Homework 01

Submission Notices:

- *Conduct your homework by filling answers into the placeholders given in this file (in Microsoft Word format). Questions are shown in black color, instructions/hints are shown in italic and blue color, and your content should use any color that is different from those.*
- *After completing your homework, prepare the file for submission by exporting the Word file (filled with answers) to a PDF file, whose filename follows the following format,*
  <StudentID-1>_<StudentID-2>_HW01.pdf (Student IDs are sorted in ascending order)
  *E.g., **1852001_1852002_HW01.pdf***
  and then submit the file to Moodle directly WITHOUT any kinds of compression (.zip, .rar, .tar, etc.).
- *Note that you will get zero credit for any careless mistake, including, but not limited to, the following things.*
  1. *Wrong file/filename format, e.g., not a pdf file, use "-" instead of "_" for separators, etc.*
  2. *Disorder format of problems and answers*
  3. *Conducted not in English*
  4. *Cheating, i.e., copy other students' works or let the other student(s) copy your work.*

Problem 1. (1pt) Briefly describe the concepts of the following research fields: Artificial Intelligence, Machine Learning, Deep Learning, and Data Science. For each concept, the description should be expressive enough to discriminate the corresponding research field from other fields.

Please write your answer in the table

Concept	**Description**
Artificial Intelligence	*Any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving". (Wikipedia)*
Machine Learning	*A field of artificial intelligence that uses statistical techniques to give computer systems the ability to "learn" (e.g., progressively improve performance on a specific task) from data, without being explicitly programmed. (Wikipedia)*
Deep Learning	*A part of a broader family of machine learning methods based on artificial neural networks with representation learning. (Wikipedia)*
Data Science	*Data science is an interdisciplinary academic field that uses statistics, scientific computing, scientific methods, processes, algorithms and systems to extract or extrapolate knowledge and insights from noisy, structured and unstructured data. (Wikipedia)*

Problem 2. (1pt) Discuss that, to what extent, the following systems are instances of AI. That is, you first decide its level of intelligence, low, fair/medium, or high, and then give your reasons.

• **Product 01**: Streetlights turn on automatically at night.	

• **Product 02**: The hotel card helps turning on the electricity in a hotel room when being put into a wall slot.	
• **Product 03**: Deep Nostalgia uses video reenactment technology to animate the faces in still photos and create high-quality, realistic video footage.	
• **Product 04**: Autonomous drone delivers packages to customers in a variate of operating environments.	

Please write your answer in the following table.

Product	Level of intelligence	Reason
Product 01	*Medium*	*The amount of light that comes to the sensor controls the status of the streetlight.*
Product 02	*Low*	*The card just lets you indirectly push a switch hidden in the wall slot to turn on the electricity. Any card that fits in the slot will work.*
Product 03	*High*	*The system needs complex Computer Vision algorithm to train the Deep Learning model so that it can understand and manipulate with the content of the image.*
Product 03	*High*	*The system must have special design that match the delivery mechanism. There are too many unexpected factors in practical operating environments, asking for a flexible enough decision-making component.*

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Facte	
Perfo meas	P : the agent completes the performance successfully without mistakes and keeps synchronized with its comrades
Envi	E : larger square, comrades, audiences
Actu	A : hands (to perform), legs (to move with comrades), human-body (to synchronize body's parts)
Sens	S : eyes (to see), ears (to hear the commands of performance),

hear the commands from the leader)

Problem 4. (1.5pts) Describe the task environment properties for the online video game Dota 2, where OpenAI Five agent plays the five-on-five game against the professional players.
Refer to the following link for more information about the game: https://www.dota2.com/home

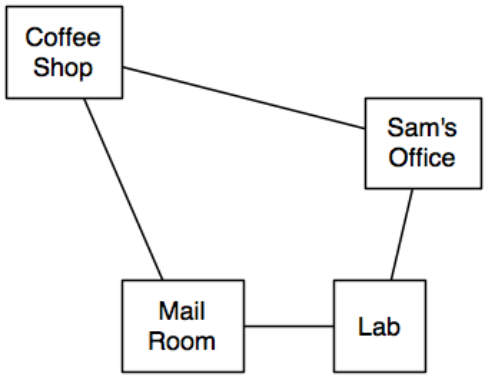
Please write your answer in the table

Property	**Description**

Fully observable vs. Partially observable	*Partially observable. Although the players have the map in hands, which displays in real time the location and status of game elements, they may not observe all the elements in that environment due to the team vision https://dota2.fandom.com/wiki/Minimap*
Single-agent vs. Multi-agents	*Multi-agents. There are two teams playing against each other. One team has five characters*
Stochastic vs. Deterministic	*Some abilities are stochastic while the others are deterministic. For example, death Prophet: Spirits choose their targets randomly. Once chosen, they stick with that target until they can't attack it anymore. The spirits prioritize units the caster attacks. https://dota2.fandom.com/wiki/Random_distribution*
Episodic vs. Sequential	*Sequential. The agents must perform a series of actions to fulfil the goal, which is to win the game.*
Static vs. Dynamic	*Dynamic. The agents have complex activities, forcing the environment to change from one state to another state with a high frequency.*
Discrete vs. Continous	*Discrete. One character has a finite set of actions (movements and skills to cast)*

Problem 5. (2.5pts) Consider a delivery robot world with mail and coffee to deliver.

Assume a simplified domain with *four locations* as shown aside. This domain is quite simple, yet it is rich enough to demonstrate many of the problems in representing actions and in planning.



The robot, called Rob, can *pick up coffee at the coffee shop, pick up mail in the mail room, move, and deliver coffee and/or mail*. Delivering the coffee to Sam's office will stop *Sam from wanting coffee*. There can be *mail waiting at the mail room* to be delivered to Sam's office.

Rob can *move clockwise (mc)* or *move counterclockwise (mcc)*. Rob can *pick up coffee (puc)* if Rob is at the coffee shop and it is not already holding coffee. Rob can *deliver coffee (dc)* if Rob is carrying coffee and is at Sam's office. Rob can *pick up mail (pum)* if Rob is at the mail room and there is mail waiting there. Rob can *deliver mail (dm)* if Rob is carrying mail and at Sam's office. Assume that it is only possible for Rob to do one action at a time.

Formulate the task above as a search problem by determining the primary concepts.

Please write your answer in the table

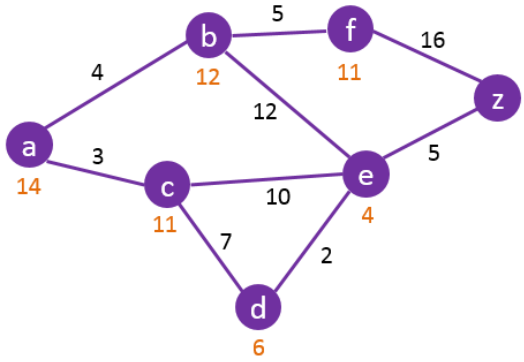
Search concepts	**Descriptions**
(0.5pt) Representation for a state	*The states are the quintuples specifying* ***the robot's location, whether the robot has coffee, whether Sam wants coffee, whether mail is waiting, and whether the robot is carrying the mail****.*

<table>
<tr><td></td><td>For example, the tuple ⟨lab, ¬rhc, swc, ¬mw, rhm⟩ represents the state where Rob is at the Lab, does not have coffee, Sam wants coffee, there is no mail waiting, and Rob has mail.
Another example, the tuple ⟨lab, rhc, swc, mw, ¬rhm⟩ represents the state where Rob is at the Lab, carrying coffee, Sam wants coffee, there is mail waiting, and Rob is not holding any mail.</td></tr>
<tr><td>(0.5pt) State-space graph: how many states there are and how they connect together</td><td>There are 4×2×2×2×2= 64 states. Intuitively, all of them are possible, even if you would not expect that some of them would be reached by an intelligent robot.
Students are not required to draw the graph, however, they must provide examples or general description that can show the characteristics of the state-space graph.</td></tr>
<tr><td>(0.5pt) Set of actions</td><td>There are six actions, ⟨mc, mcc, puc, dc, pum, dm⟩. Not all of which are applicable in each state.</td></tr>
<tr><td>(0.5pt) Transition model</td><td>The complete problem representation includes the transitions for the 64 states. This following table shows the transitions for two of the states.
Students just need to provide examples or general description that can show the characteristics of the transition model.
<table>
<tr><th>State</th><th>Action</th><th>Resulting State</th></tr>
<tr><td>⟨lab, ¬rhc, swc, ¬mw, rhm⟩</td><td>mc</td><td>⟨mr, ¬rhc, swc, ¬mw, rhm⟩</td></tr>
<tr><td>⟨lab, ¬rhc, swc, ¬mw, rhm⟩</td><td>mcc</td><td>⟨off, ¬rhc, swc, ¬mw, rhm⟩</td></tr>
<tr><td>⟨off, ¬rhc, swc, ¬mw, rhm⟩</td><td>dm</td><td>⟨off, ¬rhc, swc, ¬mw, ¬rhm⟩</td></tr>
<tr><td>⟨off, ¬rhc, swc, ¬mw, rhm⟩</td><td>mcc</td><td>⟨cs, ¬rhc, swc, ¬mw, rhm⟩</td></tr>
<tr><td>⟨off, ¬rhc, swc, ¬mw, rhm⟩</td><td>mc</td><td>⟨lab, ¬rhc, swc, ¬mw, rhm⟩</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table></td></tr>
<tr><td>(0.5pt) Path cost</td><td>Since the problem description does not mention the cost for each move, we can simply assume that each action costs 1.</td></tr>
</table>

Problem 6. (3pts) You are given a graph as shown below.

- The start and goal states are **a** and **z**, respectively.
- Numbers in orange are the heuristic values.
- For each of the following graph search strategies, work out *the order in which states are expanded*, as well as *the path returned*.

In all cases, assume ties resolve in such a way that states with earlier alphabetical order are expanded first.



For each of the following search strategies, work out order in which states are expanded, as well as the path returned. In all cases, assume ties resolve in such a way that states with earlier alphabetical order are expanded first.

a) Tree-search depth-first search (DFS)
b) Breadth-first search (BFS)
c) Uniform cost search (UCS)
d) Iterative deepening search (IDS)
e) Graph-search greedy best first search (GBFS) with the heuristic h shown on the graph
f) Graph-search A* with the same heuristic.

Note that

- A state is expanded at most once in graph search, while it may be expanded more than once in tree search.
- Tree-search DFS avoids repeated states by checking new states against those on the path from the root to the current node.
- For DFS, BFS, and GBFS, the goal test is applied to each node when it is generated rather than when it is selected for expansion

Please write your answer in the table

Algorithms	List of expanded states (in exact order)	Path Returned
DFS	*a b e (z)*	*a b e z*
BFS	*a b c e*	*a b e z*
UCS	*a c b f d e* ***z***	*a c d e z*
IDS	Level 0: *a* Level 1: *a b c* Level 2: *a b e f c d e* Level 3: *a b e (z)*	*a b e z*
GBFS	*a c e (z)*	*a c e z*
A*	*a c b d e* ***z***	*a c d e z*

Nodes in parentheses are optional. Nodes in bold must be present.