August 2022 Admissions

AY2023 Examination Questions for the Graduate School of Information Science and Engineering, Ritsumeikan University (Master's Program)

Major in Information Science and Engineering
Information Science and Engineering Course

【How to answer questions】

Please follow the instructions below and answer the questions.

<u>Choose two questions from the common subjects and choose either the Computer Science section or the Human Information Science section.</u>

In case choosing the Computer Science section, answer three questions from question ④~⑨.

In case choosing the Human Information Science section, choose one question either ⑩ or ⑪.

There will be two blank answer sheets in case choosing the Human Information Science section.

<table>
<tr><td>Common Subjects</td><td colspan="2">①Linear Algebra
②Probability and Statistics
③Data Structure and Algorithms</td></tr>
<tr><td rowspan="2">Specialized Subjects</td><td>Computer Science</td><td>④Computer Architecture
⑤Operating System
⑥Software Engineering
⑦Computer Networks
⑧Databases
⑨Artificial Intelligence</td></tr>
<tr><td>Human Information Science</td><td>⑩Image Processing
⑪Artificial Intelligence</td></tr>
</table>

【Examination time】

9:30-11:30 (120minutes)

※Leaving the examination venue is not allowed during the examination time.

※In case you feel sick or need to go to the bathroom, let examination supervisors know by raising your hand.

【Notes】

(1) Use one answer sheet for one question.

(2) Fill out your examination number and name for all the answer sheets. Also, make sure to fill out all the other necessary sections such as the questions number column.

(3) Do not remove the staple of your answer sheets.

(4) Answer sheets with no names will be invalid. Do not take the question sheets and answer sheets with you after the examination.

Common Subjects

①Linear Algebra
②Probability and Statistics
③Data Structure and Algorithms

Choose two questions from the above.

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Common Subjects① Linear Algebra

Answer all the questions below.

Question 1. Given the following matrix A, find a that satisfies $|A| = 1$.

$$A = \begin{bmatrix} a & 1 & 3 & 4 \\ 5 & 3 & 1 & 0 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 2 & 1 \end{bmatrix}$$

Question 2. Solve the following system of equations.

$$\begin{cases} a - 3b + 2c - d = 9 \\ -a + 2b + c + 2d = -3 \\ 2a + b - c + d = -2 \\ 3a - b + 2c - 3d = 11 \end{cases}$$

Question 3. Given the following matrices B and P, diagonalize matrix B by $P^{-1}BP$.

Note that $\boldsymbol{u}_1$ and $\boldsymbol{u}_2$ are the eigenvectors for the eigenvalues λ_1 and λ_2 $(\lambda_1 < \lambda_2)$ of matrix B, respectively.

$$B = \begin{bmatrix} 3 & 1 \\ 2 & 2 \end{bmatrix}$$

$$P = [\boldsymbol{u}_1 \quad \boldsymbol{u}_2]$$

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Common Subjects② Probability and Statistics

Answer all of the following questions with all calculation processes and concepts.

Question 1. For each of the following probability functions $P(X = k)$ or probability density functions $f(x)$, $f(x, y)$, find the value of the constant C_j $(j = 1,2,3,4)$. Furthermore, for (1)-(3), find the values of the mean and variance.

(1) $P(X = k) = \begin{cases} C_1, & (k = -2, -1, 0, 1, 2) \\ 0, & (k = \text{the other integers}) \end{cases}$.

(2) $P(X = k) = \frac{C_2 2^k}{k!}$.

(3) $f(x) = C_3 \exp(-2|x|)$.

(4) $f(x, y) = C_4 \exp(-x^2 - y^2)$.

Question 2. Consider a point A that is moved along the x-axis by Δx, determined by each fair die roll, from its current position. Point A is initially at the origin $x = 0$. After the dice rolls once, if the roll is 1 or 2, point A is not moved ($\Delta x = 0$), else if the roll is 3, 4, 5, or 6, point A is moved by $\Delta x = 1$. Let $P_n(x)$ be the probability that point A is at x after repeating the above operation n times.

(1) Find an expression for $P_n(x)$ in terms of P_{n-1}.

(2) Find $P_n(x)$.

(3) Find the mean and standard deviation of $P_{120}(x)$.

Question 3. Suppose that a lottery has winning probability p and losing probability $1 - p$ (thought of as a Bernoulli trial). You draw the lottery 100 times and win 5 times.

(1) Find the log-likelihood function $L(p)$.

(2) Find the parameter p that maximizes the log-likelihood function $L(p)$.

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Common Subjects③　Data Structure and Algorithms

This question consists of 2 pages. Answer all the questions below.

Question 1.

Figure 1 is pseudocode of an insertion sort that sorts an array A in ascending order. The number of elements in the array A is n, A[k] represents the kth element of the array A, and the range of index is 1 to n. Answer all the questions below.

(1) Fill up (a) and (b) in the pseudocode shown in Figure 1.

(2) Assume that the contents of the array A are as follows:
48, 73, 36, 5, 22, 17.
At this time, illustrate the process of changing the value of array A when performing InsertionSort(A, 6) of Figure 1.

(3) The time complexity of insertion sort can be evaluated by counting the number of loop iterations. In the insertion sort, the time complexity changes depending on how the array A (input series) is arranged. Explain what kind of input series makes the sorting end earliest, and calculate the corresponding time complexity.

(4) Calculate the total number of iterations when the inner "while" loop is repeated (i -1) / 2 times on average during the i-th iteration in the outer "for" loop. In addition, calculate the average time complexity in that case.

```
InsertionSort(A, n) {
  for (i = 2; i <= n; i++) {
    temp = A[i]
    j = i
    while (j > 1 && A[j-1] > temp) {
      [          (a)          ]
      j = j-1
    }
    [          (b)          ]
  }
}
```

Figure 1　Pseudcode of an insertion sort

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* This question consists of 2 pages.

Question 2.

Searching is an operation to find a record with a specific value (key) from a table. When considering a search algorithm, it is common to think about the following three operations.

- Insertion: Register a record in the table
- Search: Find a record that has a given value as a key.
- Deletion: Delete a record with a given value as a key from the table.

Answer the following questions.

(1) There are algorithms called the linear search (sequential search) and the binary search. When realizing a table using an array, enter the complexity of each operation of these algorithms in the blanks [(a)] to [(f)] in Table 1 using big O notation, where the number of data registered in the table is n.

Table 1 The complexity of each operation of linear search and binary search

	Linear search	Binary search
The complexity of "Insertion" (one time)	[(a)]	[(b)]
The complexity of "Search" (one time)	[(c)]	[(d)]
The complexity of "Deletion" (one time)	[(e)]	[(f)]

(2) Hashing is a search algorithm that can perform the operations of insertion, search, and deletion on average with the computational complexity of $O(1)$. The principle of hashing is to directly associate the key value with the position where the data is stored (the value of the index of the array is used as a table). An array that stores data is called a hash table, and we consider a hash function $h(x)$ that maps the key value x to the index of the array. The position to store the data is determined by the hash value returned by the hash function $h(x)$. However, sometimes the hash function may return the same value for two different keys.

① Answer the name of such a situation.

② Suppose that the numerical sequence $\{a_n\} = \{20, 6, 56, 74, 3, 45, 12, 85, 46, 30\}$ is given. Let y be the size of the array used as the hash table, and the remainder of dividing a_n by y (a_n mod y) is used as the hash function. In addition, the situation ① will be solved by the chaining (direct chain method).
Write the length of the longest list (chain) if $y = 3$ is used.
Also, write the minimum y where the length of the longest list is 2 or less.

③ Explain when the complexity of each operation of hashing cannot be regarded as $O(1)$.

Specialized Subjects

Computer Science

④Computer Architecture
⑤Operating System
⑥Software Engineering
⑦Computer Networks
⑧Databases
⑨Artificial Intelligence

In case choosing the Computer Science section, answer three questions from question ④～⑨

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Computer Science④　Computer Architecture

Answer all the questions below.

Question.

Answer the following questions about a RISC processor. In the following questions, ISE2022 is a fictitious RISC processor. ISE2022 has general-purpose registers R1 to R15, and its instruction set is equipped with an Execute addition instruction ADD. The ADD instruction has three register operands.　For example, the assembly notation of the instruction word that stores the Execute addition result of R1 and R2 in R3 is "ADD R3, R1, R2". Here we assume that the values have already been written in R1 to R8 at the start of the execution of the program.

(1) Briefly describe the functionality of the program given by the assembly code of ISE2022 shown in Fig. 1.　Here, the inputs and the output of the program are R1 to R8 and R15, respectively. Assume that no overflow occurs during the calculation.

(2) ISE2022 fetches one instruction every clock cycle and performs instruction pipeline processing consisting of four stages.　In the case of the ADD instruction, the instruction-fetch, register-read, Execute addition, and register-write-back are performed in the first, second, third, and fourth cycles, respectively.　How many clock cycles are required for the program in Fig. 1 from the start of instruction fetch of instruction I1 to the end of register write back of instruction I4?

```
I1:  ADD R9, R1, R2
I2:  ADD R10, R3, R4
I3:  ADD R11, R5, R6
I4:  ADD R12, R7, R8
I5:  ADD R13, R9, R10
I6:  ADD R14, R11, R12
I7:  ADD R15, R13, R14
```

Figure 1

(3) The register file that retains the values of R1 to R15 in ISE2022 can read the values written in the same cycle when writing and reading the same register occur in the same clock cycle.　The ISE2022 is also equipped with a forwarding mechanism in case data hazards still occur.　Answer whether the forwarding mechanism operates if ISE2022 runs the program shown in Fig. 1.　Also, if the forwarding mechanism operates, answer which register value is forwarded between which instruction and which instruction.

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Computer Science⑤ Operating System

Answer all the questions below.

Question. The table below shows the set of processes for the performance evaluation of CPU scheduling algorithms. There are four processes, A through D. The table shows each process's arrival time, response start time, and burst time. Draw Gannt charts illustrating the execution of the processes, and give waiting time, response time, and turnaround time for each process, for the two algorithms, FCFS and Round Robin (time slice = 3).

Process	Arrival Time	Response Start Time	Burst Time
A	0	4	7
B	2	2	4
C	5	1	3
D	8	1	6

Computer Science⑥ Software Engineering

Answer all the questions below.

Question 1.
Explain a benefit of introducing encapsulation in object-oriented modeling.

Question 2.
Describe what the difference is between functional requirements and non-functional requirements.

Question 3.
Describe an example in which trade-offs occur in software architecture design.

Question 4.
There are two types of software reuse: black-box and white-box. Explain pros and cons of them.

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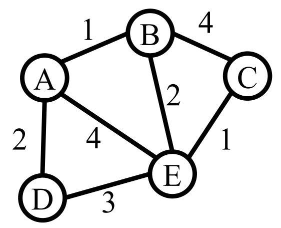
Computer Science⑦ Computer Networks

Answer all the questions below.



Question 1. The figure on the right shows a network. The letter inside the circle denotes a node and its name. The line between two nodes denotes a link between the nodes. The number near the link denotes the distance (or the cost to pass) for the link.

(1) Describe the Dijkstra's algorithm by demonstrating all procedures on the network for determining all the shortest distances from node "A" to other nodes. Skipping any step or omitting the explanation of each step is not allowed.

(2) Show the order of nodes where the shortest distance is determined by the Dijkstra's algorithm in the sub-problem (1). The order should be denoted as the list of node names separated by comma ",". For example, if you want to answer that the nodes A, D, C, and B are the order of shortest distance to be determined, answer that the order of determination is A, D, C, B.

Also show all shortest paths from node "A" to other nodes in this setting. The shortest path should be denoted as the list of node names separated by dash "-" proceeded by the destination node name and colon ":" followed by colon and its distance. If you want to answer that the path from node "A" via node G to node E is at a distance of 10, denote it as E:A-G-E:10 for example. Note that the shortest distance from node "A" to node "A" is determined to be zero at the beginning the steps of the Dijkstra's algorithm, so A:A-A:0 is self-evident. However, you should also clearly state it in your answer without omission.

Question 2. For the descriptions regarding computer networks from (1) to (8) below, complete each description by selecting a correct answer from the options inside rectangles if any exists. Or you can answer by writing a suitable keyword or phrase if you find no suitable options.

(1) The acronyms of the organization that formulates standards for technologies used on the Internet and stores and publishes technical specifications in a format called RFCs (Request for Comments) is Q(a) ① ITU ② IETF ③ IEEE ④ IrDA in English.

(2) The maximum throughput of the media access control scheme ALOHA (or Pure ALOHA) is denoted as Q(b) using the natural logarithm of the base (or Napier's constant) *e*.

(3) In the OSI Basic Reference Model (or OSI Reference Model), the layer that transfers bits using a transmission medium such as electrical signals or light is the Q(c) layer. On the other hand, Q(d) ① administrating session check-pointing and recovery ② converting from abstract syntax data to transfer syntax ones ③ definitions of standard specs for optical fibers ④ routing control is one of the major functions of the session layer.

(4) In a local area network (LAN), Q(e) ① a repeater ② a router ③ a bridge ④ an ONU is a device that relays frames in the middle of a transmission path to extend the transmission distance and only transfers at the data link layer.

(5) For an IPv4 (Internet Protocol version 4) address that is denoted as 10.11.23.58 in dotted decimal notation, the addressing of this IP network is a class Q(f) ① A ② B ③ C ④ D ⑤ E . Assuming a dotted decimal subnet mask of 255.255.255.192, the broadcast address used in this IP network would be Q(g) ① 10.255.255.255 ② 10.11.255.255 ③ 10.11.23.63 ④ 10.11.23.255 .

(6) The first four bits of the IP header indicate the IP version number. This means that the field is Q(h) ① 0001 ② 0100 ③ 0110 ④ 1001 in binary for IPv6 (Internet Protocol version 6) header.

(7) Among IP, TCP and UDP in IPv4, Q(i) ① only TCP has a fixed length header ② only UDP has a fixed length header ③ only TCP and UDP have fixed length headers ④ only IP has a fixed length header ⑤ only IP and TCP have fixed length headers ⑥ only IP and UDP have fixed length headers ⑦ all of them have fixed length headers .

(8) Q(j) ① Return-to-zero ② NRZ(L) ③ Manchester code ④ MLT-3 is a line code in which the encoding of each data bit is either low then high, or high then low, for equal time and was adopted for Ethernet standards such as 10BASE-T.

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Computer Science⑧ Databases

This question consists of 2 pages. Answer all the questions below.

Question. For the following explanations on Databases from (i) to (iii), choose the most appropriate word or equation for the boxes (1) to (15) from the options and answer with the symbols shown in the alphabets. Note that some unrelated options are included, and some of the alphabets are omitted. Assume that the same word is enclosed in the box with the same number.

(i) In relational algebra, $\boxed{\text{(1)}}$ is an operator to combine tuples from two relations that satisfy the combination condition. The particular type of $\boxed{\text{(1)}}$ whose combination is equality is $\boxed{\text{(2)}}$. Moreover, an operator to remove duplicated attributes from the results of $\boxed{\text{(2)}}$ by $\boxed{\text{(3)}}$ operator is called $\boxed{\text{(4)}}$.

(ii) Normal forms in a relational database are a property of relations normalized to prevent inconsistency. The third normal form is a relation in the second normal form where all attributes except for $\boxed{\text{(5)}}$ do not have a $\boxed{\text{(6)}}$ on the $\boxed{\text{(5)}}$. Consider the following relation `Order` in the second normal form. The underline indicates the primary key. Customers are assumed to be uniquely specified by the customer number.

`Order (order_no, price, customer_no, customer_name, customer_affiliation)`

In order to express this relation in the third normal form, it is necessary to split it into the following two relations.

`Order1 (order_no,` $\boxed{\text{(7)}}$`)`

`Customer (`$\boxed{\text{(8)}}$`)`

To calculate the total price of orders from customers whose affiliation is a university, the SQL statement is as below.

SELECT $\boxed{\text{(9)}}$

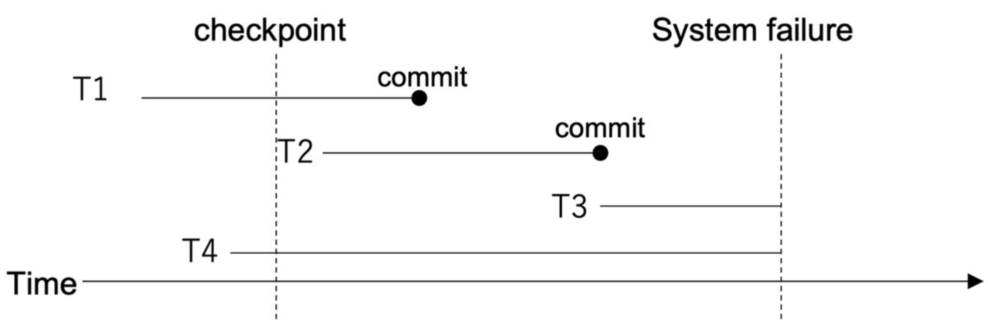
FROM Order1

WHERE customer_no $\boxed{\text{(10)}}$ (SELECT customer_no

FROM Customer

WHERE customer_affiliation $\boxed{\text{(11)}}$ '%University');

(iii) There are two operations to restore the database from a system failure: $\boxed{\text{(12)}}$, an operation that returns the database from the current state to some previous state, and $\boxed{\text{(13)}}$, an operation that returns the database from the checkpoint to the state just before the system failure. When the system failure occurs in the following time-lapse, $\boxed{\text{(13)}}$ can restore the transaction $\boxed{\text{(14)}}$ and $\boxed{\text{(15)}}$.



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* This question consists of 2 pages.

[Options]

a	rollback	b	RAID	c	equijoin	d	foreign key
e	AVG(price)	f	full functional dependency	g	candidate key	h	roll forward
j	natural join	k	IN	l	feedback	m	selection
n	superkey	o	SUM(price)	p	LIKE	q	join
r	TOTAL(price)	s	transitive functional dependency	t	Cartesian product	u	ADD(price)
v	projection	w	=	x	multivalued dependency	y	OUTER JOIN
z	price	A	price, customer_name	B	price, customer_no	D	price, customer_no, customer_name
E	customer_no, customer_name	G	customer_name, customer_affiliation	H	customer_no, customer_affiliation	J	customer_no, customer_name, customer_affiliation
L	T1	M	T2	Q	T3	R	T4

Computer Science⑨ Artificial Intelligence

This question consists of 2 pages. Answer all the questions below.

Question. For the following explanations of Artificial Intelligence (AI) from (i) to (v), choose the most suitable word or number for the boxes (1) to (15) from the options shown below. Note that some unrelated options are included. Assume that the same word is enclosed in the box with the same number.

(i) In graph G_1 shown in Fig.1, the numbers along edges are the actual costs and ones in parentheses are the estimated costs. For graph G_1, the path from node S to G obtained using the Dijkstra algorithm is (1), and the path from node S to G obtained using the A* algorithm is (2). Also, the A* algorithm (3) that "the optimal path is always obtained".

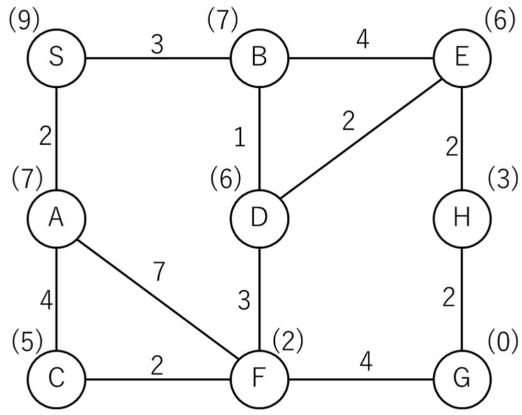

Fig.1 Graph G_1 (The numbers along edges are the actual costs and ones in parentheses are the estimated costs)

【Options for (i)】

a	guarantees	b	does not guarantee	c	S→A→C→F→G	d	S→A→F→G
e	S→B→D→E→H→G	f	S→B→D→F→G	g	S→B→E→H→G	h	S→B→E→D→F→G

(ii) Fig.2 shows the game tree of a game where two players make decisions in turn, with □ nodes representing the board of the first mover and ○ nodes representing the board of the second mover. The alphabet in each node is the name of each board, and the numbers under the leaf nodes denote the evaluation values of the nodes. If the first mover takes the min-max strategy, the evaluation value of node A is (4). When the αβ method is applied to avoid unnecessary search where the board evaluation proceeds from left to right in the game tree shown in Fig. 2, the set of nodes to be pruned by α-cut is (5), and the set of nodes to be pruned by β-cut is (6).

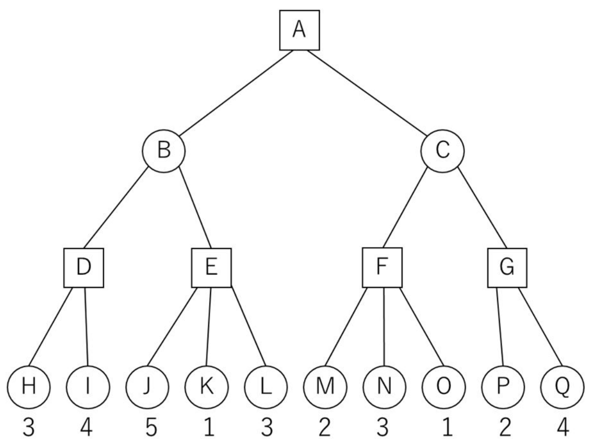

Fig.2 Game tree

* This question consists of 2 pages.

【Options for (ii)】

a	3	b	4	c	5	d	{K, L}
e	{K, L, O}	f	{L, N, Q}	g	{G}	h	{E, G}

(iii) Bayesian filter is a method for estimating self-location based on observed information and previous action history, and it is assumed to be a (7) in which the observed information o_t at time t depends only on the location information s_t at time t. However, Bayesian filters must always maintain existence probabilities for all locations. In contrast, the (8) is an approximation method that applies (9) to the Bayesian filter update formula to obtain the existence probability of each location from the distribution of a finite number of sample points.

【Options for (iii)】

a	Bayes' theorem	b	Posterior probability	c	Normality	d	Monte Carlo approximation
e	Linearity	f	Partially observable Markov decision process	g	Naïve Bayes filter	h	Particle filter

(iv) One of the features of neural networks is that the feature extractor part is optimized, and thus what are called (10) . Neural networks have an input layer, (11) , and an output layer, and nonlinear transformation using an activation function is performed in (11) . For learning by gradient descent method and error back propagation algorithm, it is important that the activation function is (12) , and sigmoidal functions and ReLU functions are often used as the functions.

【Options for (iv)】

a	Differentiable	b	End-to-End learning	c	A transformation layer	d	Reinforcement learning
e	A convolution layer	f	Linear	g	An intermediate layer	h	Supervised learning

(v) To deal with documents written in natural language by computers, we consider the information representation of words contained in the documents. An analysis that divides a sentence into the smallest meaningful units and estimates the part of speech is called (13) . Furthermore, a (14) is a vector that represents the k-th word with only the k-th dimension being 1 and the remaining dimensions being 0 when all words in the target document are assigned an index. A (15) is a representation of a feature of a document by counting the frequency of words contained in the document, and is used for topic analysis and information recommendation.

【Options for (v)】

a	BERT	b	Syntactic analysis	c	n-gram model	d	Distributed representation
e	One-hot vector	f	Bag-of-Words representation	g	Semantic analysis	h	Morphological analysis

Specialized Subjects

Human Information Science

⑩Image Processing
⑪Artificial Intelligence

In case choosing the Human Information Science section, choose one question either ⑩ or ⑪

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Human Information Science⑩ Image Processing

This question consists of 3 pages. Answer all the questions below.

Question 1. Choose the best answers from the given options (a) to (m).

(1) The Second-Order Derivative methods for Edge Detection
(2) Filter used to restore blurred images
(3) A geometric transformation that preserves lines and parallelism but not necessarily distances and angles.
(4) Distribution of pixel values
(5) Method for corner detection
(6) Methods for transformation of data from a high-dimensional space into a low-dimensional space which retain some meaningful properties of the original data.

(a). Fourier transform (b). Gaussian filter (c). Laplacian filter (d). Wiener filter
(e). Hough transform (f). Affine transformation (g). Sobel filter (h). Pseudo color transformation
(i). Harris operator (j). Histogram (k). Template matching (l). Homography (m). Principal component analysis

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* This question consists of 3 pages.

Question 2. In the image $f(x, y)$, the density values at coordinates (1,1), (1,2), (2,1), (2,2) are $f(1,1) = 80$, $f(1,2) = 160$, $f(2,1) = 145, f(2,2) = 90$. Calculate the values of $f(1.3, 1.6)$ using the nearest neighbor and bilinear interpolation methods.

Question 3. Any coordinates (x, y) can be transformed into (x', y') using the linear transformation. Similarly, an image can be transformed performing a linear transformation on its all pixel points.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix} \quad (1)$$

When the image is rotated by 30 degrees in the clockwise direction and is moved 15 units to the x direction and -8 units to the y direction. What are the values of $a \sim f$.

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* This question consists of 3 pages.

Question 4. Choose the best answer for the following two questions, and select the answers from the options.

(1) In the given figures, two normalized histograms p (Figure 1) and q (Figure 2) are shown for two images. The similarity intersection S can be calculated using Equation ①.
Select the value of S for the similarity intersection.

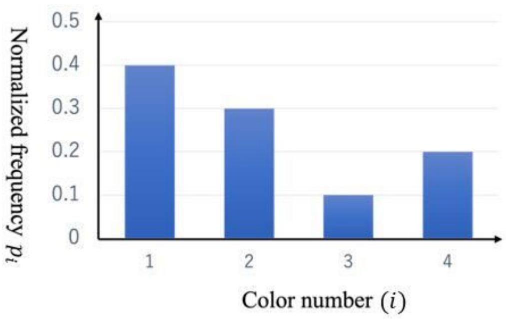

Figure 1 Normalized histogram p

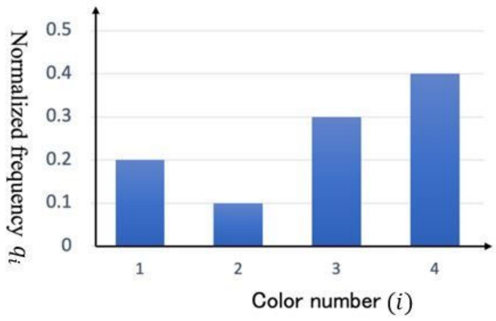

Figure 2 Normalized histogram q

$$S(p,\ q) = \sum_{i=1}^{n} \min(p_i, q_i) \quad ①$$

【Options】

(a) 0.0 (b) 0.4 (c) 0.5 (d) 0.6 (e) 0.8

(2) Sum of Squared Difference (SSD) can be used for Template matching. Figure 3 represents the target image I(x,y). Template T(x,y) is shown in Figure 4. SSD can be defined as $R(x,y)$ by Equation ②. This shows the degree of difference between the template and part of the target image (part: area covered by the template). We can assume the size of the template is M x N. The origin (0,0) is considered at the upper-left corner both in the image and template. On the x-axis, positive values are in the right direction while positive values are downward direction on the y-axis. Figure 5 shows the resulted values of degree of the difference for the given target image. Please calculate the value of A.

2	1	1	2	0
1	2	0	1	1
1	0	2	2	0
3	2	3	2	1
2	1	2	0	2

Figure 3 Target image

1	2
0	2

Figure 4 Template

3	9	1	7
5	5	6	9
13	A	10	10
9	3	12	2

Figure 5 Degree of difference

$$R(x,y) = \sum_{j=0}^{N-1} \sum_{i=0}^{M-1} \left(I(x+i, y+j) - T(i,j)\right)^2 \quad ②$$

【Options】

(a) 0 (b) 1 (c) 2 (d) 6 (e) 9

Master's Program, Information Science and Engineering Course, Graduate School of Information Science and Engineering, Ritsumeikan University

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Human Information Science⑪ Artificial Intelligence

This section consists of 2 pages. Answer all the questions below.

Question 1.

Answer the words or phrases suitable for blanks (1) and (2) in the breadth-first search algorithm below.

Line 1 Insert the initial state to the open list and initialize the closed list to empty.

Line 2 **while** (1) $\boxed{}$ **do**

Line 3 Remove the first element s from the open list. Add s to the closed list.

Line 4 If s is the target state, the search ends because a solution was found.

Line 5 Add all the states that are connected from s but have not been inserted in any lists yet to (2) $\boxed{}$ of the open list.

Line 6 **end while**

Question 2.

Let B be the event that an undergraduate student in computer science browses the homepage of this graduate school to decide if they should apply, where the information to be collected related to event A consisting of the following four mutually exclusive elements is considered.

A_1 : International efforts

A_2 : Research ability

A_3 : Curriculum

A_4 : Others

Here, let each of the prior probabilities A_i be

$$P(A_1) = 0.25,\ P(A_2) = 0.10,\ P(A_3) = 0.45,\ P(A_4) = 0.20$$

In addition, let each conditional probability of browsing the homepage of this graduate school to collect each element, from the access history so far, etc., is as follows:

$P(B|A_1) = 0.35$

$P(B|A_2) = 0.10$

$P(B|A_3) = 0.10$

$P(B|A_4) = 0.30$

(1) Find $P(B)$ using the total probability theorem.

(Choose the most appropriate answer from ① to ④ below.)

① 0.20

② 0.30

③ 0.40

④ 0.50

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* This section consists of 2 pages.

(2) Next, find the posterior probability $P(A_3|B)$ using Bayes' theorem.
(Choose the most appropriate answer from ① to ④ below.)

① 0.03
② 0.06
③ 0.11
④ 0.22

Question 3.

Explain <u>the processing flow of one of the typical</u> clustering methods by giving a <u>concrete example</u>.