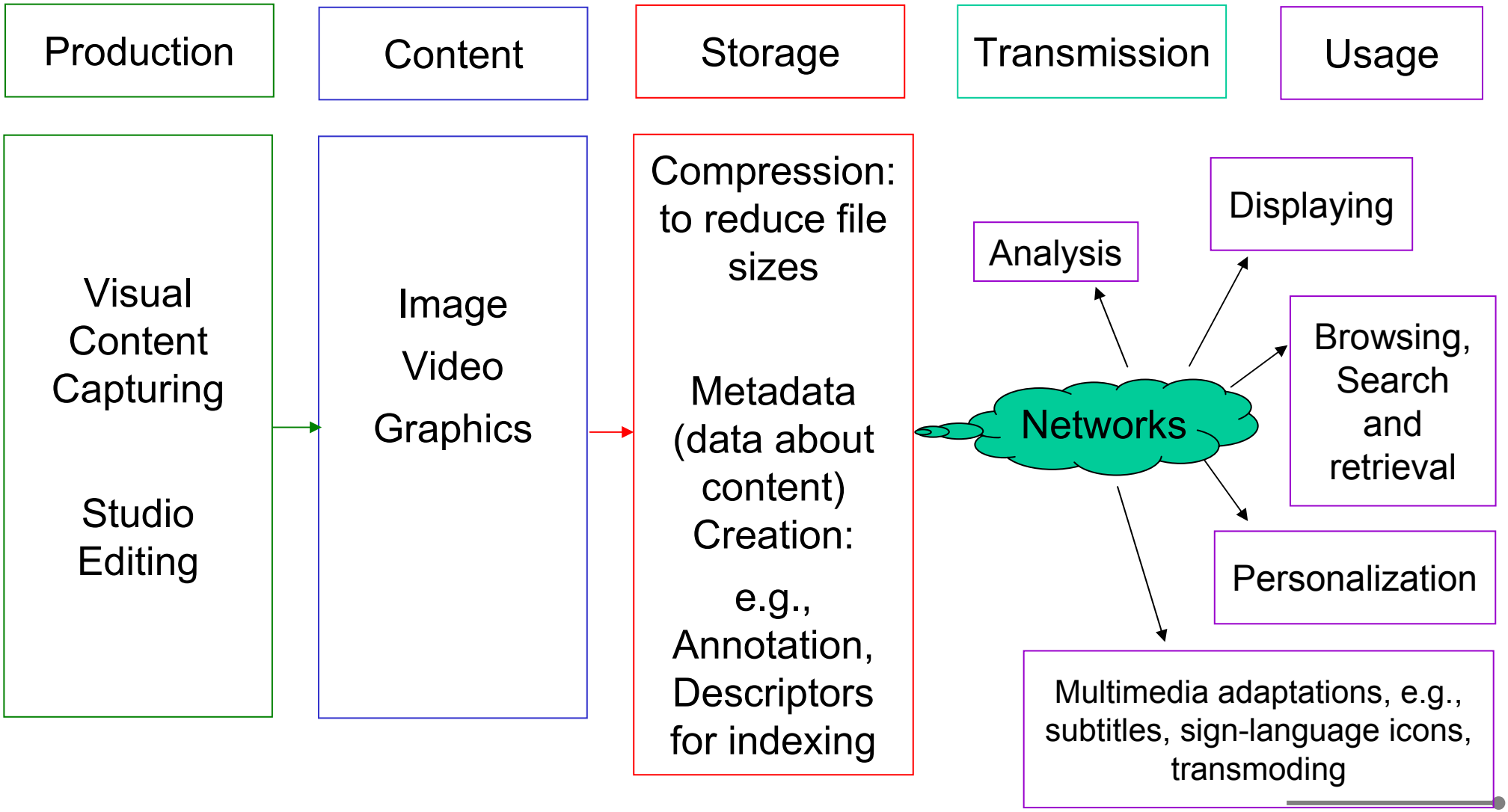
EEE6081 (EEE421)
Visual Information Engineering (VIE)

Dr Charith Abhayaratne

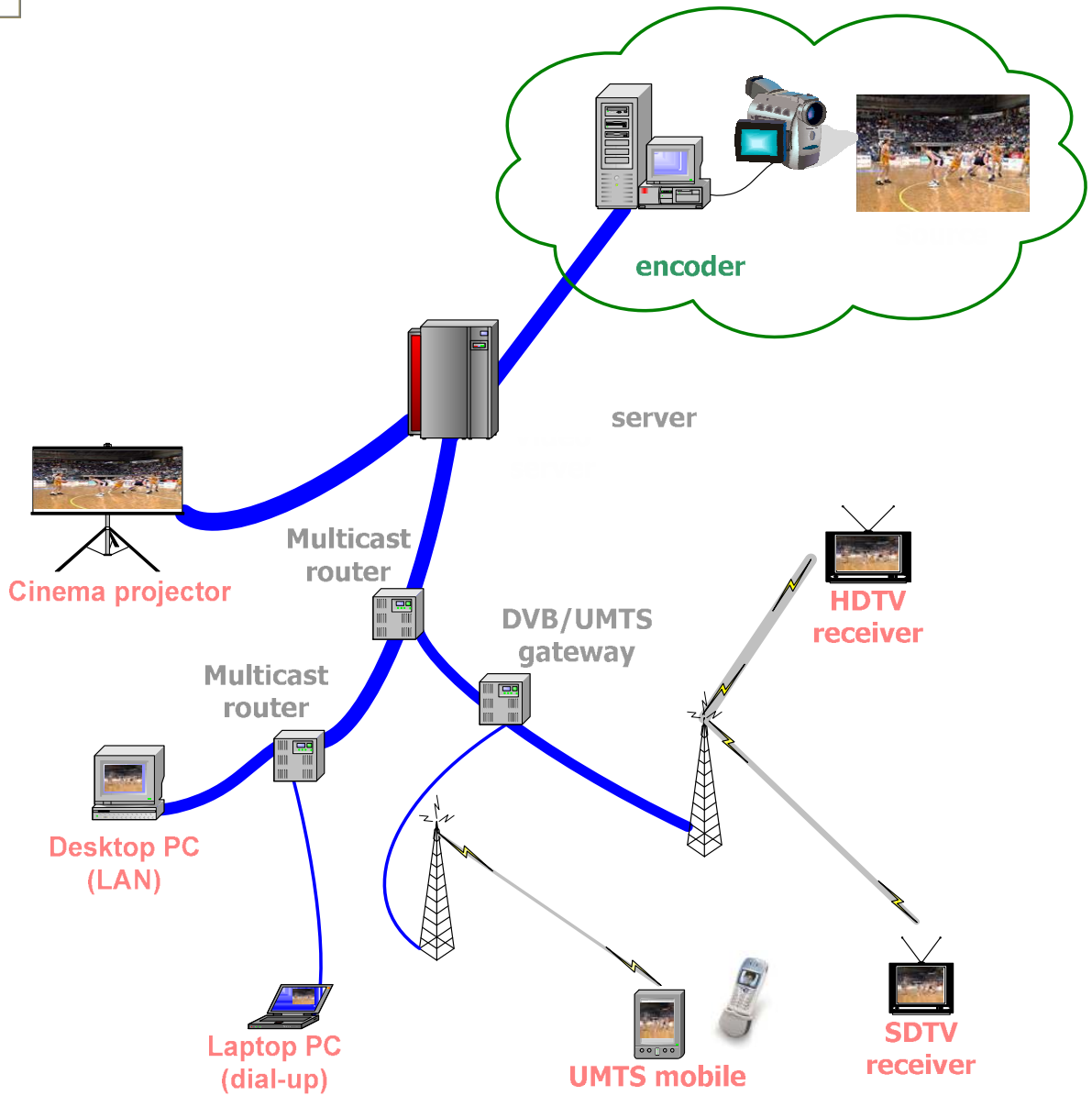
Tel: 25893
Email: c.abhayaratne@sheffield.ac.uk
Office: F176

- Course Delivery:
  - Lectures: 2 hours/week Monday @ 9 am & Thursday @ 3 pm

Visual Information Engineering



- Visual Information Engineering
  - Visual content
    - Images/video/graphics etc.
  - Visual content engineering
    - Capturing
    - Pre-processing
    - Compression
    - Content adaptation (change of format/resolution/quality/mode according to usage requirements and available resources)
  - Analysis for information extraction and representation
    - Search and retrieval
    - Event detection, surveillance and security applications


encoder
server
Cinema projector
Multicast router
Multicast router
DVB/UMTS gateway
HDTV receiver
Desktop PC (LAN)
Laptop PC (dial-up)
UMTS mobile
SDTV receiver

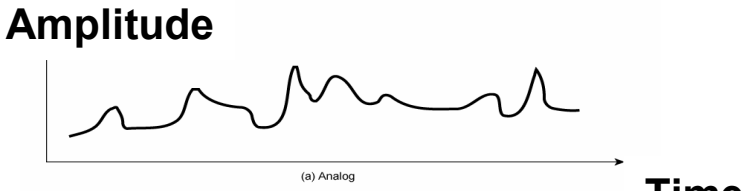
Mainly focus on 3 concepts:

Signal
Data
Information

Signal

Detectable transmitted energy that can be used to carry information.

A time/spatially-varying characteristic of a physical phenomenon, used to convey information.



Visual content can be regarded as signal with higher dimensions.
e.g., images -2D, video - 3D

1D Signal Processing concepts can be easily extended to higher dimensions

Data

- Representation of
  - facts,
  - concepts, or instructions
- in a formalized manner suitable for
  - communication,
  - interpretation, or processing by
    - humans or by automatic means.
- E.g., any representations such as characters or analogue quantities to which meaning could be assigned.

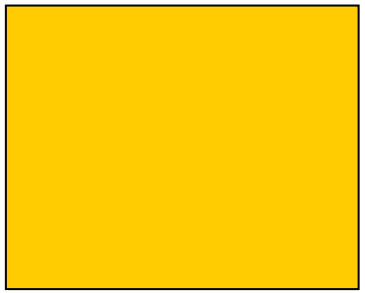
Information

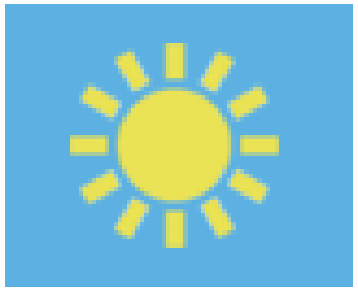
The meaning that a human assigns to data
by means of the known conventions used in their representation.
“Entropy” is a measure of information content.

Information

- The meaning that a human assigns to data
- by means of the known conventions used in their representation.

- “Entropy” is a measure of information content.





Higher the entropy of a message, the more information it contains.

The entropy is high if the uncertainty is high.

How much information?

Message	How much Information?	What is the probability?

- Tomorrow is Tuesday.
  (Saying this on a Monday)
- It will rain tomorrow.
- South Korea to host football world cup in 2018.
- Next Saturday's lottery winning combination is
  4, 8, 15, 16, 23, 42.

Information content

From the previous slide we can conclude that the information content is inversely proportional to the probability of occurrence.

We measure the information content of an event (symbol) using entropy (H).

$$I \propto \frac{1}{P}$$

$$H = \log_2\left(\frac{1}{P}\right) \quad \text{Bits}$$

$$= -\log_2(P)$$

Information content in the winning number combination

= -$\log_2$(1/13,983,816)

= 23.7 bits

Information content

The total entropy for a collection of symbols:
The sum of the entropy of all symbols

$$H_{Total} = \sum_{t=1}^{T} \log_2(1/p_t) = \sum_{i=1}^{C} s_i \log_2(1/p_i)$$

The average entropy For C groups of different symbols in the message

$$H_{AVG} = \frac{1}{T}\sum_{i=1}^{C} s_i \log_2(1/p_i) = \sum_{i=1}^{C} \frac{s_i}{T} \log_2(1/p_i) = \sum_{i=1}^{C} p_i \log_2(1/p_i)$$ Bits per sample

This is called Shannon's Entropy formula

Homework: For a binary source find the probabilities of symbols when H_{AVG} is maximum.

Information content of an image

"A picture is worth ten thousand words"

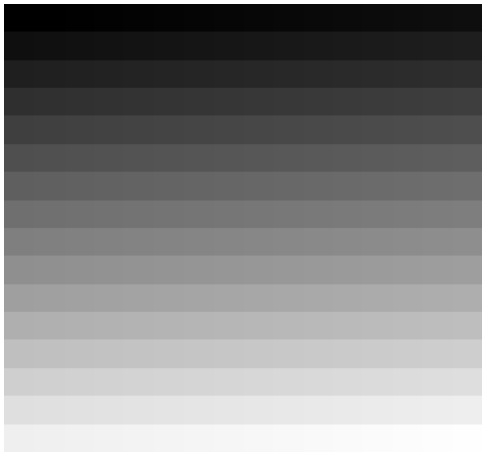
Literally means –
A picture's meaning can express ten thousand words ?

Image databases – requires huge amount of metadata (keywords) image indexing.

Information content of an image

Only one colour.

What is the entropy?



16x16 pixels
In total 256 pixels.

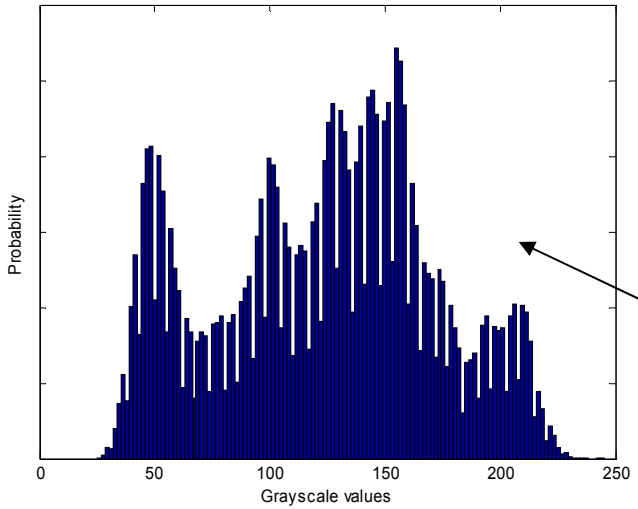
Each pixel represent
Each of the 256 colours.

What is the entropy?

Information content of an image

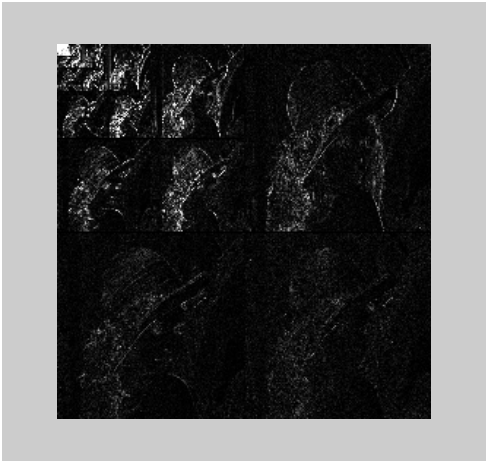
Gray scale images usually use 256 gray levels. That means 8 bits per pixel (bpp).

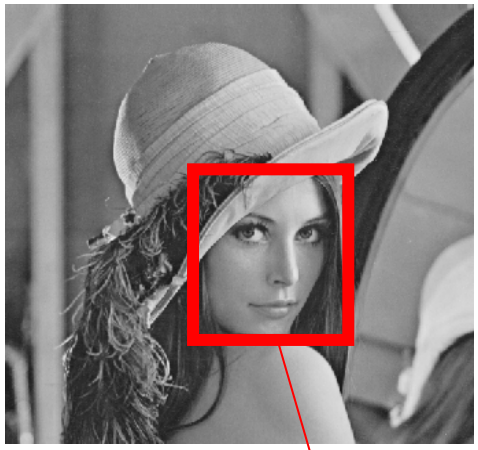
The Shannon's entropy 7.46 bpp



Probability distribution of Lena image.
We have to modify this distribution to one with a narrow peak and long tails to reduce entropy.

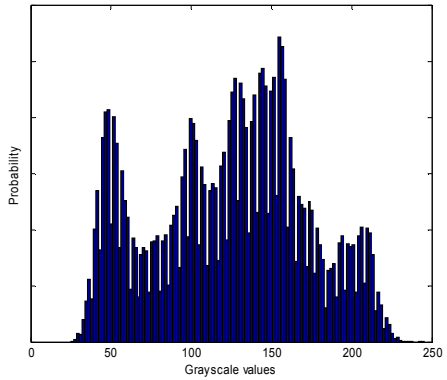
Information content of an image

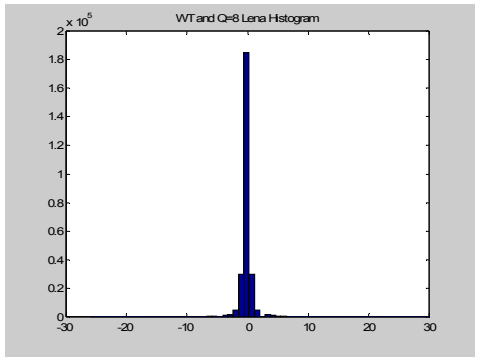




compressing

decoding





In this course we will discuss on signal processing tools for content engineering and efficient representation.

EEE 6081 Visual Information Engineering

- Aims:
  - to introduce signal transform techniques and low level visual information extraction for visual content engineering.
  - to emphasise the use of these techniques for applications such as compression, retrieval and other content engineering applications.
  - to provide an understanding of using software tools in designing and implementing technologies for visual information engineering.

EEE 6081 Visual Information Engineering

- Learning Outcomes:

  By the end of the unit, students will be able to

  – demonstrate the understanding of the basic theory on signal transforms.
  – demonstrate the understanding of wavelet theory.
  – use the common transform techniques for image/video compression.
  – model, extract and use visual features for image/video descriptions.
  – design simple algorithms for visual information engineering

  – implement simple algorithms for visual information engineering using software tools.

EEE 6081 Visual Information Engineering

- Course Structure: 3 Parts
  - Transforms
    - Filter banks, wavelets and lifting
    - 2D transforms – introduction
    - Multi-resolution representation
    - Application on Image and video
  - Content
    - Multi-resolution (MR) analysis and MR domain content engineering.
    - Image and video compression
    - Motion estimation in video and extension to 3D transforms.
  - Information extraction
    - Low-level visual features.
    - Application to Search and retrieval

EEE 6081 Visual Information Engineering

- Course Organisation

Topic No.	Title	Lecture No.
1	Introduction	L1
2	Revision: imaging + signal processing	L2 – L3
3	Signal transforms	L4 – L5
4	Filter Banks and wavelets -1	L6 – L7
5	Multi-resolution analysis	L8 – L9
6	Coursework introduction	
7	Filter Banks and wavelets -2	L10 – L11
8	Image and video coding	L12 – L15
9	Low level visual features	L16 – L17

EEE 6081 Visual Information Engineering

- Reference Books (for background reading only)
  - Digital image processing
    R. Gonzalez & R. Wood (Prentice Hall).
  - Digital video processing
    A. M. Tekalp (Prentice Hall).
  - Multimedia and Communications Technology
    S. Heath (Focal Press).
  - Digital Signal Processing
    J. Proakis & D. Manalokis (Prentice Hall).
  - Wavelets & Subband coding
    M. Vetterli & J. Kovacavic.
    (available online at http://www.waveletsandsubbandcoding.org/)
  - Visual Information retrieval
    A del Bimbo (Morgan Kaufmann)

EEE 6081 Visual Information Engineering

- Course delivery
  - 2 hours lecture / week
    - 17 lectures on VIE topics
      - Printed handouts and/or online lecture notes
      - Class activities / Demos
      - Research paper reading
    - 2 lectures on the coursework + Matlab
  - Tutorials
    - Problem sheets
      - 1 tutorial class
      - Other problem solving during lectures.

EEE 6081 Visual Information Engineering

– Relevant course materials available in MOLE.
  - Login via MUSE
  - Module description / Handouts / lecture notes / problem sheets + solutions / (past exams + solutions) / revision questions / online tests/ Coursework information/ relevant research papers/ Matlab exercises/ assignments
  - Discussion forum for the coursework

EEE 6081 Visual Information Engineering

- Assessment
  - Continuous assessment (25%)
    - Course work
    - An assignment based on Matlab and implementing a small algorithm related to a VIE application.
    - Marks decomposition:
      - Initial observations (3 marks)
      - Results + working codes (4 marks)
      - Codes (6 marks)
      - Report 1000-1500 words + loads of images (7 marks)
    - Submission via MOLE + turnitin (plagiarism detection)
    - More details later

EEE 6081 Visual Information Engineering

- Assessment
  - End of Semester exam (75%)
    - In May/June
    - 2 hour exam
    - Answer 3 questions out of 4.

EEE 6081 Visual Information Engineering Lectures 2 & 3

- Revision: Imaging, Signal processing and Matlab preliminaries

- Homework:
  - Revise
    - Discrete time signals
    - Convolution
    - Impulse response
    - Correlation
    - FFT
    - Frequency response
    - Filters (low pass and high pass)