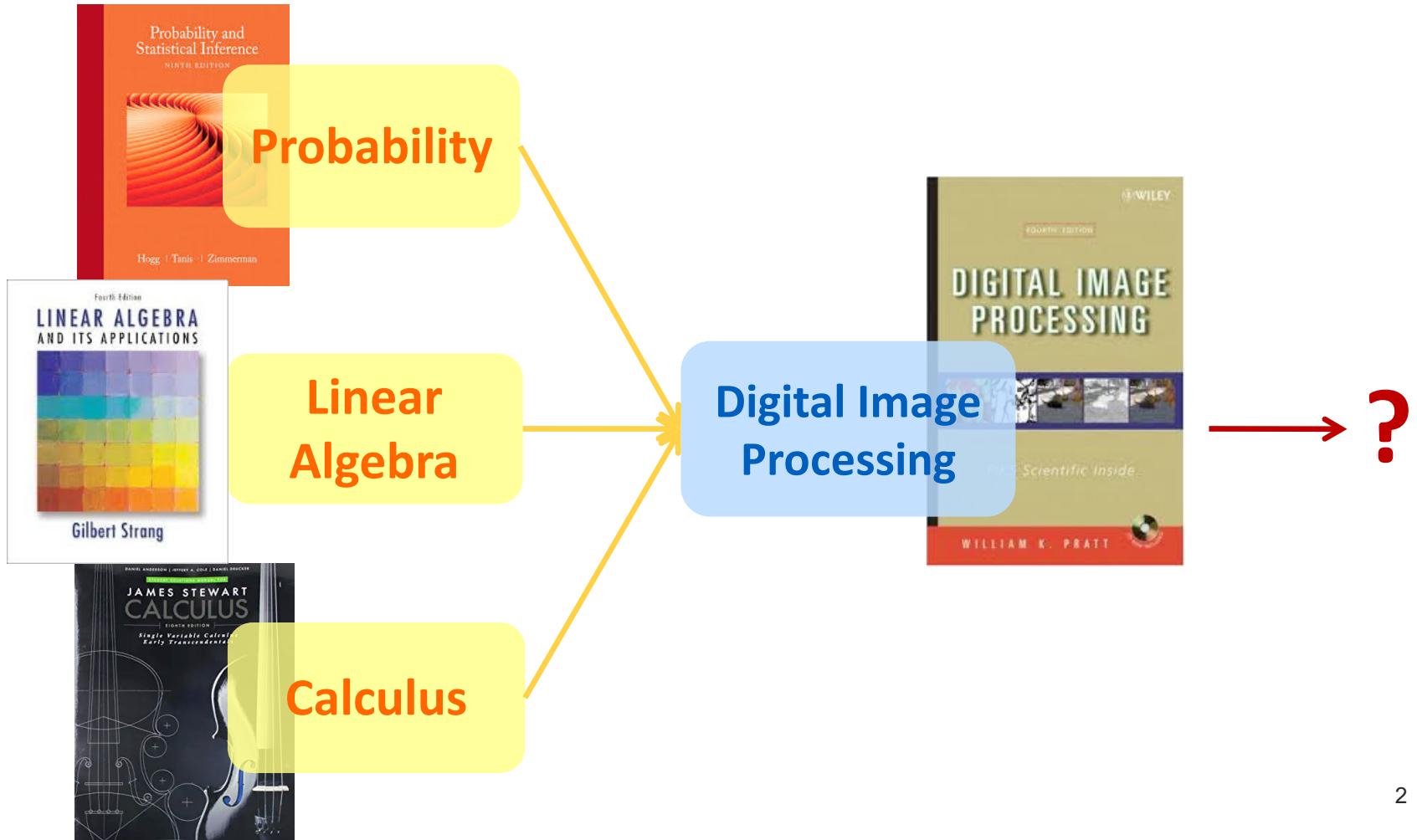


# Digital Image Processing

Ming-Sui (Amy) Lee  
Lecture 01

# Prerequisites



# [ Related Courses ]

- 醫學影像處理: 張瑞峰教授  
Medical Image Processing
- 多媒體資訊分析與檢索:徐宏民教授  
Multimedia Analysis and Indexing
- 資訊理論與編碼技巧:吳家麟教授、李明穗教授  
Information Theory and Coding Techniques
- 數位訊號處理導論:吳家麟教授、陳祝嵩教授、李明穗教授  
Introduction to Digital Signal Processing
- 電腦視覺:傅楸善教授  
Computer Vision

# [ Related Courses ]

- 圖形分析辨認:洪一平教授  
Pattern Analysis and Classification
- 數位影像生成 & 數位視覺效果:莊永裕教授  
Digital Image Synthesis & Digital Visual Effects
- 電腦圖學:歐陽明教授  
Computer Graphics
- 多媒體安全:吳家麟教授  
Multimedia Security
- 視訊通訊:李明穗教授  
Video Communications

# Important Journals

- IEEE Trans. Pattern Analysis and Machine Intelligence (IEEE-T-PAMI)
- IEEE Trans. Image Processing
- IEEE Trans. Circuits and Systems for Video Technology
- Journal of Visual Communication & Image Representation
- Journal of Electronic Imaging
- Pattern Recognition Letter
- Computer Vision and Image Understanding
- 影像與識別 Image Processing and Pattern Recognition  
(中華民國影像處理與圖形識別會刊, IPPR)

# Important Conferences

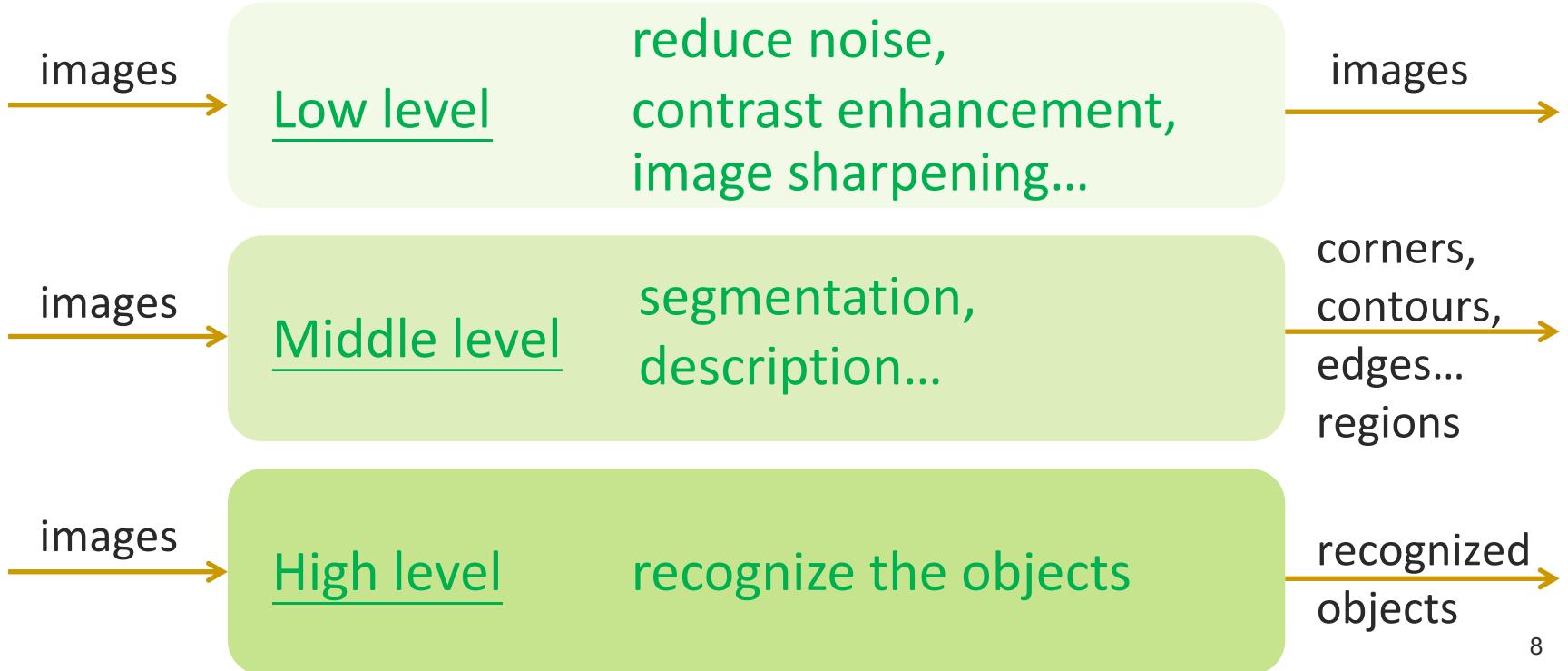
- IEEE International Conference on Multimedia & Expo (ICME)
- IEEE International Conference on Image Processing (ICIP)
- IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)
- IEEE International Symposium on Circuit and System (ISCAS)
- IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR)
- International Conference on Computer Vision (ICCV)
- Asian Conference on Computer Vision (ACCV)
- European Conference on Computer Vision (ECCV)

# Important Conferences

- SPIE conference on Visual Communication and Image Processing (VCIP)
- IPPR Conference on Computer Vision, Graphics and Image Processing (CVGIP @ Taiwan)
- International Computer Symposium (ICS or NCS @ Taiwan)

# What is this course about?

- **Digital Image Processing**  
→ process digital images



# Announcement

## ■ Instructor:

- Dr. Ming-Sui (Amy) Lee
- Department of Computer Science and Information Engineering
- CSIE Building, Room #520
- National Taiwan University
- E-mail: [mslee@csie.ntu.edu.tw](mailto:mslee@csie.ntu.edu.tw)
- Phone: (02) 3366-4888 Ext 520

# Announcement

## ■ Class Information

- Class website
  - NTU COOL  
<https://cool.ntu.edu.tw/courses/5350>
  - Syllabus
  - Lecture #1
  - Student Information Form (Mail to TA by Mar. 3)
- Teaching Assistant
  - 黃偉綸 & 朱世耘 @532  
Office Hours: 14:00 ~ 16:00, Tuesday  
10:00 ~ 12:00, Friday
  - Email: [dip.mslee@gmail.com](mailto:dip.mslee@gmail.com)

# Announcement

## ■ Textbook:

- William K. Pratt: Digital Image Processing, 3rd Edition, John Wiley & Sons Inc., 2001.

## ■ Reference Books:

- 1. D. E. Dudgeon and R. M. Mersereau: Multidimensional Digital Signal Processing, Prentice Hall, 1984.
- 2. Anil K. Jain: Fundamentals of Digital Image Processing, Prentice Hall, 1989.
- 3. J. S. Lim: Two-Dimensional Signal and Image Processing, Prentice Hall, 1990.
- 4. Rafael C. Gonzalez and Richard E. Woods: Digital Image Processing, Prentice Hall, 2010.
- 5. Ronald N. Bracewell: Two-Dimensional Imaging, Prentice Hall, 1995.
- 6. Kenneth R. Castleman: Digital Image Processing, Prentice Hall, 1996.

# Announcement

## ■ Homework Related

- There will be 5~6 assignments
- All assignments require computer programming
- Due at 11:59 am (noon) on the due date
- **Note**
  - may discuss but no duplicating
  - TA's NOT responsible for debugging
  - No late homework will be accepted

## ■ Grading Policy

- 1. Homework: 40%
- 2. Midterm Exam: 30%
- 3. Term Project: 30%

# Announcement

## ■ Tentative Schedule:

- Introduction and Digital Image Fundamentals
- Image Enhancement in Spatial Domain
- Edge Detection
- Geometrical Modification
- Morphological Processing
- Digital Halftoning and Inverse Halftoning
- Texture Analysis
- Document Processing
- Image Sampling and Transforms
- Image Enhancement in Frequency Domain
- Color Image Processing
- Image Compression

[

# Announcement

]

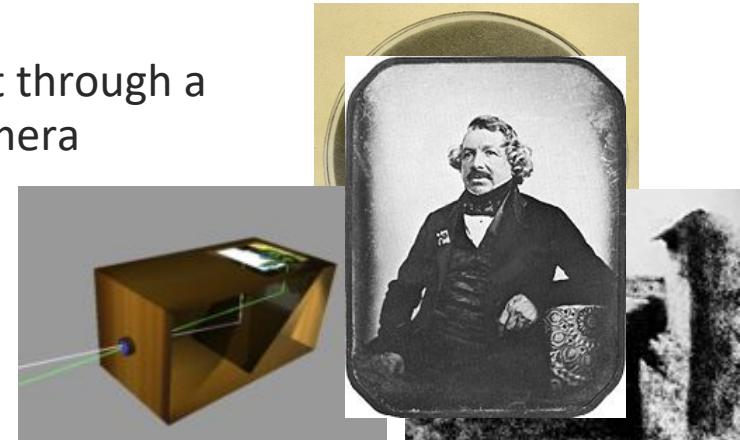
## ■ Tentative schedule

02/25	Lecture 1	04/29	Lecture 8
03/04	Lecture 2	05/06	Proposal
03/11	Lecture 3	05/13	Lecture 9
03/18	Lecture 4	05/20	Lecture 10
03/25	Lecture 5	05/27	Lecture 11
04/01	溫書假	06/03	Lecture 12
04/08	Lecture 6	06/10	Demo
04/15	Lecture 7	06/17	Demo
04/22	Midterm	06/24	Final Package Due

# Introduction

# Invention of Photography

- **1826** -- first world negative on the idea  
“making permanent photographs on a support through a compound, the images seen at the back of camera obscura.”
  - Joseph Nicephore Niepce (France)  
“heliography”(照相製版法) – sun writing
- **1839** -- “Daguerreotypes ” (銀版照相法)
  - French painter, Louis J. M. Daguerre
- **1839** “Photography”, “Negative”, “Snapshot”
  - England astronomer Sir John Herschel
- **1880** “paper-backed film ”
  - instead of “glutted dry plate”
  - USA George Eastman
- **1884** -- “Kodak Camera”
  - Eastman Kodak
- **1889** -- “Pocket Kodak Camera”
  - Eastman



Camera Obscura



The first Kodak handheld camera



Pocket Kodak Camera

# Film Camera



Once Time Use Camera



Polaroid Camera



Portable Camera



Professional SLR  
(single lens reflex)



Medium Format Camera

[



]





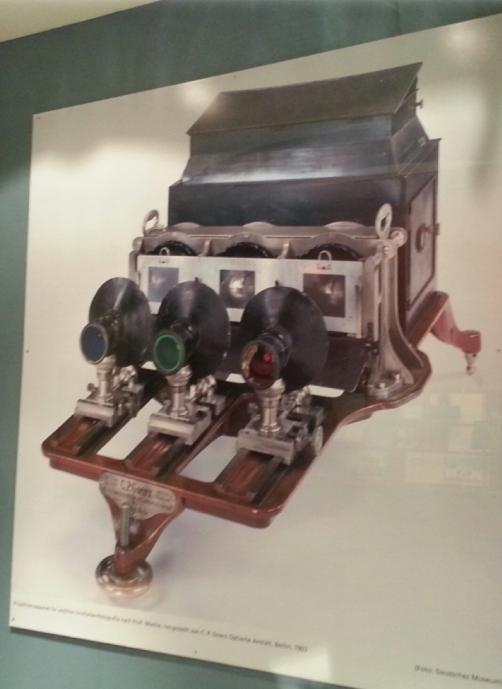
**Leica**  
die Universal-Kleinamera  
mit automatischer Schärfeinstellung  
Leica Kamera nach dem  
Prinzip der von der Firma  
LEITZ WETZLAR





Drei-Farben-Kamera, 1929  
Naturfarbenkamera, Bernloehr & CO., Berlin  
Plasmat-Olyekta, Meyer, Görlitz

Strahlentellerkamera für drei simultan aufzunehmende Farbaufzüge über halbdurchlässige Spiegel

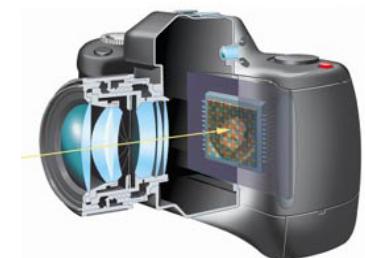


(Foto: Deutsches Museum)

# Digital Still Camera (DSC)

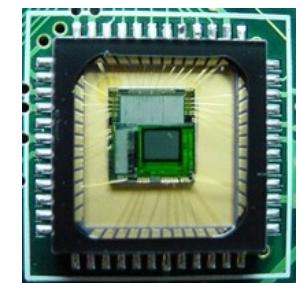
## ■ Main difference

- no film needed
- has a sensor that converts light into electrical charges



## ■ Image sensor

- most DSC: charge coupled device (CCD)
- some low-end camera: complementary metal oxide semiconductor (CMOS) technology



**CMOS**

## ■ Resolution

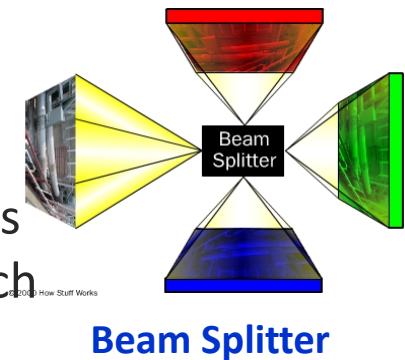
- measured in pixels
  - 256x256 pixels: cheap cameras
  - 640x480 pixels: low-end cameras. Great for e-mail exchange
  - 1216x912 pixels: (1.1 megapixel) good for print images
  - 1600x1200 pixels: (2 million pixels) good for 8x10 inches image

# Digital Still Camera (DSC)

## ■ Several ways of recording RGB color

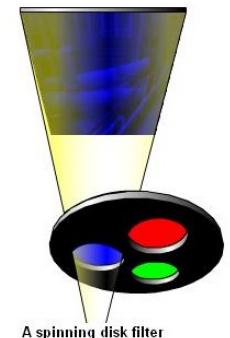
### ○ Beam Splitter

- separates the light into different sensors
- each sensor responds to one of the primary colors
- Advantage: records each of the three colors at each pixel location



### ○ Spinning Disk

- rotating a series of red, blue and green filters in front of a single sensor
- camera and the target of the photo remain stationary for all three readings
- not practical for candid photography or handheld cameras



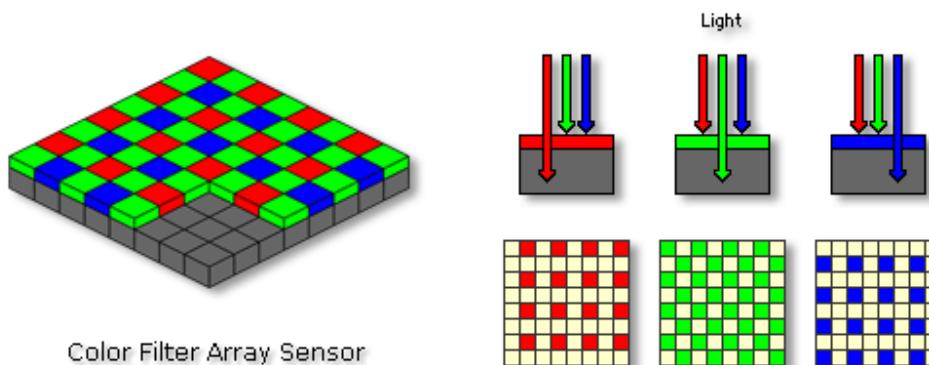
Spinning Disk

# Digital Still Camera (DSC)

## ■ Several ways of recording RGB color

### ○ Bayer Filter

- alternates a row of R and G filter with a row of B and G filters
- not evenly divided
- Advantage: only one sensor is required and all the color information is recorded at the same moment.  
Smaller, cheaper in camera design



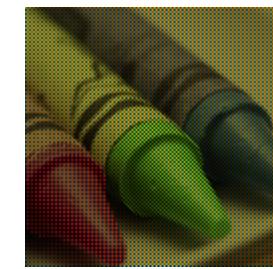
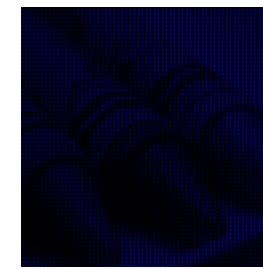
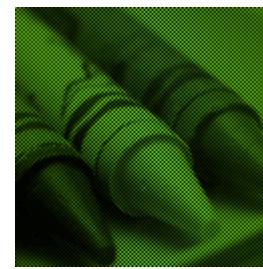
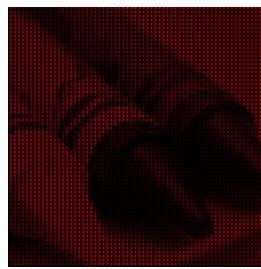
# Digital Still Camera (DSC)

## ■ Several ways of recording RGB color

### ○ De-mosaicking Algorithms

- convert the mosaic of separate colors into an equally sized mosaic of true colors
- each colored pixel can be used more than once
- true color can be determined by averaging the values from the closest surrounding pixels

Before



# Digital Image Processing

# Storage and Image Capacity

- A number of storage systems (reusable digital film)
  - Build-in memory
  - Smart Media cards
  - Compact Flash
  - Floppy Disk and Hard Disk
  - Writeable CD and DVD
- Two main file formats
  - TIFF: uncompressed format
  - JPEG: compressed format and also providing quality setting

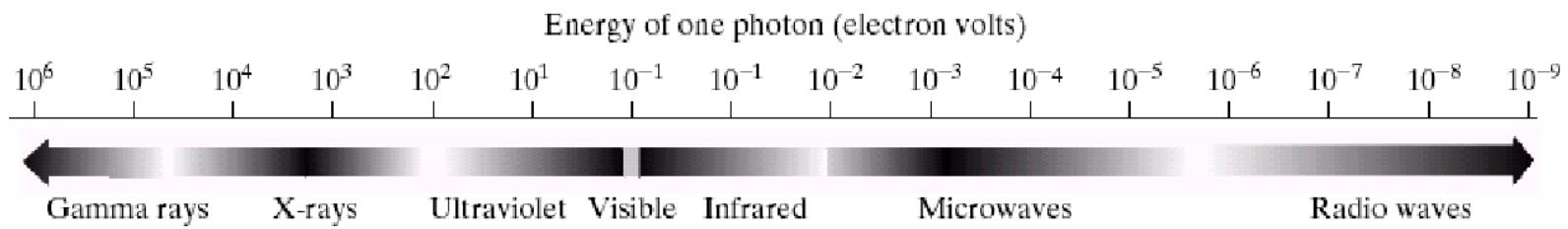
Image Size	TIFF (uncompressed)	JPEG (high quality)	JPEG (medium quality)
640x480	1.0 MB	300 KB	90 KB
800x600	1.5 MB	500 KB	130 KB
1024x768	2.5 MB	800 KB	200 KB
1600x1200	6.0 MB	1.7 MB	420 KB

# Applications of DIP

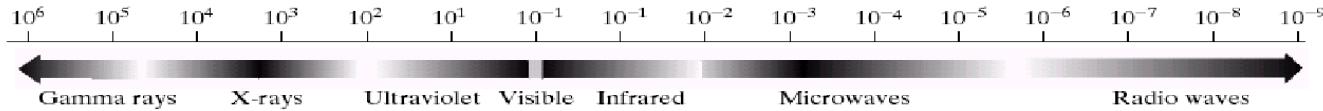
- Industry
  - Digital camera, camcoder, scanner,...
  - LCD TV, Plasma TV, ...
  - Vision-based vehicle detection
  - OCR, alignment, positioning
- Medical Imaging & Image Analysis
  - CT, MRI, X-ray, Ultrasound
  - Bioinformatics for drug design
- Others
  - Satellite imaging, resource analysis, national defense

# Categorize Images via Source

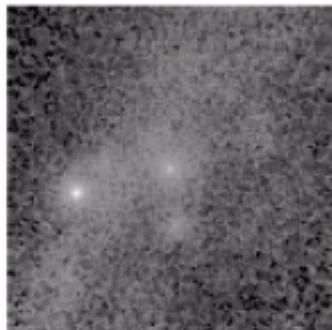
- Image sources may come from:  
electromagnetic (EM) bands (see below), acoustics,  
ultrasound, electron, range measurement or simply  
computer-generated
- Others
  - Electron Microscopy, Synthetic Imaging
- Electromagnetic (EM) Spectrum



# Examples



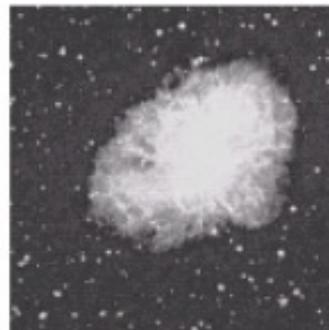
蟹狀星雲(Crab Nebula)



Gamma



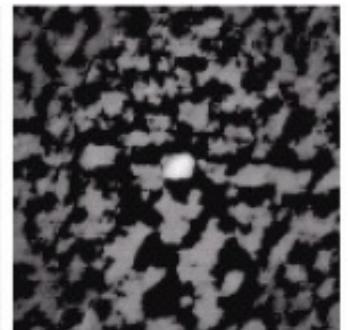
X-ray



Optical



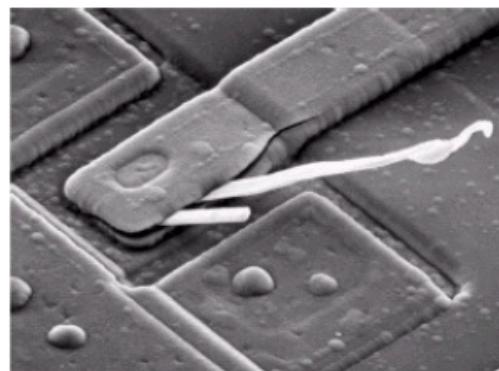
Infrared



Radio

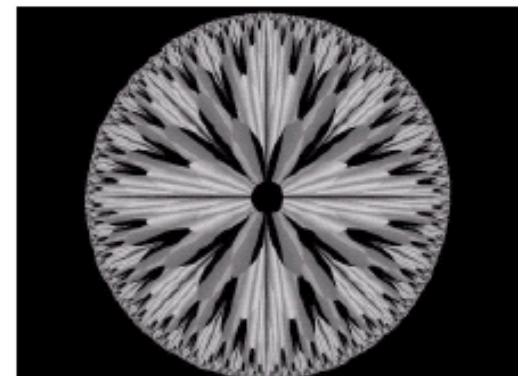


Ultrasound



SEM

Scanning Electron Microscope



synthetic

# Examples

## ■ X-Ray Imaging



[

# Examples

]

## ■ Infrared and Thermal Imaging



# Examples

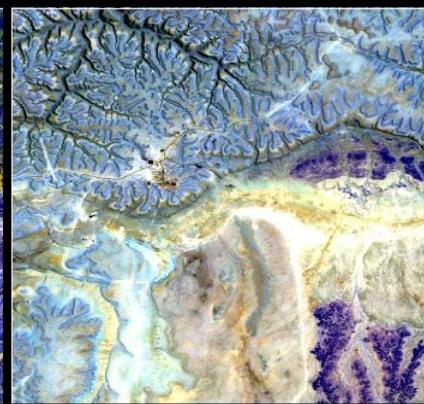
## Multispectral Imaging



1. ASTER (Visible to Near infrared VNIR) - BANDS 231



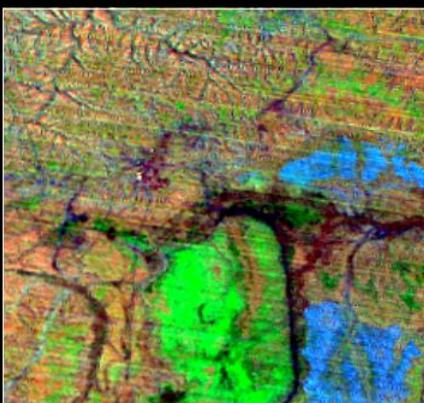
2. ASTER (SWIR and VNIR) - BANDS 931



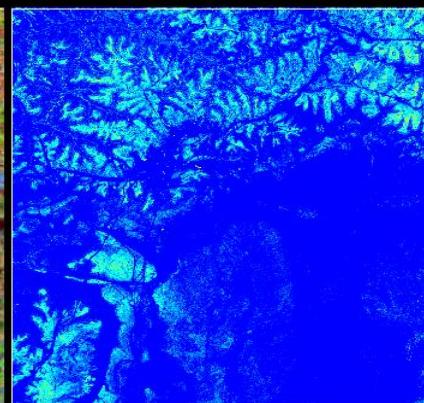
3. ASTER (Shortwave Infrared SWIR) - BANDS 954



4. ASTER (SWIR) - BANDS 975 normalized to 4



5. ASTER (Thermal) - BANDS 14 - 14.11 normalized to 10



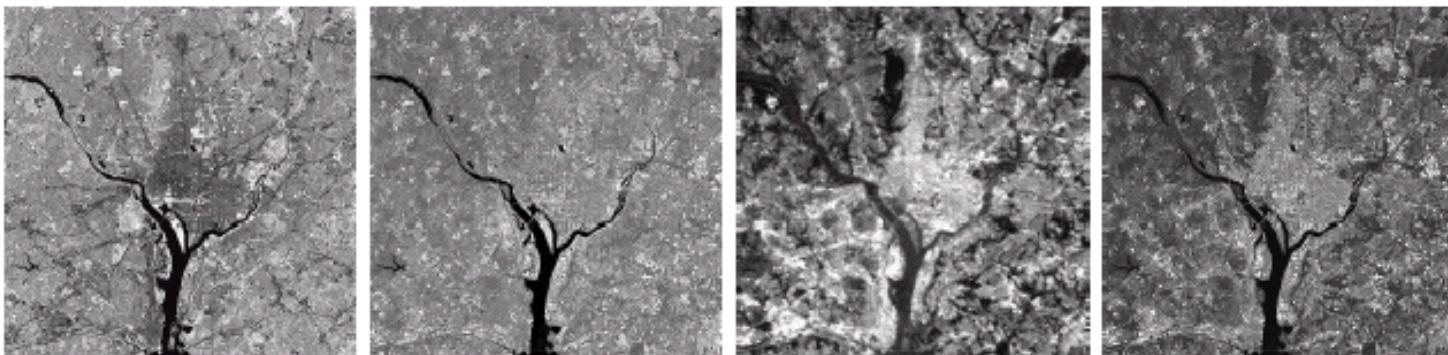
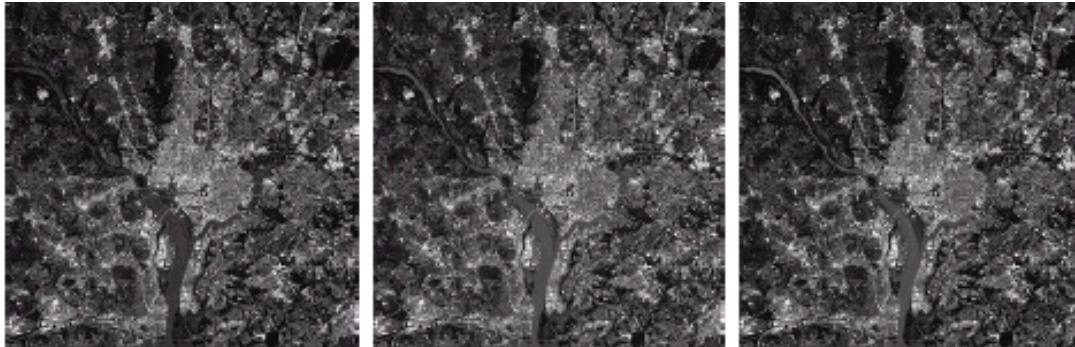
6. ASTER (Vegetation Cover)- BANDS 3/2

[

# Examples

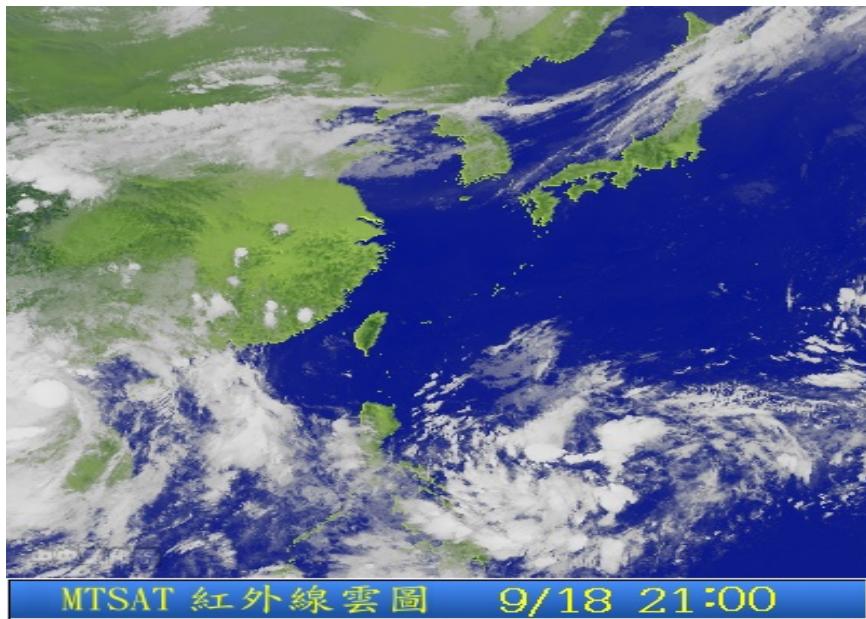
]

- Multispectral Imaging
  - Satellite images of the D.C. area



# Examples

## ■ Satellite Imaging

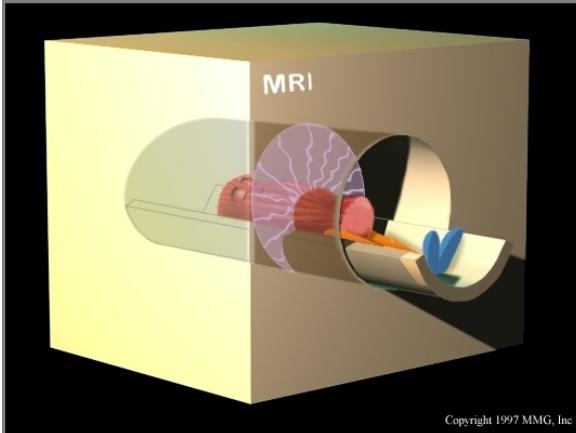


[

# Examples

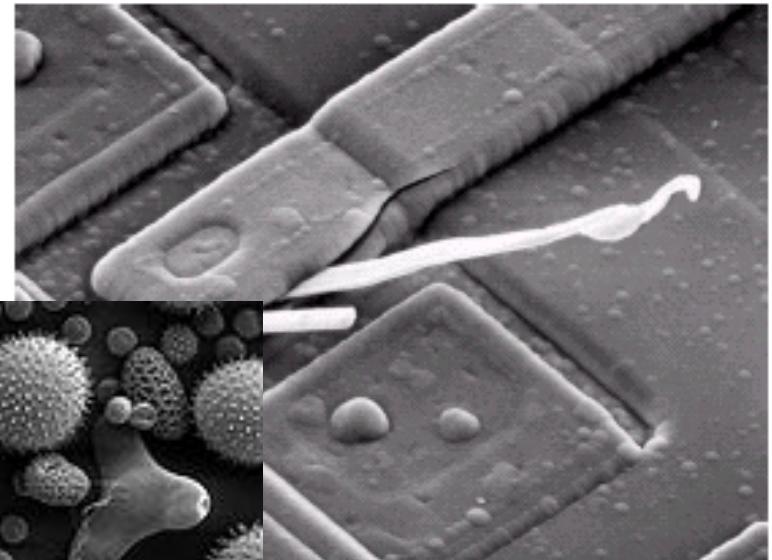
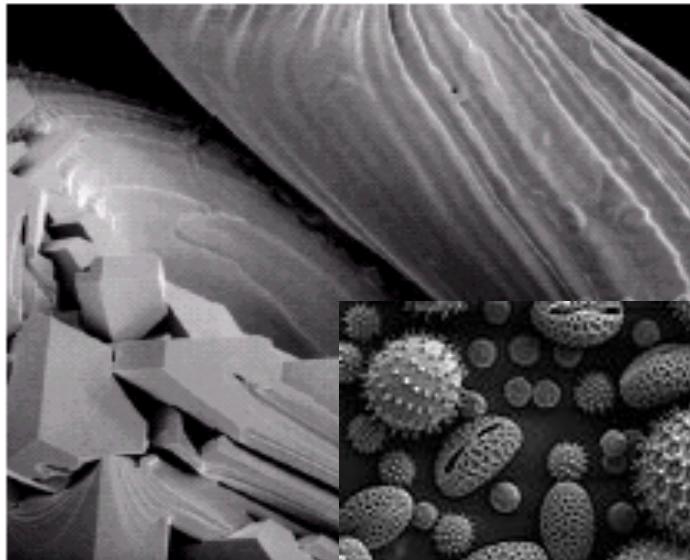
]

## ■ MRI (Magnetic Resonance Imaging)



# [Examples]

## ■ SEM (Scanning Electron Microscope)



# **Traditional Topics**

# Traditional Topics

## ■ Image Enhancement

- Improve image contrast by adjusting its histogram



# Traditional Topics

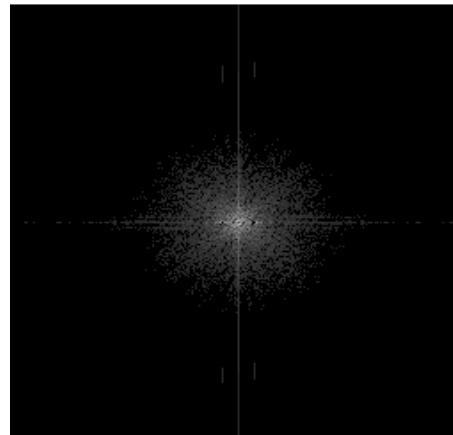
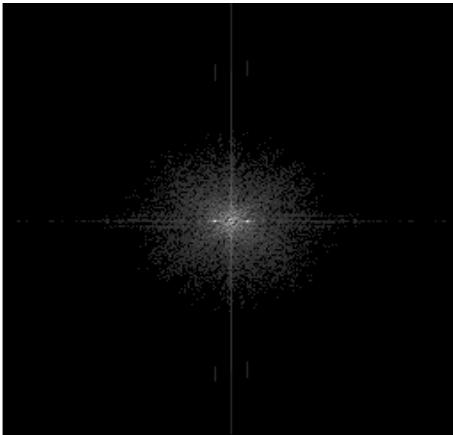
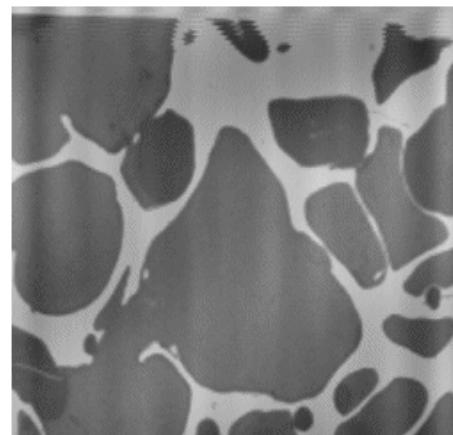
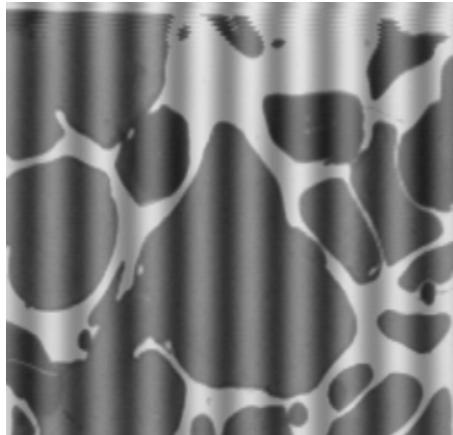
## Image Restoration

- Remove the degradation effects to recover an image to its original condition



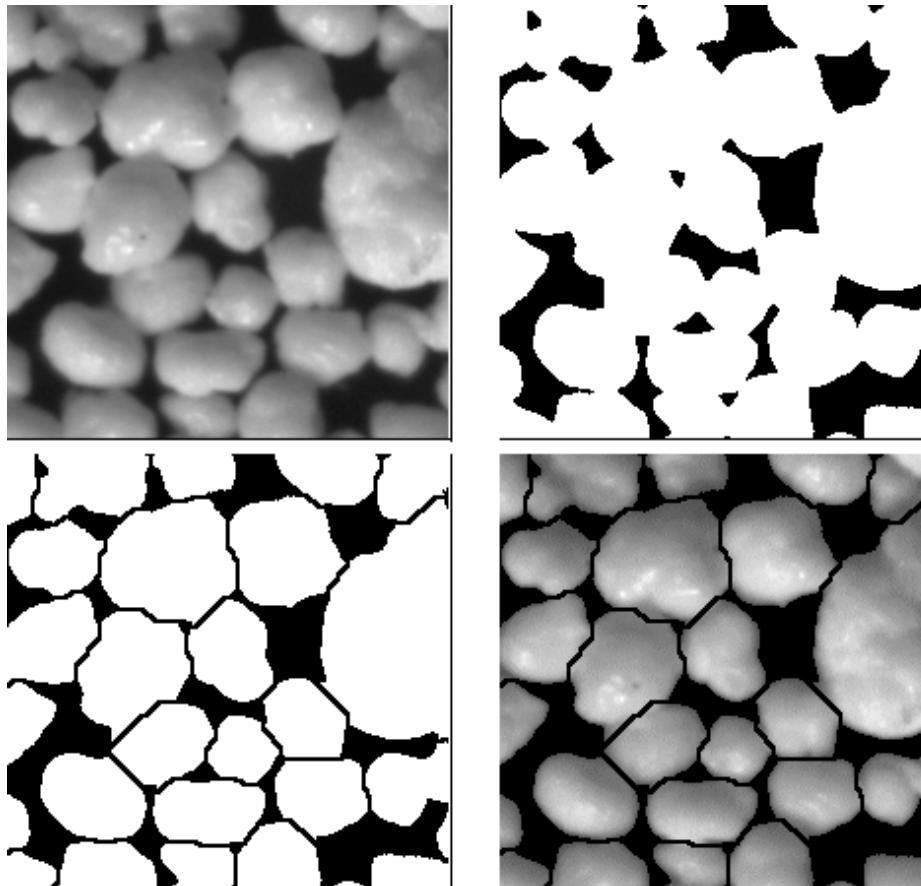
# [Traditional Topics]

## ■ Image Transformation



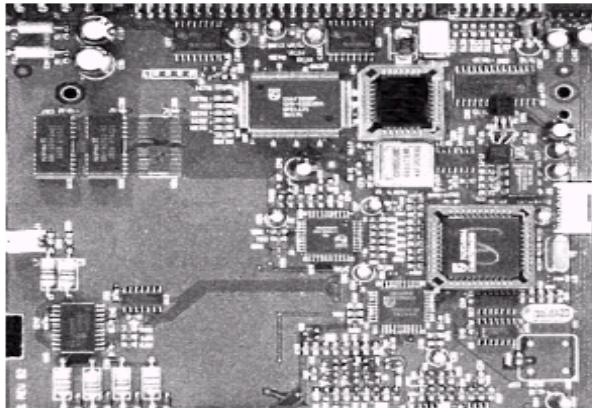
# Traditional Topics

## ■ Image Segmentation



# Examples

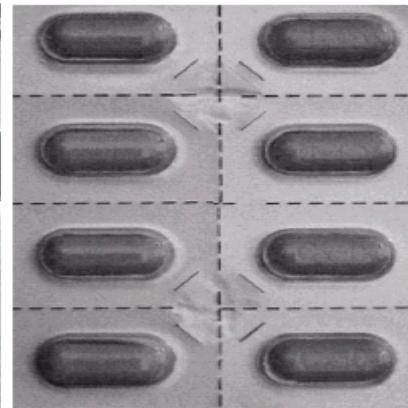
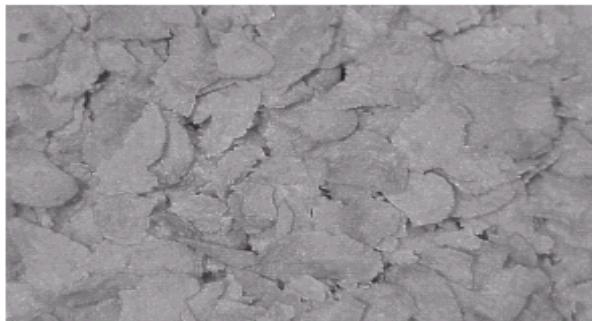
A circuit board



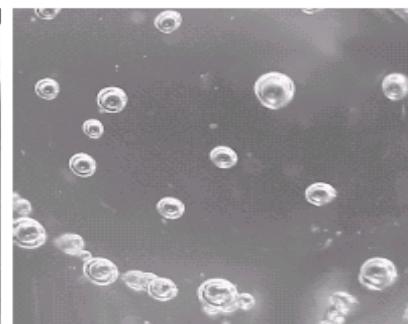
bottles



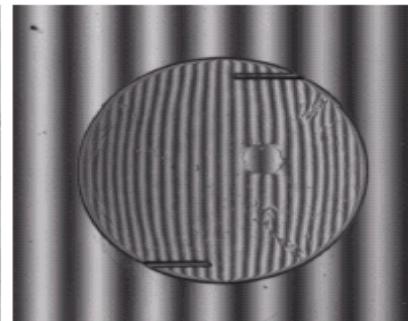
cereal



Packaged pills



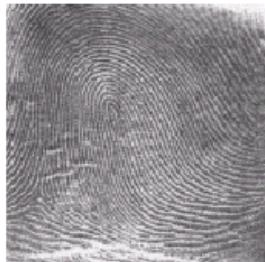
bubbles



Intraocular implant

# Examples

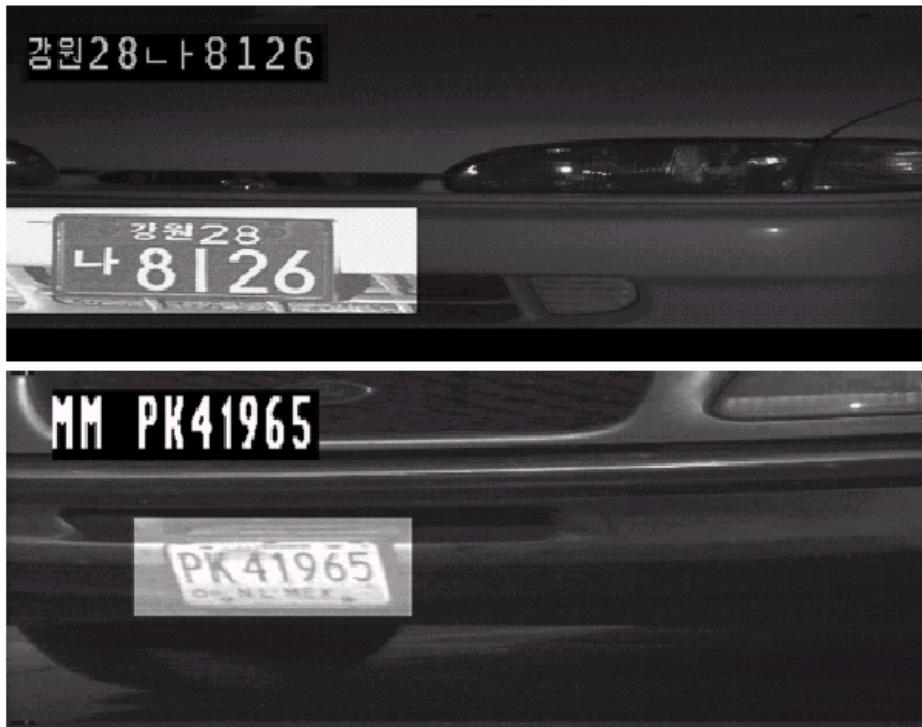
Fingerprint



Serial number



License plates



# [Student Information Form]

- Name, Student ID and Department
  - Email address
  - Your portraits
    - including a sketch and a photo, both 512x512
  - Why do you want to take this course?  
What do you expect to learn?
  - What do you want to do in the Final Project?
- Students who registered already  
[Submit to NTU COOL](#)
- Students who has not registered  
[Email TA: dip.mslee@gmail.com](#)  
[\[DIP\] Student xxxxxx](#)