Student Answer Sheet Analysis

Automated Processing System

July 6, 2025

Questions and Student Responses

Question 1

Question: (a) Consider the following incidence matrix of a simple undirected graph. Convert this into an adjacency matrix representation. [2 marks] Matrix: 1 0 0 1 1 1 0 1 0 0 0 1

Student Answer:

Competely 0 1 0 0
Adjacency -s 1 0 1 0
Matrix 0 1 0 1
0 0 1 0

Question 1 (b)

Question: Which network model assumes that edges are formed between pairs of nodes with a uniform probability, independent of other edges? [2 marks] A. Barabási-Albert Model B. Erdős–Rényi (Random Network) Model C. Watts-Strogatz (Small-World) Model D. Configuration Model

Student Answer:

B -¿ Erdős-Rényi (Random Network) Model connects nodes with fixed probability generates random graphs without considering node properties.

Question 1 (c)

Question: In game theory, a situation where no player can improve their outcome by unilaterally changing their strategy, given the strategies of other players, is known as: [2 marks] A. Zero-Sum Game B. Dominant Strategy C. Nash Equilibrium D. Mixed Strategy

Student Answer:

C Nash equilibrium (optimal)
Combination of strategies for both players, unilateral change of strategy reduces chances of wing

Question 1 (d)

Question: The tendency for individuals in a social network to associate and bond with similar others is defined as: [2 marks] A. Structural Equivalence B. Assortative Mixing C. Regular Equivalence D. Network Density

Student Answer:

B. Assortative mixing
Preference of individuals to connect with similar ones like same interest, age group, profession, in social networks

Question 1 (e)

Question: Why might betweenness centrality be a more relevant measure than degree centrality for identifying critical nodes in a network transmitting information that must follow specific paths? [2 marks] A. Because it measures the total number of connections a node has. B. Because it prioritizes nodes with high clustering coefficients. C. Because it is easier to calculate for large graphs. D. Because it quantifies how often a node lies on

Student Answer:

D. Because it quantifies how often a node lies on shortest paths b/wo other nodes
Betweenness centrality measures frequency
nodes (centrality) at which node appears on
definition shortest paths.

Question 1 (f)

Student Answer:

C. Presence of many nodes with high degree that maintain connectivity

Question 1 (g)

Student Answer:

No. of: intra community edges ¿ exper in randomly

Question 1 (h)

Student Answer:

B (2/5)

Question 1 (i)

Student Answer:

(Intersection / Union)= 2 sentences Jaccard co-of = intersection / Size of Union
= (AB)CDE/ neigh-sets

Question 1 (l)

Student Answer:

(A) Nodes in ICN are activated based on independent edge probabilities but LTM uses threshold depending on sum of neighbor influences.

Question 1 (j)

Student Answer:

(B) As connected nodes are dissmellgnt (?), less accurate feature aggregation poor classif

Question 2

Question: Q2

Student Answer:

Strategy to identify individuals for most effectively use limited vaccines for minimizing infecting.

(1) Identify individuals that might act as bridges to spread across groups using Betweenness centrality

(2) Vaccinate individuals with high degree of connectivity. -¿ high no. of direct contact using Degree centrality

This minimizes spread within and across groups effectively

Question 3

Question: Q3

Student Answer:

Combining link prediction algorithm with node embedding to generate recommendation.

(1) Use Node2Vec to capture structural semantic relationships in network.

(2) Predict potential collaboration within existing network using Link prediction

(3) Homophily in context of collaboration among researchers.

While generating recommendation for collaborations, use the factor that the suggested researcher be from a different field but complimenting disciplines can create a crosstalk to suggest which disciplines other than own are complimentary for collaboration for each researcher looking to collaborate.

Question 4 (a)

Student Answer:

Girvan-Newman Algorithm for community detection - Iteratively removes edges with highest betweenness centrality to discover community structure

Question 4 (b)

Student Answer:

It identifies and removes edges that act as bridges between communities by using edges betweenness centrality

Question 4 (c)

Student Answer:

Computational limitation of Girvan is its high cost of computation, which becomes prohibitive for large networks.

Question 4 (d)

Student Answer:

For optimizing modularity Louvain method uses hierarchical clustering -¿ As a scalable alternative.

Question 5 (a)

Student Answer:

Intuition in PageRank algorithm - Node importance is determined based on number of quality links of a Node.

Question 5 (b)

Student Answer:

The surfer-based Page-Rank algorithm (d) damping factor accounts for probability that a random surfer continuing following links terminating sink

Question 5 (c)

Student Answer:

Problem with nodes that have no outgoing links, is they disrupt convergence ranks of such dangling nodes can be redistributed to other nodes to ensure convergence of algorithm.

Question 6

Student Answer:

Player 2 strat A strat B Nash equilbria Player 1 Strat U (3,2) (0,1) = optimal strat L (2,0) (2,3) = best strategy combo for both players any one switching will only do worse -Continued in nxt pg.

Question 6 (a)

Student Answer:

Finding Nashequilibria identifying if a players outcome can improve me by changing strategy. (1) Player 1's strategy "U" v/s Player 2's A.

If player 1 switching from U to L, Player 2 A B Player 1 U 3,2 0,1 Player 1 decreases from 3 to 2 L 2,0 2,3 Player 2 switching from A to B decreases players from (2 to 1) (U,A) is a Nash equilibrium

(2) U v/s B. Player 2 from B to A, Player 2 switching from B to A Player 2 payoff increases from 1 to 2. X Nash

(3) (L,A) Player 1 switch L to U, X doesnt qualify Player A to B. Increases, doesnt qu.

(4) (L,B) Player switches from L to U -¿ equilibrium Player payoff decreases 2 to 0. Ditto Player 2 switch from B to A, 3-¿0

Question 6 (c)

Student Answer:

(Continued) So, pure strategy Nash equilibria are (U,A) and (L,B) where unilateral change of strategy reduces chance of payoff for both players.

(b) When player 1 chooses U with prob P Player 2's strategy A payoffs. (P*2)+(1-P)*0 = 2P

Player 2's strategy B Playoffs. P*1 + (1-P)*3 = 3-2P

(c) When p=0.7, 2P = 1.4 Payoffs for player 2 with strategy A. Payoffs for Player 2 = 3-2P with strat. B = 3-1.4 = 1.6

Player 1 A B U 0.7 L

Question 7 (a)

Student Answer:

GNN - Layer $h^(0)_A = (1), h^(0)_c = (0,3) h^(0)_B = (2,2)$

Step 1 Aggregation of neighbor features Avg of initial feature vectors

$h^(0)_N(B) = 1/3[(1,1) + (0,3) + (2,2)] = 1/3[(3,6)] = (1,2)$

Step 2 Transformation h(1)$_N B = W * h^(0)_N B$

Transform Weights matrix

= (0.5 0) (1) (0.1 0.2) (2)

= (0.5*1 + 0.2) (0.5 + 0) (0.1*1+0.2*2) (0.4+0.4)

= (0.5) (0.5)

Step 3 Activation sigma(0.5 0) (1/2 sum of h$^(0))sigma(0.50)(1/19)(1) + (0, 3) + (2)$

Question 1 (e)

Student Answer:

(Again answered with justification - Q1 (e)) For identifying critical nodes in a network, betweenness centrality is more relevant because it quantifies how often a node lies on the shortest path b/wo other nodes as this indicates the nodes importance in communication information flow across the network.

Question 1 (f)

Student Answer:

Ans "C" - Presence of many nodes with high degrees that maintain connectivity gives scale-free networks their robustness because hubs are critical for network connectivity random failure affects less connected nodes. But the hubs targeted attacks on hubs make them vulnerable.

Question 1 (g)

Student Answer:

Ans "A" High modularity indicates strong community structure with dense intra community connections, which is an important goal in community detection. hence optimization finds partitions with high no. of intra community edges.