ECE 6258: Digital Image Processing (DIP)

Instructor	Dr. Imtiaz Ahmad Taj (imtiaz@case.edu.pk)
Teaching Assistants	**Talal Ibrahim** and **Mubeen Ghafoor**
Lecture timings	Tuesday (7:30-9:00), Friday (6:00-7:30).
Text books and notes	1. R. C. Gonzalez and R. E. Woods, "***Digital Image Processing***", 2nd edition, Pearson Education, Inc., 2002. 2. ***"Digital Image Processing using MATLAB"*** R. C. Gonzalez , R. E. Woods and S.L. Eddins Pearson Education, Inc., 2004. 3. Class Slides
Additional books	J. C. Russ, "***The Image Processing Handbook***", fourth edition, CRC Press, 2002.

Pre-requisites for the course

1. Knowledge of probability and random variables, Vectors and Matrices.
2. Working knowledge of Matlab
3. Signals and Systems, and DSP courses especially the concepts of Convolution, FFT, filtering, etc.

Class yahoo group:

case_dip_f2006

Grading Policy: Breakup

- Sessional 1: ~15%
- Sessional 2: ~15%
- Surprise Quizzes: ~5%
- Assignments (written + programming) ~20%
- Project ~15%
- Final: ~30%

Grading breakup can change without any notice during the semester in benefit of all the students

Grading Policy: evaluation

- Grades are given according to the class standings of the student (**relative marking**)
- Average marks of the class will get around B grade
- Around top 10% of the class student will get A
- The grading will follow the approximate bell shaped curve

Assignments

- Please check the class yahoo group **case_dip_F2006** every day, for the notification of assignments, projects and other updated information.
- Assignments will have ~20% weight in the total marks.
- Assignments may be written assignments of programming assignments.
- There will be a total of around 8 assignments.
- The deadline for the submission of assignment will be given with the assignment.
- Assignments submitted after the deadline will not be accepted and will carry **ZERO MARKS.**
- Cheated assignments will get **ZERO MARKS**.

Labs

- There will be a total of 3 to 4 labs in this course
- The purpose of the labs is to guide the students to practically implement the concepts covered in the class
- The lab will cover only the basic image processing techniques like image enhancement, restoration and filtering
- The programming part of first four assignments will be covered in the lab
- Labs will not be mandatory if you feel that you can do the assignments yourself then you can quit the labs

Project

- Projects will have ~15% weight in the total marks.
- Projects may be conducted individually or in groups of two students.
- Different suggested topics for projects will be uploaded on the class yahoo group within the first two weeks of the course.
- Reading material and other sources for every project to help the students will also be given.
- If you want to do your own project take permission first.
- Project topics should be selected and approved within the first five weeks of the course.
- Project presentation date will be announced and projects will not be accepted after the presentation date.
- Projects consisting of Downloaded codes or presentations will not be accepted will carry ZERO MARKS.

Why do we process images?

- Facilitate picture storage and transmission
  - *Efficiently store an image in a digital camera*
  - *Send an image through mobile phone*
- Enhance and restore images
  - *Remove scratches from an old photo*
  - *Improve visibility of tumor in a radiograph*
- Extract information from images
  - *Measure water pollution from aerial images*
  - *Measure the 3D distances and heights of objects from stereo images*
- Prepare for display or printing
  - *Adjust image size*
  - *Halftoning*
- Biometrics based identification

Image Processing Examples

Photo restoration

Damaged Image

Restored Image

Image Processing Examples

Photo colorization

Original B/W Image

colorized Image

Original Image

Colorized Image

Image Processing Examples

Color photo enhancement




Original Images

Enhanced Images

Image Enhancement

Initial image

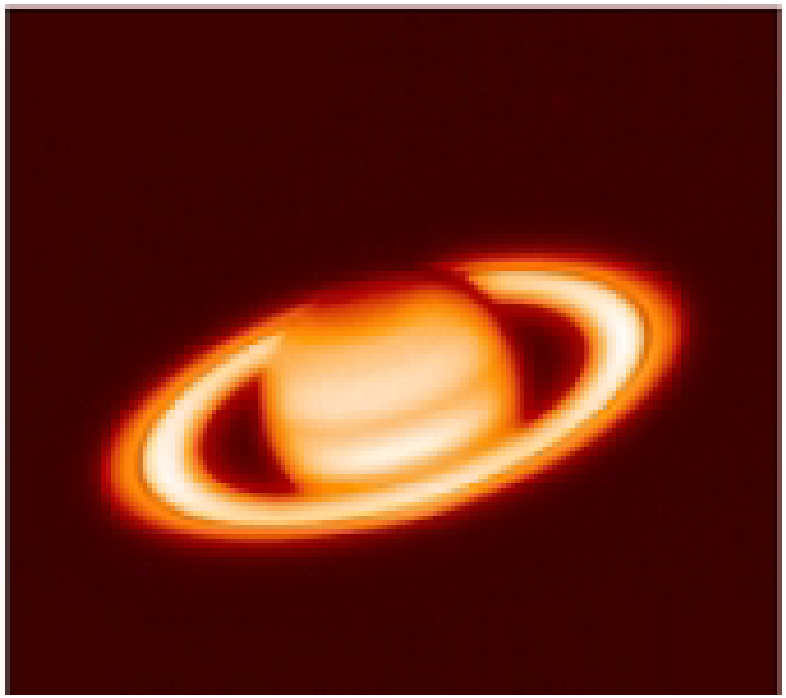
Final image

Performed steps: Gaussian blur, contrast enhancement, median filter and sharpening. Processing made by Photoshop.

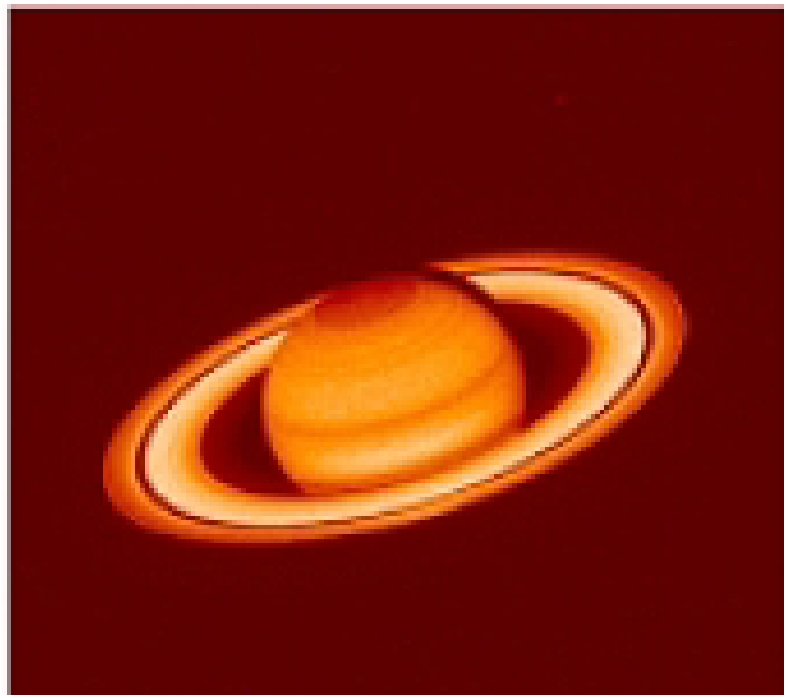
Example taken from microscopy.berkeley.edu/courses/dib

Image Processing Examples

Restoration of image from Hubble Space Telescope



Faulty image of Saturn



Recovered image

Image Processing Examples

Extraction of settlement area from an aerial image

Image Processing Examples

Earthquake analysis from space

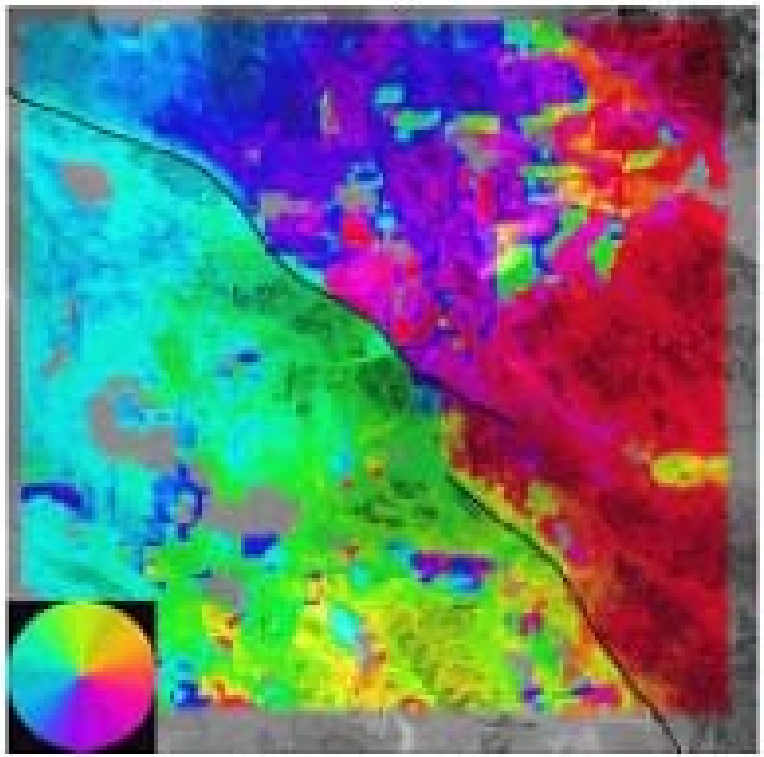
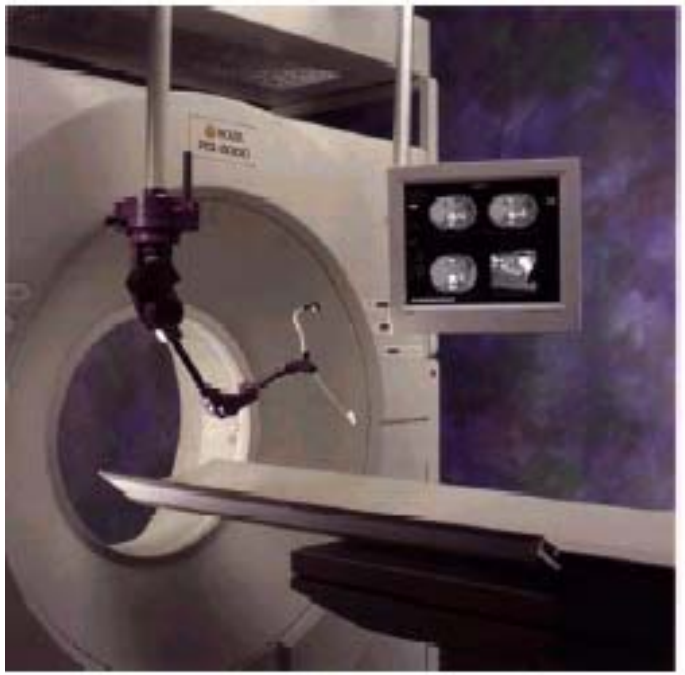


Image shows the ground displacement of a typical area due to earthquake

Image Processing Examples

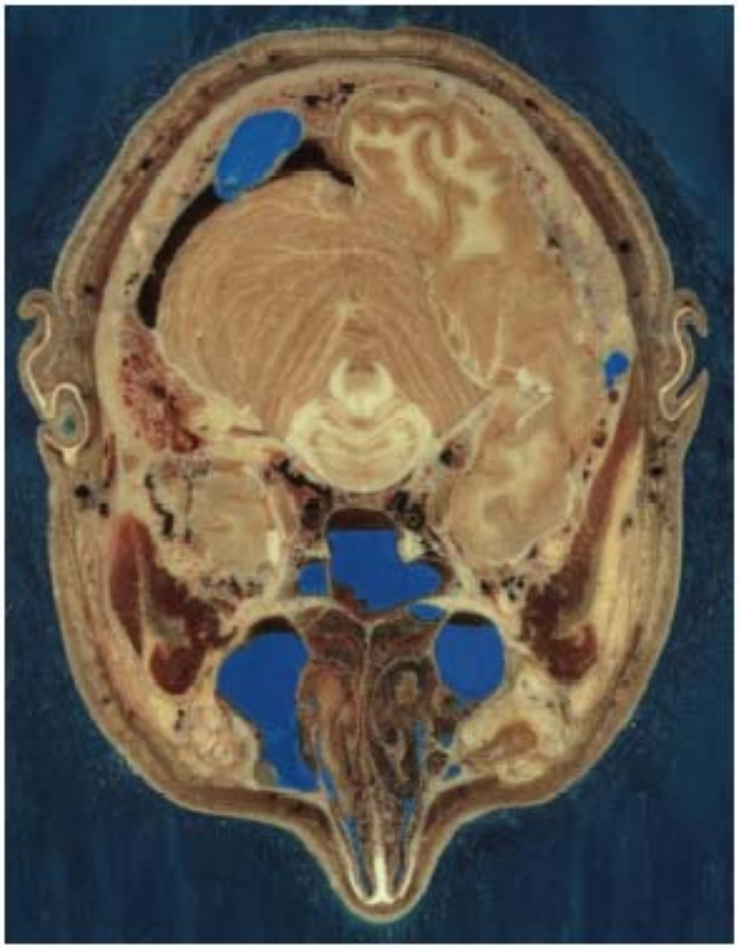
- Medical Imaging: Computer Tomography (CT)
  - *Generating 3-D images from 2-D slices.*
  - *CAD, CAM applications*
  - *Industrial inspections*



CT Scanner Picker PQ 6000 Model
- GE Medical High Speed Advantage scanner
- Picker PQ 6000

Image Processing Examples

- Medical Imaging: Computer Aided Tomography (CAT)



[545x700 24-bit color JPEG, 69069 bytes] Section through Visible Human Male - head, including cerebellum, cerebral cortex, brainstem, nasal passages (from Head subset)
http://www.nlm.nih.gov/research/visible/photos.html)

Image Processing Examples

- Medical Imaging: Ultrasound imaging

Profile of a fetus at four months. This face is approximately 1 inches (4cm) long. (http://www.parenthood.com)

Image Processing Examples

Medical imaging: Averaging MRI slices for knee image

Image Processing Examples

Image compression

Original

JPEG 27:1

Image Processing Examples

Image compression

Original

JPEG2000 27:1

Image Processing Examples

Face detection

Image Processing Examples

Face Tracking

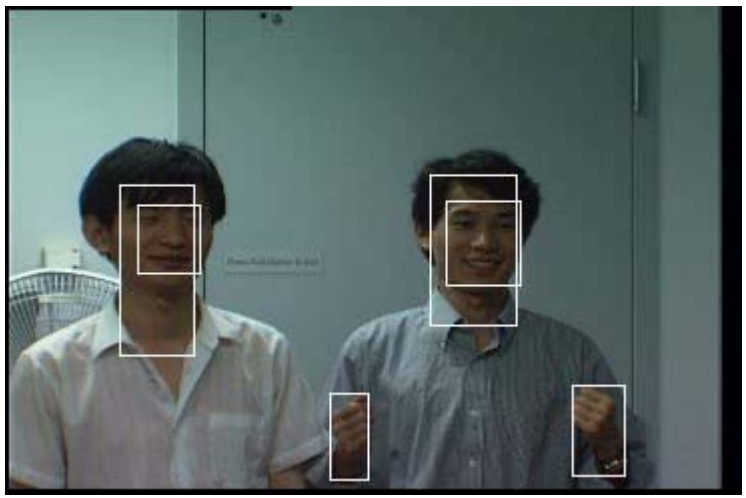


Image Processing Examples

Face Morphing

Image Processing Examples

Fingerprint recognition

X

X

√

Personal Identification using Iris Recognition

National Geographics: “Afghan Girl”

Removing geometric distortions of camera

Applications of DIP

Categorization according to image sources

- Electromagnetic (EM) band Imaging
  - *Gamma ray images*
  - *x-ray band images*
  - *ultra-violet band images*
  - *visual light and infra-red images*
  - *Imaging based on micro-waves and radio waves*
- Non-EM band Imaging
  - *Acoustic and ultrasonic images*
  - *Electron Microscopy*
  - *Computer-generated synthetic images*

EM Spectrum

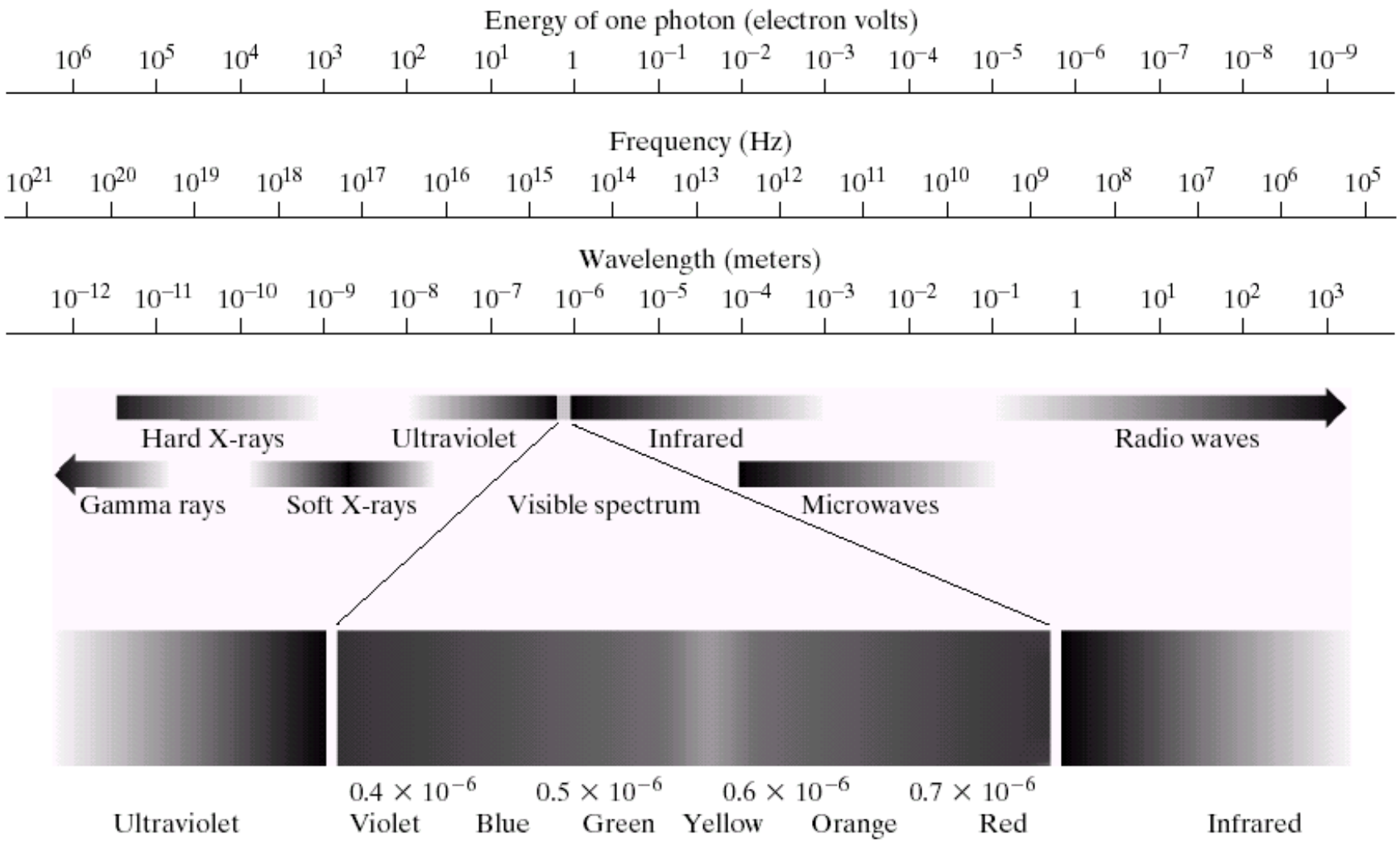


FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanation, but note that the visible spectrum is a rather narrow portion of the EM spectrum.

Applications of DIP

EM band imaging

- Gamma-ray imaging
  - *Nuclear medicine, astronomical observations.*
- X-ray Imaging
  - *Medical diagnostics (CAT scans, x-ray scans), industry, astronomy.*
- Ultra-violet imaging
  - *Fluorescence microscopy, astronomy,*
- Visible & Infrared-band imaging (most widely used)
  - *Light microscopy, astronomy, remote sensing, industry, law enforcement, military recognizance, etc.*
- Micro-wave and radio band imagery
  - *Radar, Medicine (MRI), astronomy*

Applications of DIP

Non-EM band imaging

- Acoustic imaging (hundreds of Hz)
  - *Geological exploration (oil exploration)*
- Ultrasound imaging (millions of Hz)
  - *Industry and medicine especially in obstetrics, determine the health of the fetal development*
- Electron microscopic imaging
  - *Used to achieve magnification of 10,000x or more*
    - (Light microscopy is limited to around 1000x)
- Synthetic imaging
  - *3D modeling or visualization systems for flight simulators, machine design, special effects and animations,etc.*

Classification of DIP and Computer Vision Processes

- Low-level process: (DIP)
  - *Primitive operations where inputs and outputs are images Major functions: image pre-processing like noise reduction, contrast enhancement, image sharpening, etc.*
- Mid-level process (DIP and Computer Vision and Pattern Recognition)
  - *Inputs are images, outputs are attributes (e.g., edges) major functions: segmentation, description, classification / recognition of objects*
- High-level process (Computer Vision)
  - *make sense of an ensemble of recognized objects; perform the cognitive functions normally associated with vision*

Image Processing Steps

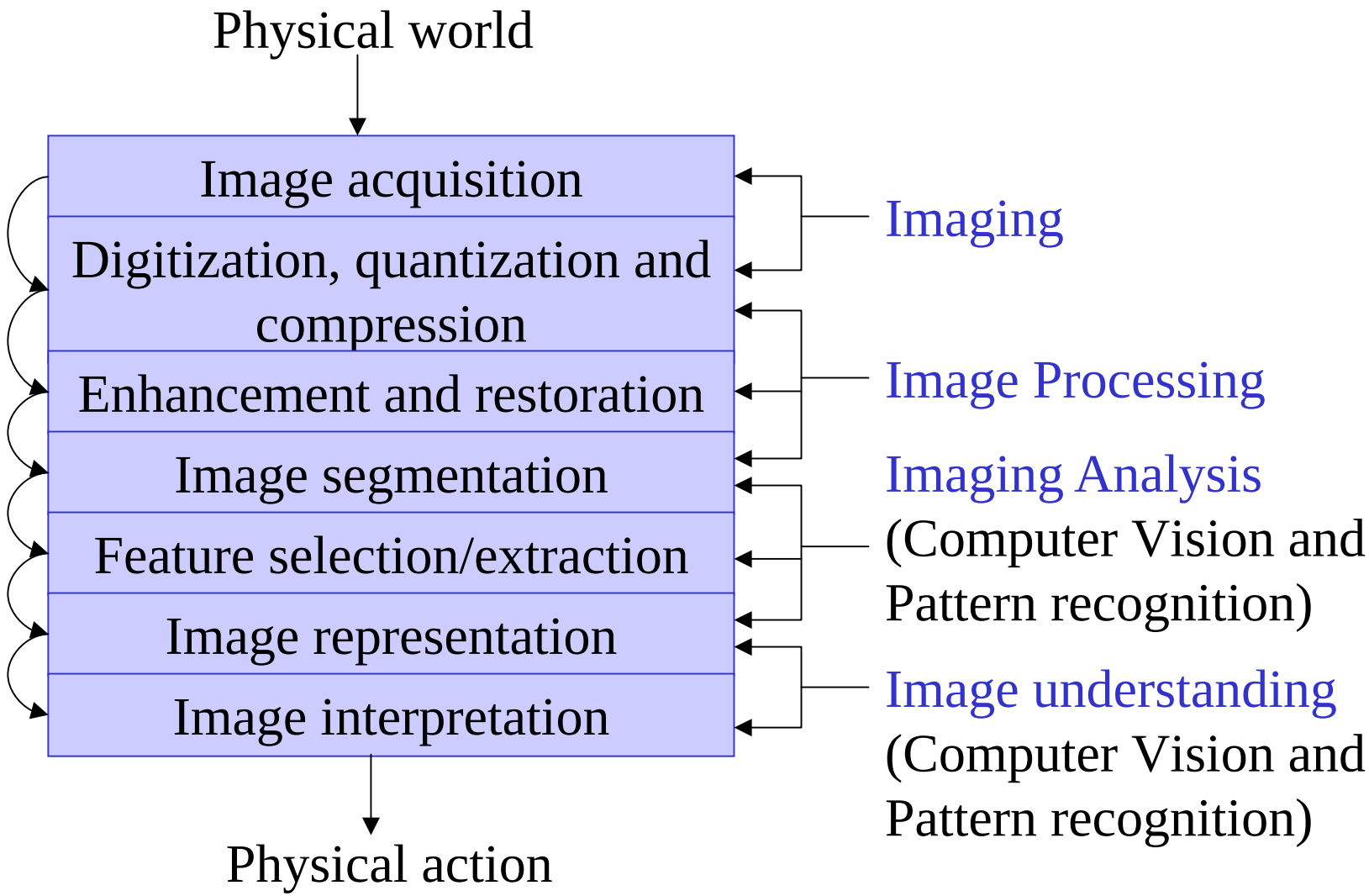


Image Processing Computer vision and PR

Digital Image Processing

- Image acquisition by sensor
- Image sampling and quantization

Image enhancement and restoration
- Filtering in spatial domain or frequency domain

Feature Extraction
- Edge detection
- Interest points

Colored image Processing
- Pseudo coloring
- Color segmentation

Multi-resolution analysis
- Pyramids
- Wavelets
- Other transformations

Image and video compression
- Image compression standards
- Video compression standards

Computer Vision

Image Geometrical Rectification
- Camera geometry

Feature Extraction
- Edge and Interest points detection
- Texture and shading
- Shape from texture and shading

Calculation on Multiple Views
- Multi-view geometry and Stereo imaging
- Structure from motion

Segmentation
- Impose some order on group of pixels to separate them from each other

Template matching

Pattern Recognition

Segmentation

Classification and Recognition
- Classification and interpretation of objects based on selected features
- Recognize objects using probabilistic techniques

Scope of DIP Course

- Digital image fundamentals and image acquisition (briefly)
- Image enhancement in spatial domain
  - *pixel operations*
  - *histogram processing*
  - *Filtering*
- Image enhancement in frequency domain
  - *Transformation and reverse transformation*
  - *Frequency domain filters*
  - *Homomorphic filtering*
- Image sampling
- Image restoration
  - *Noise reduction techniques*
  - *Geometric transformations*
- Color image processing
  - *Color models*
  - *Pseudocolor image processing*
  - *Color transformations and color segmentation*

Scope of DIP Course (continued)

- Wavelets and multi-resolution processing
  - *Multi-resolution expansion*
  - *Wavelet transforms, etc.*
- Image compression
  - *Image compression models*
  - *Error free compression*
  - *Lossy compression, etc*
- Image segmentation
  - *Edge, point and boundary detection*
  - *Thresholding*
  - *Region based segmentation, etc*
- Morphological image processing
  - *Dilation and erosion*
  - *Opening closing*
  - *Hit or miss transformation*
  - *Basic morphological algorithms*