

Multimedia
Module No: CM3106
Laboratory Worksheet Lab 5 (Week 6):
MATLAB Graphics, Images and Video
Formats

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Aims and Objectives

After working through this worksheet you should be familiar with:

- colour maps in 8-bit images
- Graphics and Image Colour Spaces
- Chroma Subsampling
- Aliasing effects due to subsampling
- The basic use of MATLAB to investigate the above.

None of the work here is part of the assessed coursework for this module

MATLAB Graphics Images and Video Formats

1. **Dithering:** Implement a Dithering algorithm in MATLAB. A basic approach to dithering is described in the lecture notes (www.cs.cf.ac.uk/Dave/Multimedia/PDF/08_MMREPS_Grap_Im_Vid.pdf). Try other dithering patterns of your own.

You may use the Lena images (as used in lecture notes example): www.cs.cf.ac.uk/Dave/Multimedia/exercises_BSC/lena.bmp or built in MATLAB images or any image for that matter.

Hint: Given a 4x4 dithering Matrix, `di`, we can use the MATLAB function `repmat()` to Repeat the matrix to same size (`m x n`) as the image e.g. `mat = repmat(di,m/4, n/4)`; See MATLAB doc/help for `repmat()`.

Some example code (with a very stupid dithering pattern, just for illustration) is available at:

www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/Graphics/dither_q1_hint.m.

2. **Colour maps:** Load the example image from the tutorials, *parrots.gif*, into a MATLAB array. The image is downloadable from: www.cs.cf.ac.uk/Dave/Multimedia/exercises_BSC/parrots.gif
 - Read in the image and its corresponding colour map to appropriate MATLAB structures and *display* the colormap in a MATLAB figure.
 - Find out about *default* MATLAB colour maps (`help colormap()`) and apply it to the parrot image. *I.e.* Display the image with its new colour map in a MATLAB figure.
 - Return the in original image colour map, *negate* the image via manipulation of its colour map.
3. **Graphics and Image Colour Spaces:** Load the example image from the tutorials, *parrots.jpg*, into a MATLAB array. The image is downloadable from: www.cs.cf.ac.uk/Dave/Multimedia/exercises_BSC/parrots.gif. Convert the image to to following color space formats and display each colour channel in a separate MATLAB figure.
 - LAB colour format

- YUV (NTSC) colour format
- YCrCb colour format
- Write a MATLAB function to convert from RGB to CMY and CMYK colour space. Write a reverse CMY(K) to RGB conversion function also.

See the example program to get started here:

www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/Graphics/rgb_eg.m

4. **Chroma Subsampling.** Write a MATLAB function to perform chroma subsampling on an input YIQ or YCrCb image. The function should support the input of all the common subsampling formats *i.e* 4:2:2, 4:1:1, 4:2:0 and possibly other variations.
5. **Image Aliasing errors:** This question is meant to get to to investigate the effects of downsampling and then up-sampling an image:
 - Read in a RGB image, *e.g.* the parrots.jpg above will do.
 - Apply MATLAB's **imresize()** function to subsample the image by a 1/4. Display this image.
 - Now apply **imresize** on the subsampled image to restore the image to its original size, rescale by a factor of 4. Display this image. Note the change from the original.
 - Compute the absolute difference of this image and the original and display the resultant difference image. Explain the results you see.
 - Experiment with other scaling factors, *e.g.* 2, 8, 16 ...
6. **Chroma subsampling aliasing errors:** Similar to previous question but this question is meant to get you to investigate how chroma subsampling aliasing errors arise and what they look like:
 - Read in a RGB image, *e.g.* the parrots.jpg above will do.
 - Convert the image to YIQ and/or YCrCb Colour Space
 - In a similar fashion to the previous question, apply a down and up sampling on the IQ or CrCb channels with a scale factor of 2,4,8 etc. You may also try real common subsampling formats *i.e* 4:2:2, 4:1:1, 4:2:0.

- Reconvert the image back to RGB and display this image. Compare original with the displayed image.
 - Compute the absolute difference of this image and the original and display the resultant difference image. Explain the results you see.

See examples for hints to do the above:

- [chromasubsampling_eg1.m](#)
- [chromasubsampling_eg2.m](#)
- [chromasubsampling_eg3.m](#)
- [chromasubsampling_eg4.m](#)

7. Download and run the **Aliasing in Video** MATLAB demos from the lecture:

www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/image_aliasing/aliasing_wheel.m
www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/image_aliasing/raster_aliasing.m

The supporting images for the above are available at:

www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/image_aliasing/spokes.gif,
www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/image_aliasing/spokesR.gif
 (used in [aliasing_wheel.m](#)) and
www.cs.cf.ac.uk/Dave/Multimedia/Lecture_Examples/image_aliasing/barbara.gif
 (used in [raster_aliasing.m](#))

Examine the code and try and change a few parameters and observe the effect. Try and understand what each step of the code achieves.

Revision Questions

The following questions are examples of the sort of questions you will be asked in the exam — in fact practically all these questions are taken from past exam papers. For full exam paper questions and solutions please see the CM3106 web page: www.cs.cf.ac.uk/Dave/Multimedia/EXAMS/

1. **Question 2 Exam 2012 Solution:**

www.cs.cf.ac.uk/Dave/Multimedia/EXAMS/Multimedia_BSC_Exam_2012SOLNS.pdf

- (a) How does the *human eye* sense colour? What characteristics of the human visual system can be exploited for the compression of colour images and video?
- (b) What is the *YIQ colour model* ? How is compression achieved with YIQ in Analog NTSC Video and Digital MPEG Video?
- (c) What is a *colour look-up table* and how is it used to represent colour? [5]
 Give an advantage and a disadvantage of this representation with respect to true colour (24-bit) colour. [2]
 How do you convert from 24-bit colour to an 8-bit colour look up table representation?
- (d) Describe how colour look-up tables can be used to implement simple computer animations. Illustrate your answer with the following example: In a 7x7 image you have to animate a 3x3 red square moving from left to right at a rate of 2 pixels per frame. The square is centred vertically within the image and the image background is black.
 Give a limitation of colour look-up table animation.

2. **Question 2 Exam 2011.** Solution:

www.cs.cf.ac.uk/Dave/Multimedia/EXAMS/Multimedia_BSC_Exam_2011SOLNS.pdf

- (a) Dithering is often used when converting greyscale images to monochrome.
- i. What is the basic idea of dithering?
 - ii. For the given 2×2 dither matrix, briefly describe the *ordered dithering* algorithm.

$$\begin{pmatrix} 0 & 2 \\ 3 & 1 \end{pmatrix}$$

- iii. Use the same dither matrix, what is the result for the following input? Assume that the input is greyscale intensities normalised to **0 to 1**.

0.66	0.18	0.03	0.19
0.54	0.13	0.56	0.37
0.70	0.99	0.88	0.46
0.67	0.17	0.67	0.98

- (b) Different colour models are often used in different applications. What is the CMYK colour model? Give an application in which this colour model is mostly used and explain the reason.
- Given a colour represented in RGB colour space as $R = 0.2$, $G = 0.6$, $B = 0.3$, what is its representation in the CMYK colour model?
- (c) Give *three* colour models other than RGB/CMYK and give a practical application in which that model is used.
- (d) What is chroma subsampling? Why is chroma subsampling meaningful? What is the benefit of doing chroma subsampling? For the following array of colour values, give chroma subsampling results with 4:2:2, 4:1:1 and 4:2:0 schemes.

80	88	96	12
60	8	72	68
24	52	52	8
28	20	48	12

3. **Question 2 Exam 2006 Solution:**

www.cs.cf.ac.uk/Dave/Multimedia/EXAMS/MM_BSC_SOLNS_2006.pdf

- (a) List three distinct models of colour used in multimedia. Explain why there are a number of different colour models exploited in multimedia data formats.
- (b) Compression of colour has been exploited since analog video. How was colour compression achieved in analog video? Compare this colour compression technique to those used in digital video.

4. **Question 2 Exam 2004 Solution:**

www.cs.cf.ac.uk/Dave/Multimedia/EXAMS/MM_BSC_SOLNS_2004.pdf

(a) What is the YIQ color model and why is this an appropriate color model used in conjunction with compression methods such as JPEG and MPEG?

(b) Given the following YIQ image values:

128	126	127	129
124	123	124	124
130	136	132	132
154	143	132	132

Y

55	66	54	54
56	57	56	56
45	56	58	49
34	36	39	37

I

44	44	55	55
44	44	55	55
34	34	36	35
35	35	34	34

Q

What are the corresponding chroma subsampled values for a

- i. 4:2:2 subsampling scheme
- ii. 4:1:1 subsampling scheme
- iii. 4:2:0 subsampling scheme