CM2202: Scientific Computing and Multimedia Applications

Module Introduction

Prof. David Marshall, Dr. Yukun Lai & Dr. Steven Schockaert

School of Computer Science & Informatics

Outline:Scientific Computing and Multimedia Applications

Module Leader : Prof. David Marshall

Lecturers : Prof. David Marshall, Dr. Yukun Lai & Dr. Steven Schockaert

Full contact details on Learning Central

Module Format

20 Credit Module:

- 44 lectures on key principles:
  - **4 per week**
- In-lab instruction (10 sessions):
  - 2 hours per week (from week 2)
- 10 example classes/tutorials:
  - 1 hour per week (from week 2)

What do you want to get out of this module?

- What do you think this module is about?
- Why are you doing this module?
- What skills from the module are important to you?
  - Why?

Any Interest in?

- Computer Graphics?

Any Interest in?

- Computer Graphics?
- Image Processing?

Any Interest in?

- Computer Graphics?
- Image Processing?
- Computer Vision?

Any Interest in?

- Computer Graphics?
- Image Processing?
- Computer Vision?
- Multimedia?

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- Image Processing?
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- Multimedia?
- Scientific Computing?

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- Image Processing?
- Computer Vision?
- Multimedia?
- Scientific Computing?
- Mathematics for Computer Science?

Any Interest in?

- Computer Graphics?
- Image Processing?
- Computer Vision?
- Multimedia?
- Scientific Computing?
- Mathematics for Computer Science?
- MATLAB Programming?

Module Description

- Gives a **broad grounding** in **MATLAB programming**
- Applications in **data**, **audio**, **graphics** and, **image** and **signal processing**.
- Provides continuous mathematical and programming skills necessary for a computer scientist specialising in **Multimedia**, **Graphics**, **Image Processing** or **Scientific Computing**.
- Provides the **fundamental mathematical background** for an understanding of these topics.

Underpins Theory for above final year modules

Basic Syllabus Outline

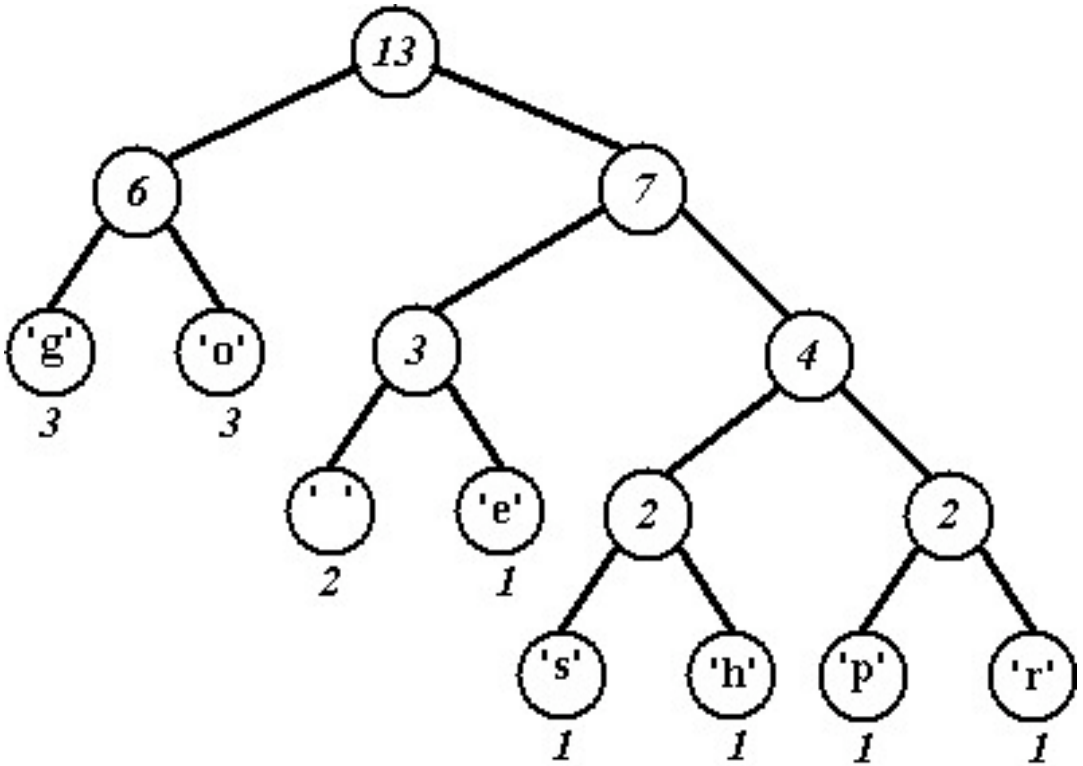
Topic	*Lecturer*	*Number of Lectures*
1. General Mathematics	DM	7
2. Discrete Probability Theory	SS	6
3. Linear Algebra	YL	4
4. MATLAB Programming	YL	6
5. Basic Digital Signal Processing	DM	3
6. Basic Digital Image Processing	DM	2
7. Fourier Transform and Its Applications	DM	2
8. Geometric Computing for Computer Graphics	YL	6
9. Formal Languages and Automata Theory	SS	8

DM = **David Marshall** YL = **Yukun Lai** SS = **Steven Schockaert**

Selected Examples of Use in Computer Science (1):Counting, Statistics, Probability

- Basic Counting and Statistics: Empiric measurement and evaluation in almost every scientific discipline
- Probability: Dealing with uncertainty in data. Many Applications
- Data Compression: Use Data Statistics to compress data: GIF, JPEG, MPEG, security coding/transmission.
- Artificial Intelligence: Uncertain Reasoning, Planning.
- Image Processing/Computer Vision: Identification of objects, tracking, Image Analysis.
- Market Analysis, Surveys, Risk Assessment in Many Areas
- Knowledge Based Systems: Database and Knowledge Representation, Deductive reasoning

Statistics/Graphs Example: Compression/Coding

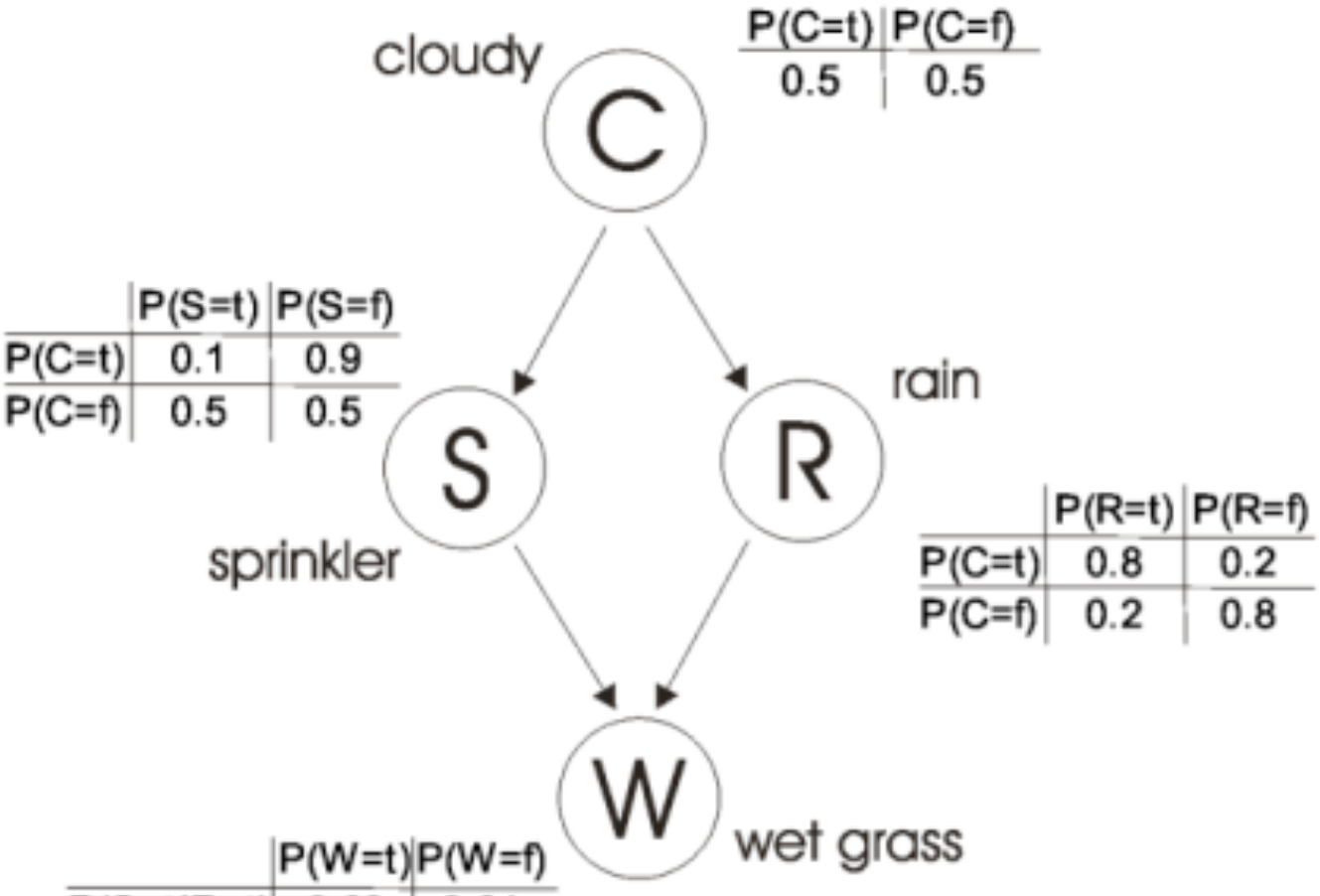


Codes:

char	binary
'g'	00
'o'	01
'p'	1110
'h'	1101
'e'	101
'r'	1111
's'	1100
' '	100

- Count number of occurrences of tokens (characters here) in a sequence.
- Sort then in a tree
- Code via tree traversal

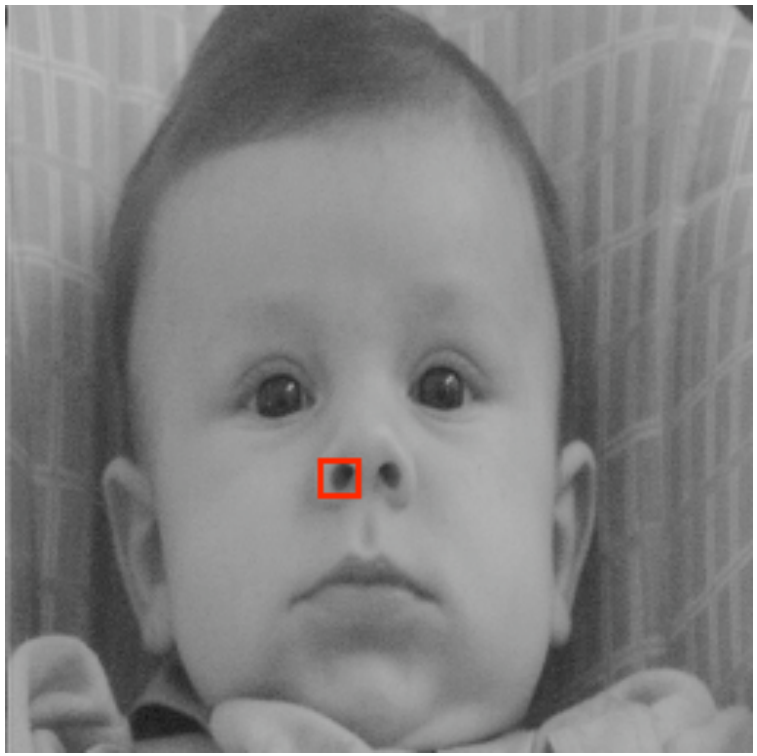
Statistics/Graphs Example: Knowledge Repesentation and Reasoning



Selected Examples of Use in Computer Science (2): Mathematical Representations and Manipulation

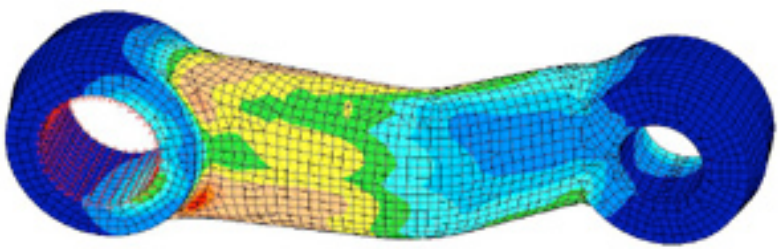
- Basic Linear Algebra — solutions of equations needed in almost every scientific discipline
- Vectors and Matrices — fundamental data structures in computer science e.g. *Arrays, Linked Lists*, **Computer Graphics** and **Image Processing/Computer Vision**
- Numerical Analysis — scientific computing and practical computational mathematics
- Computer Graphics: Transformations, moving object around the screen, 3D deformations ...
- Image Processing/Computer Vision: Images = matrices, Tracking objects, Object Recognition, Camera Calibration ...
- Data Compression: JPEG/MPEG, Image/Video/Audio Compression, Vector Quantisation

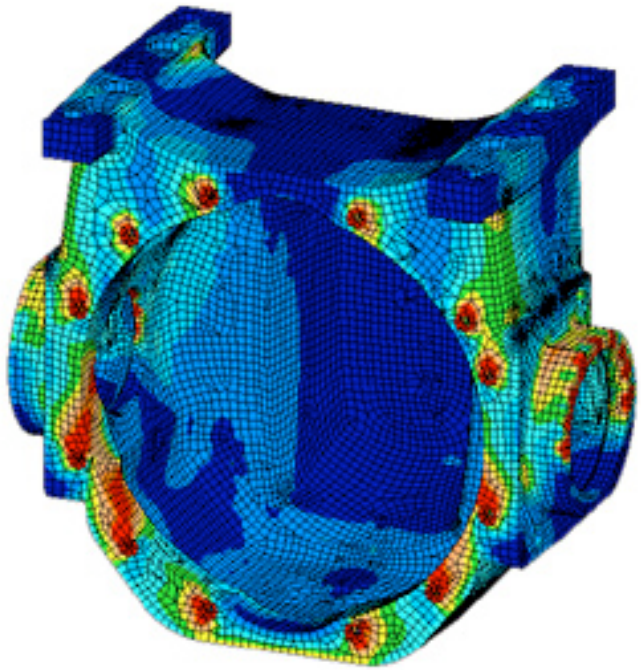
Matrices Example: Image Representation



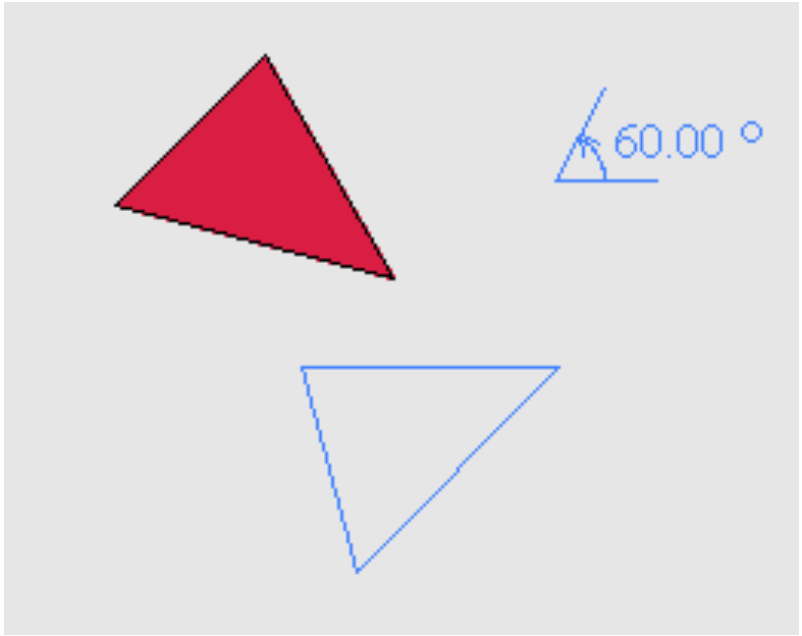
99	71	61	51	49	40	35	53	86	99
93	74	53	56	48	46	48	72	85	102
101	69	57	53	54	52	64	82	88	101
107	82	64	63	59	60	81	90	93	100
114	93	76	69	72	85	94	99	95	99
117	108	94	92	97	101	100	108	105	99
116	114	109	106	105	108	108	102	107	110
115	113	109	114	111	111	113	108	111	115
110	113	111	109	106	108	110	115	120	122
103	107	106	108	109	114	120	124	124	132

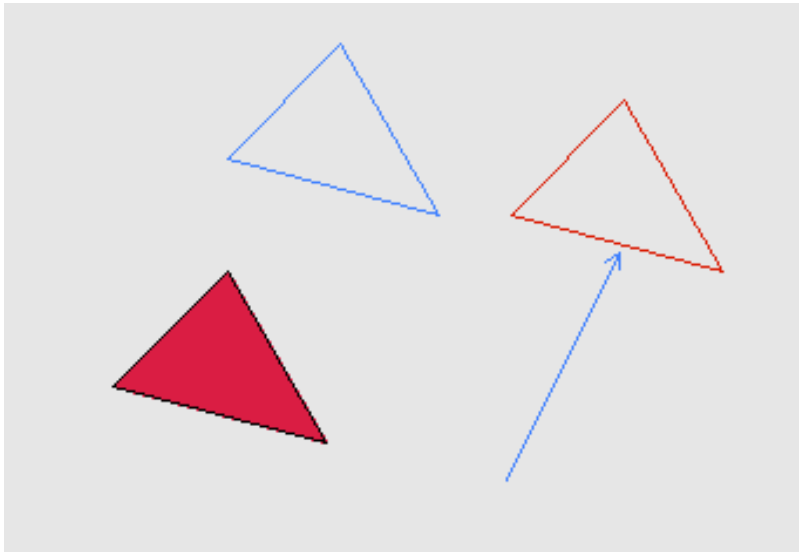
Algebra/Graphs Example: Finite Element Modelling





Matrices Example: Computer Graphics Transformations

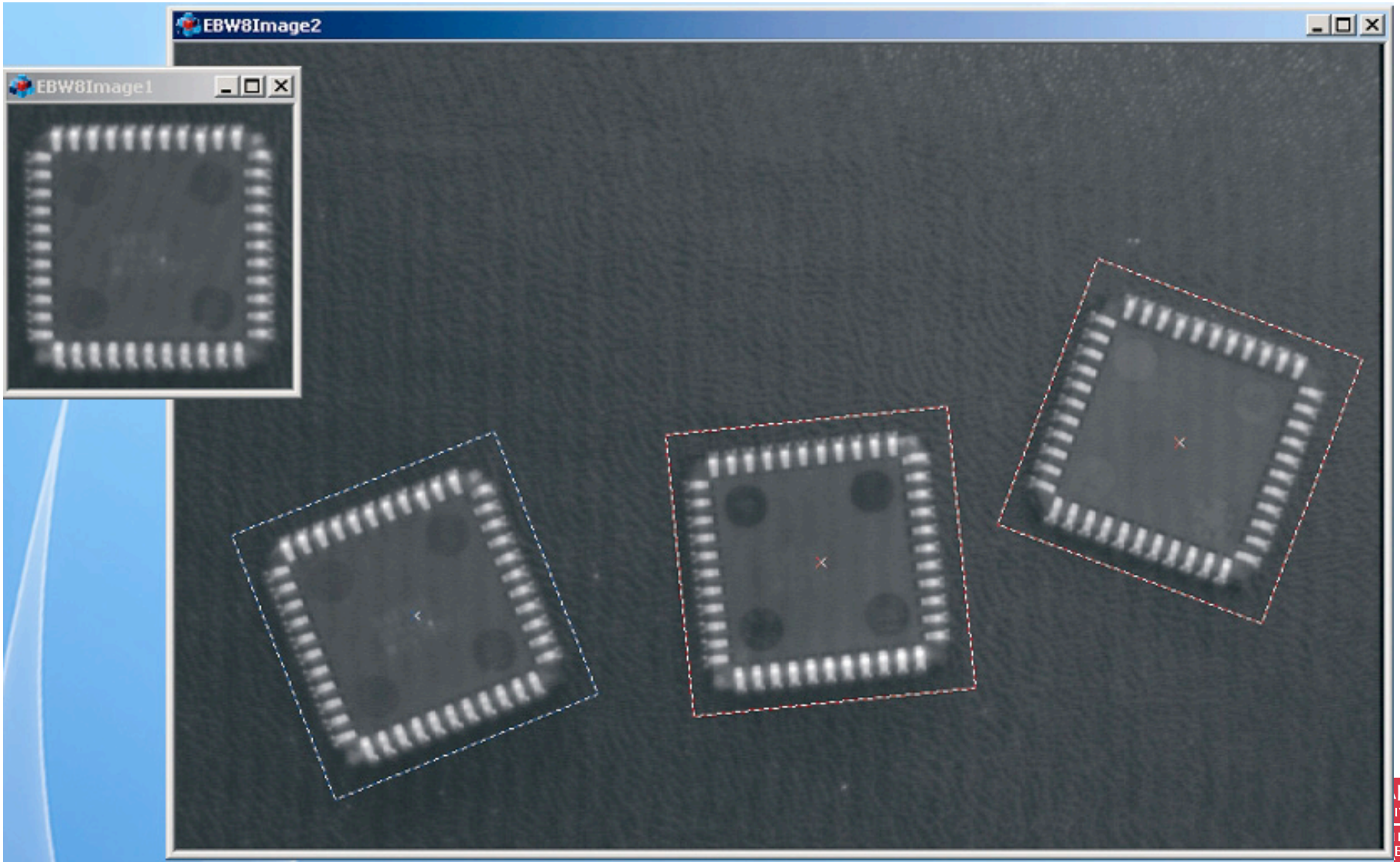




$$\begin{bmatrix} X_{rotated} \\ Y_{rotated} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} X_{translated} \\ Y_{translated} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & D_x \\ 0 & 1 & D_y \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

Matrices Example: Object Registration/Matching



Matrices Example: Image Warping (Transformation)

Matrices/Vector Example: Image Compression

Relevant Final Year Modules

Precursor Module for Year 3 Modules

CM3106 : Multimedia

CM3102 Graphics, Visualisation and Computer Vision

which either use MATLAB as a base programming language and/or build on some theory developed in this module.

Some potential relevance to:

CM3203 : Individual Project

Lecture Schedule

Week 1	4	4	1	1
Week 2	4	4	1	1
Week 3	4	4	1	1
Week 4	3	3	1	5
Week 5	3	3	5	5
Week 6	8	8	6	6
Week 7	8	8	7	7
Week 8	8	8	2	2
Week 9	2	2	2	2
Week 10	9	9	9	9
Week 11	9	9	9	9

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Assessment

Type of assessment	% Contribution	Title	Learning Outcomes	Approx. date of Assessment
Project	30	Individual project work	4,5,6	11
Examination (2 hours)	70	Examination	1,2,3,4,5,6,7 ,8	Spring Exam Weeks

Recommended Reading

- **Engineering mathematics**, K.A. Stroud and Dexter (ISBN 0-8311-3152-7)
- **Discrete Mathematics and its Applications**, KH Rosen (ISBN: 0-071-19881-4)
- Probability and Statistics for Computer Science, J. L. Johnson (ISBN 0-471-32672-0)
- **Mastering MATLAB** , Duane C. Hanselman (Author), Bruce L. Littlefield (Author), Pearson, ISBN 013-185-7142
- DAFX: Digital Audio Effects, U. Zoelzer, John Wiley and Sons Ltd (2002) ISBN 013-978-0471490784
- Digital Signal Processing using MATLAB, V Ingle and J Proakis, Brooks Cole Thomson Learning, (2000) ISBN 013-978-0534371746
- Digital Image Processing Using MATLAB, Gonzalez, Woods and Eddins Prentice Hall, ISBN 9780982085400 (2009)

All books in library: Plenty of other related books there too

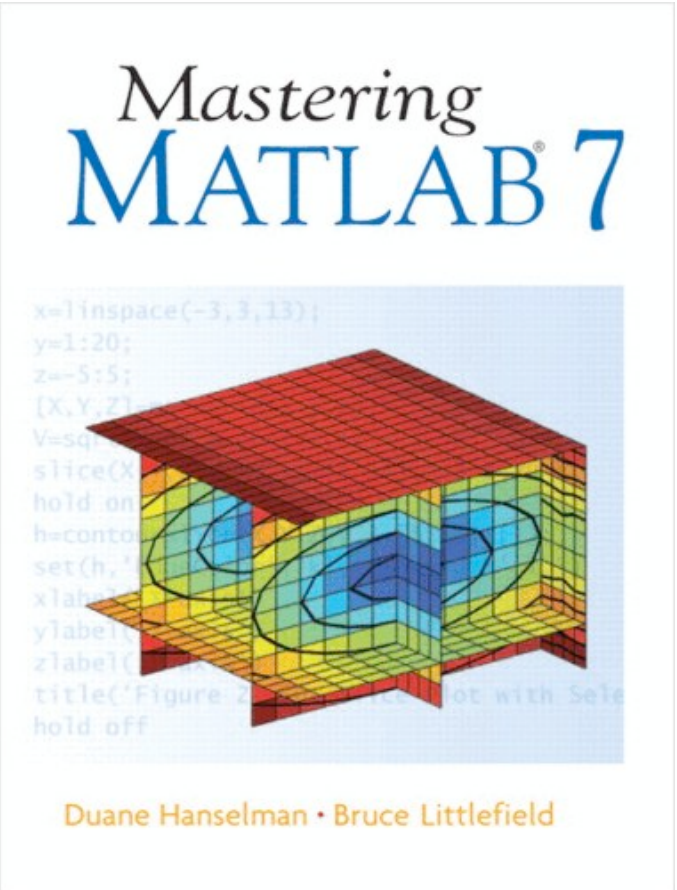
Which Book(s) to buy?

Mastering MATLAB
Duane C. Hanselman and Bruce L. Littlefield
Prentice Hall, 2004
(ISBN-13: 978-0131857148)

Excellent coverage of Basic MATLAB programming

Copies in library

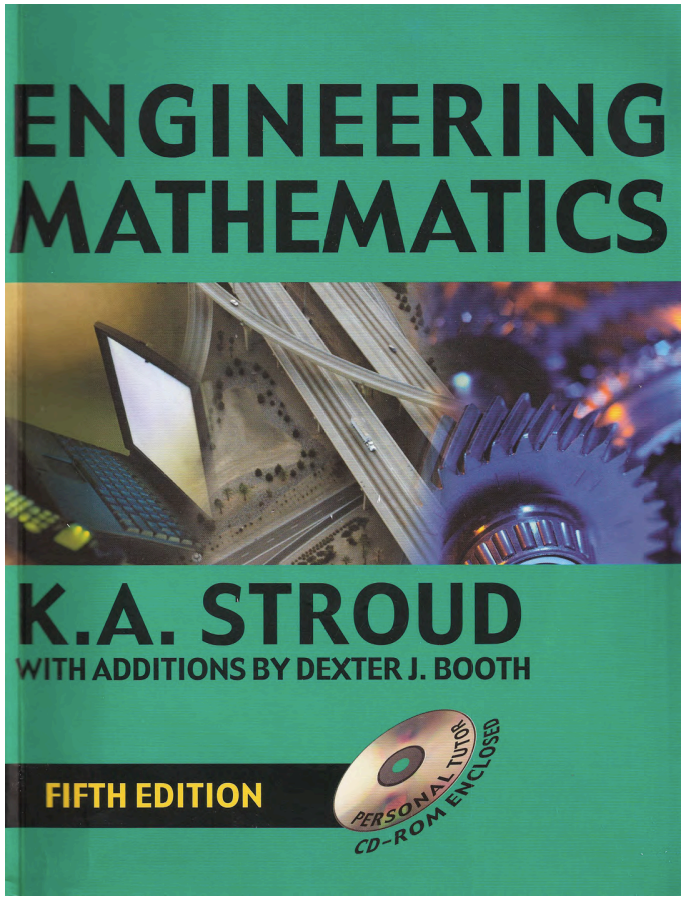
Useful Reference Book?



Which Book(s) to buy?

If you need more Maths:

- Engineering mathematics, K.A. Stroud and Dexter – Any Edition Cover the Material.
  - **General Maths**
- Discrete Mathematics and its Applications, KH Rosen
  - **Probability** and **Formal Languages and Automata Theory**
- Probability and Statistics for Computer Science, J. L. Johnson
  - **Probability Theory**



Library well stocked these with other relevant Maths Books