Maximum grade on this exam is: 100
Number of questions on the exam: 5
Number of pages of the exam: 9 (including cover page)

On this midterm is 100 points.
Carefully and answer the questions in the order which best suits you. The maximum grade
that can be earned is 100 points. The problems are of varying degrees of difficulty so please pace yourself.
If needed, use the backs of pages for additional work. Do your work inside this booklet, using the backs of pages
as necessary. Please staple this booklet together before returning.

This is a closed book, closed notes exam. You may use calculators and 1 side of a
cheat sheet.

Print your Name and NetID in the space provided below.

Instructions

Exam duration: 50 minutes
Spring 2012
CS 414 - Multimedia Systems Design
Midterm
Department of Computer Science
University of Illinois at Urbana-Champaign

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NetID: 
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Name: 
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Problem I: Multiple-choice (20 points - 10 questions 2 points each)

Need: Answer
10. ZF-4 in JPEG compression is introduced because
a. It is computationally more efficient to work with vectors rather than with
b. It allows better entropy encoding due to DC and AC coefficients

c. It allows better prediction of DC coefficients for entropy encoding.

9. In MPI, how did you change the playback file using Getframe?

4. Development robustness:
   a. Code flaws, buffer overflow handling
   b. Resolution, aspect ratio, viewing distance
   c. HDMI system differs from NTSC system in
   d. Code flaws, buffer overflow handling

8. Need:
For each element, use the name according to their functionality. Make sure that:

- Store the encoded video (not audio) in the file
- "AppSink" element and "FileSink" element
- Encode the video using "JPEGenc" and send it to a "FileSink"
- Show the uncompressed recorded video on the screen
- Read video frames from the webcam using "V4L2" interface

Problem 2 (20 Points)
2. (10 Points) Provide five differences between MPEG-4 video encoding standard and the previous MPEG video encoding standards (MPEG-1, MPEG-2).

- MPEG-4 works with all objects, MPEG-1/2 does not.
- MPEG-4 considers basic line and enhanced layer 3 encoding, MPEG-1/2 does not.
- MPEG-4 also supports motion data, while MPEG-1/2 does not.
- MPEG-4 video includes graphics, text and natural video.
- MPEG-4 has higher scalability than MPEG-1/2.
That we increase the original by $10 \cdot \log C = 3 \text{ dB}$.

So doubling physical intensity of sound means

\[
\frac{10 \log C + 10 \log \frac{C}{I}}{I} = 10 \log \frac{C}{I} + 10 \log C = 7, \quad \text{lives} \rightarrow 2 \times \text{lives}.
\]

How many decibels is the resulting sound?

b. (10 points) If you double the physical intensity of a sound, how many

\[
10 \log \left(\frac{I}{C}\right) + 10 \log I = 7
\]

combined source?

dB. What is the dB reading when both guitars play together (loudness of

a. (10 points) One guitar produces 45 dB while the other guitar produces 50

level, equal to the threshold of hearing

level, equal to 1 W/m². Assume dB = 10 \times \log(I/I_0), where I_0 is the reference

Consider that the threshold of hearing is at 1.12 W/m² and the threshold of pain

Problem 3 (20 points)

Need:
Consider the alphabet $A = \{a, b, g\}$. Let $p(a) = 0.5$, $p(b) = 0.3$, $p(g) = 0.2$.

1. (10 Points) Consider Arithmetic coding and consider a word that has the encoded value $0.275$, and the length of the word is $3$. What is the word? Show your work.

2. (10 Points) Encode the word “baggage” with variable Huffman coding (see Table 1) and with fixed coding (assuming 8 bits per character) and compare the compression ratios, i.e., determine which coding provides better compression ratio for the specified word.

Table 1: Huffman Table for Alphabet $A = \{a, b, g\}$

<table>
<thead>
<tr>
<th>Character</th>
<th>Huffman Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>01</td>
</tr>
<tr>
<td>b</td>
<td>00</td>
</tr>
<tr>
<td>g</td>
<td>01</td>
</tr>
</tbody>
</table>

Example:

- Baggage: $110000100 \rightarrow 10$ bits
- Huffman coding: $48 \times 8 = 384$ bits
- Fixed coding: $110000100 \Rightarrow 56 \times 8 = 448$ bits

Huffman coding provides $448/384 = 1.167$ times better compression.
Problem 5 (20 Points)

Consider uncompressed video with 640x480 pixels per frame, 24 bits per pixel resolution, 30 frames per second. Consider that the video frames are going to be segmented into transport packets and sent over the transport protocol, where the payload of the transport packet is 9 Kbytes and header of the transport packet is 24 bytes.

1. (15 Points) Translate the video characteristics into network QoS parameters.
   a. Network bandwidth BN (bits per second)
   b. Network rate RN (transport packets per second)
   c. Network packet inter-arrival time (in ms)

\[
\begin{align*}
M_A &= 640 \times 480 \times 24 = 921,600 \text{ Bytes} \\
R_A &= 30 \text{ fps} \\
M_N &= 9 \text{ KBytes} \\
N_P &= 9 \times 1024 = 9216 \text{ Bytes} \\
R_N &= \left[ \frac{M_A}{N_P} \right] = \left[ \frac{921,600}{9216} \right] = 100 \text{ packets per second} \\
B_N &= (M_N + \text{Header}) \times R_N = (9216 + 24) \times 100 = 271,720,000 \text{ Bits per second} \\
T_N &= \frac{1}{R_N} = \frac{1}{100} = 0.01 \text{ ms} \\
R_N &= \frac{M_A}{N_P} = \frac{921,600}{9216} = 100 \text{ packets per second} \\
B_N &= 271,720,000 \text{ Bits per second} \\
R_N &= \frac{1}{T_N} = \frac{1}{0.01} = 100 \text{ packets per second}
\end{align*}
\]
Second of 4 transport packets per second is 4 video frames per second. Hence, the worst case, the maximum number of lost video frames per second is 1 lost video frame. The worst case of loss for applications can be.

Frame rate is expected to be around 30 frames per second. Hence, any loss of transport packets will impact the loss of application data. Assume that the transport protocol does not retransmit the frames received. What is the maximum number of video frames per second that the application can expect to lose? (Note: 4 transport losses per second, 5 points).