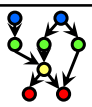

LECTURE 1 OF 42

Intelligent Agents Overview
Discussion: Machine Prob. 1, Term Projects 1 of 5

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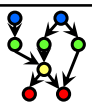
KSOL course page: http://snipurl.com/v9v3
Course web site: http://www.kddresearch.org/Courses/CIS730
Instructor home page: http://www.cis.ksu.edu/~bhsu

Reading for Next Class:

Sections 1.3 – 1.5, p. 16 – 29, Russell & Norvig 2nd edition
Sections 2.1 – 2.2, p. 32 – 38, Russell & Norvig 2nd edition
Syllabus and Introductory Handouts

LECTURE OUTLINE

- Reading for Next Class: Sections 1.3 – 1.5 & 2.1 – 2.2, R&N 2e
- Today and Friday: Intelligent Agent (IA) Design, Chapter 2 R&N
  - Shared requirements, characteristics of IAs
  - Methodologies
    - Software agents
    - Reactivity vs. state
    - Knowledge, inference, and uncertainty
- Intelligent Agent Frameworks
  - Reactive
  - With state
  - Goal-based
  - Utility-based
- Next Week: Problem Solving and Search, Chapter 3
  - State space search handout (Nilsson, *Principles of AI*)
  - Search handout (Ginsberg)



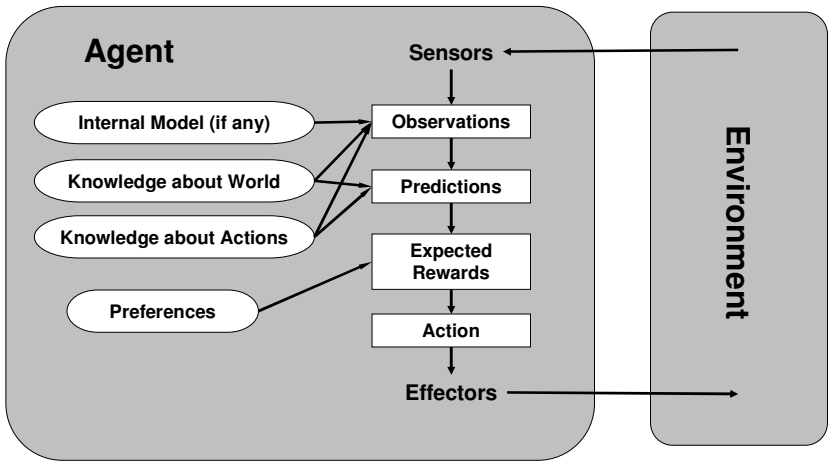
Problems and Methodologies (Review)

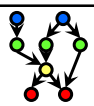
- **Problem Solving**
  - Classical search and planning
  - Game-theoretic models
- **Making Decisions under Uncertainty**
  - Uncertain reasoning, decision support, decision-theoretic planning
  - Probabilistic and logical knowledge representations
- **Pattern Classification and Analysis**
  - Pattern recognition and machine vision
  - Connectionist models: artificial neural networks (ANNs), other graphical models
- **Data Mining and Knowledge Discovery in Databases (KDD)**
  - Framework for optimization and machine learning
  - Soft computing: evolutionary algorithms, ANNs, probabilistic reasoning
- **Combining Symbolic and Numerical AI**
  - Role of knowledge and automated deduction
  - Ramifications for cognitive science and computational sciences

Intelligent Agents (Review)

- **Agent: Definition**
  - Any entity that perceives its environment through sensors and acts upon that environment through effectors
  - Examples (class discussion): human, robotic, software agents
- **Perception**
  - Signal from environment
  - May exceed sensory capacity
- **Sensors**
  - Acquires percepts
  - Possible limitations
- **Action**
  - Attempts to affect environment
  - Usually exceeds effector capacity
- **Effectors**
  - Transmits actions
  - Possible limitations

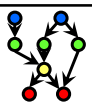
Generic Intelligent Agent Model (Review)





Term Project Topics

- 1. Game-playing Expert System
  - "Borg" for Angband computer role-playing game (CRPG)
  - http://www.thangorodrim.net/borg.html
- 2. Classic Trading Agent Competition (TAC)
  - Supply Chain Management (TAC-SCM) scenario
  - http://www.sics.se/tac/
- 3. Link Prediction (Social Networks, Bioinformatics)
  - Social network friendship predictor
    - Hsu *et al.*, ICWSM 2007: http://bit.ly/2LUSL
  - Protein-protein Interaction
    - Paradesi, 2008: http://hdl.handle.net/2097/931
    - Data set to be published

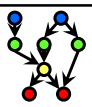


Homework 1: Machine Problem

- Assigned: 23:00 Central Time, Lecture 1 (third day of classes)
- Due: before midnight Central Time, Lecture 7 (end of third week)
- Topics
  - Intelligent agents concepts
  - State space representations
  - Informed search
- To Be Posted
  - KSOL web site
  - KDDresearch.org (URL mailed to class mailing list)
- Questions and Discussion
  - General discussion on class mailing list: CIS730-L@listserv.ksu.edu
  - Questions for instructor: CIS730TA-L@listserv.ksu.edu
- Outside References: On Reserve (Cite Sources!)

How Agents Should Act

- Rational Agent: Definition
  - Informal: "does the right thing, given what it believes from what it perceives"
  - What is "the right thing"?
    - ⇨ First approximation: *action that maximizes success of agent*
    - ⇨ Limitations to this definition?
  - First: how, when to evaluate success?
  - Later: representing / reasoning with uncertainty, beliefs, knowledge
- Why Study Rationality?
  - Recall: aspects of intelligent behavior (last lecture)
    - ⇨ Engineering objectives: optimization, problem solving, decision support
    - ⇨ Scientific objectives: modeling correct inference, learning, planning
  - Rational cognition: formulating *plausible* beliefs, conclusions
  - Rational action: "doing the right thing" given beliefs

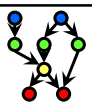


Rational Agents

- "Doing the Right Thing"
  - Committing actions: limited effectors, in context of agent knowledge
  - Specification (cf. software specification): pre/post-conditions
- Agent Capabilities: Requirements
  - Choice: select actions (and carry them out)
  - Knowledge: represent knowledge about environment
  - Perception: capability to sense environment
  - Criterion: *performance measure to define degree of success*
- Possible Additional Capabilities
  - Memory (internal model of state of the world)
  - Knowledge about effectors, reasoning process (reflexive reasoning)

Measuring Performance

- Performance Measure: *How* to Determine Degree of Sucesss
  - Definition: *criteria that determine how successful agent is*
  - Depends on
    - Agents
    - Environments
  - Possible measures?
    - Subjective (agent may not have capability to give accurate answer!)
    - Objective: *outside observation*
  - Example: web crawling agent
    - Precision: did you get only pages you wanted?
    - Recall: did you get all pages you wanted?
    - *Ratio* of relevant hits to pages explored, resources expended
    - Caveat: "you get what you ask for" (issues: redundancy, etc.)
- When to Evaluate Success
  - Depends on objectives (short-term efficiency, consistency, etc.)
  - Episodic? Milestones? Reinforcements? (e.g., games)

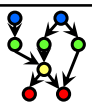


What Is Rational?

- Criteria
  - Determines what is rational *at any given time*
  - Varies with agent, environment, *situation*
- Performance Measure
  - Specified by outside observer or evaluator
  - Applied (consistently) to (one or more) IAs in given environment
- Percept Sequence
  - Definition: *entire history* of percepts gathered by agent
  - NB: agent may or may not have state, i.e., memory
- Agent Knowledge
  - Of environment – "required"
  - Of self (reflexive reasoning)
- Feasible Action
  - What can be performed
  - What agent believes it can attempt?

Ideal Rationality

- Ideal Rational Agent
  - Given: any possible percept sequence
  - Do: ideal rational behavior
    - ⇨ Whatever action is expected to maximize performance measure
    - ⇨ NB: expectation – informal sense for now; mathematical def'n later
  - Basis for action
    - ⇨ Evidence provided by percept sequence
    - ⇨ Built-in knowledge possessed by the agent
- Ideal Mapping from Percepts to Actions (Figure 2.1 p. 33 R&N 2e)
  - Mapping *p*: *percept sequence* → *action*
  - Representing *p* as list of pairs: infinite (unless explicitly bounded)
  - Using *p*: ideal mapping from percepts to actions (i.e., ideal agent)
  - Finding explicit *p*: in principle, could use trial and error
  - Other (implicit) representations may be easier to acquire!

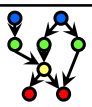


Knowledge and Bounded Rationality

- **Rationality versus Omniscience**
  - Nota Bene (*NB*): not the same
  - Omniscience: knowing *actual* outcome of all actions
  - Rationality: knowing *plausible* outcome of all actions
  - Example: is it too risky to go to the supermarket?
- **Key Question**
  - What is a *plausible* outcome of an action?
  - Related questions
    - ⇨ How can agents make rational decisions given beliefs about outcomes?
    - ⇨ What does it mean (algorithmically) to "choose the best"?
- **Bounded Rationality**
  - What agent *can* perceive and do
  - What is "likely" to be right – not what "turns out" to be right

Structure of Intelligent Agents

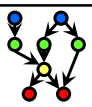
- **Agent Behavior**
  - Given: sequence of percepts
  - Return: IA's actions
  - Simulator: description of results of actions
  - Real-world system: committed action
- **Agent Programs**
  - Functions that implement *p*
  - Assumed to run in computing environment (architecture)
  - *Agent = architecture + program*
  - This course (CIS730): primarily concerned with *p*
- **Applications**
  - Chapter 22 (NLP/Speech), 24 (Vision), 25 (Robotics), R&N 2e
  - Swarm intelligence, multi-agent sytems, IAs in cybersecurity



Agent Programs

- **Software Agents**
  - Also known as (*aka*) software robots, softbots
  - Typically exist in very detailed, unlimited domains
  - Examples
    - Real-time systems: critiquing, avionics, shipboard damage control
    - Indexing (spider), information retrieval (IR; e.g., web crawlers) agents
    - Plan recognition systems (computer security, fraud detection monitors)
  - See: Bradshaw (*Software Agents*)
- **Focus of This Course: Building IAs**
  - Generic skeleton agent: Figure 2.4, R&N
  - function *SkeletonAgent* (*percept*) returns action
    - static: *memory*, agent's memory of the world
    - *memory* ← *Update-Memory* (*memory*, *percept*)
    - *action* ← *Choose-Best-Action* (*memory*)
    - *memory* ← *Update-Memory* (*memory*, *action*)
    - return *action*

Example: Game-Playing Agent [1]
Project Topic 1 of 5

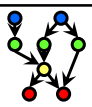


Example: Game-Playing Agent [2] Problem Specification

- Angband
  - Roguelike game – descended from Rogue, Moria
    See: http://en.wikipedia.org/wiki/Roguelike
  - v3.0.6 (2006)
    Source code: http://www.thangorodrim.net
- Automated Roguelike Game-Playing Agents
  - Rog-O-Matic (1984)
    http://en.wikipedia.org/wiki/Rog-O-Matic
  - Angband Borgs (1998-2001)
    http://www.thangorodrim.net/borg.html
- Problem Specification
  - Study Borgs by Harrison, White (2006 - present: http://bit.ly/1y9vn)
  - Develop scheduling, planning, or classification learning system
  - Use White's APWBorg interface to develop new Borg
  - Compare to classic Borgs

Course Topics

- Overview: Intelligent Systems and Applications
- Artificial Intelligence (AI) Software Development Topics
  - Knowledge representation
  - Search
  - Expert systems and knowledge bases
  - Planning: classical, universal
  - Probabilistic reasoning
  - Machine learning, artificial neural networks, evolutionary computing
  - Applied AI: agents focus
  - Some special topics (NLP focus)
- Implementation Practicum (≈ 40 hours)

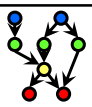


PEAS Framework

- Performance Measure
  - Specified by outside observer or evaluator
  - Applied (consistently) to (one or more) IAs in given environment
- Environment
  - Reachable states
  - "Things that can happen"
  - "Where the agent can go" TAC-SCM
  - To be distinguished (TBD) from: observable states
- Actuators
  - What can be performed
  - Limited by physical factors *and* self-knowledge
- Sensors
  - What can be observed
  - Subject to error: measurement, sampling, postprocessing

Problem-Solving Agents [1]: Goals

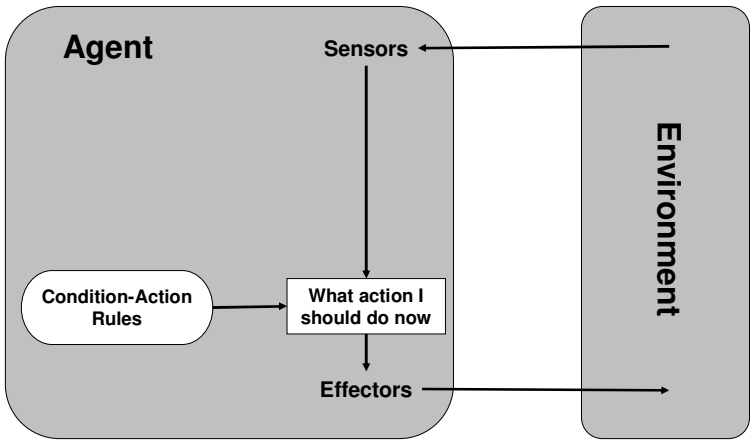
- Justification
  - Rational IA: act to *reach* environment that maximizes performance measure
  - Need to formalize, operationalize this definition
- Practical Issues
  - Hard to find appropriate *sequence of states*
  - Difficult to translate into IA design
- Goals
  - Translating agent specification to formal design
  - Chapter 2, R&N: decision loop simplifies task
  - First step in problem solving: formulation of goal(s)
  - Chapters 3-4, R&N: state space search
    - ⇨ Goal ≡ {world states | goal test is satisfied}
    - ⇨ Graph planning
  - Chapter 5: constraints – domain, rules, moves
  - Chapter 6: games – evaluation function



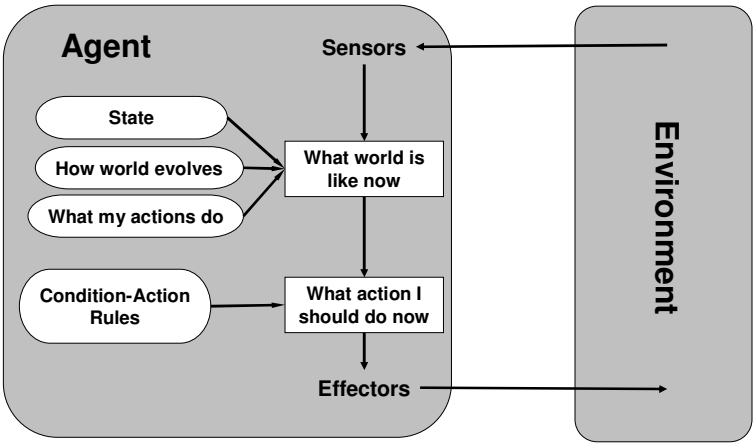
Problem-Solving Agents [2]: Definitions

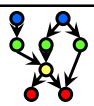
- **Problem Formulation**
  - ✸ **Given**
    - ⇨ **Initial state**
    - ⇨ **Desired goal**
    - ⇨ **Specification of actions**
  - ✸ **Find**
    - ⇨ ***Achievable* sequence of states (actions)**
    - ⇨ **Represents mapping from initial to goal state**
- **Search**
  - ✸ **Actions**
    - ⇨ **Cause transitions between world states**
    - ⇨ **e.g., applying effectors**
  - ✸ **Typically specified in terms of finding sequence of states (operators)**

Agent Framework 1 of 4: Simple Reflex Agents

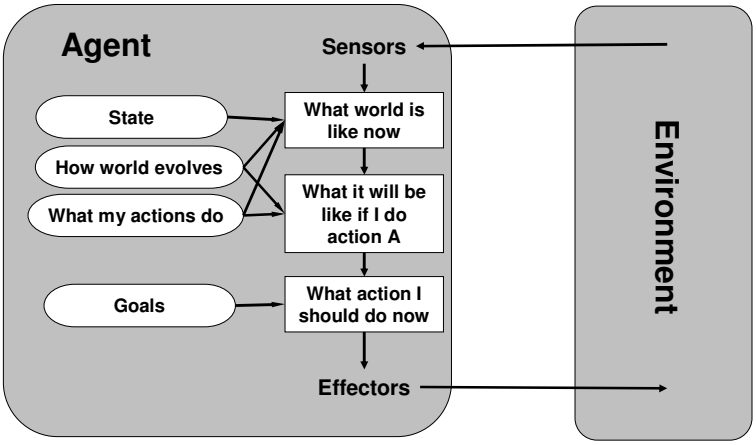


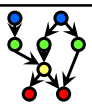
Agent Framework 2 of 4: (Reflex) Agents with State



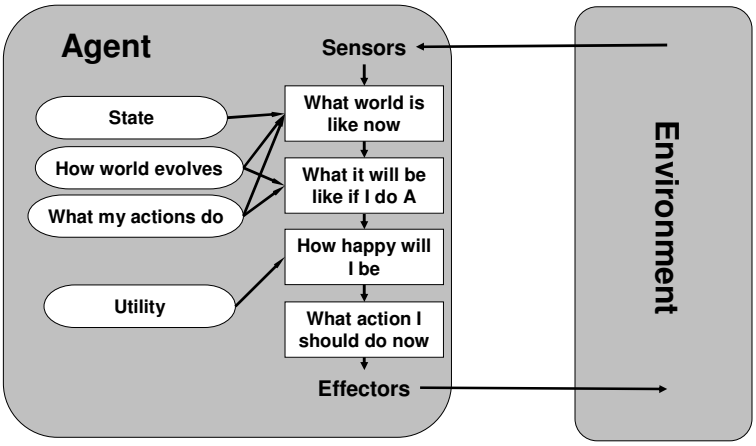


Agent Framework 3 of 4: Goal-Based Agents



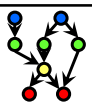


Agent Framework 4 of 4: Utility-Based Agents



Looking Ahead: Search

- Next Monday - Wednesday: Sections 3.1-3.4, Russell and Norvig
- Thinking Exercises (Discussion in Next Class): 3.3 (a, b, e), 3.9
- Solving Problems by Searching
  - Problem solving agents: design, specification, implementation
  - Specification: problem, solution, constraints
  - Measuring performance
- Formulating Problems as (State Space) Search
- Example Search Problems
  - Toy problems: 8-puzzle, N-queens, cryptarithmetic, toy robot worlds
  - Real-world problems: layout, scheduling
- Data Structures Used in Search
- Next Monday: Uninformed Search Strategies
  - State space search handout (Winston)
  - Search handouts (Ginsberg, Rich and Knight)



Terminology

- Rationality
  - Informal definition
  - Examples: how to make decisions
  - Ideal vs. bounded
- Automated Reasoning and Behavior
  - Regression-based problem solving (see p. 7)
  - Goals
  - Deliberation
- Intelligent Agent Frameworks
  - Reactivity vs. state
  - From goals to preferences (utilities)

Summary Points

- Intelligent Agent Framework
- Rationality and Decision Making
- Design Choices for Agents (Introduced)
- Choice of Project Topics
  - 1. Game-playing expert system: Angband
  - 2. Trading agent competition, supply chain management (TAC-SCM)
  - 3. Knowledge base for bioinformatics: proteomics ontology
- Things to Check Out Online
  - Resources page
    http://www.kddresearch.org/Courses/CIS730/Resources
  - Course mailing list archives (class discussions)
    http://listserv.ksu.edu/archives/cis730-l.html