states.

## Mars Explorer Example

⇒ Weather {S, C}

⇒ Temperature { $-40$ ,  $+40$ }

*longitude* LocX 0-359 *latitude* LocY 0 179

*one possible state* {S, +35, 30°, 110°}

$2 * 81 * 360 * 180$   
number of possible states  
mutually exclusive



# Explicit State or propositions or relations

- States can be described in terms of **objects** and **relationships**.
- There is a proposition for each relationship on each “possible” tuple of individuals.

## University Example

<sup>1 relationship</sup>

*Registered*(*S*, *C*)

$R(\underline{s_1}, \underline{c_2}) \in A_c$

12 propositions

Students (*S*) = { *s*<sub>1</sub> *s*<sub>2</sub> *s*<sub>3</sub> *s*<sub>4</sub> }

Courses (*C*) = { *c*<sub>1</sub> *c*<sub>2</sub> *c*<sub>3</sub> }

<sup>individuals/objects</sup>

12  
2  
states

- Textbook example: One binary relation and 10 individuals can represent  $10^2=100$  propositions and  $2^{100}$  states!

# Flat or hierarchical

Is it useful to model the whole world at the same level of abstraction?

- You can model the world at one level of abstraction: **flat**
- You can model the world at multiple levels of abstraction: **hierarchical**
- *Example: Planning a trip from here to a resort in Cancun, Mexico*

go to airport   fly to Cancun . . . .  
  /                  |  
go by cab . . . . .  
/                  |  
call cab   take cab . . . . .

# Knowledge given vs. knowledge learned from experience

The agent is provided with a model of the world once and for all

- The agent **can learn** how the world works based on experience
    - in this case, the agent often still does start out with some **prior knowledge**
- not in this course*

# Goals versus (complex) preferences


An agent may have a **goal** that it wants to achieve 

- e.g., there is some **state or set of states** of the world that the agent wants to be in

- 
- e.g., there is some **proposition or set of propositions** that the agent wants to make true

An agent may have **preferences**

 [0, 1]

- 
- e.g., there is some **preference/utility function** that describes how happy the agent is in each state of the world; the agent's task is to reach a state which makes it as happy as possible

Preferences can be **complex...**

but Cappuccino takes 2mins  
Espresso takes 1min  
Agent must consider  
a TRADE-OFF

What beverage to order?

- *The sooner I get one the better*
- *Cappuccino better than Espresso*

# Single-agent vs. Multiagent domains

Does the environment include other agents?

Everything we've said so far presumes that there is only one agent in the environment.

- If there are other agents whose actions affect us, it can be useful to **explicitly model their goals and beliefs** rather than considering them to be part of the environment
- Other Agents can be: **cooperative, competitive, or a bit of both**

# Dimensions of Representational Complexity in CPSC322

not in this  
course  
~

- Reasoning tasks (Constraint Satisfaction / Logic&Probabilistic Inference / Planning)
- Deterministic versus stochastic domains



**Some other important dimensions of complexity:**

- Explicit state or features or relations
- Flat or ~~hierarchical~~
- Knowledge given versus knowledge ~~learned from experience~~
- Goals vs. (~~complex~~) preferences
- Single-agent ~~vs. multi-agent~~

simple

grad course

# Next class

(SEE AI LANDSCAPE  
ON NEXT SLIDE)

- Assignment 0 due: **submit electronically** and **you can't use late days**
- **Hint:** AAAI is the main AI association
- Come to class ready to discuss the **two examples of fielded AI agents** you found  
*or experimental*
- I'll show some pictures of cool applications in that class

• Read carefully Section 1.6 on textbook: “Example Applications”

- The Tutoring System
- The autonomous delivery robot
- The trading agent
- The diagnostic assistant





Autonomous Vehicle



AI Paintings



AI Music Composition & Performance



Robot Tour Guide

Characters for Virtual Worlds



Humanoid Robot



Social Simulation Game



Smart Environmental Controls



Intelligent Tutoring System



Vehicle Navigation System



Smart Desk with Gesture Recognition



Robots for Education



Disease Diagnosis



Drug Design



Smart Wheelchair



Handwriting & Sketch Recognition



How Can AI Systems Solve Problems Creatively?



Robotic Surgery



Recommender System



Fraud Detection



Web Search



Spam Filtering



Machine Translation



Leibniz



Aristotle



Descartes



Lovelace



Russell



Turing



See the AI timeline and more at  
[www.aaai.org/AIlandscape](http://www.aaai.org/AIlandscape)

# The AI Landscape