



# **AUM**

**American University Of The Middle East**

COURSE Project (30%)

*Data Structures*

*CE368*

*Semester: Summer 2024*

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## 1. Introduction

Engineering projects help students learn and acquire practical knowledge. In addition to theoretical concepts, various industries also need to assess students' capacity to complete projects using specific initiatives. Therefore, we recommend that students undertake engineering projects during their four years of engineering studies and strive to present as many white papers as possible. Students who prioritize their course projects are expected to learn how to:

- Work effectively in teams, including multidisciplinary teams where applicable.
- Develop significant design experience based on the knowledge and skills acquired in coursework.
- Incorporate appropriate engineering standards and addresses multiple realistic constraints.
- Apply both analysis and synthesis in the engineering design process, resulting in designs that meet the desired needs.

## 2. Project Description

**Project Title:** Image Compression Using Huffman Coding

Encoding is the process of converting data from one format into another by putting a sequence of characters (letters, numbers, punctuation, and certain symbols) into a specialized format for efficient transmission or storage. In addition, encoding algorithms are generally useful to compress the data in which there are frequently occurring characters. There are many different encoding schemes or methods that can be used to encode data. Some schemes include: Burrows–Wheeler transform, Huffman Code, Run-length Encoding, etc. In this Project, we will be exploring and implementing Huffman Code for image compression.

**Huffman coding** was developed by David Huffman. Its main idea is to assign variable-length codes to inputs in which the lengths of the assigned codes are based on the frequencies of corresponding pixel intensity values. The variable-length codes assigned to inputs are known as Prefix Codes where each symbol is assigned a unique code which is not assigned to any other pixel intensity values. This is how Huffman Coding makes sure that there is no ambiguity when decoding the generated bitstream. There are two major steps in Huffman Coding:

1. Building a Huffman Tree from the input image.
2. Assigning code to the pixel intensity values by traversing the Huffman Tree

**The Pseudocode for Huffman Coding:**

1. Calculate the frequency of each pixel intensity value in the image and fill table-1-

Pixel Intensity Value	Frequency

Table-1-

2. Make each unique pixel intensity value as a leaf node.
3. Sort the pixel intensity values in increasing order of their frequency value.
4. Considering the first two nodes having minimum frequency. Create a new node Z. Assign the node with the first minimum frequency (smallest between) to the left child of Z and assign the node with the second minimum frequency to the right child of Z. Set the value of the Z as the sum of the above two minimum frequencies. (See Example -1-).
5. Insert node Z into the tree.
6. Repeat steps 3 to 5 for all remaining pixel intensity values.
7. Once the tree is completed:
  - a. For each non-leaf node, assign 0 to the left edge and 1 to the right edge.
  - b. Show the corresponding Tree
  - c. Fill the table-2-
8. Show/display/print the compressed image as a binary sequence (also called bitstream).

Pixel Intensity Value	Frequency	Code-word	Size.

Table-2

#### Example-1-:

Suppose we have the following 5x5 image with 8-bit color represented by the following matrix:

10	5	5	10	10
10	9	5	8	10
10	9	9	8	10
10	9	9	9	10
10	10	10	10	10

The uncompressed image will take  $5 \times 5 \times 8 = 200$  bits of storage. Table 1 will be as follows:

Pixel Intensity Value	Frequency
10	14
9	6
5	3
8	2

Table 2 will be as follows:

Pixel Intensity Value	Frequency	Code-word	Size
10	14	0	14*1
9	6	10	6*2
5	3	110	3*3



#### Deliverable 1-(100 points) 15% (Week 6):

- Students of each class need to form project groups (Group of 3 students)
- Deliverable 1 must be submitted through Moodle.
- Do not try to copy exact flowchart from the websites. Do not try to copy from other groups. Do not use ChatGPT.
- In Deliverable 1, A Power Point Presentation (PPT) with voice over must be **prepared** and submitted (Recording & Adding your Audio to slides in your PowerPoint. All Students should participate. Do not exceed 5 minutes). The PPT should include the following:
  - Using the above pseudocode and explanation, draw a flowchart for Huffman encoding algorithm along with a description of the different stages you have.
  - Test the algorithm for the image in appendix A. Show and explain the results and conclude. Solve this question by hand and Do not write a C Code. The C code is only required for Deliverable 2.
  - Show the corresponding tables with all entries (table 1 & 2) for each testing image. Show and explain the results. Solve this question by hand and Do not write a C Code. The C code is only required for Deliverable 2.
  - Show **the Huffman trees** built for two testing image I2 and I3 from appendix A.
  - Show each compressed image from **appendix A** as a binary sequence
  - Find the compression threshold for each testing image and conclude.
  - Find the height for the trees for testing images I2 and I3. Show and explain the results and conclude. Solve this question by hand and Do not write a C Code. The C code is only required for Deliverable 2.

#### Deliverable 2-(100 points) 15% (Week 7):

- Students need to form project groups (Same Group of students as in deliverable 1).
- In Deliverable two, a scientific report must be written and an interview will be held.
- Do not try to copy exact code from the websites. Do not try to copy from other groups. Do not use ChatGPT

#### Scientific Report [7.5%]:

- You have to answer the following:
  - Write a C code to implement the Huffman algorithm (Compression). The program must be menu driven. Upon running the program, the user is given a menu with the functions that can be performed. The user should be able to compress any image
  - Test your code for the images in **appendix B**. Show the result and conclude.
  - Show the corresponding tables with all entries (table 1 & 2) for each testing image for appendix B.
  - Show each compressed image from **appendix B** as a binary sequence.

- Find the compression threshold for each testing image and conclude.
- Test your code for the images in **appendix A**. Compare results from PD1 with results from PD2 and conclude.
- The scientific report must be **written** and submitted. **The report must be submitted through Moodle** and should include the following:
  - Full analysis of the above questions
  - The written C code along with comments must be included in the report. (**Source code and comments** to describe your code).
  - Screen shots of the all outputs must be provided in the report. The screen shots should demonstrate the functionality of the program showing all menus and showing the correct execution of all the functions.

#### **Interview/demo [7.5%]:**

- An interview will be held for PD1 and PD2. Grading will be individual based on answering questions regarding the program code and all details related to the project including PD1 and PD2. **In other words, a group of 3 people can have three different grades based on the oral exam.**
- The written C code must not include comments during the interview/demo. (**Source code with no comments** to describe your code).

### **3. ABET Learning Outcome**

- i. An understanding of various basic data structures, including stacks, queues, and trees. [1,6, 7]
- ii. An ability to analyze time complexity and space complexity of algorithms. [1,6, 7]
- iii. An ability to apply appropriate sorting and searching algorithms for a given application. [1,2,6, 7]
- iv. An ability to apply graph theoretic techniques, data structures and algorithms for problem solving. [1,2,6, 7]
- v. An ability to design and implement appropriate data structures and algorithms for engineering applications. [1,2,6, 7]

### **4. Student Project Evaluation:**

#### **Grade Distribution with Demo/prototype/simulation**

		<b>Weight</b>
<b>Project</b>	PD 1:	15%
	PD 2:	15%
<b>Total</b>		<b>30%</b>

- ✓ **Students may be asked to work in groups to complete certain assignments. Depending on the needs of the course, the faculty may arrange the groups and inform students on Moodle in advance.**
- ✓ **PD: Project Deliverable**



#### Notes:

- ✓ *Students have the full responsibility of:*
  - *submitting the required documents within the deadline*
  - *verifying that the correct files are submitted*
  - *verifying that the submitted files are not corrupted*
- ✓ *Softcopies are required to be uploaded into Turnitin when applicable.*

### 5. Overall Course Grading Scale

Please refer to the Student Handbook for more information on the Letter Grading System.

### 6. Group formation

Important notes:

- ✓ *Students of each class need to form project groups (Group 3)*

### 7. Project Management & Deliverables

This project is divided into the following deliverables:

**Deliverable 1 (PD1): PPT + Voiceover (Due date is week 6 – 15/07/2024-11:59pm):**

**Deliverable 2 (PD2): Scientific Report (Due date is week 7 – 21/07/2024-11:59pm)**

**Deliverable 2 (PD2): Demo (Due date is week 7 – Monday and Tuesday During your lectures)**

### 8. Academic Integrity and AI Utilization

Please refer to the syllabus

### 9. APA Style

AUM adopts the APA writing style for all its academic programs. AUM students need to use this style for their assignments. The following web site is of value for students: <http://owl.english.purdue.edu/owl/resource/560/01/>. Students are also encouraged to visit the AUM Writing Lab to receive help and guidance on all APA-related questions. The IEEE citation style is also accepted.

### 10. Project and team-based work

*The Project component of the course, if it exists, is essential to passing this course. The project shows competency in understanding and applying the course objectives and achieving learning outcomes. The project should allow students to investigate, apply, research, and practice real-life business situations. Each student should fully participate in the project as an effective team member. A project document will be distributed later in the semester with details.*

*For all collaborative projects, **the entire team bears collective responsibility for the outcome and deliverables of the project.** However, certain sections of the project may be evaluated on an individual basis, in accordance with the project's specific requirements as outlined in the project documentation.*



## 11. Student Assessment Rubric:

### 11.1 PD1 Grading Rubric: (Presentation with voiceover)

	<b>Unsatisfactory (0-59%)</b>	<b>Developing (60%-74%)</b>	<b>Satisfactory (75%-87%)</b>	<b>Excellent (&gt;88%)</b>
<b>Slides Content (20% - Group)</b>	The slides fail to meet any of the following criteria: 1) Information presented is accurate and relevant to the presentation topic 2) Content is well-organized, all key points are covered and clearly articulated. 3) An adequate level of detail is provided to cover and analyze the topic comprehensively	The slides meet only one of the following criteria: 1) Information presented is accurate and relevant to the presentation topic 2) Content is well-organized, all key points are covered and clearly articulated. 3) An adequate level of detail is provided to cover and analyze the topic comprehensively	The slides meet only two of the following criteria: 1) Information presented is accurate and relevant to the presentation topic 2) Content is well-organized, all key points are covered and clearly articulated. 3) An adequate level of detail is provided to cover and analyze the topic comprehensively	The slides meet all of the following criteria: 1) Information presented is accurate and relevant to the presentation topic 2) Content is well-organized, all key points are covered and clearly articulated. 3) An adequate level of detail is provided to cover and analyze the topic comprehensively
<b>Slides Design (10% - Group)</b>	The slides fail to meet any of the following criteria: 1) Video is of very good quality, visually engaging, and balanced in terms of text and figures. 2) Effective use of font and colors to emphasize key points and maintain visual appeal. 3) Consistent use of fonts, colors, and design elements throughout the presentation.	The slides meet only one of the following criteria: 1) Video is of very good quality, visually engaging, and balanced in terms of text and figures. 2) Effective use of font and colors to emphasize key points and maintain visual appeal. 3) Consistent use of fonts, colors, and design elements throughout the presentation.	The slides meet only two of the following criteria: 1) Video is of very good quality, visually engaging, and balanced in terms of text and figures. 2) Effective use of font and colors to emphasize key points and maintain visual appeal. 3) Consistent use of fonts, colors, and design elements throughout the presentation.	The slides meet all of the following criteria: 1) Video is of very good quality, visually engaging, and balanced in terms of text and figures. 2) Effective use of font and colors to emphasize key points and maintain visual appeal. 3) Consistent use of fonts, colors, and design elements throughout the presentation.

<b>Voiceover Delivery (20% - Individual)</b>	The voiceover fails to meet any of the following criteria: 1) Clear and audible voiceover, appropriate use of English language, and terminologies. 2) The student is explaining, not just reading, the presented information effectively. 3) Effective integration between the voiceover and slide content with minimal stumbles, filler words, or awkward pauses.	The voiceover meets only one of the following criteria: 1) Clear and audible voiceover, appropriate use of English language, and terminologies. 2) The student is explaining, not just reading, the presented information effectively. 3) Effective integration between the voiceover and slide content with minimal stumbles, filler words, or awkward pauses.	The voiceover meets only two of the following criteria: 1) Clear and audible voiceover, appropriate use of English language, and terminologies. 2) The student is explaining, not just reading, the presented information effectively. 3) Effective integration between the voiceover and slide content with minimal stumbles, filler words, or awkward pauses.	The voiceover meets all of the following criteria: 1) Clear and audible voiceover, appropriate use of English language, and terminologies. 2) The student is explaining, not just reading, the presented information effectively. 3) Effective integration between the voiceover and slide content with minimal stumbles, filler words, or awkward pauses.
<b>Voiceover Delivery (10% - Group)</b>	The team voiceover fails to meet any of the following criteria: 1) The time allocation between team members is fair and provides equal opportunities for each member to contribute 2) The presentation is delivered within the exact provided time. 3) Smooth transitions between team members' segments.	The team voiceover meets only one of the following criteria: 1) The time allocation between team members is fair and provides equal opportunities for each member to contribute 2) The presentation is delivered within the exact provided time. 3) Smooth transitions between team members' segments	The team voiceover meets only two of the following criteria: 1) The time allocation between team members is fair and provides equal opportunities for each member to contribute 2) The presentation is delivered within the exact provided time. 3) Smooth transitions between team members' segments	The team voiceover meets all of the following criteria: 1) The time allocation between team members is fair and provides equal opportunities for each member to contribute 2) The presentation is delivered within the exact provided time. 3) Smooth transitions between team members' segments
<b>Proposed Design(s) (40% - group)</b>	The proposed solution(s) fails to meet any of the following criteria: 1) Well-developed and detailed with no mistakes	The proposed solution(s) meets only one of the following criteria: 1) Well-developed and detailed with no mistakes	The proposed solution(s) meets only two of the following criteria: 1) Well-developed and detailed with no mistakes	The proposed solution(s) meets all of the following criteria: 1) Well-developed and detailed with no mistakes

	2) Clear and understandable explanation of the design concept 3) Adequate consideration of relevant and realistic constraints	2) Clear and understandable explanation of the design concept 3) Adequate consideration of relevant and realistic constraints	2) Clear and understandable explanation of the design concept 3) Adequate consideration of relevant and realistic constraints	2) Clear and understandable explanation of the design concept 3) Adequate consideration of relevant and realistic constraints
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## 11.2 PD2 Grading Rubric: (Technical Report with Q&A)

	Unsatisfactory (0-59%)	Developing (60%-74%)	Satisfactory (75%-87%)	Excellent (>88%)
<b>Scientific Report (50% - group)</b>	1) The solution/code is not well-developed through the needed approaches or may be incomplete or has numerous mistakes. 2) Prototype/model/simulation is poorly executed, lacking functionality or demonstrating significant flaws 3) Prototype/model/simulation results are not or incorrectly analyzed	1) The solution/code is partially developed through the needed approaches, has some mistakes, but may lack detail or cohesiveness 2) Prototype/model/simulation shows some functionality, but improvements are needed to enhance its quality and effectiveness 3) Prototype/model/simulation results are partially analyzed while not showing students understanding of the results	1) The solution/code well-developed through the needed approaches and detailed with minimal mistakes 2) Prototype/model/simulation is of good quality, demonstrating functionality and providing a realistic representation of the proposed design 3) Prototype/model/simulation results are briefly analyzed and discussed showing students understanding of the results	1) The solution/code is exceptionally well-developed and detailed through the needed approaches and has no mistakes, with a clear and cohesive design that demonstrates an exceptional level of thought and creativity 2) Prototype/model/simulation is of exceptional quality, accurately representing the proposed design and showcasing advanced functionality. 3) Prototype/model/simulation results are carefully analyzed and discussed
<b>Questions and Answers (50% - Individual)</b>	1) Provides incorrect or incomplete answers. 2) Does not exhibit any confidence in answering questions.	1) Provides partially correct or vague answers. 2) Shows limited confidence in answering questions and often appears hesitant/unsure.	1) Provides mostly correct answers with minor mistakes or limited details. 2) Shows confidence in answering questions but occasionally appears hesitant/unsure.	1) Provides correct and detailed answers. 2) Consistently demonstrates a high level of confidence while answering questions.

## Appendix A: Images for Testing

I1

5	5	5	10	10
10	9	5	8	8
9	9	9	8	10
9	9	8	7	10
10	10	8	10	10

I2

10	5	5	10	10	5
10	9	5	8	6	5
10	9	9	8	6	8
10	9	8	10	6	8
10	10	10	10	10	10
10	9	9	9	10	10

I3

9	5	5	10	6	6
9	9	5	8	5	5
10	9	9	8	10	8
10	9	8	10	10	8
9	10	10	10	10	10
10	8	8	8	10	10

## Appendix B: Images for testing

### I4

10	5	5	10	10	8	7	7
10	9	5	8	10	7	7	6
10	9	9	8	10	10	10	6
10	9	8	10	10	8	10	6
10	10	10	10	10	8	10	6
9	10	10	9	7	10	10	6
7	7	8	7	8	10	10	10
7	9	8	9	10	10	10	10

### I5

128	75	72	75	102	169	122	100
122	75	83	84	146	122	122	139
118	75	89	84	122	96	143	75
122	102	79	84	84	102	102	75
122	75	75	75	75	102	102	75
125	75	122	140	75	102	84	75
122	75	122	140	75	102	119	75
140	75	122	140	75	140	153	75

### I6

128	75	72	105	149	169	127	100
122	84	83	84	146	138	142	139
118	98	89	94	136	96	143	188
122	106	79	115	148	102	127	167
127	115	106	94	155	124	103	155
125	115	130	140	170	174	115	136
127	110	122	163	175	140	119	87
146	114	127	140	131	142	153	93