Data structures and algorithms
Practical midterm
Mock midterm (translation of 2023 midterms)

Overview

1. float conversion, **versions:**
   (a) encoding
   (b) decoding
2. extended Euclidean algorithm
3. open address hash table, **versions:**
   (a) linear trial
   (b) quadratic trial
   (c) double hash
4. quicksort
5. counting sort (aka binsort)
6. Huffman encoding

Scoring

- 5 points per exercise, total 30 points
- 15-17 points: 2 (sufficient),
- 18-20 points: 3 (mediocre),
- 21-23 points: 4 (good),
- 24+ points: 5 (excellent).

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Data Structures and algorithms
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Group A

1. Assuming a floating point number with single precision, what value do the (hexadecimal) bytes `C4 16 2A 00` represent?

2. Calculate the greatest common divisor $d^\star$ of $a = 208$ and $b = 101$, then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 9$, with hash function given by:

$$h_0(k) = k \mod N, \qquad h(k,t) = \big(h_0(k) + t\big) \mod N.$$

   Draw the empty table, then insert (or delete, when instructed) the following keys, in order:

   66, 59, 37, 49, 22, delete 49, delete 22, 30

4. Sort the array A = $[5, 1, 4, 2, 8]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A = $[5, 4, 3, 1, 5, 3, 1, 1]$ using `BINSORT` (aka counting sort).

6. Encode the message `TRAMTRAIN` using the Huffman encoding. What is the coded message, and what is the average code length per character?

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Data Structures and algorithms
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Group B

1. Encode the value 243.34375 as a floating point number with single precision. Write the resulting bytes in hexadecimal.

2. Calculate the greatest common divisor $d^\star$ of $a = 420$ and $b = 348$ then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 8$, with hash function given by:

$$h_0(k) = k \mod N, \qquad h(k,t) = \left(h_0(k) + \frac{t(t+1)}{2}\right) \mod N.$$

   Draw the empty table, then insert (or delete, when instructed) the following keys, in order:

   65, 29, 44, 11, delete 44, 72, delete 11, 53

4. Sort the array A = $[6, 8, 3, 4, 2]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A = $[4, 4, 5, 3, 5, 2, 4, 2]$ using `BINSORT` (aka counting sort).

6. Encode the message `FEHÉR EGÉR` using the Huffman encoding. What is the coded message, and what is the average code length per character?

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Data Structures and algorithms
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Group C

1. Assuming a floating point number with single precision, what value do the (hexadecimal) bytes `C3 F6 E8 00` represent?

2. Calculate the greatest common divisor $d^\star$ of $a = 456$ and $b = 222$ then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 7$, with hash function given by:

$$h_0(k) = k \bmod N, \qquad h_1(k) = 1 + \big(k \bmod (N-1)\big),$$
$$h(k,t) = \big(h_0(k) + t \cdot h_1(k)\big) \bmod N.$$

   Draw the empty table, then insert (or delete, when so instructed) the following keys, in order:

   67, 9, 28, 37, 23, delete 9, delete 23, 64

4. Sort the array A $= [8, 5, 4, 2, 6]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A $= [5, 1, 2, 4, 1, 2, 5, 1]$ using `BINSORT` (aka counting sort).

6. Encode the message `RÉPATORTA` using the Huffman encoding. What is the coded message, and what is the average code length per character?

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Data Structures and algorithms
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Group D

1. Encode the value -413.375 as a floating point number with single precision. Write the resulting bytes in hexadecimal.

2. Calculate the greatest common divisor $d^\star$ of $a = 975$ and $b = 600$ then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 9$, with hash function given by:

$$h_0(k) = k \mod N, \qquad h(k,t) = \big(h_0(k) + t\big) \mod N.$$

   Draw the empty table, then insert (or delete, when instructed) the following keys, in order:

   85, 11, 42, 23, 50, delete 42, delete 50, 61

4. Sort the array A $= [9, 8, 2, 3, 1]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A $= [2, 3, 5, 3, 3, 4, 3, 5]$ using `BINSORT` (aka counting sort).

6. Encode the message `ESŐFELHŰ` using the Huffman encoding. What is the coded message, and what is the average code length per character?

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Group E

1. Assuming a floating point number with single precision, what value do the (hexadecimal) bytes `43 22 58 00` represent?

2. Calculate the greatest common divisor $d^\star$ of $a = 960$ and $b = 102$ then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 8$, with hash function given by:

$$h_0(k) = k \mod N, \qquad h(k,t) = \left(h_0(k) + \frac{t(t+1)}{2}\right) \mod N.$$

   Draw the empty table, then insert (or delete, when instructed) the following keys, in order:

   31, 96, 82, 26, delete 82, 39, delete 26, 63

4. Sort the array A $= [6, 7, 1, 3, 4]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A $= [1, 1, 5, 5, 1, 3, 1, 4]$ using `BINSORT` (aka counting sort).

6. Encode the message `TARKABARKA` using the Huffman encoding. What is the coded message, and what is the average code length per character?

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Group F

1. Encode the value 1001.1875 as a floating point number with single precision. Write the resulting bytes in hexadecimal.

2. Calculate the greatest common divisor $d^\star$ of $a = 602$ and $b = 313$ then write $d^\star$ as a linear combination (with whole number coefficients) of a and b.

3. Consider an open address hash table of size $N = 7$, with hash function given by:

$$h_0(k) = k \bmod N, \qquad h_1(k) = 1 + \big(k \bmod (N-1)\big),$$
$$h(k,t) = \big(h_0(k) + t \cdot h_1(k)\big) \bmod N.$$

   Draw the empty table, then insert (or delete, when so instructed) the following keys, in order:

   79, 17, 32, 66, 25, delete 32, delete 66, 81

4. Sort the array A $= [2, 7, 1, 9, 6]$ using `QUICKSORT`. Also draw the recursive call tree! How many recursive calls were made? How many times was the subroutine `PARTITION` called? How many swaps happened?

5. Sort the array A $= [3, 5, 5, 5, 2, 4, 2, 5]$ using `BINSORT` (aka counting sort).

6. Encode the message `SZERENCSE` using the Huffman encoding. What is the coded message, and what is the average code length per character?