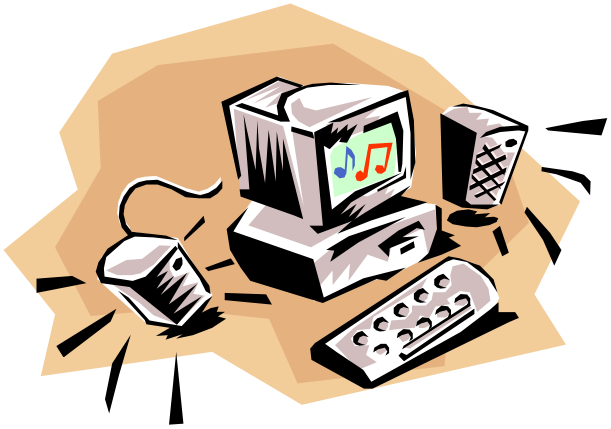
# Multimedia Computing

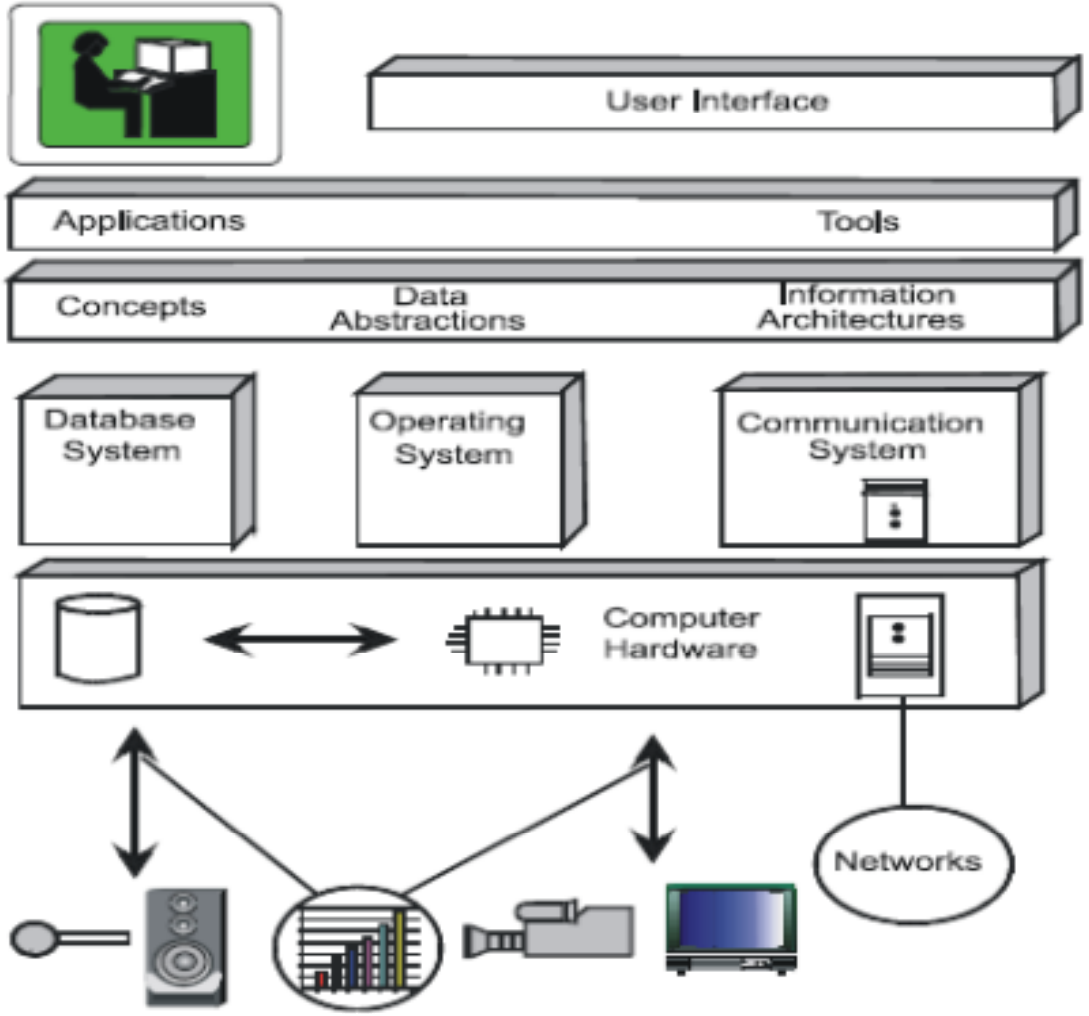
## Introduction



# What is multimedia?

- The term **multimedia** can be explained in quite different, or even opposing, viewpoints.
  - A PC vendor: a PC that has sound capability, a DVD-ROM drive, and perhaps micro-processors that understand additional multimedia instructions.
  - A consumer entertainment vendor: interactive cable TV with hundreds of digital channels available, or a cable TV-like service delivered over a high-speed Internet connection.
  - A Computer Science student: applications that use multiple modalities, including text, images, graphics, animation, video, sound, and interactivity.

# Example: Architecture of a Multimedia PC



# Multimedia & Computer Science

- Data Compression/Communication
- Computer Vision
- Human Computer Interaction
- Computer Graphics
- Visualization
- Graph Theory
- Networking
- Database Systems

# Components of Multimedia

- Multimedia involves multiple modalities of text, audio, images, drawings, animation, and video.
- Examples:
  - Video teleconferencing
  - Distributed lectures for higher education
  - Tele-medicine
  - Image/video retrieval
  - “Augmented” reality: placing real-appearing computer graphics and video objects into scenes
  - Building searchable features into new video, and enabling very high- to very low-bit-rate use of scalable multimedia products
  - Using voice-recognition to build an interactive environment
  - ……

# Multimedia Research Topics and Projects

- To the computer science researcher, multimedia consists of a wide variety of topics:
  - **Multimedia processing and coding**: multimedia content analysis, content-based multimedia retrieval, multimedia security, audio/image/video processing, compression, etc.
  - **Multimedia system support and networking**: network protocols, Internet, operating systems, servers and clients, quality of service (QoS), and databases.
  - **Multimedia tools, end-systems and applications**: hypermedia systems, user interfaces, authoring systems.
  - **Multi-modal interaction and integration**: “ubiquity” -- web-everywhere devices, multimedia education including Computer Supported Collaborative Learning, and design and applications of virtual environments.

# Current Multimedia Projects: examples

- **Camera-based object tracking**: tracking of the control objects provides user control of the process.
- **3D motion capture**: used for multiple-actor capture so that multiple *real* actors in a *virtual* studio can be used to automatically produce realistic *animated* models with natural movement.
- **Multiple views**: allowing photo-realistic (video-quality) synthesis of virtual actors from several cameras or from a single camera under differing lighting.

# Current Multimedia Projects: examples

- **Specific multimedia applications**: aimed at handicapped persons with low vision capability and the elderly -- a rich field of endeavor.
- **Electronic Housecall system**: an initiative for providing interactive health monitoring services to patients in their homes.
- **Augmented Interaction applications**: used to develop interfaces between real and virtual humans for tasks such as augmented storytelling.

# Multimedia and Hypermedia

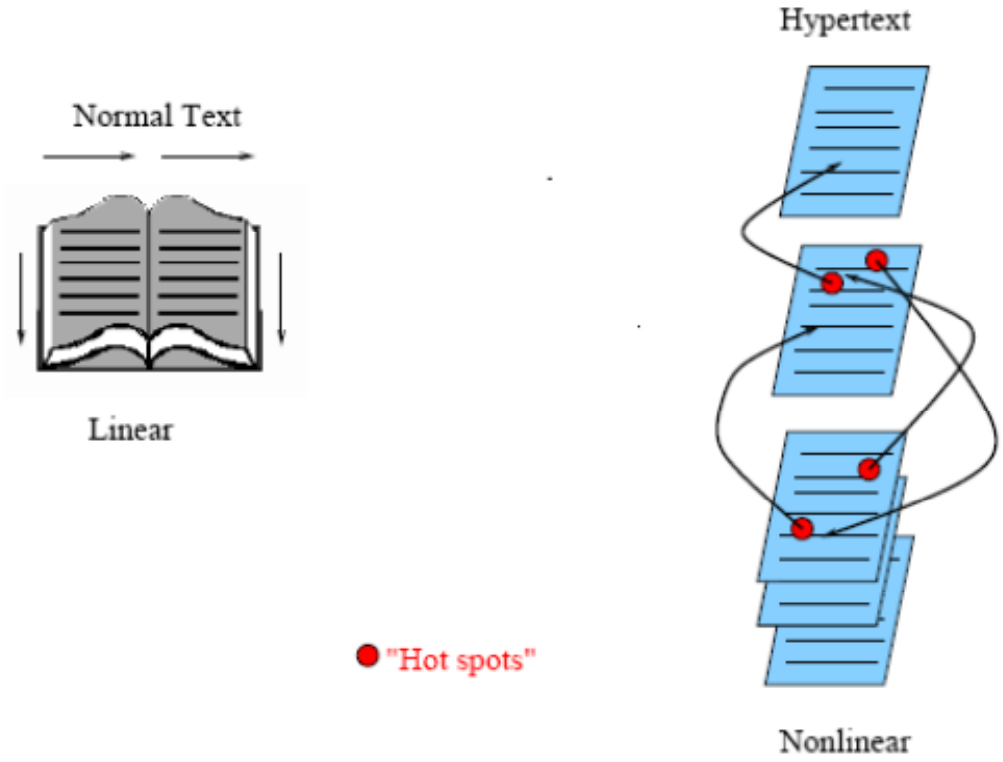

- History of Multimedia:
  1. **Newspaper**: perhaps the first mass communication medium, uses text, graphics, and images.
  2. **Motion pictures**: conceived of in 1830's in order to observe motion too rapid for perception by the human eye.
  3. **Wireless radio transmission**: Guglielmo Marconi, at Pontecchio, Italy, in 1895.
  4. **Television**: the new medium for the 20th century, established video as a commonly available medium and has since changed the world of mass communications.

# Multimedia and Hypermedia

- History of Multimedia:
  5. The **connection** between **computers** and ideas about **multimedia** covers what is actually only a short period:
     - 1945 -- Vannevar Bush wrote a landmark article describing what amounts to a hypermedia system called **Memex**.
     - 1960 -- Ted Nelson coined the term **hypertext**.
     - …… (Please refer to the textbook for details.)
     - 1991 -- **MPEG-1** was approved as an international standard for digital video -- led to the newer standards, **MPEG-2**, **MPEG-4**, and further **MPEGs** in the 1990s.
     - ……
     - 2000 -- WWW size was estimated at over **1 billion pages**.
     - **2012 -- ?<!*&>?<@*&#@*^@%#**

# Hypermedia and Multimedia

- A **hypertext** system: meant to be read nonlinearly, by following links that point to other parts of the document, or to other documents.



# Hypermedia and Multimedia

- **Hypermedia**: not constrained to be text-based, can include other media, e.g. graphics, images, and especially the continuous media -- sound and video.
  - The World Wide Web (WWW) -- the best example of a hypermedia application.

- **Multimedia** means that computer information can be represented through audio, graphics, images, video, and animation in addition to traditional media.

# Hypermedia and Multimedia

- Examples of typical present multimedia applications:
  - Digital video editing and production systems.
  - Electronic newspapers/magazines.
  - World Wide Web.
  - On-line reference works: e.g. encyclopaedias, games, etc.
  - Home shopping.
  - Interactive TV.
  - Multimedia courseware.
  - Video conferencing.
  - Video-on-demand.
  - Interactive movies.

# Overview of Multimedia Software Tools

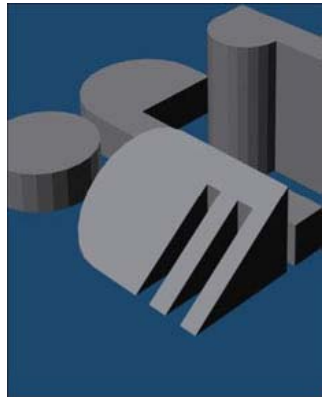
- The categories of software tools briefly examined here are:
  1. Music Sequencing and Notation (e.g. Pro Audio, Macromedia Soundedit)
  2. Digital Audio (e.g. Cool Edit, Sound Forge)
  3. Graphics and Image Editing (e.g. Adobe Photoshop, Macromedia Freehand)
  4. Video Editing (e.g. Adobe Premiere, Final Cut Pro)
  5. Animation (e.g. Java3D, DirectX, OpenGL)
  6. Multimedia Authoring (Macromedia Flash, Authorware)

# Multimedia Data: Input and Format

- **Text and Static Data**
  - Source: keyboard, speech input, optical character recognition, data stored on disk.
  - Stored and input character by character.
  - Format: Raw text or formatted text, e.g. HTML, Rich Text Format (RTF), or a program language source (C, Pascal, etc.).
  - Not temporal. BUT may have natural implied sequence. E.g. HTML format sequence, Sequence of C program statements.
  - Size is not significant compared with other multimedia data.

# Multimedia Data: Input and Format

- **Graphics**
  - Format: constructed by the composition of primitive objects such as lines, polygons, circles, curves and arcs.
  - Input: usually generated by a graphics editor program or automatically by a program (e.g. Postscript).
  - Usually editable or revisable (unlike Images).
  - Graphics input devices: keyboard, mouse, trackball or graphics tablet.
  - Graphics standards : OpenGL, PHIGS, GKS
  - Graphics files usually store the primitive assembly.
  - Do not take up a very high storage overhead.



# Multimedia Data: Input and Format

- **Audio**
  - Audio signals are continuous analog signals.
  - Input: microphones and then digitised and stored.
  - CD Quality Audio requires 16-bit sampling at 44.1 KHz, even higher rates (e.g. 24-bit, 96 KHz).
  - 1 Minute of Mono CD quality (uncompressed) audio requires 5 Mb.
  - 1 Minute of Stereo CD quality (uncompressed) audio requires 10 Mb.
  - Usually compressed (E.g. MP3, AAC).

# Multimedia Data: Input and Format

- **Images**
  - Still pictures which (uncompressed) are represented as a bitmap (a grid of pixels).
  - Input: digitally scanned photographs/pictures or direct from a digital camera. May also be generated by programs “similar” to graphics or animation programs.
  - Stored at 1 bit per pixel (Black and White), 8 bits per pixel (Grey Scale, Colour Map) or 24 bits per pixel (True Colour)
  - Size: a 512x512 Grey scale image takes up 1/4 Mb, a 512x512 24 bit image takes 3/4 Mb without compression.
  - This overhead increases rapidly with image size.
  - Compression is commonly applied.

# Multimedia Data: Input and Format

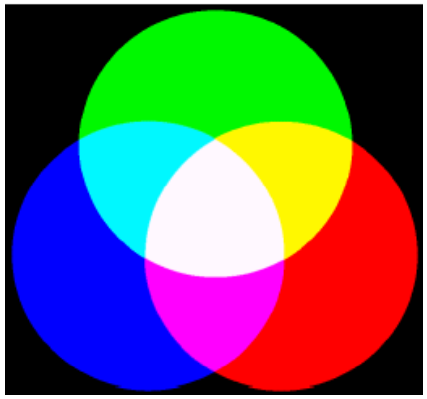
- **Video**
  - Input: Digital video camera. Analog video is usually captured by a film based video camera and then digitised.
  - There are a variety of video (analog and digital) formats.
  - Raw video can be regarded as being a series of single images. There are typically 25, 30 or 50 frames per second.
  - E.g. A 512 × 512 size monochrome video takes 25×0.25 = 6.25Mb for a minute to store uncompressed.
  - Typical PAL digital video (720 × 576 pixels per colour frame) ≈ 1.2 × 25 = 30Mb for a minute to store uncompressed.
  - High Definition DVD (1440×1080 = 1.5 Megapixels per frame) ≈ 4.5 × 25 = 112.5Mb for a minute to store uncompressed.
  - Digital video clearly needs to be compressed.

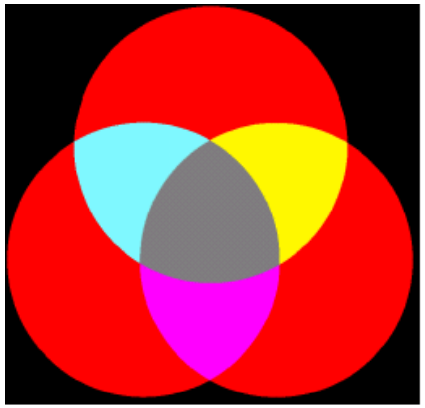
# What we will study in this course

- Programming Language Training: Matlab
- Basic Concepts of Color
  - A Case Study of Color Demosaicking of Digital Cameras
- Data Compression Techniques
  - Huffman Coding, Run-length Coding, Arithmetic Coding, Transform-based Coding, …
- Audio
  - Audio Compression, Speech Signal Processing
- Image
  - Compression (e.g., JPEG, JPEG2000), Interpolation, Digital Inpainting, …
- Video
  - Motion Estimation, Compression (e.g., MPEG2), Super-resolution, …
- Object Tracking
- Image Quality Assessment

# Examples of Multimedia Applications

- Color Transformation





# Examples of Multimedia Applications

- Image Compression

Original Size:

768x512x3=1,179,648 bytes

Size After Compression (JPEG):

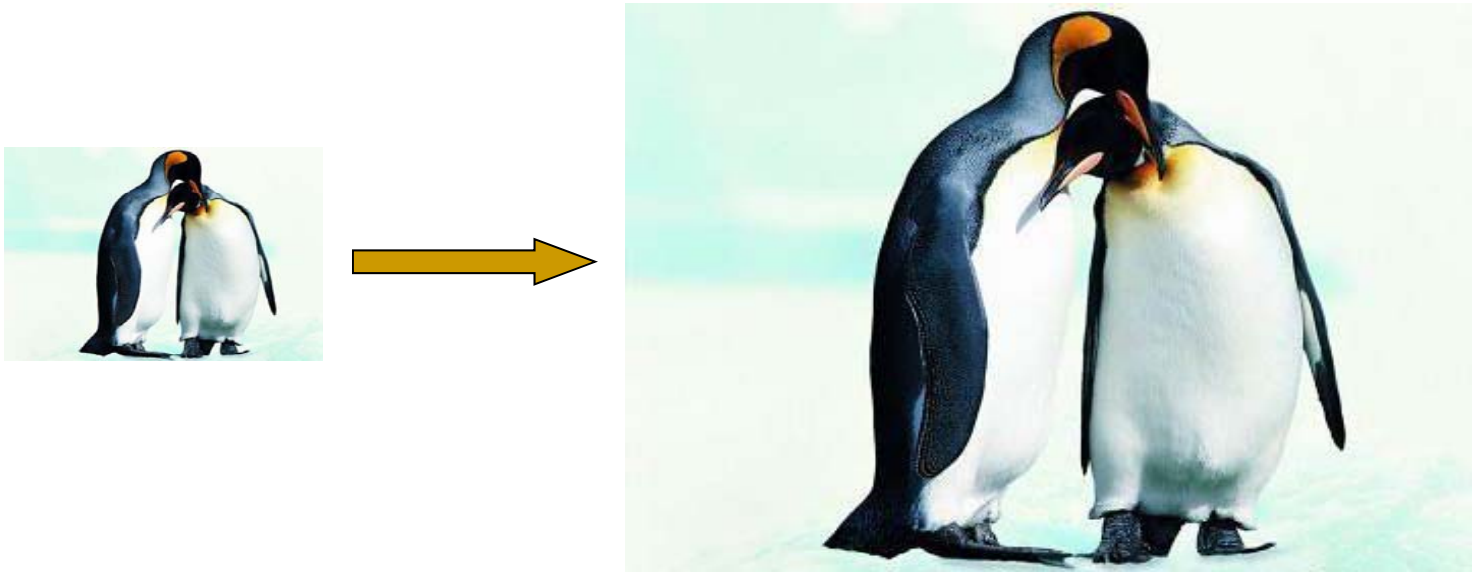
32,708 bytes

Compression Ratio:

36.07

# Examples of Multimedia Applications

- Image Interpolation and Single Frame Super-resolution



# Examples of Multimedia Applications

- Image In-painting

# Examples of Multimedia Applications

- Image Morphing: beauty and beast

# Examples of Multimedia Applications

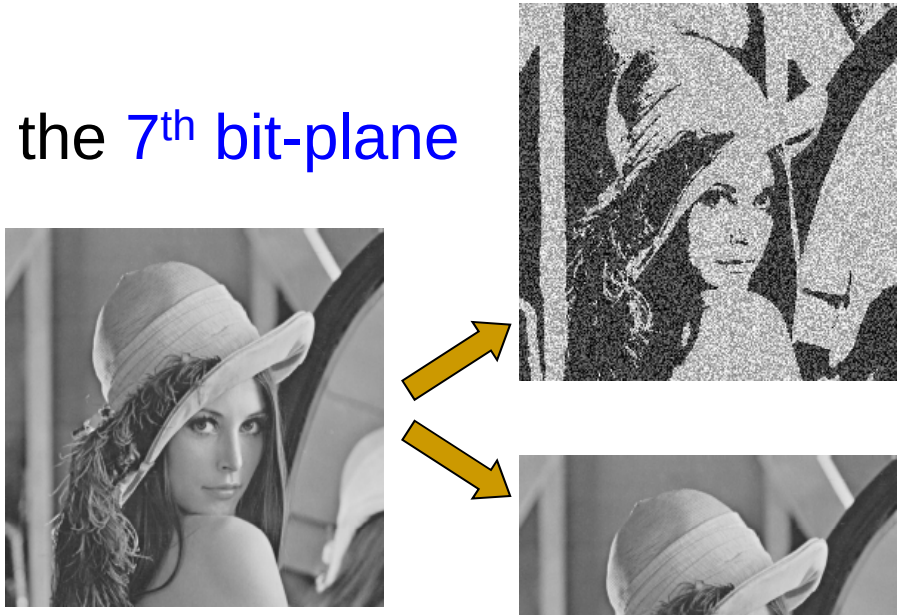
- An ancient information hiding technique -- (藏头诗)

一线情缘牵白头，　如果你我本有缘，
日日思念排忧愁，　隔山离水一线牵，
不要怪我痴情种，　三月桃花正旺盛，
见你常在梦境中。　秋后果实最香甜。

# Examples of Multimedia Applications

- Image Stegnography

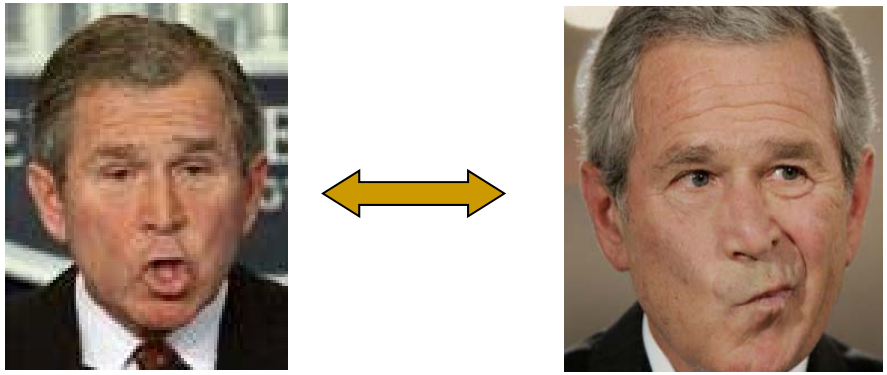
Insert information to the $7^{th}$ bit-plane



Insert information to the $0^{th}$ bit-plane

# Examples of Multimedia Applications

- Face Verification (1:1 matching)



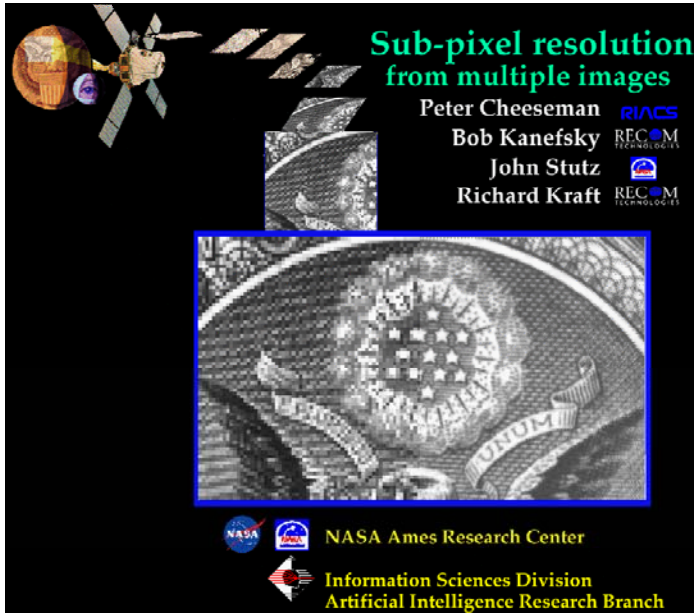
- Face Identification (1:N matching)

# Examples of Multimedia Applications

- Object Tracking

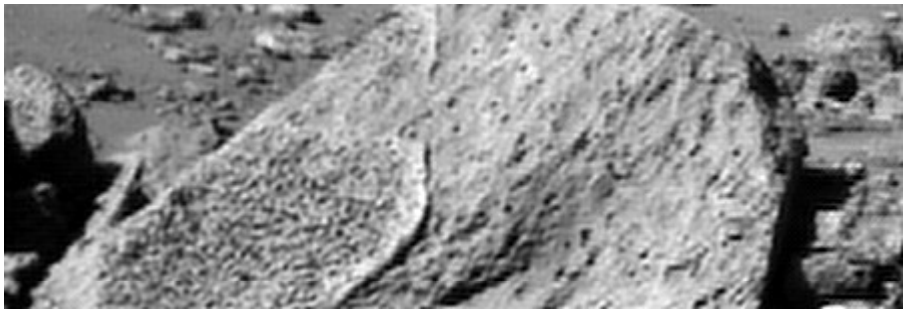
# Examples of Multimedia Applications

- Video Super-resolution

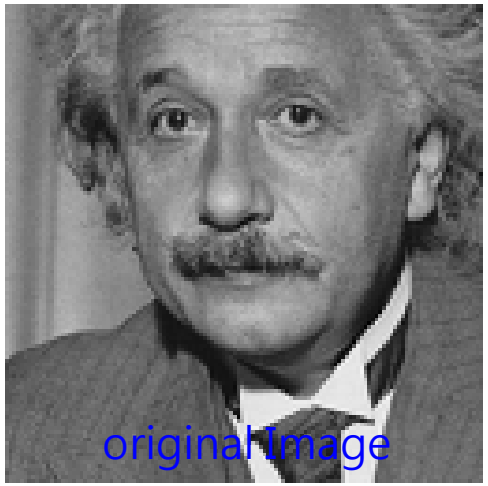



• Low resolution images sent from Mars Pathfinder

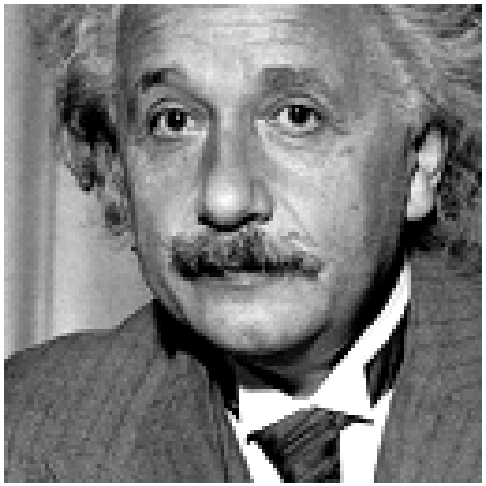
• Super-resolution applied



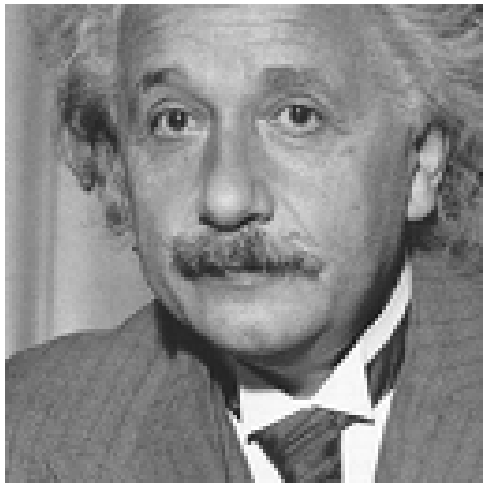
# Examples: Image Quality Assessment



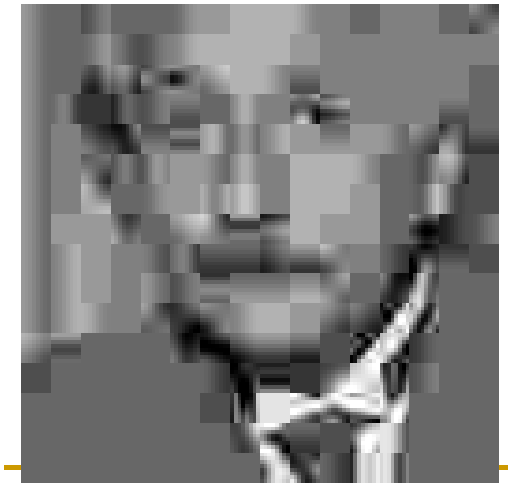

MSE=0, MSSIM=1



MSE=144, MSSIM=0.913

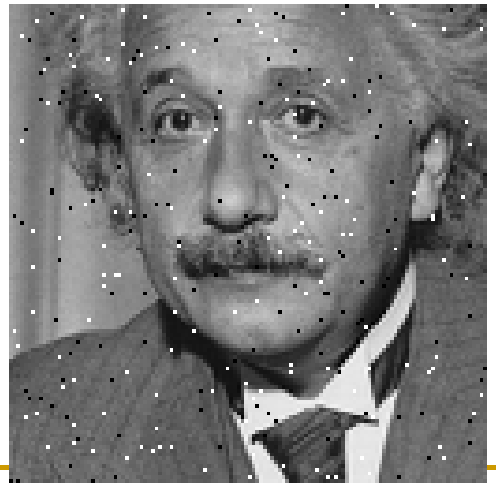


MSE=144, MSSIM=0.988



MSE=142, MSSIM=0.662

MSE=144, MSSIM=0.694



MSE=144, MSSIM=0.840

# Evaluation


- (Lab) Assignment: 1×8%
- Quizzes: 2×6%=12%
- Project: 35%
- Midterm Test: 45%×40%=18%
- Final Exam: 45%×60%=27%

# Project

- Group project.
  - 5 people/group. Individual project is NOT acceptable.
  - I will randomly form the groups for you.
- I will give you some topics of the project.
- You are encouraged to propose your project topics!
- Matlab is the preferred programming language but you can use other languages.
- You are required to submit both the project report and all the codes.

# Quiz and Midterm Test

- We will have two Quizzes.
  - Close-book and close-notes.
  - Format: multiple-choices and short-answers.
  - Date: Feb. 13 (week 6) and Mar. 26 (week 12).
- Midterm Test
  - Close-book and close-notes.
  - Format: true/false, multiple-choices, short-answers, long-answers.
  - Date: Mar. 5 (week 9).

- Reference books:

  Z.-N. Li, M. S. Drew, *Fundamentals of Multimedia*, Prentice Hall Inc., 2004.

  R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, Prentice Hall Inc., 2008.

  Y. Wang, J. Ostermann, Y.Q. Zhang, *Video Processing and Communication*, Prentice Hall Inc., 2002.

# Office hour and TAs

- Office hour:
  - Mon, 4:30PM~5:30PM, PQ729
  - Email: cslzhang@comp.polyu.edu.hk
- TA:
  - Mr. Kaihua Zhang
    - Office: PQ719
    - Email: cskhzhang@comp.polyu.edu.hk

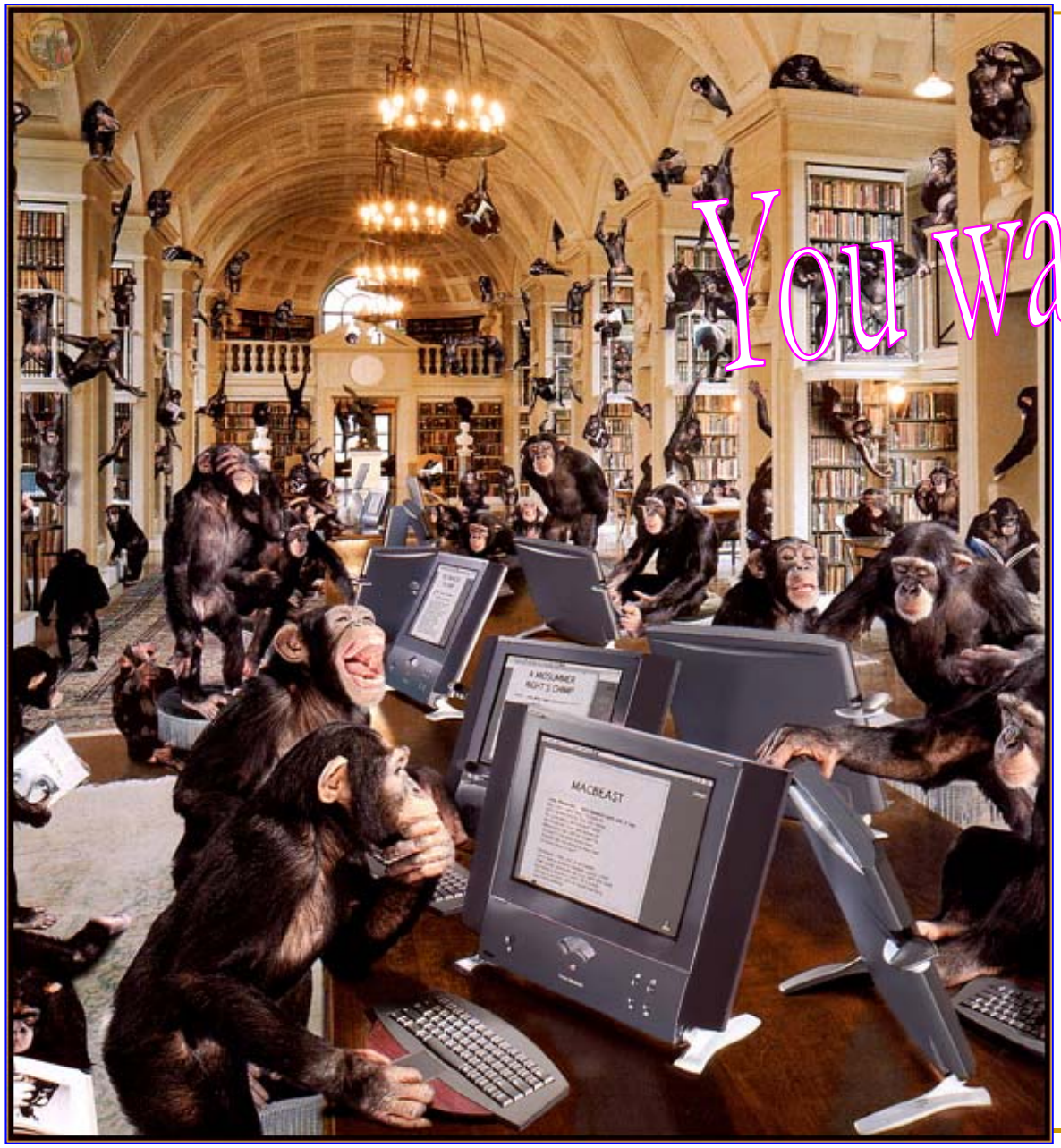
# Lab (8:30PM~9:30PM, Monday)

- Lab
  - Week 3 ~ Week 13 (except for week 9);
  - Venue: PQ604a and PQ604b.
- Please contact the Tech Team if you don't have a Lab Account yet.
- Matlab with Image Processing Toolbox
  - MATLAB Tutorial: http://www.mathworks.com/products/matlab/matlab_tutorial.html
  - MATLAB documentation: http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.shtml
- Just Google "Matlab tutorial" and you will find many materials

# Course WebCT

http://webct2.polyu.edu.hk/webct/public/home.pl

- Lecture notes, assignments and other related information will be put on this website.




# You want an A+?

**Go Library!**

**Do More Lab!**