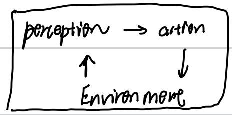
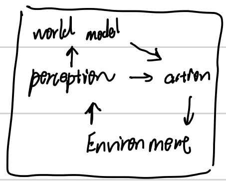
Agent:

① Reactive Agent. (simple if ... else policy)

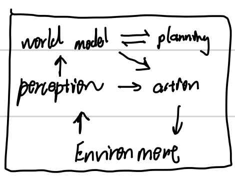


② Model-Based Agent (like: self-driving car)

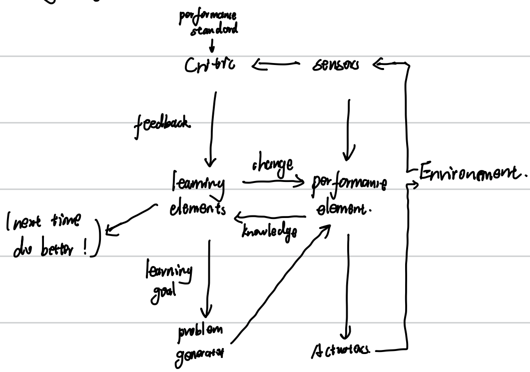


world model like the memory, it can update what they perceives. (past)

③ planning Agent (consideration of the future, 'think' about what it's doing.



④ learning Agent



	Search Algorithms Covered at this Lecture
Uninformed Search	**Breath First Search (BFS)**
	Depth First Search (DFS)
	Iterative Deepening Search (IDDFS) depent on the give 'depth'. very similiar to the BFS. but less complexity
	Uniform Cost Search (UCS) find minimum cost (have and only have one!)
Informed Searches	Greedy Best-First Search Always select node closest to goal! [h(n) is estimated cost from n to the goal] select the shortest node near the goal first!
	A* Search

Machine learning (subfileds of AI Algorithms)

three types : supervised learning

unsupervised learning

reinforcement learning

① supernised learning :
- Regression (one output, real value)
- Binary classification (two discrete classes [positive / negative])
- Multiclass classification (discrete classes , >2 possible values)

[real world input] [Model input] [Model] [Model output] [real world output]

method: decision tree
- Entropy $H(\langle p_1 \cdots p_n \rangle) = \sum_{i=1}^{n} -p_i \log_2 p_i$
- Minimal error Pruning : $E = 1 - \frac{n+1}{N+k}$

number in majority class (n)

number of class (k)

total items (N)

② unsupervised learning

learn about a dataset without labels

clustering : Grouping similar data point together

Ensemble learning:

Bagging: relay on bootstrapping to create multiple training datasets

final prediction using the majority vote rule or average

Random forest:

difference: decision tree Random forest select a random subsets of features

neural network

mathematical formula: $Z = g(s) = \underbrace{W_0}_{\text{bias (constant)}} + \sum_i \overbrace{W_i}^{\text{weight}} \underbrace{X_i}_{\text{input}}$ (transfer function)

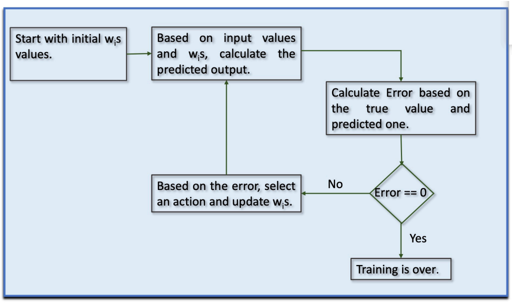
perceptron: neuron with step transfer function (like 0, 1)

and ($W_0 = -1.5$, $W_1 = 1$, $W_2 = 1$)

or ($W_0 = -0.5$, $W_1 = 1$, $W_2 = 1$)

learning:

error function: $E = \frac{1}{2}\sum_i (\underbrace{Z_i}_{\text{actual output}} - \underbrace{t_i}_{\text{targer output}})^2$



Artificial Neural Network Training Diagram

if $Z(s) = \frac{1}{1+e^{-s}}$, $Z'(s) = Z(1-Z)$

$Z(s) = \tanh(s)$, $Z'(s) = 1 - Z^2$

step: Forward pass: list all the formulas

Calculate the error: $E = \frac{1}{2}\sum_i (Z_i - t_i)^2$

Backward pass: adjust weight use derivative

Ass 1. Neural network.

input: 3 input, nino-t, nino-t-1, nino-t-2.

output: for task A, nino-tplus 1-6. 1 output

task B. nino-tplus 1-6 6 output

Ass 1.

loss function : error function. measure how far the model's predict are from the actual target value

MSE : penalises large errors more strongly, use in regression. problem

Optimisers : based on the gradient of the ls fun. update weights

Adam : fast convergence

Model : ElU activations : small gradients and stable

linear : regression. model

Dropout : prevent overfitting

Result : long-term forecasts have larger error

The model fits the short-term trend well

Model B performs worse than A due to gradient interference. in the shared layers

Model limitation : data size is small, Batch Normalization.

adaptive learning rate scheduling

standard Scaler : Fix output of similar scale to avoid large/small columns domain the gradient.

Artificial Intelligence

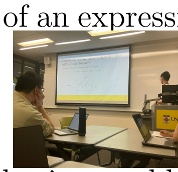
Exercises week 3 - ANN

COMP3411/9814

Question 1: Computing any Logical Function with a 2-layer Network

Recall that any logical function can be converted to Conjunctive Normal Form (CNF), which means a conjunction of terms where each term is a disjunction of (possibly negated) literals. This is an example of an expression in CNF:

$$\underbrace{(\overset{1}{A} \vee \overset{1}{B})} \wedge \underbrace{(\overset{-1}{\neg B} \vee \overset{1}{C} \vee \overset{-1}{\neg D})} \wedge \underbrace{(\overset{1}{D} \vee \overset{-1}{\neg E})}$$



Assuming False=0 and True=1, explain how each of the following could be constructed. You should include the bias for each node, as well as the values of all the weights (input-to-output or input-to-hidden and hidden-to-output, as appropriate).

- Perceptron to compute the OR function of m inputs,
- Perceptron to compute the AND function of n inputs,
- Two-layer Neural Network to compute the function

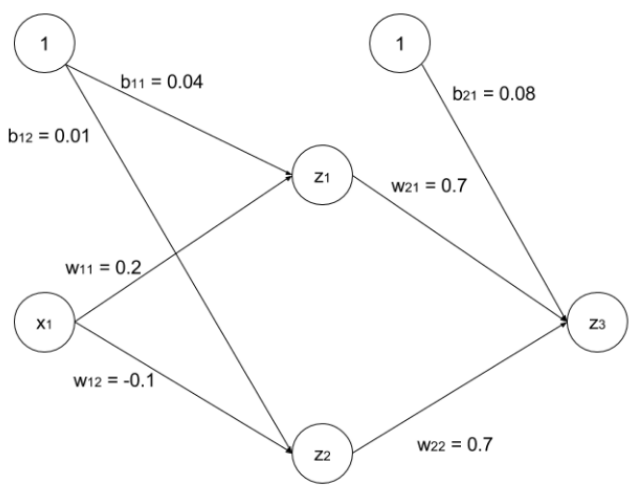
$$(A \vee B) \wedge (\neg B \vee C \vee \neg D) \wedge (D \vee \neg E)$$

With reference to this example, explain how a two-layer neural network could be constructed to compute any (given) logical expression, assuming it is written in Conjunctive Normal Form.

Hint: first consider how to construct a Perceptron to compute the OR function of m inputs, with k of the m inputs negated.

Question 2: Backpropagation

Consider the neural network architecture shown below for a binary classification problem. The values for weights and biases are shown in the figure. We define:
$a_1 = w_{11}x_1 + b_{11}$
$a_2 = w_{12}x_1 + b_{12}$
$a_3 = w_{21}z_1 + w_{22}z_2 + b_{21}$
$z_1 = ReLU(a_1), ReLU(x) = max(0, x)$
$z_2 = ReLU(a_2)$
$z_3 = \sigma(a_3), \sigma(x) = \frac{1}{1+e^{-x}}$
$Loss = \frac{1}{2}(y - z_3)^2$
Calculate the new bias b_{11} after one iteration, after performing backpropagation on the bias for a data sample $(x_1 = 1, y = 1)$ and learning rate equals to 1.



Question 3: Neural design

- What would be the MLP architecture to approximate a non-linear function of 3 inputs and 2 outputs if you have available 3,000 samples? Consider 70% data for training and 30% for validation.

- What would be the MLP architecture to approximate a non-linear function of 6 inputs and 3 outputs if you have available 100 samples? Consider 80% data for training and 20% for validation.

Artificial Intelligence

Exercises week 4 - Reinforcement learning

COMP3411/9814

Question 1: Value functions

Consider a world with two states $S = \{S_1, S_2\}$ and two actions $A = \{a_1, a_2\}$, where the transitions δ and reward r for each state and action are as follows:

$$\begin{array}{ll} \delta(S_1, a_1) = S_1 & r(S_1, a_1) = 0 \\ \delta(S_1, a_2) = S_2 & r(S_1, a_2) = -1 \\ \delta(S_2, a_1) = S_2 & r(S_2, a_1) = +1 \\ \delta(S_2, a_2) = S_1 & r(S_2, a_2) = +5 \end{array}$$

i. Draw a picture of this world, using circles for the states and arrows forthe transitions.

ii. Assuming a discount factor of $\gamma = 0.9$, determine: $Q(s,a) = r(s,a) + \gamma V^*(s')$

   (a) the optimal policy $\pi^* : S \to A$

   (b) the state-value function $V^* : S \to R$

   (c) the action-value function $Q^* : S \times A \to R$

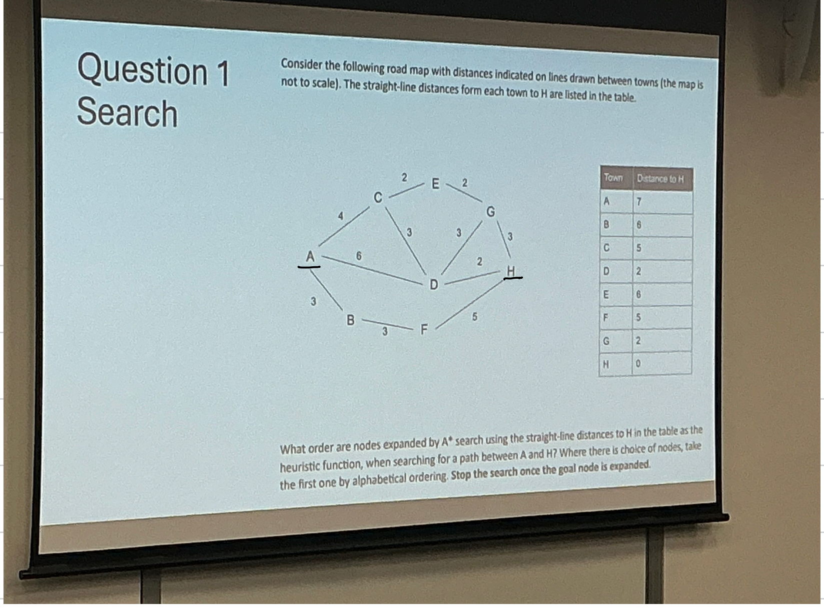
iii. Write the Q-values in a table (a.k.a. Q-table) as follows:

Q	a_1	a_2
S_1		
S_2		

Computer Vision:

image processing:

- histogram equalization: redistribute the gray-level values uniformly
- noise removal: averaging
- edge detion: convolution



A → H.

G(8).

A(0). B(3) C(4) D(6) F(6) E(6) H(8).

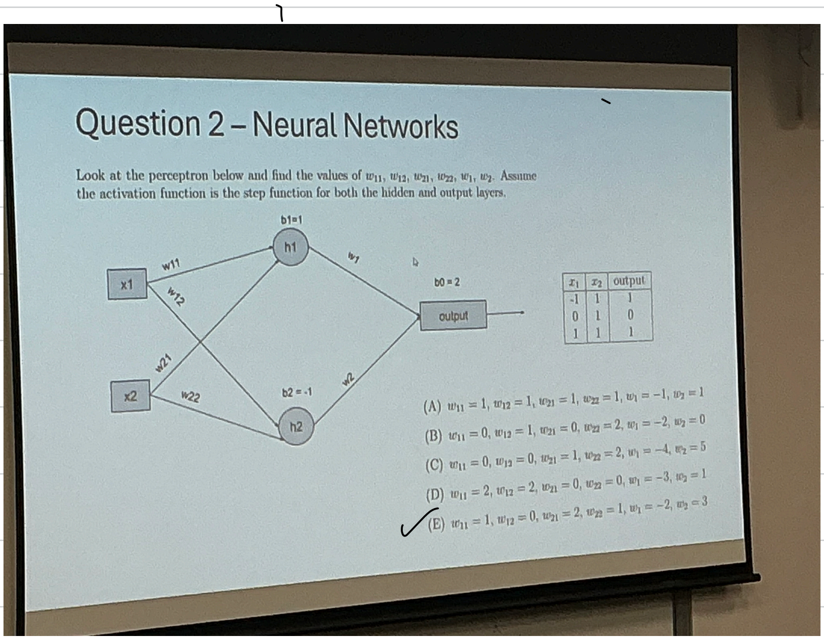
A(7) D(2) H(0).

A(7). D(8) H(8).

A(7) C(9) ~~D(8)~~ B(9) H(8)

D(8)

H(8)



$h_1 = \text{step}(W_{11}X_1 + W_{21}X_2 + 1)$

$h_2 = \text{step}(W_{12}X_1 + W_{22}X_2 - 1)$.

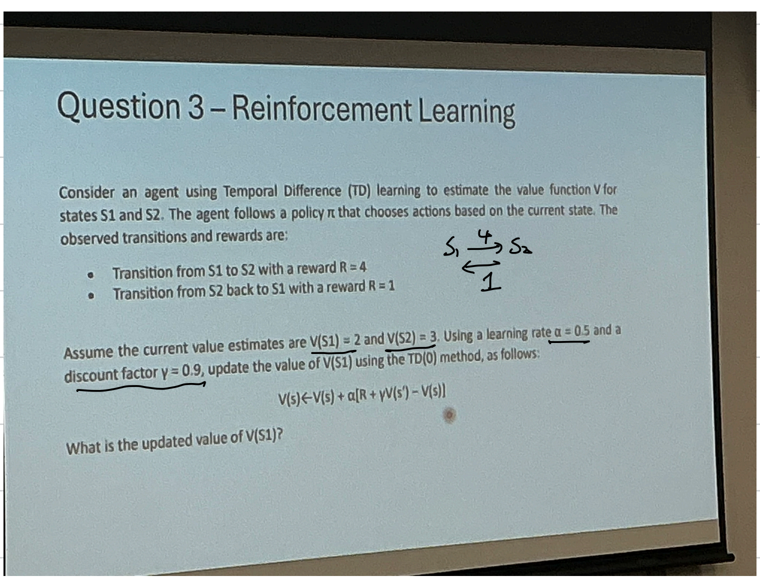
$\text{output} = \text{step}(W_1 h_1 + W_2 h_2 + 2)$.

A. $h_1 = (X_1 + X_2 + 1)$ $h_2 = (X_1 + X_2 - 1)$ $o = -h_1 + h_2 + 2)$

B. $h_1 = (1)$ $h_2: (X_1 + 2X_2 - 1)$ $O = -2h_1 + 2$.

C. $h_1 = (X_2 + 1)$ $h_2 = (2X_2 - 1)$ $O = (-4h_1 + 5h_2 + 2)$

D. $h_1 = s(2X_1 + 1)$ $h_2 = s(2X_1 - 1)$ $O = (-3h_1 + h_2 + 2)$



$V(S_1) = V(S_1) + \alpha[R + \gamma V(S') - V(S)]$

$= 2 + 0.5[4 + 0.9 \cdot 3 - 2]$

$= 2 + 0.5[4.7]$

$= 2 + 2.35 = 4.35$

Question 4 – Optimisation

Consider two chromosomes in a genetic algorithm where symbol '|' marks the crossover point. The fitness function is defined as the number of '1' in a chromosome.

Chromosome 1: 1100 | 1010

Chromosome 2: 1010 | 1011

What are the fitness values of original chromosomes? 4, 5

What would be the two offspring or children after the crossover? 11001011 10101010

What are the fitness scores of both offspring? 5, 4

Perform bit flip mutations at positions 2 and 5 on both offspring with 0 based index from left to right. What are the new offspring?

An offspring is considered fit if its fitness score > 5. How many of the offspring after mutation are fit?

11101111 ✓

10001110 ✗

(A) Original fitness values - 5, 4 ✗
offsprings after crossover - 11001011, 10101010
fitness score after crossover - 5, 4
mutated offspring - 11101111, 10001110
number of fit offspring - 1

(B) Original fitness values - 4, 5
offsprings after crossover - 11011011, 11110101 ✗
fitness score after crossover - 6, 6
mutated offspring - 11111111, 11010011
number of fit offspring - 2

(C) Original fitness values - 4, 5
offsprings after crossover - 11001011, 10101010
fitness score after crossover - 5, 4
mutated offspring - 11101111, 10001110
number of fit offspring - 1

(D) Original fitness values - 4, 5
offsprings after crossover - 11001011, 10101010
fitness score after crossover - 5, 4
mutated offspring - 11101111, 10001110
number of fit offspring - 2 ✗

(E) Original fitness values - 5, 5 ✗
offsprings after crossover - 11001011, 10101010
fitness score after crossover - 5, 4
mutated offspring - 11001011, 10101010
number of fit offspring - 0

Question 5 – Computer Vision

Consider the binary image with dimension 8x7 shown below. The image can be represented in a 2-dimensional array using 1's and 0's as shown in the table below. Using the averaging method (creating a new image) with a threshold ε = 2 and a 3x3 sliding window, what would be the resulting image?

greater

0	0	0	0	0	0	0
0	1	1	1	0	0	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	1	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	0	0	0	0	0	0

Question 6 – Knowledge & Uncertainty

A newly constructed bridge may fall down either due to wrong designing or by inferior material used in construction. The chance that the design is faulty is 10% and the probability of its collapse if the design is faulty is 95% and that due to bad material it is 45%. If the bridge collapses. Find the chance that it was due to wrong designing.

Hint: use Bayes Rule

fall down { wrong designing / inferior material.

(A) 0.19 ✓

(B) 0.39

(C) 0.15

(D) 0.26

(E) 0.38

$P(A) = 0.1$

$P(B/A) = 95\%$

$P(B/A^{\sim}) = 45\%$

$P(A/B) = \dfrac{0.95 \cdot 0.1}{0.95 \cdot 0.1 + 0.45 \cdot 0.9}$

A → Design is faulty

B → Collapse due to faulty design

$A^{\sim}$ → Bad material

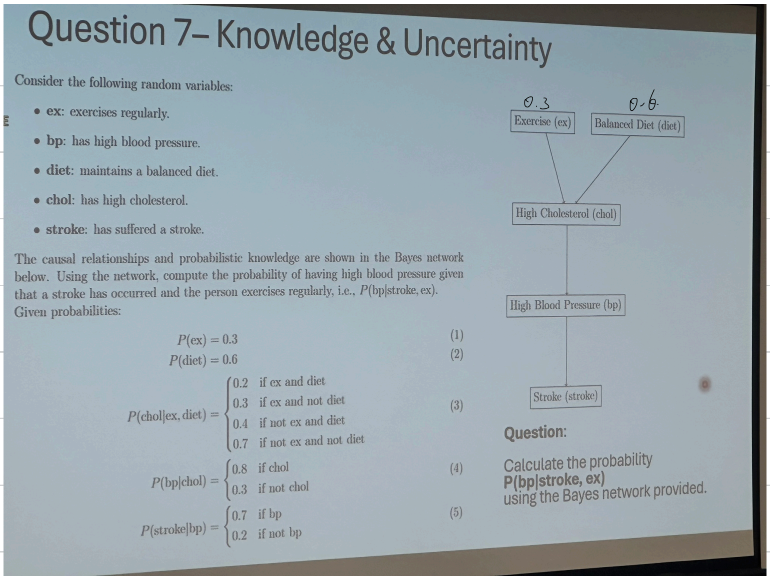
$P(B/A) \Rightarrow 0.95$

$P(A) \Rightarrow 0.1$

$P(B/A^{\sim}) = 0.45$

$\boxed{P(A^{\sim}) = 0.9}$

$\dfrac{0.95 \times 0.1}{0.95 \times 0.1 + 0.45 \times 0.9} = \boxed{0.19}$



$P(bp \mid stroke, ex) = \dfrac{P(bp, st, ex)}{p(st, ex)}.$

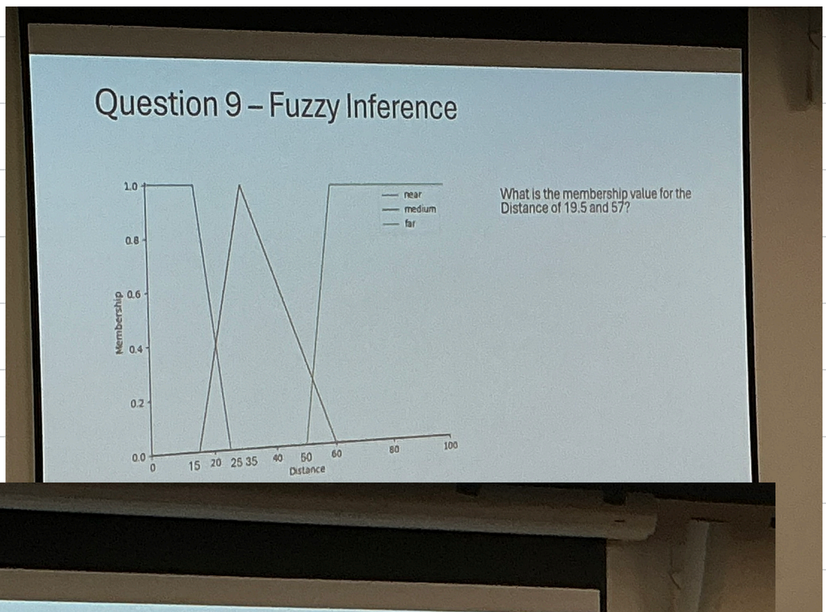
$= p(ex)\, p(diet).\, p(chol \mid ex, diet))$
$p(bp \mid chol).\, p(st \mid bp).$

$= p(ex) \cdot p(st \mid bp).\ p(bp \mid ex)$

$p(st, ex) \to p(st, bp, ex) + p(st, \neg bp, ex)$

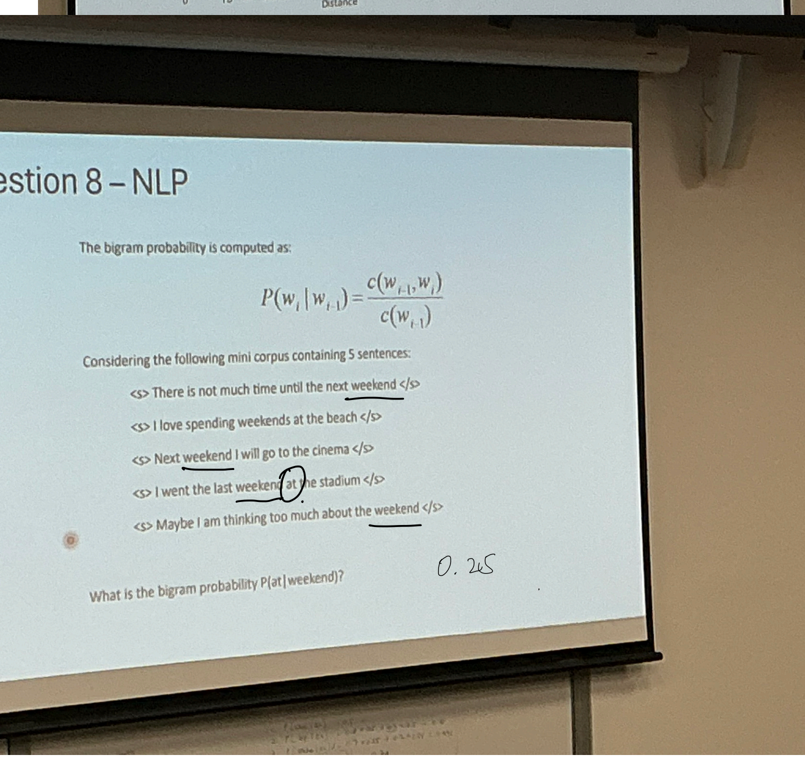
$p(ex) \cdot p(st \mid bp) \cdot p(bp \mid ex)$

$\to p(ex) \cdot p(st \mid bp) \cdot p(bp \mid ex) + p(ex) \cdot p(st \mid \neg bp) \cdot p(\neg bp \mid ex)$



near : 0–15 1 15–25 ↓.
medium 15–35 ↑ 35 → 60 ↓
far 50–60 ↑ 60 – ... 1.

near. $\dfrac{5.5}{10} = \dfrac{x}{1} \Rightarrow x = 0.55$



$p = \dfrac{\text{count}(\text{weekend}, \text{at})}{\text{count}(\text{weekend})}$

$= \dfrac{1}{4}.$

$= 0.25.$

Question 2

TOPIC: Uncertain reasoning – Bayes nets [6 marks]

Suppose a certain medical test for a disease is known to have a false positive rate of 5% and a false negative rate of 10%. The prevalence of the disease in the population is 1%. If a person tests positive, what is the probability P1 that they actually have the disease? If the false negative rate increases to 15%, recalculate the probability P2 that a person actually has the disease given a positive test result. If the false positive rate decreases to 1%, while keeping the true positive rate at 90%, what is the new probability P3 that a person has the disease given a positive test result?

positive. | no disease

a. P1 = 0.1421, P2 = 0.1311, P3 = 0.452
b. P1 = 0.1235, P2 = 0.1121, P3 = 0.386
c. P1 = 0.1538, P2 = 0.1466, P3 = 0.476
d. P1 = 0.1692, P2 = 0.1532, P3 = 0.491
e. P1 = 0.1312, P2 = 0.1022, P3 = 0.397

TOPIC: Reinforcement learning – Action selection [4 marks]

Consider two reinforcement learning agents using the ε-greedy action selection method with the following features:

- The first agent has an initial ε = 0.5. Then, it follows a strategy where epsilon decreases by 0.1 after, every 100 epochs.
- The second agent has ε = 0.6 which remains fixed during the learning process.
- Both agents draw a random number using a uniform distribution.

Considering the times each agent will perform exploration during the first 500 episodes, what is the difference between the number of times agent 2 explores and the number of times agent 1 explores?

agent 1 $(0.5 \times 100) + (0.4 \times 100) + (0.3 \times 100) + (0.2 \times 100) + (0.1 \times 100) = 150.$

a. 100
b. 150
c. 590

agent 2. $0.6 \times 500 = 300$

Question 4

TOPIC: Neural Networks – Forward propagation [6 marks]

Given the following neural network architecture and weights, what is the approximate output of the network for the input $x = [1, 0, 1]$?

Architecture:

- Input Layer: 3 neurons
- Hidden Layer: 2 neurons with ReLU activation function
- Output Layer: 1 neuron with *sigmoid* activation function

1 0 1

0.1 Relu (0.4) 0.2 Relu (0.9)

0.5 sigmoid.

Weights:

- Input to Hidden Layer weights:

$$W_i = \begin{pmatrix} 0.2 & 0.4 \\ 0.6 & 0.5 \\ 0.1 & 0.3 \end{pmatrix}$$

$0.2 + 0 + 0.1 + 0.1 = 0.4$ ✓

$0.4 + 0 + 0.3 + 0.2 = 0.9.$ ✓

$0.4 \times 0.7 + 0.9 \times 0.9 + 0.5 = 1.59$

$0.28 \quad 0.81$

- Hidden Layer biases: $b_i = [0.1, 0.2]$
- Hidden to Output Layer weights: $W_o = [0.7, 0.9]$
- Output Layer bias: $b_o = 0.5$

$$\sigma(x) = \frac{1}{1 + e^{-1.59}} = 0.83$$

0.2039

Note: 0.83

- *ReLU* activation function: $ReLU(x) = max(0, x)$
- *Sigmoid* activation function: $\sigma(x) = \frac{1}{1+e^{-x}}$

6 of 7 | Automatic Zoom

Question 9

7 Question T4_q0001 (Reinforcement Learning)

Suppose the discount factor $\gamma = 0.5$, and the following reward sequence is observed over 5 time steps:

- $R_1 = -1$
- $R_2 = 2$
- $R_3 = 6$
- $R_4 = 3$
- $R_5 = 2$
- Episode ends at time $T = 5$

$G_t = R_{t+1} + \gamma R_{t+2} + \gamma^2 R_{t+3} + \cdots$

$G_5 = R_6 + \cdots = 0.$

$G_4 = R_5 + \cdots = 2.$

$G_3 = R_4 + 0.5 R_5 = 4$

⋮

Using the formula for return: $G_t = R_{t+1} + \gamma G_{t+1}$
What are the returns G_0, G_1, G_2, G_3, G_4?

✓ (A) $G_5 = 0$, $G_4 = 2$, $G_3 = 4$, $G_2 = 8$, $G_1 = 6$, $G_0 = 2$

(B) $G_5 = 0$, $G_4 = 3$, $G_3 = 5$, $G_2 = 7$, $G_1 = 9$, $G_0 = 1$

(C) $G_5 = 0$, $G_4 = 2$, $G_3 = 3$, $G_2 = 5$, $G_1 = 6$, $G_0 = 3$

(D) $G_5 = 2$, $G_4 = 3$, $G_3 = 6$, $G_2 = 8$, $G_1 = 9$, $G_0 = 2$

(E) $G_5 = 0$, $G_4 = 2$, $G_3 = 3$, $G_2 = 4$, $G_1 = 5$, $G_0 = 6$

TOPIC: Reinforcement learning – TD prediction [4 marks]

Consider an agent using Temporal Difference (TD) learning to estimate the value function V for states S1 and S2. The agent follows a policy π that chooses actions based on the current state. The observed transitions and rewards are:

- Transition from S1 to S2 with a reward R = 4
- Transition from S2 back to S1 with a reward R = 1

$1 \xrightarrow{4} 2$

$2 \xrightarrow{1} 1$

Assume the current value estimates are V(S1) = 2 and V(S2) = 3. Using a learning rate α = 0.5 and a discount factor γ = 0.9, update the value of V(S1) using the TD(0) method, as follows:

V(s)←V(s) + α[R + γV(s') − V(s)]

What is the updated value of V(S1)?

$V(S_1) = 2 + 0.5\,[4 + 0.9 \cdot 3 - 2]$

$= 2 + \frac{1}{2}[4.7]$

$= 2 + 2.35$

$= 4.35$

a. 2.95

b. 3.45

c. 4.35

d. 3.50

e. 4.50

TOPIC: Reinforcement learning – Question: Softmax [4 marks]

Consider an RL agent navigating a gridworld, with four possible action: up (U), down (D), left (L), and right (R). The agent uses the softmax action selection method. Remember this method computes the probability of selecting an action using a Boltzmann distribution, as follows:

$$P(s_t, a) = \frac{e^{Q(s_t,a)/T}}{\sum_{a_i \in A} e^{Q(s_t,a_i)/T}}$$

In a particular given state S_t, the agent has the following Q-values to decide what action to take next:

Q(U)	Q(D)	Q(L)	Q(R)
0.7698	0.6501	0.0252	-0.7698

What would be the action selected by the agent if the temperature T used is 0.9 and the random number drawn is 0.9021.

$e^{Q(U)}/T \approx 2.35$

$\sum_{a_i \in A} e^{Q/T} = 5.864$

Answer:

a. Up
b. Down
✓ c. Left
d. Right
e. The agent would stay at the same position

9 Question T8_q0012 (Context-Free Grammar)

Look at the grammar rules below. (Note that ε means empty or no character)

$$S \to PPQA$$
$$A \to aBe \mid AA$$
$$P \to eefa \mid f \mid c$$
$$Q \to cgb \mid \epsilon$$
$$B \to f \mid \epsilon$$

Which of the following strings can be generated using the above rules?

1. eefaeefacgbafeafe ✓
2. ceefaafe ✓
   P P Q A
3. cccgbaeafe ✓
   P P Q A A A.
4. eefaccgb
   P P Q
5. ffafeafe
6. eefaccgbabeae

(A) String 1, string 2, string 3, string 4, string 5

✓ (B) String 1, string 2, string 3, string 5

(C) String 1, string 2, string 6

(D) String 1, string 2, string 3, string 4, string 5, string 6

(E) String 2, string 3, string 4, string 5

Question 8

3 Question T2_q0012 (Rule-based Systems)

What is a key characteristic of rule-based systems?

(A) They are always probabilistic in nature.

✓ (B) They operate using "if-then" statements to derive conclusions.

(C) They rely heavily on neural networks for reasoning.

(D) They cannot handle incomplete information.

(E) They require continuous retraining with large datasets to function properly.

Question 9

Question 7

Based on the following table, what will be the first feature evaluated in the decision tree structure if we use entropy as our criterion?

(a) Outlook
(b) Temperature
(c) Humidity
(d) Wind
(e) All features have equal entropy

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

NO : 5 Yes : 9.

$-\frac{5}{14}\log_2\frac{5}{14} - \frac{9}{14}\log_2\frac{9}{14}$

-0.357 0.643 0.64

0.53 + 0.41

0.94

1 Question T1_q0006 (Agents)

Which of the following tasks would be MOST challenging for a reactive agent?

(A) Escaping a simple maze with no loops.

(B) Playing chess.

(C) Cooking a multi-step recipe.

(D) Obstacle avoidance in a clean, simple environment.

(E) Following a pre-programmed patrol route.

2 Question T1_q0008 (Search)

Suppose you run Uniform Cost Search (UCS). When does UCS behave exactly like Breadth-First Search?

(A) When the cost of each action is proportional to its depth.

(B) When the search space is infinite.

(C) When the heuristic is zero everywhere.

(D) When all actions have the same cost.

(E) When the goal state is at the shallowest depth.

3 Question T2_q0012 (Rule-based Systems) What is a key characteristic of rule-based systems?

(A) They are always probabilistic in nature.

(B) They operate using "if-then" statements to derive conclusions.

(C) They rely heavily on neural networks for reasoning.

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4 Question T5_q0012 (Genetic Algorithm Crossover and Mutation)

Consider two chromosomes in a genetic algorithm where symbol '/' marks the crossover point. The fitness function is defined as the number of '1' in a chromosome.

Chromosome 1: 1100 /1010 4

Chromosome 2: 1010 /1011 What are the fitness values of original chromosomes?

5

> What would be the two offspring or children after the crossover?
>
> What are the fitness scores of both offspring?

Perform bit flip mutations at positions 2 and 5 on both offspring with 0 based index from left to right. What are the new offspring?

An offspring is considered fit if its fitness score > 5. How many of the offspring after mutation are fit?

(A) Original fitness values - 5, 4
offsprings after crossover - 11001011, 10101010 fitness score after crossover - 5, 4
mutated offspring - 11101111, 10001110
number of fit offspring - 1

(B) Original fitness values - 4, 5
offsprings after crossover - 11011011, 11110101 fitness score after crossover - 6, 6
mutated offspring - 11111111, 11010011
number of fit offspring - 2

(C) Original fitness values - 4, 5
offsprings after crossover - 11001011, 10101010 fitness score after crossover - 5, 4
mutated offspring - 11101111, 10001110
number of fit offspring - 1

5 Question T3_q0001 (Neural Networks)

You are designing a neural network with 5 inputs, 1 output, and you choose 8 neurons in a single hidden layer. Following the rule of thumb from the lecture, how many total samples do you need at minimum? Take 80-20 split

(A) 710
(B) 711
(C) 712
(D) 713
(E) 714

$6 \cdot h + (h+1) \cdot 1 = 7h + 1$ $5h+1$

$570 \div 0.8 = 712$

6 Question T3_q0005 (Neural Networks)

You are designing a neural network for binary image classification (cat vs. non-cat). The output layer consists of a single neuron with output z. You apply a ReLU activation followed by a sigmoid to produce the final output: $y = \sigma(\text{ReLU}(z))$

key issue with this network design? ( ) You classify any input with "*y ≥0.*5 as a cat. Which of the following best describes a

(A) Since ReLU discards negative values, the network quickly converges early in training and fails to capture necessary non-linearities in the data.

(B) Since the combined activations are asymmetric, the model is likely to produce sin-gular weight matrices and encounter instability during backpropagation.

(C) Since ReLU outputs are always non-negative, applying sigmoid afterward causes all predictions to be *≥*0.5, making it impossible to classify inputs as non-cats.

(D) Since ReLU may result in vanishing gradients, especially in deeper networks, this will lead to uncertain outputs and reduce classification accuracy.

7 Question T4_q0001 (Reinforcement Learning)

Suppose the discount factor γ = 0.5, and the following reward sequence is observed over 5 time steps:*

- *R1 = −1*
- *R2 = 2*
- *R3 = 6*
- *R4 = 3*
- *R5 = 2*
- *Episode ends at time T = 5*

Using the formula for return: Gt = R_{t+1} + γG_{t+1}

What are the returns G0, G1, G2, G3, G4?

(A) G5 = 0, G4 = 2, G3 = 4, G2 = 8, G1 = 6, G0 = 2
(B) G5 = 0, G4 = 3, G3 = 5, G2 = 7, G1 = 9, G0 = 1
(C) G5 = 0, G4 = 2, G3 = 3, G2 = 5, G1 = 6, G0 = 3
(D) G5 = 2, G4 = 3, G3 = 6, G2 = 8, G1 = 9, G0 = 2
(E) G5 = 0, G4 = 2, G3 = 3, G2 = 4, G1 = 5, G0 = 6

$G_t = R_{t+1} + \gamma R_{t+2} \cdots$

$G_5 = R_6 = 0$

$G_4 = R_5 + \gamma R_6 = 2.$

$G_3 = R_4 + \gamma R_5 = 3 + 1 = 4.$

8 Question T4_q0003 (Reinforcement Learning)

(Calculation reinforcement learning) You are training a small delivery robot in the CSE building at UNSW for your COMP9414 project. The environment is unknown to the robot and is modeled as a Markov Decision Process (MDP). The robot can be in one of three rooms labelled [A, B, C], and it can choose one of two actions in each room: [Stop, Go]. During training, you collect some experience samples by observing how the robot beha~~ves when ta~~king actions in the environment. The robot doesn't yet know the dynamics of the environment, so it will learn purely from these observed transitions. The discount factor γ = 1 (no discounting) and the learning rate α = 0*.*5

(1) We run Q-learning on the following samples:

S	A	S'	R
A	GO	B	2
C	STOP	A	0
B	STOP	A	-2
B	GO	C	-6
C	GO	A	2
A	GO	A	-2

$Q(s,a) = r(s,a) + V^*(s')$

$Q(A, GO) = 0 + 0.5[2] = 1.$

$Q(C, stop) = 0 + 0.5[0 + 1 - 0] = 0.5.$

(1) What are the estimates for the following Q-values as obtained by Q-learning? All Q-values are initialised to 0.

- *Q(C, Stop) = _____*
- *Q(C, Go) = _____*

(A) Q(C, Stop) = 0.0, Q(C, Go) = 1.0
(B) Q(C, Stop) = 0.5, Q(C, Go) = 1.5
(C) Q(C, Stop) = 0.5, Q(C, Go) = 2.0
(D) Q(C, Stop) = 1.0, Q(C, Go) = 1.5
(E) Q(C, Stop) = 0.5, Q(C, Go) = 0.0

$Q(B, stop) = 0 + 0.5[-2 + 1 - 0] = -0.5$

$Q(B, go) = 0 + 0.5[-6 + 1 - 0] = -2.5$

$Q(C, go) = 0 + 0.5[2 + 1 - 0] = 1.5.$

9 Question T7_q0012 (Computer Vision)

Suppose you have a 7 × 7 greyscale image. You apply a 3 × 3 convolution kernel with stride 2 and zero-padding 1. What will be the size of the output feature map?

(A) 3 × 3
(B) 4 × 4
(C) 5 × 5
(D) 6 × 6
(E) 7 × 7

$\frac{7-3+2}{2} + 1 = 4$

10 Question T8_q0012 (Context-Free Grammar) Look at the grammar rules below. (Note that ε means empty or no character)

S →PPQA
A →aBe | AA
P →eefa | f | c
Q →cgb | ε
B →f | ε

Which of the following strings can be generated using the above rules?

1. eefaeefacgbafeafe
2. ceefaafe
3. cccgbaeafe
4. eefaccgb
5. ffafeafe
6. eefaccgbabeae

(A) String 1, string 2, string 3, string 4, string 5

11 Question T9_q0003 (Uncertainty and Reasoning) A newly constructed bridge may fall down either due to wrong designing or inferior material used in construction. The chance that the design is faulty is 10%, the chance that the material is inferior is 90% and the probability of its collapse if the design is faulty is 95% and that due to bad material it is 45%. If the bridge collapses. Find the chance that it was due to wrong designing.

Hint: use Bayes Rule

(A) 0.19
(B) 0.39
(C) 0.15
(D) 0.26
(E) 0.38

$p(\text{fault}) = 0.1$

$p(\text{material}) = 0.9$

$p(\text{coll} \mid \text{faulty}) = 0.95.$

$p(\text{coll} \mid \text{mate..}) = 0.45.$

$p(\text{des} \mid \text{coll}) = \frac{p(\text{col} \mid \text{des}) \cdot p(\text{des})}{p(\text{col} \mid \text{des}) \cdot p(\text{des}) + p(\text{col} \mid \neg\text{des}) \cdot p(\neg\text{des})}$

$\frac{0.95 \cdot 0.1}{0.95 \cdot 0.1 + 0.45 \cdot 0.9}$

12 Question T9_q0018 (Fuzzy Sets and Membership Functions)

Consider a fuzzy set A representing the concept of "young age." The membership function μA(x) is defined as follows:

Which of the following statements about the fuzzy set A is correct?

$\mu A(x) = 1$ if $0 \le x \le 20$
$\mu A(x) = (40-x)/20$ if $20 < x \le 40$
$\mu A(x) = 0$ if $x > 40$

(A) The support of A is the interval [10, 40]. X. 0→40

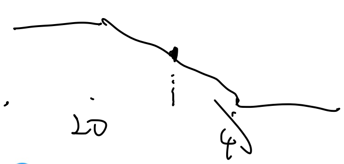
(B) The core of A is the interval [0, 20].

(C) The height of A is 1 at (x = 20).

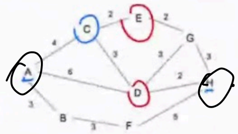
(D) The α-cut for α = 0.5 is the interval [20, 30]. X.

(E) The crossover point of A occurs at x = 20.

30.



Consider the following road map with distances indicated on lines drawn between towns (the map is not to scale). The straight-line distances form each town to H are listed in the table.

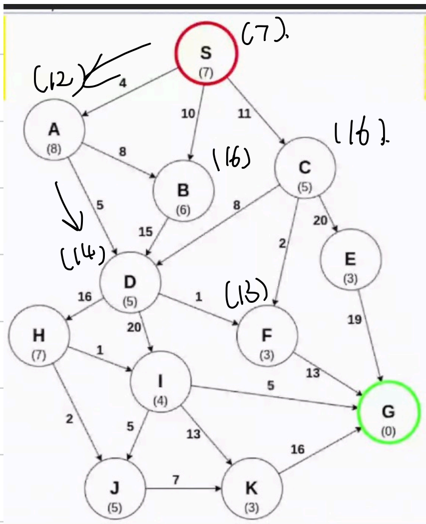


Town	Distance to H
A	7
B	8
C	5
D	2
E	8
F	5
G	2
H	0

What order are nodes expanded by iterative deepening depth first search when searching for a path between A and H? Where there is choice of nodes, take the first one by alphabetical ordering. Assume the search algorithm includes cycle checking along a path, Tree-Search-IDDFS. Stop the search once the goal node is expanded.

a. A ABCD ABFCDEDCGH b. A ABCD ABFCDH c. A ABCD ABCDE ABFCDH
d. A ABCD ABFH e. A ABCD ABFCDEGH

A. ABCD ABFCDEH



A* Search

Consider the directed graph below. The number on each edge is the actual step cost, and the number in parentheses next to each node is the heuristic value h(n), which estimates the remaining cost from that node to the goal node G.
Run A* search to find the shortest path from the start node S to the goal node G. Assume:

Which path from S to G will A* return?
a. $S \to C \to F \to G$
b. $S \to C \to E \to G$
c. $S \to B \to D \to F \to G$
d. $S \to A \to D \to F \to G$
e. $S \to A \to D \to I \to G$

Decision Tree

Given is the following training data (left table) where ***location, weather*** and ***expensive*** are the features and ***holiday*** is the class
You may use right table for calculation

location	weather	expensive	holiday
nice	sunny	Y	good
nice	sunny	N	bad
boring	rainy	Y	good
boring	sunny	N	bad
nice	rainy	Y	good
boring	rainy	N	good
boring	rainy	N	good

x	y	-(x/y)* log2(x/y)	x	y	-(x/y)* log2(x/y
1	2	0.50	1	6	0.43
1	3	0.53	5	6	0.22
2	3	0.39	1	7	0.40
1	4	0.5	2	7	0.52
3	4	0.31	3	7	0.52
1	5	0.46	4	7	0.46
2	5	0.53	5	7	0.35
3	5	0.44	6	7	0.19
4	5	0.26			

If we split on each attribute separately, what are the information gains for **location**, **weather**, and **expensive** (in this order)? Choose the *closest* correct triple:
a. location: 0.30, weather: 0.48, expensive: 0.01
b. location: 0.10, weather: 0.57, expensive: 0.20
c. location: 0.01, weather: 0.48, expensive: 0.30
d. location: 0.01, weather: 0.30, expensive: 0.48
e. location: 0.20, weather: 0.40, expensive: 0.27

location (nice) = $\frac{3}{7}\left(-\frac{1}{3}\log\frac{1}{3} - \frac{2}{3}\log\frac{2}{3}\right) = \frac{3}{7}(0.53 + 0.39) = 0.394$

location (boring) = $\frac{4}{7}\left(-\frac{3}{4}\log\frac{3}{4} - \frac{1}{4}\log\frac{1}{4}\right) = \frac{4}{7}(0.31 + 0.5) = 0.291$

0.67

$\frac{5}{7}\log\frac{5}{7}$ $\frac{2}{7}\log\frac{2}{7}$ $\cdot$ 0.35 + 0.52 $= 0.87$

Decision Tree

Given is the following training data (left table) where ***location, weather*** and ***expensive*** are the features and ***holiday*** is the class. You may use right table for calculation

location	weather	expensive	holiday
nice	sunny	Y	good
nice	sunny	N	bad
boring	rainy	Y	good
boring	sunny	N	bad
nice	rainy	Y	good
boring	rainy	N	good
boring	rainy	N	good

c) Using the Laplace error estimate $E = 1 - \frac{n+1}{N+K}$, where N is the total number of examples at a node, n is the number of examples in the majority class at that node, and K is the number of classes (here K = 2, "good" and "bad").

1. Compute the Laplace error estimate for the root node **before** any split.
2. Compute the Laplace error estimates for the two child nodes obtained by splitting on **weather** (sunny / rainy), and the weighted average Laplace error after this split.
3. Based on the Laplace error, does the split on **weather** reduce the estimated error (i.e., should we keep this split instead of pruning it to a leaf)?

1. Error $= 1 - \frac{5+1}{7+2} = 1 - \frac{5+1}{9} = \frac{1}{3}$

2. $E = \frac{3}{7} E_{sunny} + \frac{4}{7} E_{rainy} = \frac{3}{7}\left(1 - \frac{2+1}{3+2}\right) + \frac{4}{7}\left(1 - \frac{4+1}{4+2}\right) = 0.27$

$0.27 < \frac{1}{3}$

Computer Vision

Consider the first convolutional layer of LeNet-5, where the input is a 32×32 greyscale image. This layer uses:

- Number of filters: 6
- Filter size: 5×5
- Stride = 1
- No padding
- Input channels = 1

Compute the following quantities for this convolutional layer:

- Output feature map size
- Weights per filter
- Number of neurons in this layer
- Number of connections
- Total trainable parameters

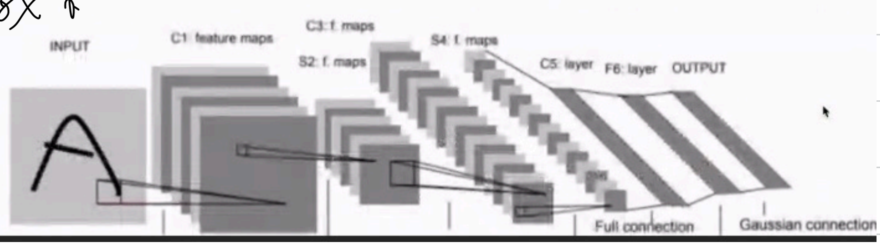
28. 29 30 31 32

$\frac{32-5+0}{1} + 1 = 28.$

$28 \times 28 \times 6$

Which option correctly lists all five quantities?

A. 27×27, 26, 4374, 113724, 156
B. 28×28, 25, 4704, 117600, 150
C. 28×28, 26, 4704, 122304, 156
D. 28×28, 26, 4704, 117600, 156



$5 \times 5 \times 1 + 1 = 26.$

$6 \times 28 \times 28 = 4704.$

$4704 \times 26.$

Neural Network

You'd like to train a fully-connected neural network with the following configuration:

- 5 hidden layers, each with 10 hidden units
- The input is a 20-dimensional vector
- The output is a scalar

50 hidden.

$21 \cdot 50 + 51 \cdot ? <$ 10

1050

What is the total number of trainable parameters in your network?

A. 521 B. 661 C. 1100 D. 231 E. 610

$440 + 210 + 11$

$650 + 11 = 661$

$20 \to 10 \to 10 \to 10 \to 10 \to 10 \to 1$

$20 \times 10 + 10 = 210$ 110 110 110 110 11.

Reinforcement Learning

Consider a reinforcement learning environment with three states S= $\{S_1, S_2, S_3\}$ and two actions A= $\{a_1, a_2\}$. The transition probabilities and rewards are as follows:

State	Action	Next State	Reward
S_1	a_1	S_2 (70%), S_3 (30%)	2
S_1	a_2	S_3 (100%)	1
S_2	a_1	S_1 (100%)	0
S_2	a_2	S_2 (80%), S_3 (20%)	3
S_3	a_1	S_1 (50%), S_2 (50%)	-8
S_3	a_2	Terminal (100%)	4

Assuming a discount factor γ = 0.9, what is the expected value of taking action a_1 in state S_1, given that the optimal policy will be followed thereafter? (Round your answer to two decimal places)

A. 15.88 B. 14.07 C. 13.29 D. 12.34 E. 11.45

$0.27 \cdot 4$

$V(S_1) = 2 + 0.9(0.7V(S_2) + 0.3(V(S_3)))$

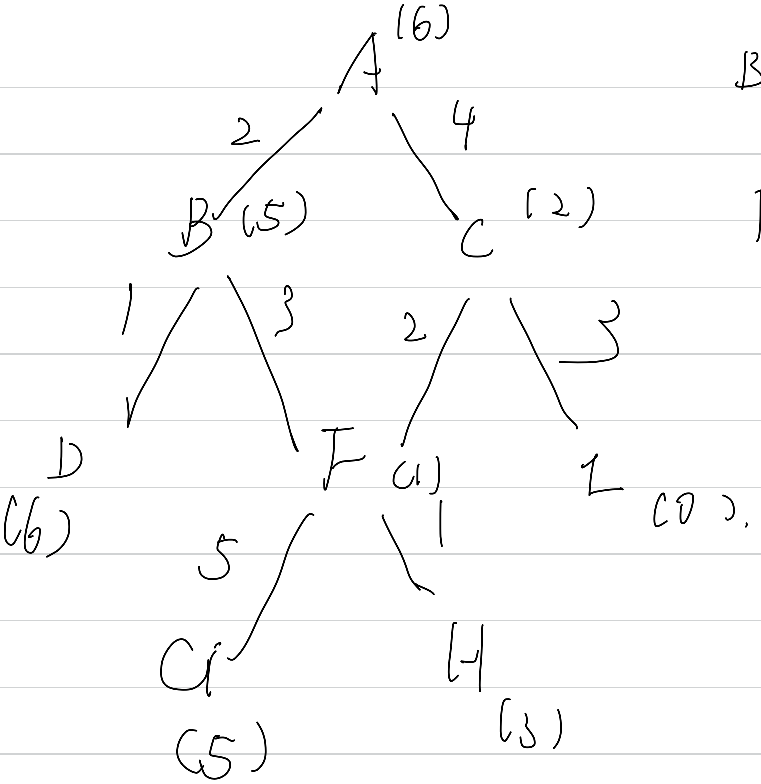
$V(S_2) = 3 + 0.9(0.8V(S_2) + 0.2V(S_3))$

$V(S_3) = 4 + 0.9 \cdot 0 = 4$

$V(S_2) = 3.72 + 0.72V(S_2)$

$V(S_2) = 13.29$ $V_1 = 11.45$

$V(S_2 a_1) = 0 + 0.9 \cdot (11.45) = 10.3$



B = 7. C. (6) ✓

F (7) I (7).

20 × 8 = 160 + 400 = 560

50 × 5 + 20 × 3 + 150 = 460

~~250 + 60~~ 310

50 × 3 + 20 × 5 + 100

44.4
9) 400
36
40

51.1 44.4 51.1

44.4 34.4 44.4

51.1 44.4 51.1

46.2.