CAP5600: Artificial Intelligence

Spring 2014

# Final Exam

Name: Brett HenneTotal score:(100 points total): \_\_\_\_\_\_\_\_

**Instructions:**

* **This exam is due on Sunday, April 27, 2014, by 11:59 PM**. Include all of your answers in one document (PDF or MS Word format). Submit your document via the final exam drop box in eLearning.
* This exam has 5 questions. Read the questions carefully and provide **CONCISE** answers. All answers must be typed. The point value of each question is noted before the question.
* Please e-mail me if you have any questions about the exam. Do not post questions on the discussion boards. Note that I cannot answer questions about your answers. I will post questions and answers that are of a general nature on the discussion board.
* **This exam should be done individually**. You may consult the textbook, lecture notes, and course resources, but you may not consult each other or other people or sources. **List all references you consult for each question at the end of each question**.

**Questions:**

**(1)** (20 points) For each of the following: (i) develop a PEAS description of the task environment, (ii) characterize the properties of the environment, and (iii) select and justify a suitable agent design:

(a) Internet shopping agent (shops for an item on the Internet)

**Develop a PEAS description of the task environment**

Performance Measure: Convenient, efficient, economical

Environment: internet, wires, routers, switches, servers, databases

Actuators: websites, online classifieds, online magazines, online retailers,

Sensors: SKU, price, description, barcode, model, name, type, category

**Characterize the properties of the environment**

Partially Observable, because some online retailers block internet shopping agents from entering websites by making it difficult for an AI agent by using a login with a skewed written text that is not easily decoded by machines.

Stochastic, because the agent is designed to search online retail, which is ever changing marketplace. The information obtained at one retailer should have no affect on the next.

Episodic, because the actions of the agent should have no affect on future decisions. Each retail search is independent and will not affect the information gathering of the agent.

Dynamic, because the online marketplace is constantly changing. Any given moment, the item can be added or removed. In addition, an online retailer can change the price of the item after the agent first searched.

Continuous, because internet shopping agents are continuously scouring the internet for products and prices and building up databases of information. Products offerrings, sales, and supply/demand make this a continuous endeavor.

Multiple Agent, when searching for an item, randomized behavior of multiple agents may yield more results.

Known, because the agent knows the laws of the environment. Items have to be found, the price and stock information is then provided.

**Justify a suitable agent design**

Simple reflex agent because searching the internet for an item doesn't require past percept, rather only the current percept. Agent finds item, and stores information about that item to publish later. Since the agent is not buying, rather shopping, it does not need to know past prices. That decision will be left to the consumer.

**References:**

Artificial Intelligence A Modern Approach, Chapter 2

Lecture Notes

"PEAS." Wikipedia. Wikimedia Foundation, 03 July 2014. Web. 25 Apr. 2014.

(b) Autonomous Mars rover

**Develop a PEAS description of the task environment**

Performance Measure: Navigation accuracy, obstacle avoidance, terrain negotiation, efficiency, etc

Environment: various terrains (rocky, sandy, etc), wind storms, extreme temperatures

Actuators: wheels, robotic arms, servo motors, gear motors

Sensors: camera, temperature sensor, light sensor, etc

**Characterize the properties of the environment**

Partially Observable, because the rover is not able to see beyond its camera.

Deterministic, because the actions of the rover and its current state affect its next decision and state.

Sequential, because decisions made by the rover will affect its path on mars. A decision to go left or right will

Dynamic, because the terrain on mars could change quickly and dramatically.

Discrete, because the mars rover will most likely have predefined goals and outcomes. Some of which may not be clear due to the dynamic nature of the rover. In addition, these rovers are designed to operator for only a short few years.

Multiple Agent, when searching for an item, randomized behavior of multiple agents may yield more results.

Known, because the agent knows the laws of the environment. Items have to be found, the price and stock information is then provided.

**Justify a suitable agent design**

A model based agent is the most effective way to handle partial observability. The agent can use information based on it's own action and the information of it's environment to make decisions more effectively.

**References:**

Artificial Intelligence A Modern Approach, Chapter 2

Lecture Notes

"PEAS." Wikipedia. Wikimedia Foundation, 03 July 2014. Web. 25 Apr. 2014.

**(2)** (20 points) For each search algorithm below: (i) identify the main strength and limitation of each algorithm, (ii) describe a potential use/application of each algorithm, and (iii) provide a performance evaluation of each algorithm. Provide concise answers! You may provide your answer in a tabular format or bulleted list.

(a) Iterative deepening search

**Strength** – uses less memory than breadth-first search on each iteration

**Limitation** - nodes at higher levels are generated multiple times

**Potential Use** - can be used in path finding

**Performance Evaluation** - combines depth-first search's space-efficiency and breadth-first search's completeness

**References:**

Artificial Intelligence A Modern Approach, p. 88

"Iterative Deepening Depth-first Search." Wikipedia. Wikimedia Foundation, 25 Apr. 2014.

(b) A\* search

**Strength** - uses a heuristic and movement cost to determine the next best node to visit

**Limitation** - large memory requirement because the entire open list must be in memory

**Potential Use** - shortest path finding

**Performance Evaluation** - evaluates less nodes than Dijkstra's algorithm

**References:**

Artificial Intelligence A Modern Approach, p. 93-98

"A\* Search Algorithm." Wikipedia. Wikimedia Foundation, 25 Apr. 2014.

(c) Min-conflicts search

**Strength** – algorithm run-time is independent of problem size.

**Limitation** – the pure min-conflicts algorithm cannot go beyond a local minimum

**Potential Use** – scheduling problems in order to determine the minimum number of conflicts.

**Performance Evaluation** – can solve a very large CSP problems in very few steps. The million-queen problem can be solved in about 50 steps according to the textbook.

**References:**

Artificial Intelligence A Modern Approach, p. 221

"Min-conflicts Algorithm." Wikipedia. Wikimedia Foundation, 25 Apr. 2014.

**(3)** (20 points) Consider the problem of constructing (not solving) a crossword puzzle: fitting words into a rectangular grid. The grid, which is given as part of the problem, specifies which squares are blank and which are shaded. Assume that a list of words is provided and that the task is to fill in the blank squares using any subset of the list.

(a) Formulate this problem precisely as a general search problem. Choose an appropriate search algorithm, and specify a heuristic function if necessary. Is it better to fill in the blanks one letter or one word at a time?

**Problem Formulation**

1. Initial State: Empty Puzzle specifying blank and shaded squares.
2. Actions: Insert Word into puzzle
3. Goal Test: Complete? Word character count equal? Across/Down Conflict?
4. Path Cost: Time required to solve puzzle.

**Search Algorithm**

Breadth-first search since the set of available words is finite and the algorithm is complete.

**Heuristic**

A function can be defined that sums the number of letters in the word that match an already set letter or if no letter has been assigned.

**Fill Method**

Since a list of words is provided and each word length is most likely not the same, I would choose to fill the blanks a word at a time. The length of the word would shorten the domain of possible values and the min-conflicts heuristic would further decrease that domain.

**References:**

ch3-search.ppt

Artificial Intelligence A Modern Approach

(b) Formulate this problem precisely as a constraint satisfaction problem. Should the variables be words or letters?

**Problem Formulation**

1. Initial State: Empty Puzzle specifying blank and shaded squares.
2. Action: Assign a word to an unassigned variable that does not conflict with the current assignment, fail if no legal assignments exist
3. Goal Test: The successor function passed.
4. Path Cost: Time required to solve puzzle.

Variables: Across + Down word locations

Domains: Word List

Constraints: Word length must match variable length and word cannot be used more than once.

I would choose to use words vs letters because the list of words is finite and because the domain of each state can be reduced by the length of the word. By reducing the domain, there are less possible word choices for each state.

**References:**

Lecture PowerPoint Slides: ch6-csp.ppt

Artificial Intelligence A Modern Approach, p. 202-207

"Constraint Satisfaction Problem." Wikipedia. Wikimedia Foundation, 25 Apr. 2014.

(c) Which formulation would you choose to solve this problem and why?

I would choose the constraint satisfaction problem because the domain is finite and the constraints can be clearly defined. The down/across word state is defined by variable from an available domain of words. The words in the domain can be reduced by word length and further by already used words. The min-conflicts heuristic can be used to choose the least constrained word.

**References:**

Lecture PowerPoint Slides: ch6-csp.ppt

Artificial Intelligence A Modern Approach, p. 202-207

"Constraint Satisfaction Problem." Wikipedia. Wikimedia Foundation, 25 Apr. 2014.

**(4)** (20 points) This semester, we discussed various machine learning approaches, including decision tree learning and neural networks.

* + 1. Compare the strengths and weaknesses of decision trees to neural networks.

**Decision Trees**

Strengths:

* Are fast once trained
* can prune input features that are not useful
* easy to follow top-down approach of looking at the data
* easy to program using IF, THEN, ELSE statements
* can use information gain to decide the splitting value at an internal node

Weaknesses:

* Can easily overfit data (which can be negated by pruning)
* All variables in a decision tree is forced to interact with every variable further up in the tree which is not very efficient.
* Reliability depends on precise internal and external information at the onset
* Prone to errors in classification
* Large trees with many branches are complex to construct and are very time-consuming
* Small changes in the data set can lead to large changes in the tree

**Neural Networks**

Strengths:

* Perceptron learning rule converges to a consistent function for any linearly separable data set
* Perceptrons can represent complex Boolean expressions very compactly
* Works well with noisy data
* Can be used for supervised learning and unsupervised clustering
* Can handle binary data better than a decision tree
* Can utilize hidden layers
* May have multiple outputs

Weaknesses:

* Perceptrons cannot learn if the function is not linearly separable
* Not easy to understand
* May not provide optimal solutions to problems
* slower for both training and classification
* inputs have to be binary and numeric
* outputs have to be binary and numeric
* categorical data has to be binary coded (4 values 🡪 00, 01, 10, 11)
* outputs of hidden layers are not directly known

**References:**

* Week 13 Recording (3/31/2014) - Chapter 18, Part 2 (neural networks, discussion of final systems)
* Lecture Slides: chapter18-neuralnets.pdf
* Artificial Intelligence A Modern Approach, Chapter 18
  + 1. Compare the strengths and weaknesses of perceptrons (single layer feed-forward neural networks) to multilayer feed-forward networks.

**Single Layer Feed-Forward Neural Network**

Strengths:

* There are no cycles or loops in the network
* Guaranteed success if the training samples are linearly separable
* Easy to implement the majority function

Weaknesses:

* Will run indefinitely if the given samples are not linearly separable
* Cannot support short term memory

**Multi Layer Feed-Forward Network**

Strengths:

* Can use back-propagation as a learning technique
* Are sufficiently expressive
* Can be trained by gradient descent
* With a single large hidden layer it is possible to represent any continuous function of the inputs with arbitrary accuracy
* With two hidden layers it is possible to represent discontinuous functions

Weaknesses:

* There exists cycles or loops in the network
* Can end up in a local minimum
* For any particular network structure, it is harder to characterize exactly which functions can be represented and which ones cannot.
* Cannot support short term memory

**References:**

* Week 13 Recording (3/31/2014) - Chapter 18, Part 2 (neural networks, discussion of final systems)
* Lecture Slides: chapter18-neuralnets.pdf
* Artificial Intelligence A Modern Approach, Chapter 18
  + 1. What type/class of applications are decision trees more suitable for?

Decision trees are useful in applications where an input can be tested against a finite set of values. These values can be a range, and number, a color, etc, the key is that it can be compared to a known attribute. Each answer spawns a node in the tree, if the node is a leaf node then the answer is found. Once the tree has been constructed from a training set, real world data can then be applied to obtain a result. This has many useful applications to include:

* Medical Diagnosis
* Troubleshooting an electronic circuit
* Computational Biology
* Weather Forecasting
* Classifying loan applicants by their likelihood to default on payment

**References:**

* Machine Learning, Tom M. Mitchell, Chapter 3
* Russell, Stuart J., and Peter Norvig. Artificial Intelligence: A Modern Approach. Upper Saddle River: Prentice-Hall, 2010. Chapter 18
  + 1. What type/class of applications are neural networks more suitable for?
* Speech
* Driving
* Handwriting
* Credit cards
* Character recognition
* Image Compression
* Stock Market Prediction
* Finger print recognition

**References:**

* Dr. El Sheik, Eman. "Chapter18-neuralnets.pdf"
* Hashmi, Ahmed, and Chinmoy Das. "Neural Network & Its Applications." Neural Network & Its Applications. N.p., n.d. Web. 26 Apr. 2014.
* Russell, Stuart J., and Peter Norvig. Artificial Intelligence: A Modern Approach. Upper Saddle River: Prentice-Hall, 2010. Chapter 18

**(5)** (20 points) Throughout the semester, we have discussed the evolution of the field of AI from the various definitions of the term AI to the many accomplishments of the field.

(a) In your opinion, what are two of the major goals that the AI field has accomplished so far?

**Autonomous Vehicles**

The area of autonomous vehicles has proved to be a major accomplishment in the field of AI. When I was working on my undergraduate degree in Electrical Engineering in 2004 I was in the process of designing my first autonomous system. I remember reading an article about the Darpa Grand Challenge and how 15 vehicles were to navigate a 142 mile course in the desert and that none of the teams finished. That very next year 5 teams out of 95 completed the 132 mile course. These earlier competitions spawned the Urban Challenge in 2007 in which autonomous vehicles had to navigate a 60mile urban course in 6 hours. This was more challenging as the vehicles had to deal with other vehicles, and traffic signs.

**Path Finding**

Path-finding algorithms have been around for decades. When most people first think of its uses, they tend to imaging vehicles or games. But path-finding has seen its usefulness in many fields to include:

* Navigation
* Traffic Networks
* Animal Migration Modeling
* Video Games
* Printed Circuit Board Trace Routing

Since Dikjstra published his algorithm in 1959 many algorithms have been developed in this field. Here is just a short list that shows the accomplishments in this field of AI.

1959 – Dijkstra

1968 – A\*

1994 – D\*

1995 – Focused D\*

1996 – DynamicSWSF-FP

1997 – LPA

2001 – LPA\*/Incremental A\*

2002 – D\* Lite

2002 – SetA\*

2004 – HPA\*

2005 – Anytime D\*

2005 – PRA\*

2007 – Field D\*

2007 – Theta\*

2008 – HAA\*

2008 – GAA\*

2009 – Learch

2009 – BDDD\*

2009 – Incremental Phi\*

2010 – GRFA\*

2010 – MTD\*-Lite

2011 – Tree-AA\*

**References:**

* "How Do the State-of-the-art Pathfinding Algorithms for Changing Graphs (D\*, D\*-Lite, LPA\*, Etc) Differ?" *Ds.algorithms*. Web. 26 Apr. 2014.

(b) In your opinion, what are two of the major challenges that the AI field currently faces?

1. Human language processing has come a long way over the years, but I believe it still has a long way to go. Many of the tools that have been developed utilize an extensive library and brute force methods to analyze speech. If one does not speak clearly without a regional dialect the software tends to produce incorrect results. An AI system that can learn as well as utilize a standard library to successfully produce results in real-time application can have a significant impact on both consumer products, navigation systems, and those with disabilities.

2. I’ve done some work on pattern recognition while working at Actigraph. In the field of human activity research there is many tools that can measure human activity using sensors worn on the body, but there is very little AI that can infer what that individual is doing accurately. Currently the research is focused on taking the raw data from these sensors and extracting features such as frequency, magnitude, entropy, correlation, etc. What is lacking is an AI system that can determine what that person is doing (walking, riding a bike, swimming, etc). The major obstacle is that this is very open-ended and AI research projects that have been successful have solved finite problems. If research can be done in this field I believe it would help doctors diagnose health problems by using objective data collected from a sensor that a patient wears versus the current method of asking the patient what their physical activity entails.