CM2202: Scientific Computing and Multimedia Applications
Linear Algebra: 1. Introduction

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Linear Algebra, Vectors and Matrices

Vectors and Matrices are a staple data structure in many areas of Computer Science.

Computer Graphics is one prime example — here linear algebra permeates almost every area.

We will use some simple examples from Computer Graphics to visualise some simple aspects of Linear Algebra, Vectors and Matrices.

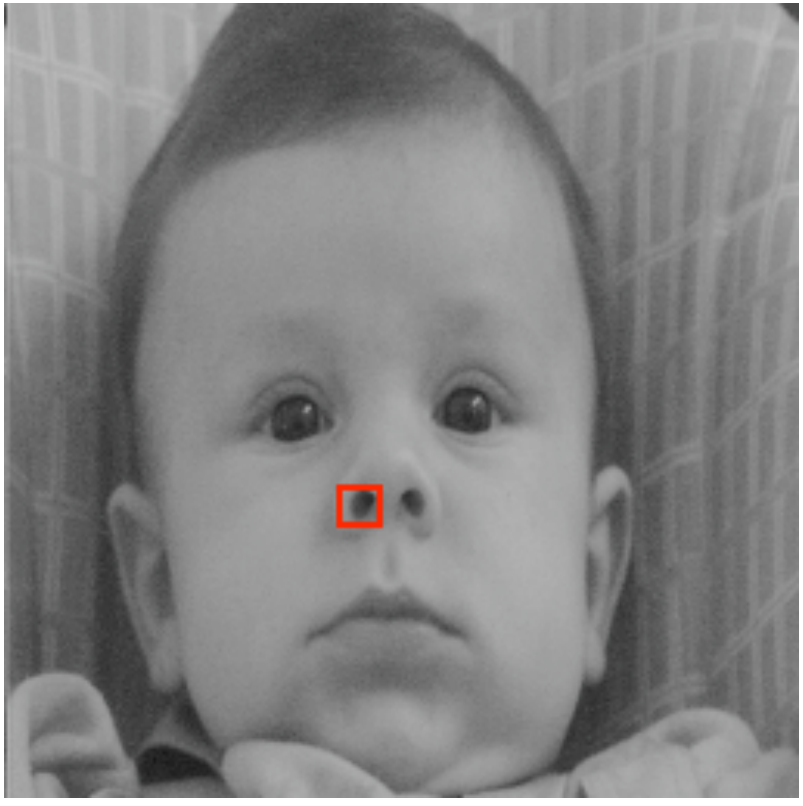
We will use other examples as appropriate.

We will use MATLAB to demonstrate the ideas.

Selected Examples of Use in Computer Science

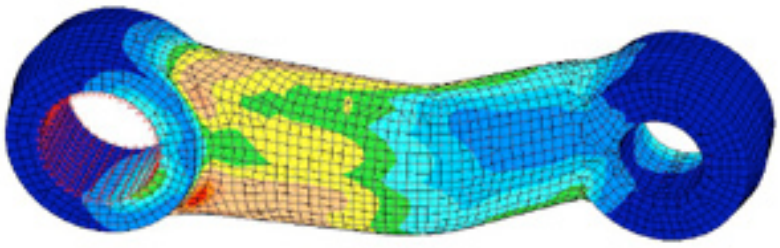
- Basic Linear Algebra — solutions of equations needed in almost every scientific discipline
- Vectors and Matrices — fundamental data structures in computer science e.g. *Arrays, Linked Lists*
- Numerical Analysis — scientific computing and practical computational mathematics
- Computer Graphics: Transformations, 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

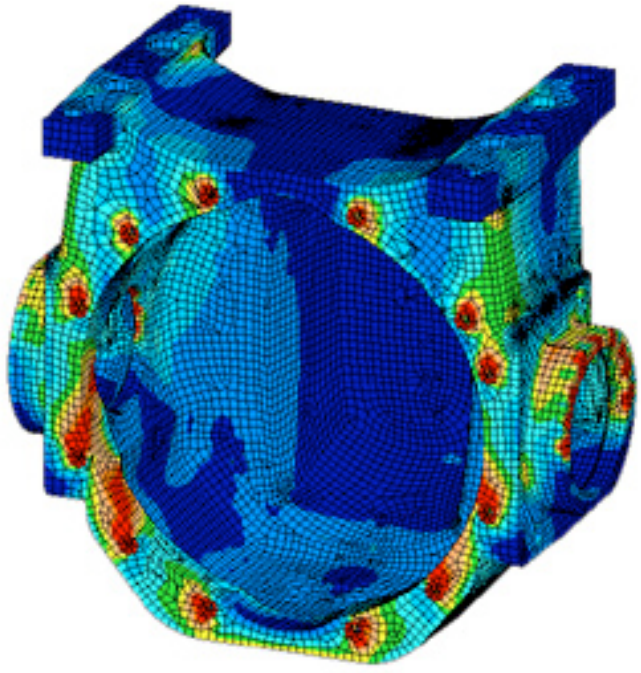
Matrices Example: Image Representation



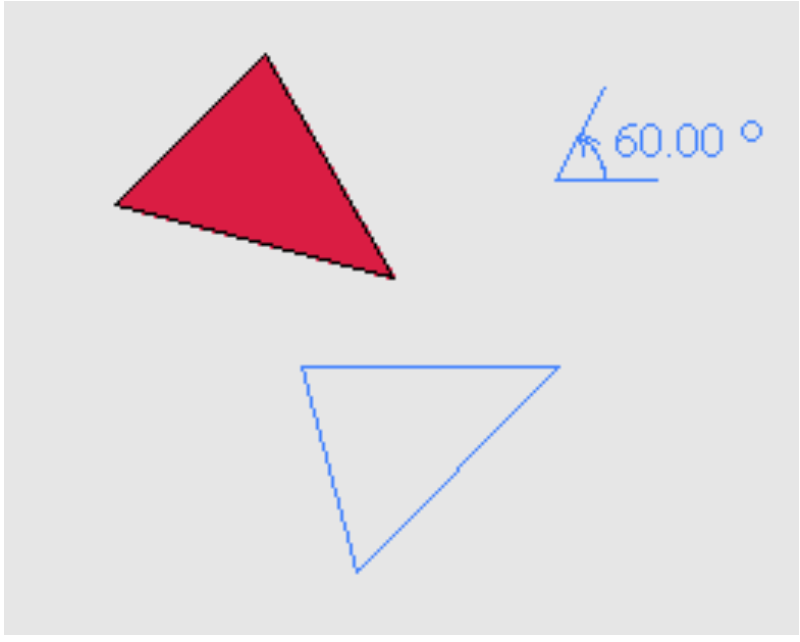
99	71	61	51	49	40	35	53	86	99
93	74	53	56	48	46	48	72	85	102
101	69	57	53	54	52	64	82	88	101
107	82	64	63	59	60	81	90	93	100
114	93	76	69	72	85	94	99	95	99
117	108	94	92	97	101	100	108	105	99
116	114	109	106	105	108	108	102	107	110
115	113	109	114	111	111	113	108	111	115
110	113	111	109	106	108	110	115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

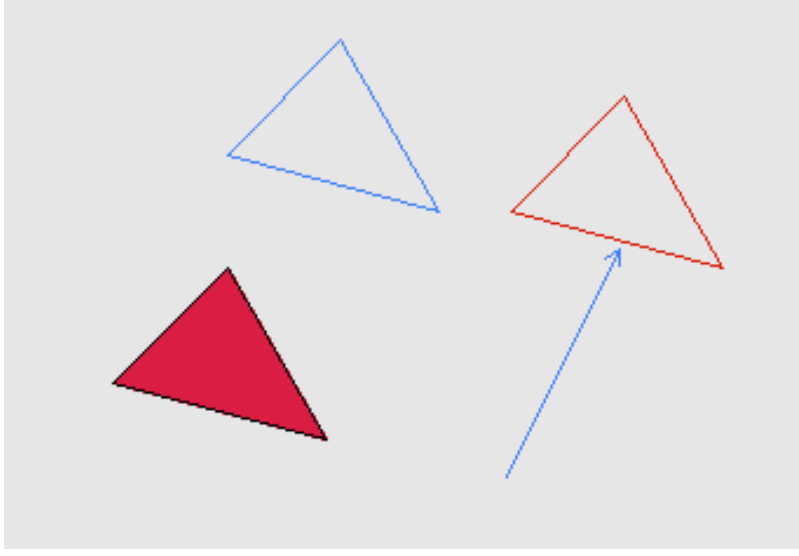
Algebra/Graphs Example: Finite Element Modelling





Matrices Example: Computer Graphics Transformations

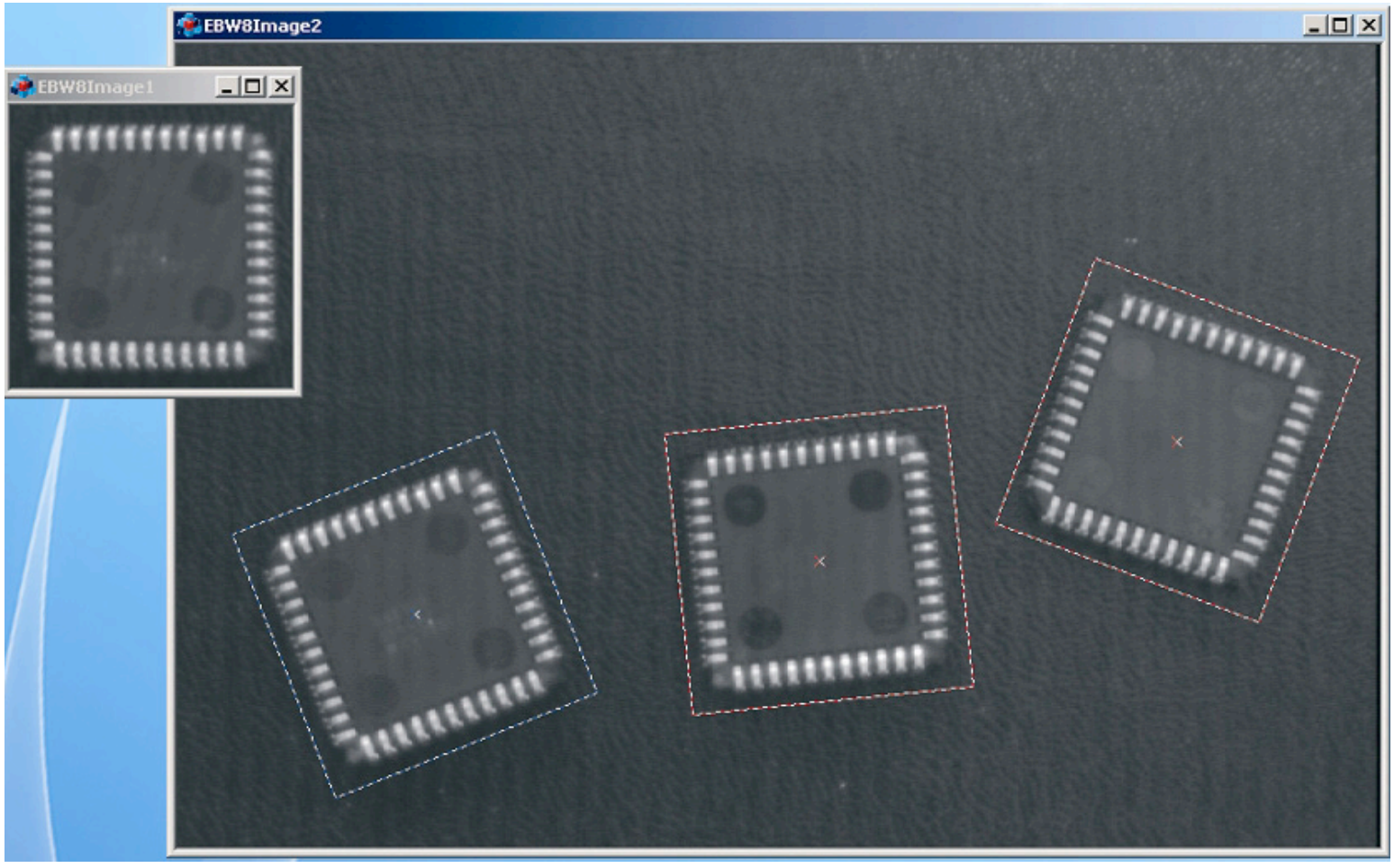




$$\begin{bmatrix} X_{rotated} \\ Y_{rotated} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

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

Matrices Example: Object Registration/Matching



Matrices Example: Image Warping (Transformation)

Matrices/Vector Example: Image Compression