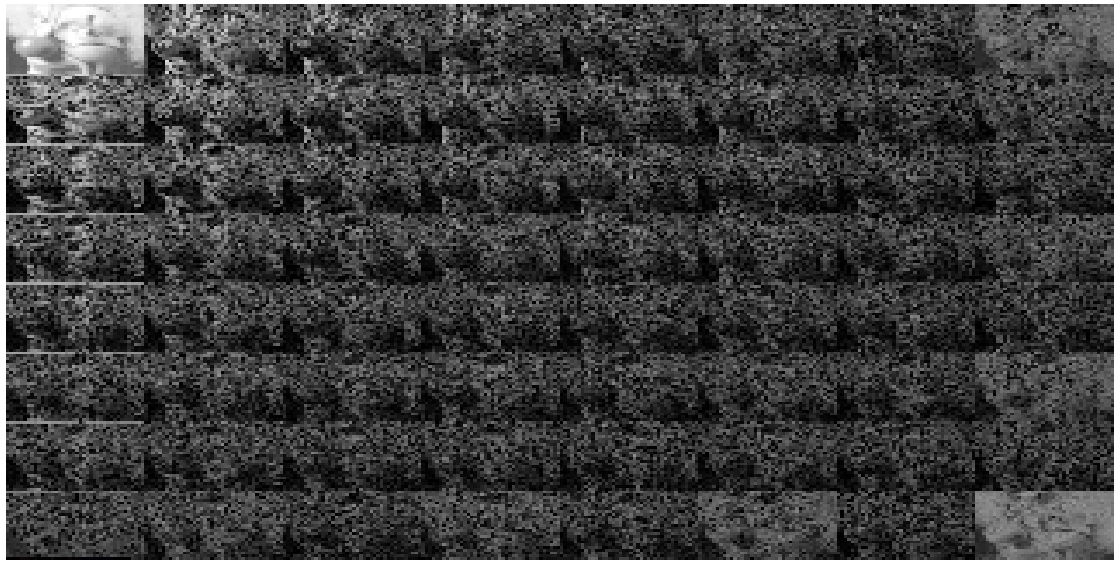

# Mathematical Methods of Image Processing - A Progress Report on Course Development

S. Allen Broughton and Edward R. Doering

Rose-Hulman Institute of Technology

# Authors


- S. Allen Broughton - Mathematics
- Edward R. Doering - Electrical and Computer Engineering

# Foundation coalition funding

- Engineering Education coalition consisting or Rose-Hulman and others
- course developed  as part of upper division curriculum development
- builds upon sophomore level matrix algebra taken by all students, developed by FC

# Outline of presentation

- Rose-Hulman background
- Imaging systems certificate program
- Foundation Coalition funding
- Course philosophy and concepts
- Course outline
- Adapting the course
- Audience questions

# Rose-Hulman background

- private, undergraduate college, 1600 mathematics, science and engineering students
- teaching paramount, scholarship expected
- 17 math faculty, pure and applied
- good interaction between departments
- upper division mathematics taken by many non-majors (few majors)
- abundant computing facilities

# Imaging certificate program

- Joint program of
  - Electrical and Computer Engineering
  - Computer Science
  - Physics and Applied Optics
  - Mathematics
- Requirements
  - three required courses
  - two electives
  - project

# Foundation coalition funding

- Engineering Education coalition consisting or Rose-Hulman and others
- course developed  as part of upper division curriculum development
- builds upon sophomore level matrix algebra taken by all students, developed by FC

# Course philosophy - 1

- Image processing = linear algebra
- key ingredients
  - vector space, vectors, matrices
  - basis,
  - dot products and orthogonality
  - transforms and matrices

# Course philosophy - 2

- use image processing as a motivation for studying matrix based linear algebra concepts
- everything is finitely sampled
- all construction can be handled by methods of linear algebra
- signal - vector
- image - matrix

# Course philosophy - 3

- pure waveforms - orthogonal basis
- energy - scalar products
- frequency decomposition - transform
- energy preserving - unitary
- frequency response - eigenvalues and eigenvectors

# Course implementation - 1

- 10-week course
- juniors and seniors
- Electrical Engineering, Computer Science main customers
- vector concepts from Calculus
- 5 weeks of matrix algebra in DE and matrix algebra course
- some Fourier series

# Course implementation - 2

- MATLAB is the enabler
- extensive classroom visualization
- Students have extensive programming experience
  - all have Maple experience
  - some Matlab experience
  - some have C++ experience

# Course outline

- Image compression (or some thing else) is the over-all motivating theme
- there are two main parts about 5 weeks each
- Part I - Fourier based methods
- Part II - Wavelet and filter bank methods
- Students complete a team based project

# Course outline Part I

- Signals as vectors
- Images as matrices
- Discrete Fourier transform is matrix transform
- Discrete Cosine Transform
- Block transforms
- Student project implement JPEG algorithm using Matlab

# Course outline Part II

- Filtering and convolution
- Filter banks
- Discrete Wavelet Transform
- Compression project

# Discrete Fourier Transform

- Fourier transform in the course context
- Define pure wave forms

$$E_k(r) = \exp(2pi\frac{kr}{N}), r = 0,1,..., N-1$$

# Discrete Fourier Transform

- Define Fourier transform

$$\hat{X}(k) = X \bullet E_k = \sum_{r=0}^{N-1} X(r) E_k(-r)$$

- Matrix form

$$\hat{X} = F_N X$$

# Discrete Fourier Transform

$$\hat{X} = F_m X F_n^t$$

- Matrix form can be exploited to obtain results

# DFT for Images

$$\hat{X} = F_m X F_n^t$$

# Modification of the course

- More theoretical and mathematics based
- DFT and filtering as a “hook” or a theme for a second linear algebra
- many mathematics topics can be interpreted in terms of image processing
- simple and interesting projects can be undertaken using MATLAB

# Thank You for listening!

# Questions???

# URL's

- Course webpage
- **http://www.rose-hulman.edu/~brought/courses/ma490mip/**

- e-lecture
- **http://www.rose-hulman.edu/~brought/Epubs/Imaging/waveimage.html**

- **Foundation Coalition**
- **http://foundation.ua.edu/**