CIS 530 Introduction to Artificial Intelligence
CIS 730 Artificial Intelligence
Fall 2018

Homework 1 of 10: Problem Set (PS1)
Warm-up: Intelligent Agents, Search

Assigned: Mon 20 Aug 2018
Due: Wed 29 Aug 2018 on-campus, Fri 31 Aug 2018 distance (before midnight)

The purpose of this assignment is to exercise your basic understanding of intelligent agents, state space search, and game theory, and to help you apply these concepts simulate the behavior of search algorithms.

This homework assignment is worth a total of 20 points (2% of the course grade).
Each problem is worth 10% for CIS 730 students and 15% for CIS 530 students.
Upload a PDF file of your solution named **`PS1.pdf`** K-State Canvas as a solution for this assignment.

1. **(530/730) Perception and rationality.** Continuing the class discussion from Lecture 1 ("Intelligent Agents" – slide 0 of Lecture 0, slide 4 of Lecture 1): **Consider voice-operated home assistant or smart home appliance as the agent to discuss.** What limitations of this agent's sensors (instruments for collecting perceptual information) limit its view of the world? How does this impact its rationality? Give at least two concrete examples of the effects of sensor error and limitations. You may use measurement error and data processing error as effects, but specify which type you are writing about.

2. **(530/730) Types of agents.** Consider the five term project domains discussed in class:
   a) ontology or other description logic reasoning task [Task 3 in Lecture 0, Slide 26]
   b) cybersecurity task [Task 4]
   c) conversational agent or cognitive service-based question-answering (QA) agent [Task 5]
   d) image processing (especially style transfer) or vision task [Task 6]
   e) expert system or analogical reasoning task [Task 7]
   f) AI for social good [Task 8]
   g) dynamic robot path planning problem [Task 1]
   h) reinforcement learning and/or deep learning task for game playing agent [Task 2]

   (The **first two topics** are the oldest and are due to be retired for at least a few years after this course; the **third and fourth topic** is in its second year and will be offered again next year, and the **last four** are new or newly relaunched topics.)

   Give an example of two agents for one of these domains to illustrate the distinction between a reflex agent with state and a goal-based or preference-based agent. Hint: take a look at AItopics.org and examples of test beds and agents such as:

   For task category (b): DARPA Cyber Grand Challenge – http://archive.darpa.mil/cybergrandchallenge/, https://github.com/CyberGrandChallenge/

   For task category (c): see the Alexa Prize – https://developer.amazon.com/alexaprize

For task category (f) games: see OpenAI Gym – https://gym.openai.com (including DOTA2 and Atari games), VizDOOM, Roguelike games, AI Birds

3. **(530/730) State space representatio.** (Adapted from Section 3.1, Russell & Norvig 3e, and Poole & Mackworth, 2e.) Consider a delivery robot of the kind discussed in Poole and Mackworth 2e (see http://artint.info/html/ArtInt_48.html for an example and excerpt). Specify a state space for the following two tasks:

    i. **8-puzzle vs. N-queens.** Read about the 8-puzzle in Section 3.2.1 of Russell and Norvig, 3rd edition (p. 70-71). Discuss differences in combinatorial complexity of the state space and simplifying properties such as symmetry – which problem exhibits these properties and which do not? What are some challenges in checking state spaces using generate-and-test? (We will come back to this when we discuss constraint satisfaction problems, aka CSPs.)

    ii. **Farmer, Fox, Goose and Grain.** The FFGG problem, alternately known as the fox, goose, and bag of beans problem, is a river crossing puzzle usually stated as follows (https://en.wikipedia.org/wiki/Fox,_goose_and_bag_of_beans_puzzle):

        A farmer comes to a river bank with a fox, a goose, and a sack of grain. He can cross over using a boat that holds himself and one of the three items at a time. If the fox is left on one bank with the goose, it will eat the goose. If the goose is left on one bank with the grain, it will eat the grain. Can the farmer get all three items and himself across without anything being eaten?

        Formulate the problem precisely as a state space. Turn in an **illustration of the state space diagram**, showing which states are the initial states and which are reachable from each other. Rather than just give the state space provided in the Wikipedia article, explain your derivation and the operations on this state space. **Answer the following:** How many distinct states (legal/reachable or not are there), if we define each object as being on one bank or the other? How many reachable states are there? How many different solutions starting from either side are there?

4. **(530/730) Understanding local search.**

    a. What search algorithm is equivalent to beam search with one initial state and beam width w = ∞? Prove your answer.
    b. Describe, in your own words, the relationship between hill-climbing and depth-first search. Give an example to illustrate the difference.

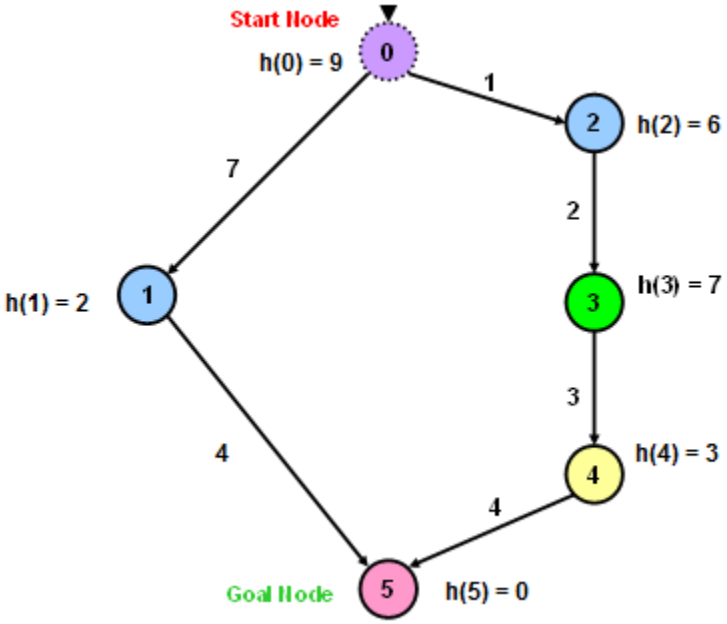
5. **(730 only) Iterative Deepening A* (IDA*) vs. Depth-Limited Search (DLS) and Uterative Deepening Depth First Search (IDDFS) vs. Breadth-First Search (BFS).** In your own words, what is the relationship between IDA* and Depth-Limited Search? Between IDDFS and Breadth First Search?

6. **(530/730) PEAS representations of problems.** For each of the following software agent tasks, develop a Performance measure, Environment, Actuators, Sensors (PEAS) description of the task environment:

    a. An autonomous unmanned aerial vehicle (UAV) or drone that looks for hand-chalked distress signs. What challenges does a drone have with such a task, as compared to the custom icon task for DroneAid, the winning entry in IBM's 2018 Call for Code (https://youtu.be/9fRcis-5Zuc)?

b. A radio-frequency identification (RFID) Internet of Things (IoT)-based restocking and product placement agent in a department store that looks at how often items such as shoes or articles of clothing are tried on versus how often they are purchased (see: http://www.rfidjournal.com/articles/view?17535).

7. **(530/730) Heuristic Search.** Simulate the behavior of greedy vs. A/A* search (is it A*?) on the following graph, showing the **nodes expanded,** the **path** actually returned, and the **cost** of the path.



8. **(530/730) Comparing blind and heuristic search.** Prove each of the following statements, or give a counterexample:

   a) Branch-and-bound search is a special case of greedy search.
   b) Hill-climbing tree search is a special case of beam search.
   c) A search is a special case of greedy search.*

9. **(730 only) Local and global search.** Show how global search can overcome the following types of problems (use heuristics as in PS1-8 above).

   a) Foothill problem (local optimum) – illustrate using *grid search*
   b) Plateau problem – illustrate using *graph search*

Class participation (required).

Artificial Intelligence for Good. Watch the AI for Good Global Summit highlight reels from the 2nd Artificial Intelligence for Good Global Summit in Geneva this spring:

- Day 1, 15 May 2018: https://youtu.be/wrdK17OKy7w
- Day 2, 16 May 2018: https://youtu.be/wmney_xXams
- Day 3, 17 May 2018: https://youtu.be/KcLK5hvc_9k

Which advance and which sustainable development goal (SDG) area did you find most compelling, and why? What might some of the relevant data be? Discuss ways in which

intelligent agents can use available data and human input, and how an artificial intelligence-based system (including but not limited to a machine learning-based system) can augment human performance and the current state of the field. For some current examples and ideas, see the digital media kit for the 2018 global summit: https://trello.com/b/mGtXvF2y/digital-media-kit-ai-for-good-global-summit

Post your discussion to the discussion thread for PS1 in CIS 530/730 (http://bit.ly/kstate-ai-class), along with a brief introduction stating your:

- name
- program (grad or undergrad) and major
- interests in AI – **optional** (this will be on a KSOL or Axio survey)
- special topics you would like to see covered, if any – **optional** (ditto above)