UNIVERSITY OF WEST LONDON
The Career University

RAK Branch Campus

Artificial Intelligence

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Mid-term Assignment

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Course: BSc. (Hons.) Computer Science

Question 1

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Or

https://uwloffice365live-my.sharepoint.com/:v:/g/personal/21587065_student_uwl_ac_uk/Ecz_o9iU0FtNp5e9gNmD9GsBy9KusvZmDfNGrGVgPrDn0g?nav=eyJyZWZlcnJhbEluZm8iOnsicmVmZXJyYWxBcHAiOiJPbmVEcml2ZUZvckJ1c2luZXNzIiwicmVmZXJyYWxBcHBQbGF0Zm9ybSI6IldlYiIsInJlZmVycmFsTW9kZSI6InZpZXciLCJyZWZlcnJhbFZpZXciOiJNeUZpbGVzTGlua0NvcHkifX0&e=DVlMVn

Question 2

You will be answering parts (a) to (c) for a “smart home assistant” like Google Home or Amazon’s Alexa. These agents listen for keywords (e.g. “Okay, Google”), and when addressed, respond to questions and perform tasks (e.g. adding an item to a list).

(a) Develop a description of the agent using the PEAS analysis, i.e.

- Performance
- Environment
- Actuators
- Sensors

(b)Describe the environment according to the following properties, i.e.,

- Fully versus partially observable
- Deterministic versus stochastic
- Episodic versus sequential
- Static versus dynamic
- Discrete versus continuous
- Single versus multi-agent

(c) Suggest the most appropriate agent design by choosing the most appropriate of the following types:

- Simple reflex agent
- Model-based agent
- Goal-based agent
- Utility-based agent
- Learning agent

Justify your answer with explanation

Answer:

Smart Home Assistants or SHAs for short is a software that enables the creation of a unified control system for an extensive array of smart home devices (such as Smart TVs, Smart Lights, Smart Speakers etc.), emphasizing local control and prioritizing user privacy.

Popular SHAs trending in market at the moment are:

- Amazon Echo (4th Gen)
- Google Nest Audio
- Apple HomePod (2nd Gen)

A) To understand **PEAS** analysis, we are considering an example of a popular and one of the best optimized SHA in the market, Amazon Echo. The keyword used to address or wake Echo is **'Alexa'**. Now let's begin the Analysis:

Performance *(What is expected of a well-designed and highly efficient SHA? Or the goal that the system aims to achieve and the metrics by which its performance is assessed*)

- Reliable, accurate and quick responses
- Successful connection with all smart home devices
- Completing assigned tasks successfully
- Adaptability to user's colloquial language

Environment *(All the things and conditions surrounding the SHA but not a part of the system, the environment can be physical social or a cyberspace)*

- Home/Office (Or any physical space the user has set the SHA)
- Digital Space (Cyberspace) (allows accessibility to the Internet, which allows total connectivity to all web services)
- Smart Home Devices (Smart TVs, Smart Lights etc.)

Actuators *(Devices, hardware or software through which the SHA performs the desired action on the environment)*

- Sound actuator (Text based responses (mimicking actual conversations), Alarms, songs, podcasts etc.)
- Device Controller (On and Off functions of Smart Lights, TV, Smoke Alarms etc.)
- Haptic Actuator (Face recognition or Fingerprint matching etc.)
- Notification Indicator (Notifying user about real time events using Voice Actuator or Displays)

Sensors (devices through which the SHA perceives or observes the environment)

- Audio Sensor (listens to the user's commands using a microphone)
- Visual Sensor (understands the user (face recognition) and the user's surroundings and respond aptly)
- Motion Sensor (detects movements in the field of view such as in a Security Camera and alerts the user)
- Temperature Sensor (measures temperature in the environment such as in a Smoke detector or a temperature detector and inform the user accordingly)

B)

- Fully v/s **partially observable**
  The environment in SHA is Partially Observable as the SHA lacks complete information about the present state of the Home/Office. It observes only a subset (using the devices connected to the SHA), with **some aspects hidden** or uncertain. Such as **activities in the courtyard** or other areas and if the **devices are undiscovered** (or disconnected).

- **Deterministic v/s stochastic**
  The environment in SHA is both Deterministic and Stochastic because sometimes SHA is tasked with ordinary and **routine based commands**, like **setting alarms, opening doors or adjusting lights** accordingly, but there can be instances where the **commands are unpredictable** (from the user) or if any device **suddenly disconnects**.

- Episodic v/s **sequential**
  The environment in SHA is purely Sequential, with the culmination and end result of several devices in perfect harmony. For example, if the **smoke detector detects excessive smoke**, the **alarm turns ON** and the user receives **a notification in his/her phone** about the emergency. This requires a series of steps and **past knowledge** to determine **the next best action** for the situation, hence it is Sequential.

- Static v/s **dynamic**
  The environment in SHA is Dynamic, as no home environment ever remains the same or predictable. There are periodic changes, such as **changes in temperature** (weather), changes in external environment (**rearrangement of objects by user**) or status of the devices. While **the physical structure of the home may be relatively static**, the **activities, user preferences, and device statuses** within it contribute to the dynamic nature of the Smart Home Assistant's operational environment.

- **Discrete v/s continuous**

The environment in SHA is <u>both Discrete and Continuous,</u> the SHA can be tasked with discrete tasks such as **setting alarm** or **closing or opening doors** but also continuous commands (where the actions performed cannot be numbered or determined) such as **adjusting the home temperature** based on the external temperature, **adjusting volume** level and even **adjusting lights** according to level of bright ness needed.

- **Single** v/s multi-agent
  The environment in SHA is <u>single agent</u>, as the **SHA operates by itself** with a set of tasks and responsibilities within the environment. While **there might be multiple smart devices controlled by the smart home assistant**, and these devices could be seen as individual agents in their own right, **the overall system is often treated as a single-agent** entity from the perspective of the user interacting with the assistant.

C) **Goal Based Agent**

The primary function of a SHA is to effectively execute assigned tasks. Goal-based agents, designed to **achieve user-defined objectives**, prioritize and fulfill specific user goals, such as turning lights ON or OFF. Moreover, these agents are adept at **breaking down cascading goals**, like receiving notifications on a phone when a smoke alarm turns on, into a sequence of sub-goals. This approach provides **a clear and structured framework for decision-making** within the environment.

While **a Simple Reflex Agent** responds to specific triggers and **Model-based and Goal-based** agents can be effective, **a Utility-based agent** offers a more comprehensive and adaptive approach. Additionally, **a learning agent** can adapt and enhance its performance over time by learning from interactions. The ultimate **choice among these agent** types depends on the **specific requirements and complexity of the tasks**. In many instances, **<u>a combination of these agent types may be implemented to create a more robust and adaptive system</u>.**

Question 3

A state space graph is shown in Figure 3.1.

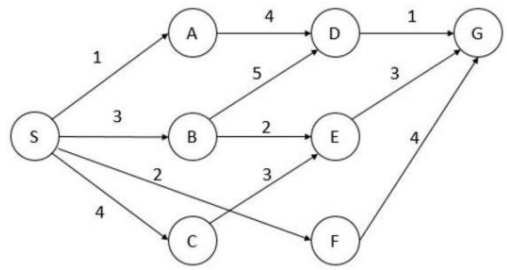


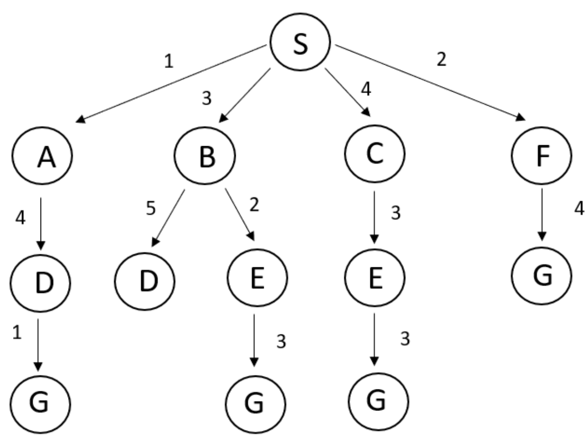
Figure 3.1.

For each of the following AI search strategies, work out the order in which states are expanded, as well as the path returned by graph search. **S: Initial State G: Goal State**

- Depth-first search.
- Breadth-first search.
- Iterative Deepening Search.
- Uniform cost search.

Answer:

The expanded state:

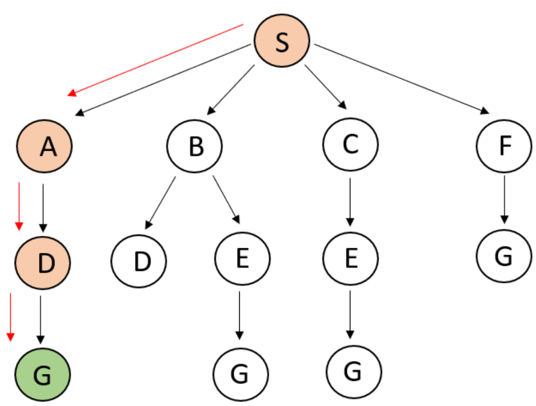


Depth First Search (DFS)

Depth-First Search is an algorithm used to traverse or search through tree or graph data structures. It starts at the root node and explores as far as possible along each branch before backtracking.

Traversal: **S -> A -> D -> G**

Path Returned: **S -> A -> D -> G**

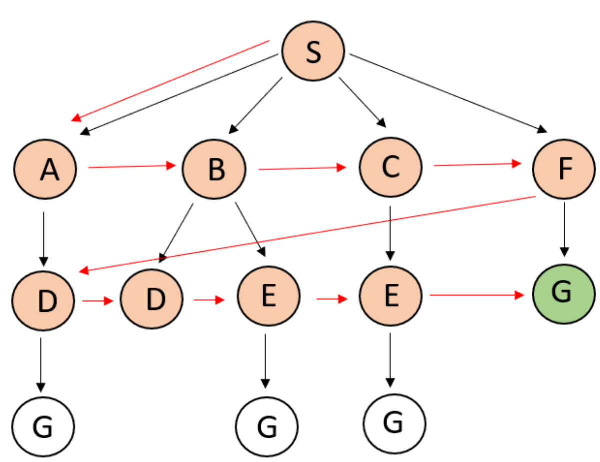


Breadth First Search (BFS)

BFS is also another search algorithm that explores the neighbor nodes at the present depth before moving on to nodes at the next level of depth.

Traversal: **S -> A -> B -> C -> F -> D -> E -> G**

Path Returned: **S -> F -> G**

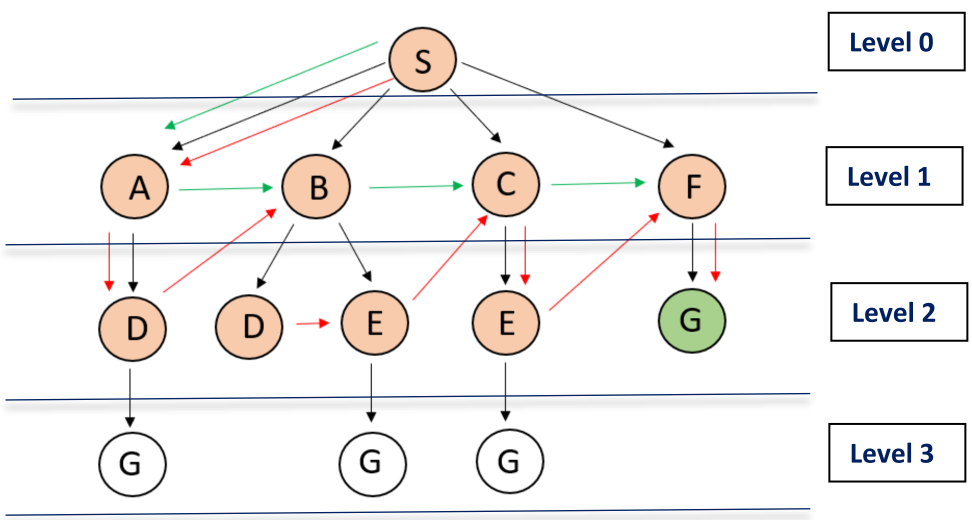


Iterative Deepening Search (IDS)

Iterative Deepening Search (IDS) is a hybrid algorithm that combines the benefits of both Breadth-First Search (BFS) and Depth-First Search (DFS). The main idea behind Iterative Deepening Search is to perform a series of depth-limited searches with increasing depth limits until the goal is found.

Traversal: **S -> A -> D -> B -> E -> C -> F -> G**

Path Returned: **S -> F -> G**



Traversal Route

Level 0 **= S**

Level 1 **= S -> A -> B -> C -> F**

Level 2 **= S -> A -> D -> B -> E -> C -> F -> G**

Uniform Cost Search (UCS)

Uniform Cost Search (UCS) is an algorithm used for traversing or searching tree or graph structures, particularly in the context of finding the path with the minimum cost in weighted graphs.

Traversal: **S -> A -> F -> B -> C -> D -> E -> G**

Path Returned: **S -> F -> G**

Total Cost = 6 (4+2)

S0 = A1, F2, B3, C4

A1 = F2, B3, C4, D5

F2 = B3, C4, D5, G6

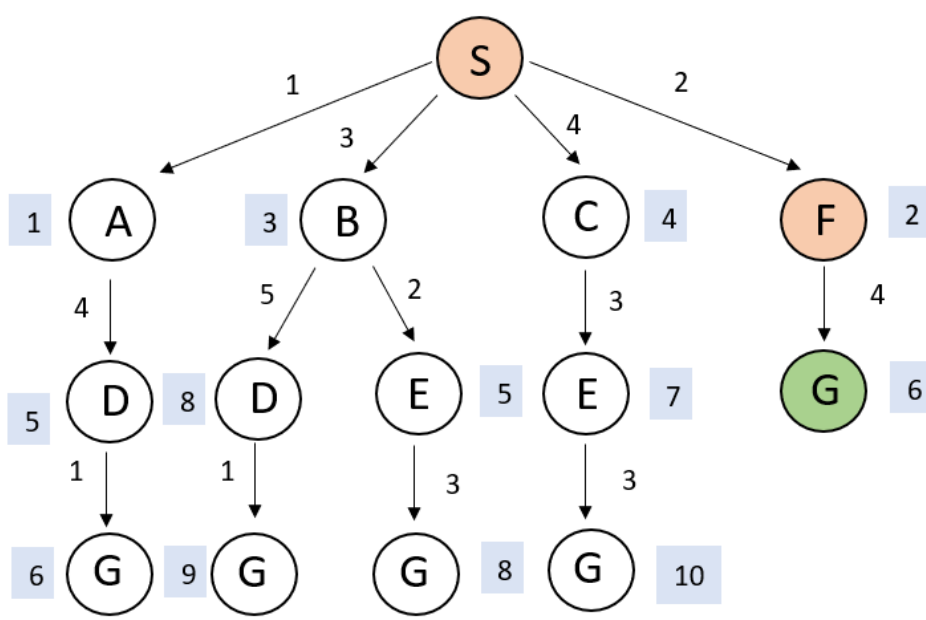
B3 = C4, D5, E5, G6, D8

C4 = D5, E5, G6, E7, D8

D5 = E5, G6, E7, D8

E5 = G6, E7, D8, G8

G8 = E7, D8, G8



Question 4

Consider the following joint probability distribution of X and Y shown in Table 4.1.

Table 4.1.

X \ Y	0	1	2
0	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{12}$
1	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{12}$
2	$\frac{1}{6}$	$\frac{1}{12}$	0
3	$\frac{1}{12}$	0	0

Find:

- P (X=1, Y=2)
- P (X=0, 1 ≤ Y < 3)
- Find the marginal probability function for X and Y
- Give the conditional probability function for X given Y=1
- Are X and Y independent?

What is the probability of any of the following events? Please provide details of your calculations, if required.

P(X,Y)		
X	Y	P
True	True	0.2
True	False	0.3
False	True	0.4
False	False	0.1

- P (X=true | Y=true)
- P (X=false | Y=true)
- P (Y=false | X=true)

Answer:

a) **P (X=1, Y=2) = 1/12**

The probability (P) is the intersection of the row corresponding to X = 1 and the column corresponding to Y = 2 in the table.

b) **P (X=0, 1 ≤ Y < 3) = 3/12 = 1/4 = 0.25**

The probability (P) is the intersection of the row corresponding to X = 0 and the column corresponding to Y, more than or equal to 1 but less than 3 i.e. Y = 1,2.

P (X=0, Y=1) + P (X=0, Y=2) = 1/12 + 1/6 = 3/12 = 1/4 = **0.25**

c) Marginal Probability Function for X and Y

P (X=0) = 1/12 + 1/6 + 1/12 = **1/3**

P (X=1) = 1/12 + 1/6 + 1/12 = **1/3**

P (X=2) = 1/6 + 1/12 + 0 = **1/4**

P (X=3) = 1/12 + 0 + 0 = **1/12**

P (Y=0) = 1/12 + 1/12 + 1/6 + 1/12 = **5/12**

P (Y=1) = 1/6 + 1/6 + 1/12 + 0 = **5/12**

P (Y=2) = 1/12 + 1/12 + 0 + 0 = **1/6**

d) Conditional Probability = $P(A|B) = \frac{P(A \cap B)}{P(B)}$ = **2/5, 1/5, 0**

Conditional probability for X given Y = 1 means it's

$$\mathbf{P(X=0|Y=1)} = \frac{P(X=0, Y=1)}{P(Y=1)} = \frac{1/6}{5/12} = \frac{1 * 12}{6 * 5} = \mathbf{2/5}$$

$$\mathbf{P(X=1|Y=1)} = \frac{P(X=1, Y=1)}{P(Y=1)} = \frac{1/6}{5/12} = \frac{1 * 12}{6 * 5} = \mathbf{2/5}$$

$$\mathbf{P(X=2|Y=1)} = \frac{P(X=2, Y=1)}{P(Y=1)} = \frac{1/12}{5/12} = \frac{12 * 1}{12 * 5} = \mathbf{1/5}$$

$$\mathbf{P(X=3|Y=1)} = \frac{P(X=3, Y=1)}{P(Y=1)} = \frac{0}{5/12} = \frac{0}{5/12} = \mathbf{0}$$

e) X and Y are **NOT Independent,** the formula to check if X and Y are independent is:

P (X, Y) ≠ P (X) * P (Y)

As, 5/12 * 1/3 ≠ 1/12

We can say that X and Y are not independent

X \ Y	0	1	2	
0	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{12}$	1/3
1	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{12}$	1/3
2	$\frac{1}{6}$	$\frac{1}{12}$	0	1/4
3	$\frac{1}{12}$	0	0	1/12
	5/12	5/12	1/6	

f) i) P (X=true | Y=true) = 0.9

X	Y	P
T	T	0.2
T	F	0.3
F	T	0.4
F	F	0.1

P (X = true) = 0.2 + 0.3

= 0.5

P (Y = true) = 0.4 (as 0.2 is already taken in X)

P (X=true | Y=true) = 0.5 + 0.4

= **0.9**

ii) P (X=false | Y=true) = 0.7

X	Y	P
T	T	0.2
T	F	0.3
F	T	0.4
F	F	0.1

P (X = false) = 0.4 + 0.1

= 0.5

P (Y = true) = 0.2 (as 0.4 is already taken in X)

P (X=false | Y=true) = 0.5 + 0.2

= **0.7**

iii) P (Y=false | X=true) = 0.6

X	Y	P
T	T	0.2
T	F	0.3
F	T	0.4
F	F	0.1

P (Y = false) = 0.3 + 0.1

= 0.4

P (X = true) = 0.2 (as 0.3 is already taken in Y)

P (Y=false | X=true) = 0.4 + 0.2

= **0.6**

Thank You