The University of Western Ontario
Computer Science 2035b
Solutions for Midterm Examination - Friday, February 26th, 2016

<table>
<thead>
<tr>
<th>Surname</th>
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<tbody>
<tr>
<td>Given Name</td>
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This exam consists of 4 questions (10 pages including this page) worth a total of 100%. It is an open book exam, course notes and any MatLab book(s) are allowed. All answers are to be written in this booklet. Scrap work may be done on the back of each page; this will not be marked. No laptops or cell phones are allowed. The exam is 50 minutes long and comprises 20% of your final mark. Please print you full name and student number in the space provided above before you start this exam.

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<th>(1) 40%</th>
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Professor: John Barron
(40%) Consider the following MatLab matrices A, B and C:

\[ A = \begin{bmatrix} 10 & 15 & 16 & 18; \\ 90 & 28 & 12 & 13; \\ 41 & 23 & 15 & 59 \end{bmatrix}; \]

\[ B = \begin{bmatrix} 1 & 2 & 3; \\ 0 & 0 & 0; \\ 3 & 2 & 1 \end{bmatrix}; \]

\[ C = \begin{bmatrix} 1; \\ 2; \\ 3 \end{bmatrix}; \]

1. (4%) Using the original A above, if \( A(3:4,4:5) = \text{eye}(2,2) \) what is the value of A?

\[
\begin{bmatrix}
10 & 15 & 16 & 18 & 0 \\
90 & 28 & 12 & 13 & 0 \\
41 & 23 & 15 & 1 & 0 \\
0 & 0 & 0 & 0 & 1
\end{bmatrix}
\]

2. (4%) Using the original A above, if \( A(2:3,:) = \text{flipud}(A(2:3,:)) \) what is the value of A?

\[
\begin{bmatrix}
10 & 15 & 16 & 18 \\
41 & 23 & 15 & 59 \\
90 & 28 & 12 & 13
\end{bmatrix}
\]

3. (4%) What is B*B:

\[
B*B = \begin{bmatrix}
1*1+2*0+3*3 & 1*2+2*0+3*2 & 1*3+2*0+3*1 \\
0*1+0*0+0*3 & 0*2+0*0+0*2 & 0*3+0*0+0*1 \\
3*1+2*0+1*3 & 3*2+2*0+1*2 & 3*3+2*0+1*1
\end{bmatrix} = \begin{bmatrix}
10 & 8 & 6 \\
0 & 0 & 0 \\
6 & 8 & 10
\end{bmatrix}
\]
4. (4%) What is \( B \cdot B \):

\[
B \cdot B = \begin{vmatrix} 1 & 2 & 3 \\ 0 & 0 & 0 \\ 3 & 2 & 1 \end{vmatrix} = \begin{vmatrix} 1 & 4 & 9 \\ 0 & 0 & 0 \\ 9 & 4 & 1 \end{vmatrix}
\]

5. (4%) What is the value of \([B; C]\)?

Error using vertcat
Dimensions of matrices being concatenated are not consistent.

6. (4%) What is the value of \([C; C]\)?

\[
[C; C] = \begin{vmatrix} 1 \\ 2 \\ 3 \\ 1 \\ 2 \\ 3 \end{vmatrix}
\]

7. (4%) Consider a 3 element column vector \( s \). How would you solve the system of equations \( B \cdot s = C \), where \( B \) and \( C \) are as above? Do not try to solve this system of equations!!!

\[
s = B \backslash C
\]

When I run it, I get: Warning: Matrix is singular to working precision.

\[
s = NaN
\]

\[-Inf
\]

\[Inf\]
8. (4%) What happens when we execute \((B\times C)'\)?

\[(B\times C)' = \begin{bmatrix} 14 & 0 & 10 \end{bmatrix}\]

9. (4%) What happens when we execute \((C\times B)'\)?

Error using *  
Inner matrix dimensions must agree.

10. (4%) Using the original 3\times4 array \(A\), what is the value of \(\text{reshape}(A,4,3)\)?

Take the elements of \(A\) column by column (i.e. \(A(:,')\)):

10 90 41 15 28 23 16 12 15 18 13 59

Now put them in the new array column by column

\(\text{reshape}(A,4,3)\) is

\[
\begin{bmatrix}
10 & 28 & 15 \\
90 & 23 & 18 \\
41 & 16 & 13 \\
15 & 12 & 59 \\
\end{bmatrix}
\]

[Take the elements of \(A\) column by column.]
(2) (15%) This is the Lab question.

1. (5%) Consider the following expression: $6-5+4*3/2^1$. Write this expression with parentheses to reflect the precedence of the operators. What is the value of the expression?

Parenthezied expression and its value:

$$(((6-5)+((4*3)/(2^1)))) = 7$$

2. (10%) Consider the follow graph.

Figure 1: $y = x.^2$ for $x \in [-10, 10]$. 
Give the MatLab to plot this graph. Label the $x$ and $y$ axes in the colours shown and using fontsize 18. Show the title printed in the colour shown with fontsize 24. Note that in order to prevent $^\wedge$ from being interpreted as a superscript you must backslash it, i.e. $\wedge$, in a character string in MatLab.

Answer:

```matlab
x=[-10:10];
y=x.^2;
plot(x,y);
title(’\fontsize{24} \color{blue} y=x.^2’);
xlabel(’\fontsize{18} \color{green} x axis’);
ylabel(’\fontsize{18} \color{red} y axis’);
print midterm2016.jpg -djpeg
```
(3) (25%) This question is related to Assignment 2 in that it is about the use of `circshift` and convolution. Suppose we want to compute $1^{st}$ order derivatives, $Y_X$, using a 4-point central difference mask with values $[1 -8 0 8 -1]/12$. Consider applying this row vector mask to a grayvalue image $Y$.

1. (3%) What is the MatLab statement for applying `mask` to image $Y$ using `imfilter` to compute $Y_X$, where the output image $Y_X$ is the same size as the input image $Y$? (We refer to this solution as $Y_{X1}$ later.)

   ```matlab
   mask=[1 -8 0 8 -1]/12;
   Y_X1=imfilter(Y,mask,'conv','same','symmetric');
   Need to specify how border are handled. If no boundary handler is specified values where the boundary is overlapped are set to zero.
   ```

2. (7%) If a vectorized solution for $Y_X$ is required, show the `circshift` statements required and the vectorized calculation required on them to get $Y_X$ (we refer to this solution as $Y_{X2}$ later):

   ```matlab
   Yp2= 1.0*circshift(Y,[0 -2]);
   Yp1=-8.0*circshift(Y,[0 -1]);
   Ym1= 8.0*circshift(Y,[0 1]);
   Ym2=-1.0*circshift(Y,[0 2]);
   Y_X2=(Yp2+Yp1+Ym1+Ym2)/12;
   ```
3. (3%) What is the MatLab statement for applying mask to image \( Y \) using \texttt{imfilter} to compute \( Y_Y \), where the output image \( Y_Y \) is the same size as the input image \( Y \)? Note that the mask values must be applied vertically. (We refer to this solution as \( Y_{Y1} \) later.)

\[
Y_{Y1} = \texttt{imfilter}(Y, \text{mask}, \text{'conv'}, \text{'same'}, \text{'symmetric'})
\]

or

\[
Y_{Y2} = \texttt{imfilter}(Y', \text{mask}, \text{'conv'}, \text{'same'}, \text{'symmetric'})
\]

4. (7%) If a vectorized solution for \( Y_Y \) is required, show the \texttt{circshift} statements required and the vectorized calculation required on them to compute \( Y_Y \) (we refer to this solution as \( Y_{Y2} \) later).

\[
Y_{p2} = 1.0 \cdot \texttt{circshift}(Y, [-2 0])
\]

\[
Y_{p1} = -8.0 \cdot \texttt{circshift}(Y, [-1 0])
\]

\[
Y_{m1} = 8.0 \cdot \texttt{circshift}(Y, [1 0])
\]

\[
Y_{m2} = -1.0 \cdot \texttt{circshift}(Y, [2 0])
\]

\[
Y_{Y2} = (Y_{p2} + Y_{p1} + Y_{m1} + Y_{m2}) / 12
\]
5. (5%) How and where do $Y_{X1}$ and $Y_{X2}$ and $Y_{Y1}$ and $Y_{Y2}$ differ from each other?

$Y_{X1}$ and $Y_{X2}$:

They differ in the first two and last two columns. imfilter uses reflection there and vectorization uses wraparound. Note that the derivative values at the top and bottom rows are the same.

$Y_{Y1}$ and $Y_{Y2}$:

They differ in the first two and last two rows. imfilter uses reflection there and vectorization uses wraparound. Note that the derivative values at the left and right columns are the same.
(4) (20%) Consider the following row vector $Q = [1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9]$;

1. (5%) What does $L = Q + 3 < 8$?

   $1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0$

2. (5%) What does $C = \text{find}(Q + 3 < 8)$ print?

   Note that $L(:,)'$ is a 1D row vector: $1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0$
   $C = \text{find}(Q + 3 < 8)$ gives the 1D coordinates:
   $C = 1 \ 2 \ 3 \ 4$

3. (5%) What does $\text{size}(Q)$ print?

   $\text{size}(Q)$
   $1 \ 9$

4. (5%) What does $\text{sum}(L(:,))$ compute?

   $L = Q + 3 < 8$. So $L'$ is $1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0$ ($L'$ is a row vector). So $L(:,)'$ which is $L'$ (as $L$ is a vector)
   has values $1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0$ and thus $\text{sum}(L(:,)) = 4$. 
2016 Midterm Statistics

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