**Instructions:**

1. There are four questions in part 1 and three questions in part 2. Answer all questions in part 1 and any one question in part 2.
2. Complete neatly with your name and student number on the first page.
3. Turnitin is enabled for this assessment. Please submit your answer file in word format. PDF format, JPEG images are not allowed.
4. Upload your answer file to
5. Submission Deadline: 23:59 12 Jun 2021 (Sat). (You are recommended to complete it as early as you can and reserve sufficient time to submit your work)
6. Question 2 and question 4 contain variables (W, X, Y and Z) whose values depend on your student number. W, X, Y and Z are the 5th, 6th, 7th and 8th digits of your student number. For example, student number “0281”, W = 0, X = 2, Y = 8 and Z = 1.
7. Marks will be deducted if you do not follow the instructions.

**Part 1 (70%): Answer all questions in this part.**

**[12 Marks] Question 1:** Determine the MIDI message (in hex) for each of the below actions.

1. Pan the stereo of Channel 6 to absolute right

To pan the stereo position of channel 13 to center

-“Control Change” message id = 011

-Channel 6d = 1100b (note: channel is one-indexed)

-Control 10d = panning = 000 1010b

-The message is 1011 0110 0000 1010 0111 1111

Hex Notation: B60A7F

1. Change the instrument on Channel 68 to Rhodes Piano

Background

Channel 68 =1000100b

Rhodes Piano=4=0100

-“Control Change” message id = 011

-Control 4d = panning = 000 1010b

-The message is 1011 0100 0100 0110 0111 1111

Hex Notation : B4467F

1. Play the A4 note using ***mf*** loudness on Channel 6

A4=69

To play note 80 with max. velocity 127 on channel 13

-“Note Off” message id = 000, “Note On” id = 001

-Channel 6d = 0110b (note: channel is one-indexed)

-Note 80d = 101 0000b

-Velocity 127d = 111 1111b

-The message is 1001 0110 0101 0000 0111 1111

Hex Notation : 96507F

1. Turn off the note played in action 3.

-“Control Change” message id = 011

-Channel 13d = 1100b (note: channel is one-indexed)

-Control 10d = panning = 000 1010b

-The message is 1000 0110 0000 1010 0111 1111

Hex Notation: 860A7F

1. System reset

Hex Notation : 0xFF

*Note: refer to the MIDI message format and GM instrument patch map in the lecture notes and tutorial notes*

**[24 Marks] Question 2:** Consider a completely new musical instrument Q. The lowest frequency played by Q is 32.703 Hz. The frequency range of Q is U octaves plus V semitones, where U = 8+1, V = 1+1.

*Note: Y = 8, Z = 1 and U = 9, V = 2.*

1. What is the highest frequency that Q can sound? Show your steps clearly. **(4 marks)**

Background

Music Instrument Q

Lowest Frequency =32.703 Hz

Frequency Range { U octaves + V semitones}

U=8+1

V=1+1

Q=U octaves + V semitones

Q=9\*12+2=110 semitones

Tuning Frequency for the Highest shake

= 32.703\*2^(110/12)=18794.4327 Hz

Highest Frequency=18794.4327 Hz

1. Given that the frequency of middle C (note name C4) is 261.63 Hz, find the name of the highest frequency note sounded by Q. Show your steps clearly. **(4 marks)**

Frequency of the Middle C4 falls between A4 and E3 groupings of octaves

C 4-261.63

Highest frequency Range Ration is 2/12 x therefore

=12/2 \*262.63Hz

=1575.78 Hz

1. You are going to record a 5 minutes solo performance of Q.
   1. Suggest a suitable sampling rate for the recording. **(2 marks)**

Nyquist Sampling Technique. The Technique allows for the easier sampling of analog to digital samples based on the Nyquist sampling theory

* 1. Instead of mono, stereo is preferred for the recording. Suggest a reason to support the decision. **(2 marks)**

Stereo sound recording improves the psychoacoustic appeal of the music and gives a somehow 3D sonic image of the sound therefore mimicking the interaction of sound with space whilst mono recorded sound just gives a 2D sonic image representation and delivering sound as it is by not capturing its nature and interactions.

Compute the raw data size (in bytes) for the recording if the sampling size is 24-bit.

**(4 marks)**

-The CD sampling quality recorded with a stereo device will be at 24-bit at 44.1 kHz

-Therefore the raw data of the sound sample will be

24-bit @44.1 kHz 2\* 24\*44.1=1411.2 kbps

1. You just learn how to play Q. Although your solo performance in (c) was bad, you would like to share your first solo to your friends. However, you find that the raw data size in (c)(iii) is too big for sharing. You consider to re-record it in MIDI format or compress it using MP3 technology.
   1. Describe two disadvantages for choosing MIDI format for (c). **(4 marks)**

MIDI provides technology to package a few tens of KBs while raw audio data weighs tens to hundreds of MBs.

MIDI has a limited number of channels (16) and programs(128).

* 1. Describe two disadvantages for choosing MP3 format for (c). **(4 marks)**

Quality of video is dependent on the type of hardware and software use.

Compression of audio files using MP3 format usually results in the presence of artifacts which are residuals of the original.

**[16 Marks] Question 3:** Consider the following decoding order of a sequence of frames of a MPEG-1 Video:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Frame ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Frame Type | I | P | B | B | B | P | B | B | B | I | B | B | B | I | P | B | P |

1. What is the display order of the frames? **(6 marks)**

Display 1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Frame ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Frame Type | I | P | B | B | B | P | B | B | B | I |

Display 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 10 | 11 | 12 | 13 | 14 |
| I | B | B | B | I |

Display 3

|  |  |  |  |
| --- | --- | --- | --- |
| 14 | 15 | 16 | 17 |
| I | P | B | P |

1. Suppose there is an error in decoding frame ID R, which of the other frames may possibly suffer from error directly? **(6 marks)**
   1. R = 6

If there is an error at R=6 then the file will be read up-to the next P and there will be 2 displays

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Frame ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Frame Type | I | P | B | B | B | P | B | B | B | I |

* 1. R = 15

The last display doesn’t have an effect on the video frame

Display 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 10 | 11 | 12 | 13 | 14 |
| I | B | B | B | I |

Display 2

|  |  |  |  |
| --- | --- | --- | --- |
| 14 | 15 | 16 | 17 |
| I | P | B | P |

1. Compare the below two designs of frame structures:

Design U: I B B P B B I B B P B B I

Design V: I B B B B B B B B B B B I

* 1. Describe an advantage of choosing design U. **(2 marks)**

U-Closed GOP due to the presence of P frames closers .Useful for creating error resilient streaming such as the ABR streaming as it allows for a new start of streaming after closing the previous error one.

* 1. Describe an advantage of choosing design V. **(2 marks)** U-Open GOP as there are no P frame closers. Useful when you want to get the compression efficiency of the B-frames

**[18 marks] Question 4:** Consider a video with frame size of 6 x 6 and macroblock size of 2 x 2. The luma values in the reference frame (left) and current frame (right) are given as follows:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | 1 | 7 | 9 | 6 | 0 |  | # | # | # | # | # | # |
| 7 | 4 | 1 | 4 | 2 | 4 | # | # | # | 0 | 2 | # |
| 8 | 0 | 6 | 0 | 8 | 5 | # | # | # | 8 | 1 | # |
| 8 | 5 | 7 | 5 | 3 | 1 | # | # | # | # | # | # |
| 3 | 0 | 3 | 1 | 2 | 7 | # | # | # | # | # | # |
| 7 | 6 | 5 | 9 | 4 | 3 | # | # | # | # | # | # |

1. Find the motion vector of the highlighted macroblock using window search with search range

±1 pixel. Show your steps clearly. (10 marks)

Center Point

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | 4 | 1 |  | 4 | 2 |  | 4 |  | # | # | # | 0 | 2 | # |
| 8 | 0 | 6 |  | 0 | 8 |  | 5 | # | # | # | 8 | 1 | # |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| (-1,-1)   |  |  | | --- | --- | | 1 | 4 | | 2 | 5 | | (0,-1)   |  |  | | --- | --- | | 4 | 6 | | 5 | 3 | | (+1,-1)   |  |  | | --- | --- | | 6 | 7 | | 3 | 7 | |
| (-1,0)   |  |  | | --- | --- | | 2 | 0 | | 1 | 1 | | (0,0)   |  |  | | --- | --- | | 0 | 2 | | 1 | 8 | | (+1,0)   |  |  | | --- | --- | | 2 | 7 | | 8 | 8 | |
| (-1,+1)   |  |  | | --- | --- | | 1 | 2 | | 2 | 4 | | (0,+1)   |  |  | | --- | --- | | 2 | 4 | | 4 | 4 | | (+1,+1)   |  |  | | --- | --- | | 4 | 8 | | 4 | 8 | |

|  |  |  |
| --- | --- | --- |
| Step | Motion Vector | SAD |
| 1 | (-1,-1) | |0-1|+|2-4|+|8-2|+|1-5|= 4+3+2+0 = 13 |
| 2 | (0,-1) | |0-4|+|2-6|+|8-5|+|1-3|= 1+1+1+2 = 13 |
| 3 | (+1,-1) | |0-6|+|2-7|+|8-3|+|1-7|= 1+0+1+2 = 22 |
| 4 | (-1,0) | |0-2|+|2-5|+|8-1|+|1-2|= 3+2+3+3 = 13 |
| 5 | (0, 0) | |0-5|+|2-3|+|8-2|+|1-4|= 0+4+2+1 = 15 |
| 6 | (+1,0) | |0-3|+|2-7|+|8-4|+|1-8|= 2+0+0+3 = 19 |
| 7 | (-1,+1) | |0-1|+|2-2|+|8-2|+|1-4|= 4+5+2+1 = 10 |
| 8 | (0,+1) | |0-2|+|2-4|+|8-4|+|1-4|= 3+3+0+1 = 11 |
| 9 | (+1,+1) | |0-4|+|2-8|+|8-4|+|1-8|= 1+1+0+3 = 21 |

Therefore the best displacement is (1, -1) with SAD=4. (9 searches has been performed)

The residual is

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 – 4 | 2 – 2 | = | -4 | 0 |
| 8 – 0 | 1 – 8 | 8 | -7 |

1. Having computed the motion vector, determine the residual to be coded after motion compensation. **(4 marks)**

Min SAD=(0-4),(2-2),(8-0),(1-8)

=(-4),(0),(8),(7)

Motion Vector=(2,2)

Residual=(-4,0 ; 8,-7)

SAD TEST

MB Mean=(0+8+2+1)/2=2.75

A=|0-2.75|+|8-2.75|+|2-2.75|+|1-2.75|=2.75+5.25+0.75+1.75=10

A+2N^2=10+2(2^2)=18

(c) Having computed the residual, explain whether intra mode or inter mode coding should be used for this macroblock. **(4 marks)**

Min SAD=(0-4),(2-2),(8-0),(1-8)

=(-4),(0),(8),(7)

Motion Vector=(2,2)

Residual=(-4,0 ; 8,-7)

SAD TEST

MB Mean=(0+8+2+1)/2=2.75

A=|0-2.75|+|8-2.75|+|2-2.75|+|1-2.75|=2.75+5.25+0.75+1.75=10

A+2N^2=10+2(2^2)=18

If SAD 𝑚𝑖𝑛 ≤ 𝐴+2𝑁2, the match is acceptable and the inter mode is chosen and while otherwise there are no acceptable matches then code that particular macroblock as an intra mode.

Min SAD=(0-4),(2-2),(8-0),(1-8)

=(-4),(0),(8),(7)

Motion Vector=(2,2)

Residual=(-4,0 ; 8,-7)

SAD TEST

MB Mean=(0+8+2+1)/2=2.75

A=|0-2.75|+|8-2.75|+|2-2.75|+|1-2.75|=2.75+5.25+0.75+1.75=10

A+2N^2=10+2(2^2)=18

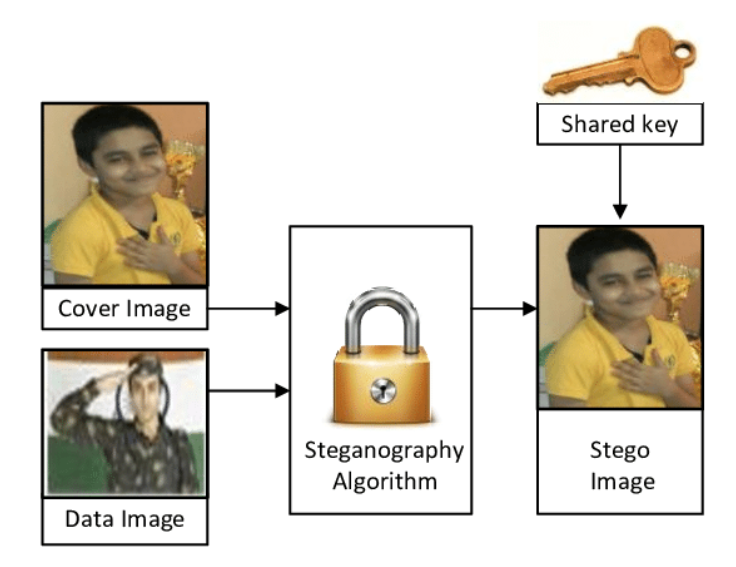
SAD min =1< A+2N^2

Therefore the searched MB is acceptable and so inter mode should be used

**Part 2 (30%):** **Answer any one question in this part**

**[30 Marks] Question 5:** JPEGsnoop ([https://www.impulseadventure.com/photo/jpeg-snoop.html)](https://www.impulseadventure.com/photo/jpeg-snoop.html) is a digital forensics software that able to tell whether a JPEG image was likely an original photo taken by a camera or had been edited using photo-editing software (e.g. Photoshop). In your own words, write a report in 300 to 400 words with appropriate diagrams to explain its digital forensics mechanism, its technical weakness, and explain whether the digital forensics mechanism can apply to MPEG videos or not.

**[30 marks]** **Question 6:** Steganography refers to techniques which hide secret information in a way that nobody but the sender and the intended recipient knows about the existence of the message. It is different from watermarking, which is a kind of digital signature to protect information against removal or modification. In your own words, write a report in 300 to 400 words with appropriate diagrams to describe how to apply steganography in images, videos and audio data, respectively. (You need to describe one method for hiding information in images, one method for videos, and one method for audio data.)

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Steganography refers to the techniques of secretly hiding data within an ordinary and non-secret file or message in order to avoid detection after which the secret data is retrieved at its destination. he definition is - we're hiding the fact that message has been sent by providing another meaningful message with some parts knowingly tweaked. Which parts and how severely tweaked - depends on the specific implementation, but it should not raise a concern that you’re exchanging those meaningful messages.

For the image it might be lower bits of colors - they don't affect the overall picture when changed - consider posting to FB. For the pure text file one bit might be defined as whether a line is shorter or longer than 80 characters - consider exchanging books or scripts or sources.

The point of steganography is to be able to pass secret messages over a channel that you know is observed. It is especially useful if strong encryption is impractical or unwise. For example, prisoners are not generally allowed access to encryption tools, and anything encrypted by hand is likely to be decrypted quickly by an attacker with access to a computer. Another example, if a secret agent wants to remain secret, it wouldn't do to be sending out encrypted messages all the time as it tends to arouse suspicion. Enter steganography.

One modern example is hiding data in computer images. The hidden stream is added to the RGB values of an image. If done correctly this is undetectable to the naked eye and can be difficult to detect even using the right tools. For even more security, the secret data can (and should) be encrypted first.

There are various techniques of Steganography that have been employed in a number of ways depending on the mode.

1.Least Significant Bit-The attacker identifies the least significant bits of information in the carrier image and replaces them with their secret message, but in this case it is the designated malicious code

2.Pallete Based Technique-The attacker firstly encrypts the message using encryption techniques cand then hides it in a stretched-pallete of their cover image. Although the technique uses a limited amount of data its threat quite frustrates hunters due to the encryption and decryption required to crack it.

3.Secure cover selection -This is a more advanced techniques where the attacker compares the block of the carrier image to the blocks of their specific malware. If the two image fit after the search then that likeness can be exploited upon . The identical malware blocks are carefully and closely fitted into the carrier image and this results to situation where the resulting image is identical to the original and the worst part I that this image cannot be flagged down or detected by threat-detection soft-wares and applications

Preventive measures that can be employed to stem out steganography include the updating of soft-wares and applications every now and then, deployment of new security patches on old-prone systems and also education the end-users about the exploit.

**[30 marks]** **Question 7:** FLAC (Free Lossless Audio Codec) is a non-proprietary lossless compression format for audio. FLAC performs better than classical lossless compression schemes for audio data and is able to reduce the size up to 50%. In your own words, write a report in 300 to 400 words with appropriate diagrams to describe the target applications, technical standards of FLAC, and explain why FLAC can achieve high compression rate for audio data.

**[End of Final Project]**