CptS 440 / 540: AI

Fall 2016

Homework #1

1. **Problem 1.14 in [AIMA], parts (a – e), g, h, k** (so, eight parts in total). Keep each answer to no more than two crisp, to-the-point sentences.
   (Note: the answers need not always simply be "Yes, because…" or "No, because…". They could be, for example, along the lines of "It depends on…", or "As of year 2016, the existing AI systems can do task X to this extent: …", or similar.)

   Answers:

   a) Robot playing ping-ping: yes, but not really at the level of skilled humans. See e.g. IEEE article: http://spectrum.ieee.org/automaton/robotics/industrial-robots/robots-playing-ping-pong-whats-real-and-whats-not

   b) Driving in the center of Cairo: difficult, b/c of very dense and very unstructured traffic (pedestrians and drivers not respecting traffic signals; high density of traffic; hard navigation; being able to break in a snap of a second, etc.)

   c) Driving in small-town, California: Google or Uber cars can already do this, as well as driving on highways. Also, company in Singapore – so, as of 2016, this is already a reality.
   In general: Driving on highway is much easier for self-driven cars than driving in a city; and driving in a small town is much easier than in a chaotic, dense-traffic metro area / big city (remember: fatigue affects human drivers, not self-driven cars; but complexity and necessity for rapid intuitive response is harder for present-day self-driven cars than semi-decent human drivers)

   d) Buying a week's worth of groceries at a market: this means, a physical robot that walks/drives to a physical store, walks down different aisles, picks groceries etc. This is quite challenging, and state-of-the-art robots that can do this sort of things are i) very complex and expensive at present; and ii) far from perfect / less reliable, accurate etc. than a normal 8-year old. Contrast this answer to the next question.

   e) Buying a week's worth of groceries on the web: this requires a software (only) agent / digital assistant; it's much easier to design a piece of software doing this, than a physical robot going to a physical store etc.

   f) Discovering & proving new math theorems: there exist theorem proving programs/software that are pretty good. Discovering a new theorem (= non-trivial mathematical result that follows from a set of axioms and previously established theorems in a given area of mathematics such as logic, set theory, algebra, etc.) is much typically much harder for humans and esp. software agents / AI than proving a specified result ("candidate theorem") based on known set of axioms. (This problem also related to the famous "P vs. NP" question: is verifying a suggested solution to a given problem provably computationally easier than finding one from the scratch?)

g) No AI program has been designed, and likely none will be designed in any foreseeable future, that can write "intentionally funny stories". Think about it: before a human can come up with his or her original jokes or funny stories, one needs to have an appreciation of humor, sarcasm, and be able to in general understand jokes (by others). No AI product to date is anywhere close to "understanding" or "appreciating" jokes or any kind, so it's very unlikely AI will be able to create jokes or funny stories any time soon.

k) (surgery) The answer critically depends, on whether you expect a robot to perform surgery fully autonomously, or allow for human partial or full (remote control). We are still years, possibly decades, away from fully autonomous robotic surgeon. That said, robots are increasingly being used for surgery, although always under the command of a doctor.
"Robotic skills demonstrated at superhuman levels include drilling holes in bone to insert artificial joints, suturing, and knot-tying. [However…] They [robots] are not yet capable of planning and carrying out a complex operation autonomously from start to finish."

2. Which of the following properties best describe the Wumpus World environment? Explain your choices briefly. (Make the following assumptions: i) the game progresses in discrete time steps, where a single turn-and-go or a single shoot-the-arrow or other single agent action takes a unit time; ii) upon shooting the arrow, the agent will know whether it was hit-or-miss within the same unit time; iii) when the game is reset, the positions of the gold, the Wumpus and the pits are 'scrambled', i.e., in general the starting configuration may change.)

   a. Fully observable or partially observable.
      Partially observable, since the agent doesn't see/know the contents of all other 15 squared.
   b. Single agent or multi-agent.
      Since we've considered the Wumpus to be a (very adversarial) part of environment, and since Wumpus doesn't learn, deliberate, plan, or adapt its behavior in any way, it's fair to not consider it an agent itself. Hence, the environment here is single-agent.
   c. Deterministic or stochastic.
      The Wumpus behavior is deterministic and fixed (= doesn't change over time), the pits don't appear or disappear, etc. So, (once the initial configuration is defined; there is a probabilistic aspect to defining the initial state, but that's a different issue from the nature of the environment), the Wumpus World is a deterministic environment (but again, only partially observable to the agent).
   d. Episodic or sequential/non-episodic.
      It is episodic in terms of the general nature, but it's not completely episodic w.r.t. the initial configuration (recall discussion in class).
      Another acceptable answer: non-episodic w.r.t. the initial configuration (but episodic in other aspects).
      Another view: if one considers just a single play, and situations from one move to the next within a single play, then the environment in that view would be non-episodic.
   e. Static or dynamic.
      Static: neither the Wumpus location and/or behavior, nor pits' or gold's locations, change with time. Hence, nothing changes in the environment, other than changes

directly caused by actions of our agent. (Also, nothing happens or changes while the agent is deliberating – all changes in the environment result from agent's actual actions. This conforms to the def. of static in AIMA.)

f. Discrete or continuous.
Since both time steps and possible configurations of the square-grid (incl. whether there's a pit, a Wumpus or gold in a particular square) and the agent (that is, the problem's "state space") are all discrete, this environment is discrete.

g. Known or unknown.
The agent may not know where the Wumpus is, but it knows what will happen if it shoots the arrow at the Wumpus, or if it walks into the Wumpus's square (and the Wumpus is still alive). Likewise, the agent may not know where the pits are, but it knows what will happen if it walks into a pit; and so on. So while the environment is clearly not fully observable, it is known (= "the laws of physics" of the Wumpus world are known to the agent at the beginning of the game, as opposed to agent having to learn them along the way, akin to how it needs to learn where pits or the Wumpus are located and similar.)

3. The Wumpus World game is described on pages 236-240 in the textbook and on the slides for Ch. 2.

   a. Define what it means for an agent to ***act rationally*** in the Wumpus World.

   Solution: The agent should choose actions in order to maximize its score in the game. An alternative is, to stay alive / minimize risk of getting killed by Wumpus or a pit.

   b. How many different 4x4 Wumpus Worlds are there? (Assume that the gold, the monster and the pits can be in any of the squares, other than (1, 1). Assume also, a square can contain either nothing, or exactly one of the gold, the Wumpus or a pit. Assume there are exactly 3 pits, and that the pits are indistinguishable from each other.) Show your work and justify your answer.

Solution:

- The Wumpus is in one of 15 locations (not in [1,1]). Total = 15.
- The gold is in one of the 15 locations (book says not in [1,1], but simulator allows it; my formulation follows the book). Total = 15.
- There is potentially a pit in any of the 15 locations (not in [1,1]). (Upper bound on) Total = 15^3 (and not 3^{15} -- that answer is completely wrong).

Total worlds (upper bound): 15^5

Solution for FULL CREDIT: If Wumpus is in one of 15 locations, there are 14 locations for the gold (since gold and Wumpus cannot be in the same location). Similarly for the pits, except that the pits are indistinguishable from each other; so that number is (13 \choose 3). Therefore, the total # of initial configurations is

15 * 14 * (13*12*11)/3! = 15*14*…*11 / 6 = 60,060

Notice, in which order you consider where to place Wumpus vs. gold vs. the 3 pits, the answer is always the same: 15*14*…*11 / 6 (where division by 3! = 6) is to capture that the pits are mutually indistinguishable.

4. Consider the task of designing an intelligent software agent to play (= invest in) the stock market for you. Describe the "PEAS": performance measure, environment, actuators and sensors of your agent. For each of the seven environment properties we discussed in class (see lecture notes for Ch. 2, as well as Problem 2. above), indicate how this environment would be described along these seven dimensions and briefly explanation as to why. Finally, of the four types of agents (simple reflex, model-based reflex, goal-based, utility-based), briefly explain which you think would be best for your stock market agent and why.

Solution: Below is my answer and a few alternatives, but answers to this one may vary.

Task

- Performance measure: maximize value of portfolio (other possibilities include: maintain diversity or minimizing risk);
- Environment: Stock market (but could be expanded to include the business world or the entire world);
- Actuators: Buy/sell stock (other possibilities are buy/sell options or gather information);
- Sensors: Stock prices – current and past/historical; additional possibilities include news feeds, company information, etc.

Environment

- Fully observable if all you care about is the stock prices; partially observable if you reason that the stock price is based on other factors (e.g., quarterly revenue, impending merger) that are not immediately observable.
- Single agent, because your individual actions generally don't have a big impact on other agents, but if you are a "big player" in the stock market, then in fact, your actions might influence others, making the environment multi-agent.
- Deterministic in the sense that if you execute a buy/sell order, it will be completed. Might be stochastic is you expect your actions to accomplish more abstract results, like "value of portfolio increases".
- Sequential in that most good stock pickers employ a long-term strategy, e.g., buy low and sell high. You can't sell high if you don't buy. But, as with most environments, a sequential environment can be turned into an episodic one by including more information in the state (e.g., in addition to the number of shares of each stock you own, also include the price at which you bought it).
- Dynamic, because the stock prices in general change in real time.

- Continuous, because the stock prices and portfolio values are real-valued. Could be viewed as discrete if these values are discretized, or you move to properties merely about change: increased, decreased, stayed the same.
- Known, because the rules of the stock market are known, and so are consequences of actions (i.e., if I order 'buy stock X at time t', I will pay $cost = the price of that stock at that time); I don't know whether a stock will go up or down in the future, but I do know the "laws governing" the world of online investment.

Appropriate type of Agent?

- A utility-based agent would be most appropriate, but goal-based is still reasonable. The quality of your portfolio is probably best measured as a formula based on the properties you desire: monetary value, diversity, or minimal risk. So a utility value can be computed for each state and the agent will take actions so as to reach states that maximize utility. These individual components of utility could also be expressed as goals for a goal-based agent.

5. **Problem 2.3 in [AIMA], parts a), d), e), f) and i)** (so, five parts total). Justify each answer with 1-2 crisp, to-the-point sentences.

a) False. An agent is acting perfectly rationally if it chooses actions that are reasonable given its knowledge about the world. So, it's conditional on the available information – rationality does not assume perfect or complete knowledge. That is, Perfect rationality refers to the ability to make good decisions given the sensor information received.

> Example: an agent in the Wumpus world that never risks walking into a pit or the Wumpus, but rather explores the world and makes "safe" moves w.r.t. what it already knows about the environment (while trying to learn more about the locations of pits, gold and Wumpus as it progresses along). This was discussed at some length in the class.

d) False. Conceptually, an agent program is a piece of software; so its input is constrained to the kind of input you can provide to any program (certain parameters, variables etc.). In contrast, an agent function is a mathematical abstraction that specifies the formal mapping from the sequence of percepts (up to & including the current time step t) to an action. Further, even if we ignore the conceptual difference, the two functions take different inputs: The agent function, notionally speaking, takes as input the entire percept sequence up to that point, whereas the agent program takes the current percept only.

e) False. This is a simple counting argument. There are countably many possible computer programs. (Recall your Automata Theory or Intro to Theory of Computation class: how many Turing Machines are there?) An agent function is a mathematical function from the domain set of precept sequences to the range set of possible actions. Assuming there are at least two possible different precepts and at least two different possible actions, and (this is crucial!) that the precept sequence can be arbitrarily long, there are uncountably many mathematical functions from the set of all possible precept sequences to the set of actions.
(To see why, recall that there are uncountably many functions **f: X –> Y** where **X** is the set of finite (w.l.o.g., it's fine to assume binary) strings of arbitrary length and **Y** = {0, 1}.)

f) True. Trivial example: an environment ignores the agent's actions and gives the same reward (or perhaps no reward) regardless of what the agent does.
Slightly Less trivial example: a deterministic environment that, at each time step, responds to agent's actions as follows:

IF (agent takes any action) **THEN** reward agent with newpay = currentpay + $1
ELSE reward agent with newpay = currentpay

i)False. Unless it draws the perfect hand, the agent can always lose if an opponent has better cards. This can even happen repeatedly, depending on one's (bad) luck.

Example: If I got the Royal Flush right away, and you got {2, 3, 5, 7, 9} across different suits, assuming standard rules of poker (and in particular, that you cannot exchange all of your cards), and assuming I'm not too drunk or high to fall for your bluffing (as I may not know what you've got, but I do know I got the Royal Flush!), you're not going to win this particular hand of poker. More generally, in any game that involves luck or chance moves, being "perfectly rational" (incl. playing the best strategy assuming such strategy exists) still doesn't guarantee that you will always win or even never lose.