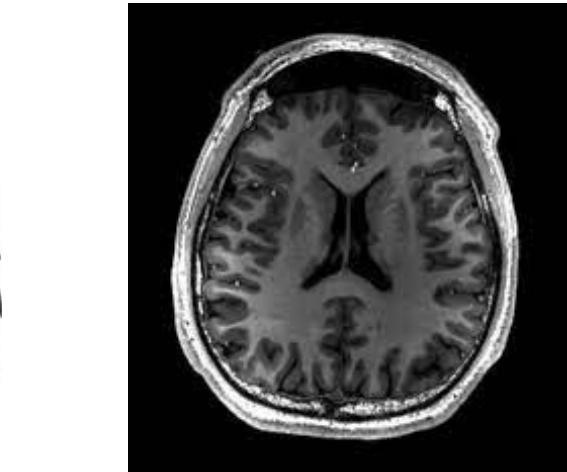


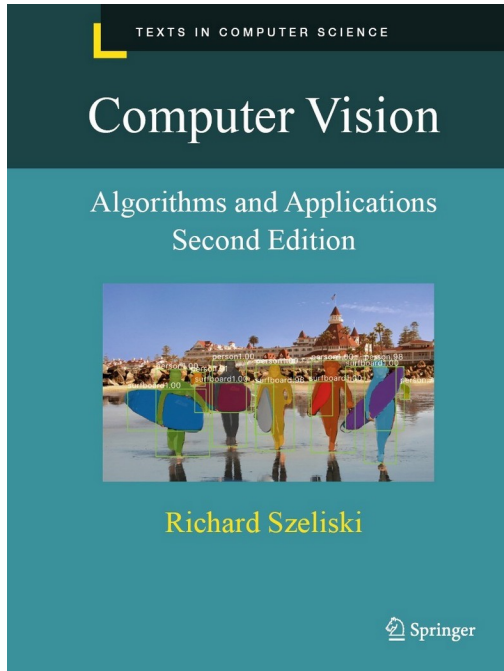
Digital Image Processing: An Overview

Stanislaus Jiwandana Pinasthika, S.Kom., M.Cs.



Course Information

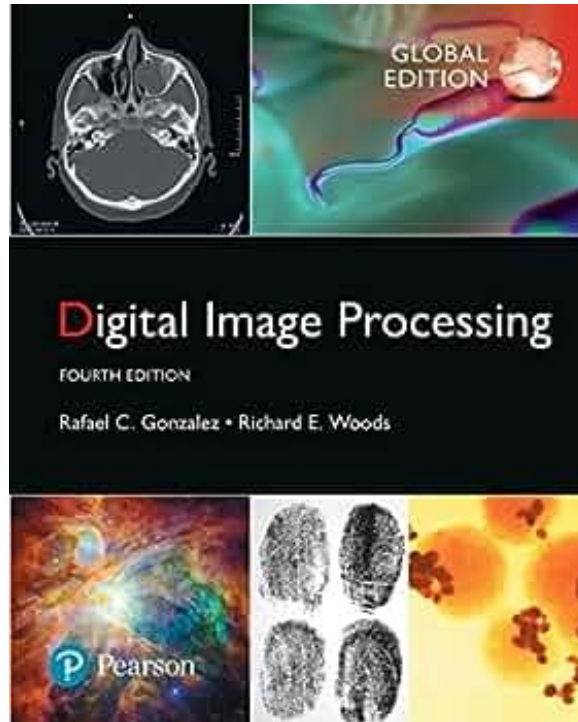
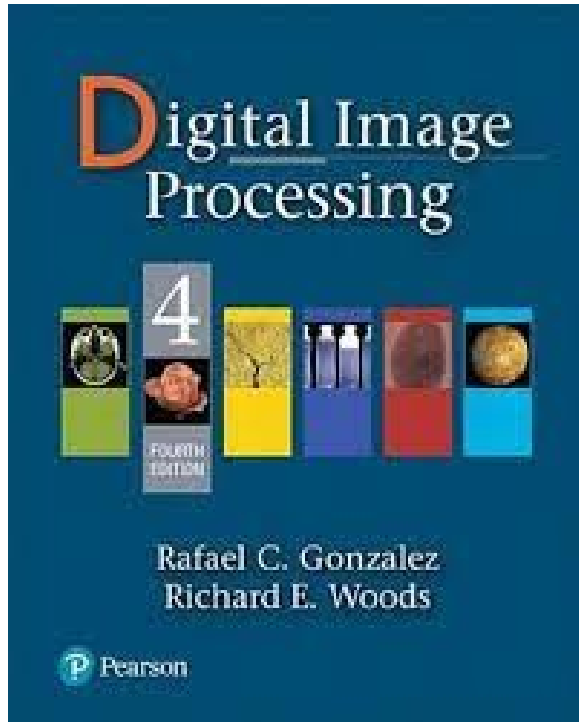
Main Reference



Richard Szeliski. (2021). "Computer Vision: Algorithms and Applications". Springer.

Available on: <https://szeliski.org/Book/>

Additional Reference



Rafael C. Gonzalez
and Richard E. Woods.
(2018). "Digital Image
Processing: Fourth
Edition". Pearson.

Available on:
https://www.imageprocessingplace.com/DIP-4E/dip4e_how_to_order.htm

Course Objectives

Students have to understand:

- Main concept of digital image processing and its application.
- Pixel-based image enhancement and its implementation.
- Filter-based image enhancement.
- Basic techniques of DIP (segmentation, morphological operations, image restoration, features extraction).
- Features representation (edge and texture).
- ML-based digital image processing.

The Fundamental of Digital Image Processing

What is images?

- Mathematically, images are two-dimensional function $f(x,y)$ where x and y are spatial coordinates and contain color intensity or *gray level*.

Thus, digital images is

- Numerical representation, usually binary, of two or three dimension images.



This digital image is being representation of 2D-function with 640 columns and 427 rows.

For color image, each pixel is represented by color intensity **R** (Red), **G** (Green), **B** (Blue).

column	R	G	B
$f(300, 300)$	117	115	118
row	Color intensity		

Lego na neve, by Bene Riobo, Wikimedia Commons, CC-BY-SA 4.0

Digital Image Processing (DIP)

- Part of signal processing (2D or 3D signal).
- Implementation of computational algorithm for processing image function.
- The objective:
 - Extracting important features from enhanced or repaired images.

Steps of DIP

Image
Acquisition

Enhancement

Segmentation

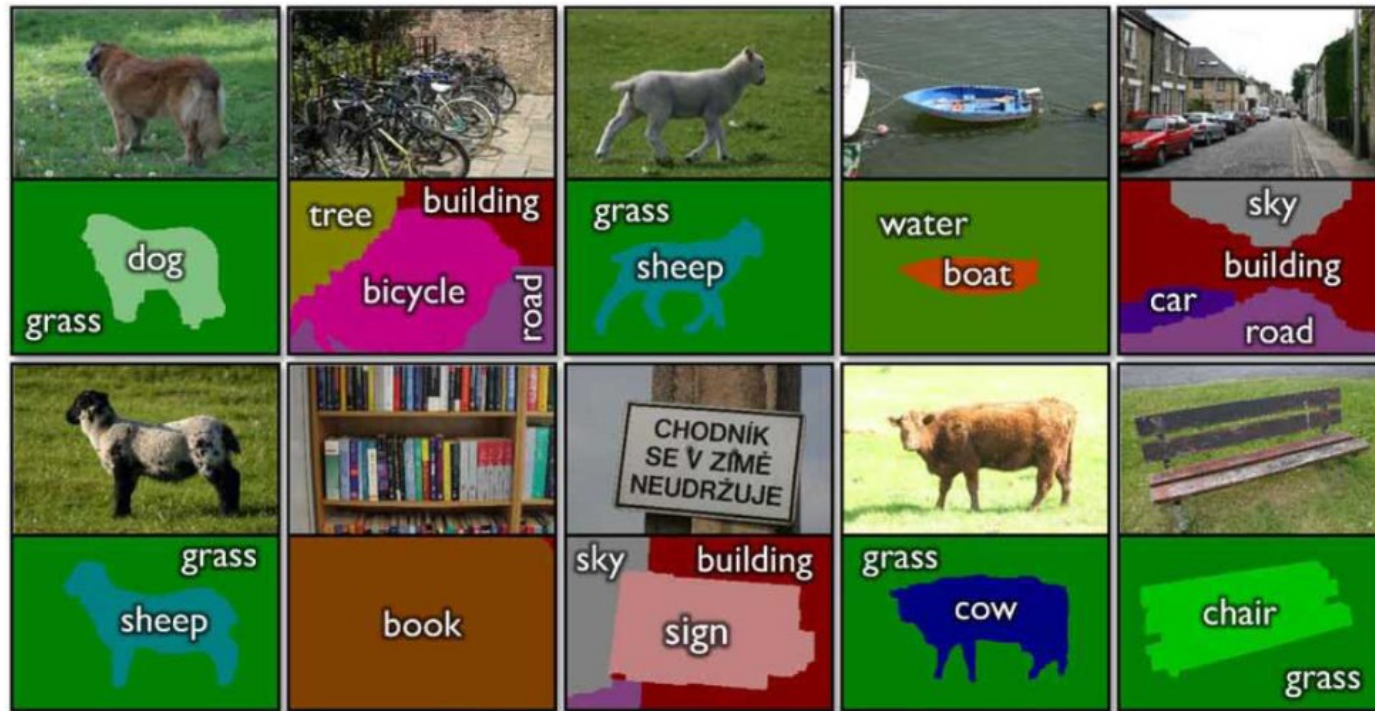
Feature
Extraction,
Representation,
and Matching

1

2

3

4



Segmentation is a process to differ and separate foreground and background.

Figure 6.33 Simultaneous recognition and segmentation using TextonBoost (Shotton, Winn et al. 2009) © 2009 Springer.

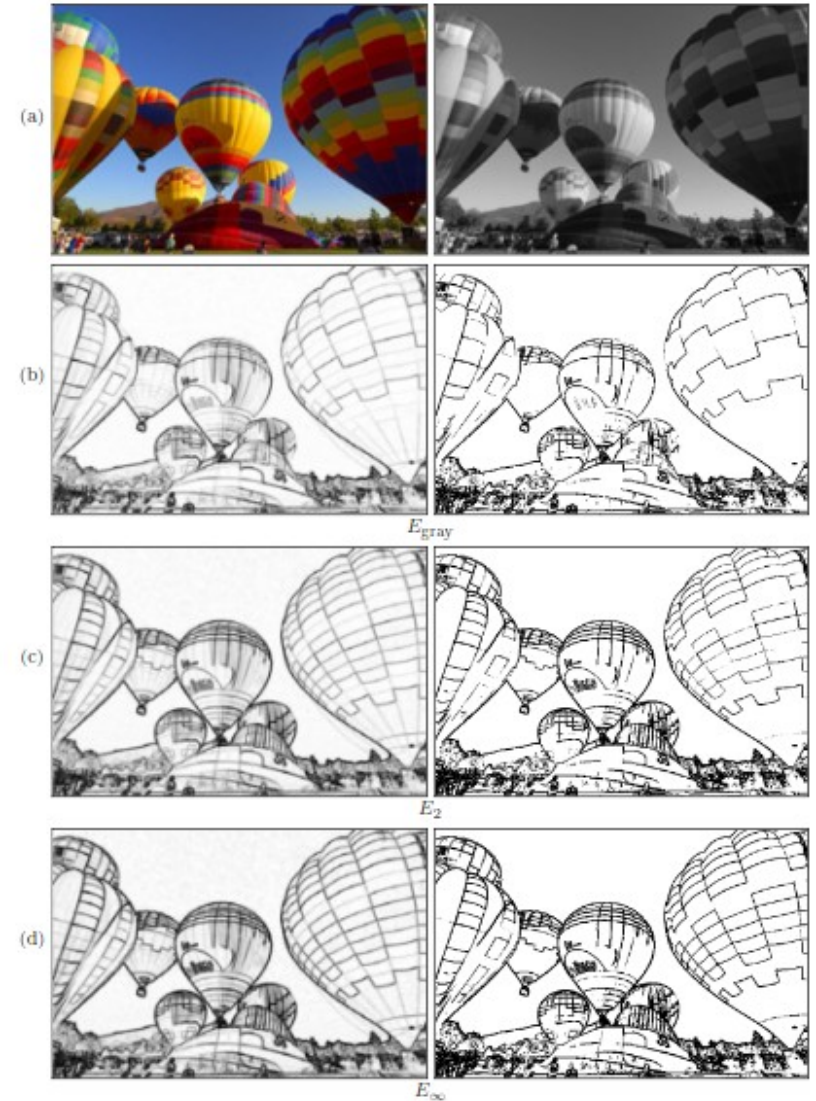
DIP Techniques

- Image enhancement (pixel-based or filtering).
- Segmentation.
- Morphological operation.
- Image restoration
- Features extraction (corner, line, and edge).
- Features representation (edges and textures).

Image Enhancement

To sharpen the image, so the features can be easily detected.

Figure 4.2 Example of color edge enhancement with monochromatic techniques (balloons image). Original color image and corresponding grayscale image (a), edge magnitude obtained from the grayscale image (b), color edge magnitude calculated with the L_2 norm (c) and the L_∞ norm (d). Binary images in the right column were obtained by thresholding the resulting edge strength.



Wilhelm Burger and Mark J. Burge. (2013). *Principles of Digital Image Processing Advanced Methods*. Springer.

Morphological Operation

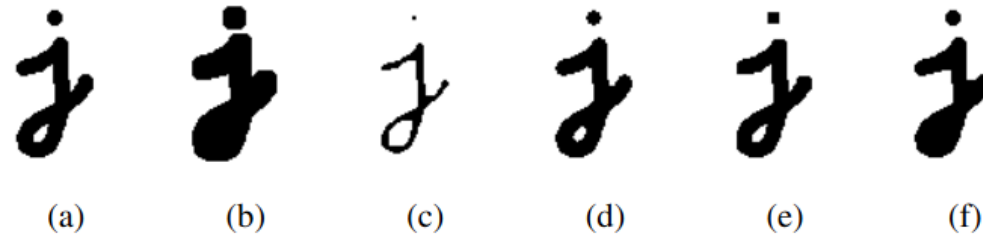


Figure 3.22 *Binary image morphology: (a) original image; (b) dilation; (c) erosion; (d) majority; (e) opening; (f) closing. The structuring element for all examples is a 5×5 square. The effects of majority are a subtle rounding of sharp corners. Opening fails to eliminate the dot, as it is not wide enough.*

Related to binary images. Used to take object shapes or reduce noise.

Image Restoration

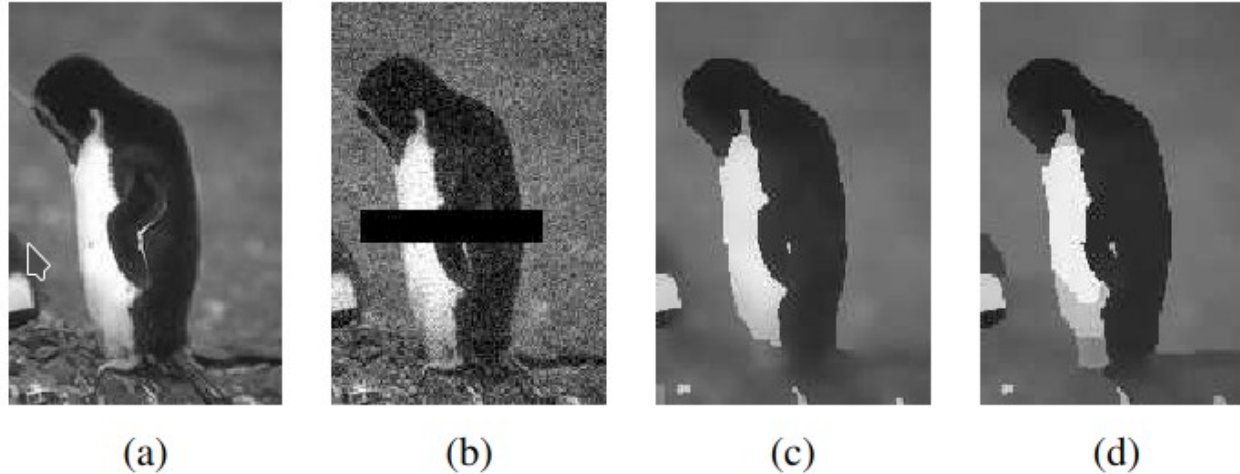


Figure 4.13 *Grayscale image denoising and inpainting: (a) original image; (b) image corrupted by noise and with missing data (black bar); (c) image restored using loopy belief propagation; (d) image restored using expansion move graph cuts. Images are from <https://vision.middlebury.edu/MRF/results> (Szeliski, Zabih et al. 2008).*

Examples of DIP Implementations

Google Maps



Vehicle Damage Detection



Fig 5 Results of vehicle damage detection and classification.

Classes	Train size	Aug. train size	Test size
Dent	150	450	30
Scratch	112	330	22
Large Dent	146	430	25
Glass shatter	104	310	25
Head light broken	57	150	14
Red light broken	39	110	11
Severe Damage	256	768	30
Mild Scratch	347	1010	50
Dislocation	115	300	20
Tear	200	630	30
Front side	200	550	35
Door side	150	400	20
Rear side	100	250	15

Table 1 Dataset Description



Fig 3 Different Damage Type Samples

Mallikarjuna B. and Arun Kumar K. L. (2022). "Vehicle Damage Detection and Classification Using Image Processing". *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)*

Sport Action Recognition

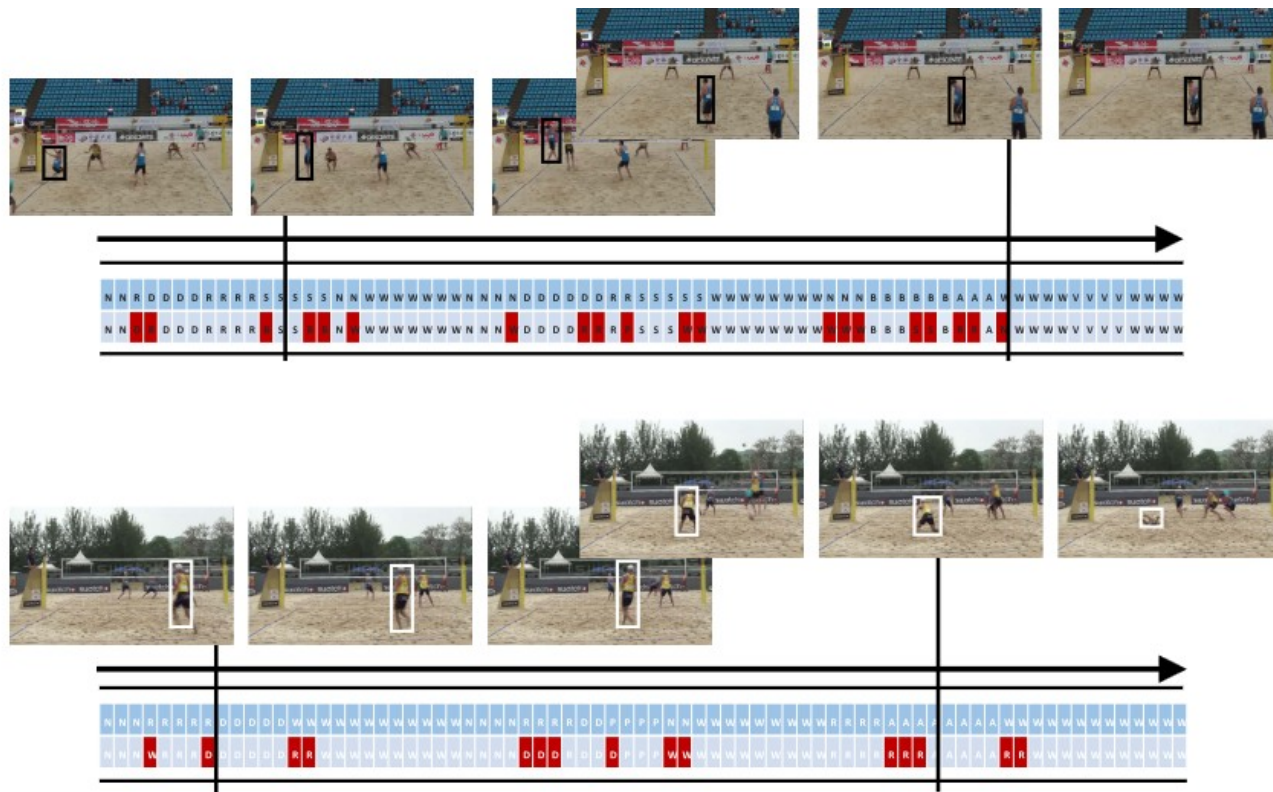


Fig. 11. Visualization of predicted class labels on the BeaVoll dataset using our model. Every sliding window is associated with one column, and every possible prediction is associated with one row. For each player, the top row denotes the ground truth and the bottom row shows the prediction. Letters in red background are incorrect results. We denote *serve* as 'V', *dig* as 'D', *non-action* as 'N', *pass* as 'P', *spike* as 'S', *block* as 'B', *save* as 'A', *walk* as 'W', and *run* as 'R'.

Longteng Kong, Di Huang, Jie Qin, and Yunhong Wang. (2020). "A Joint Framework for Athlete Tracking and Action Recognition in Sports Videos". *IEEE Transactions on Circuits and Systems For Video Technology*.

Reducing Noise in Medical Images



Fig. 3. Noise polluted medical X-ray image

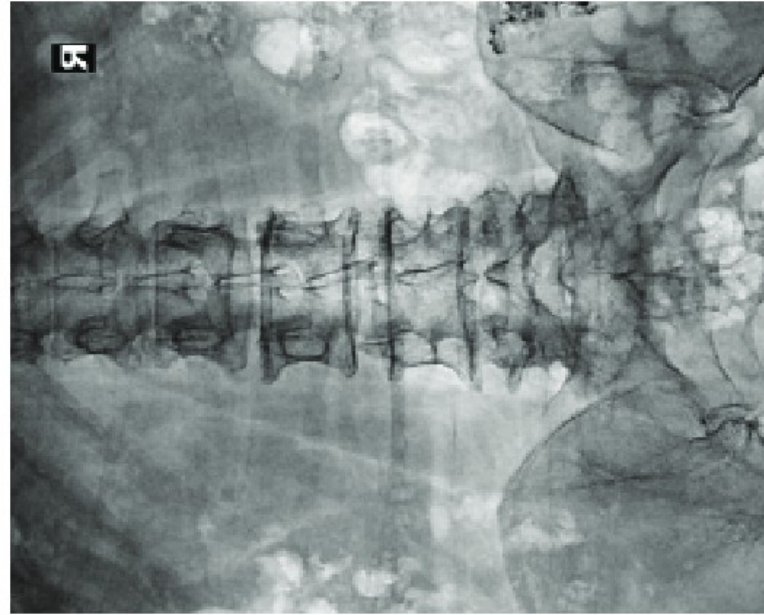


Fig. 5. Processed image by proposed mean filtering

Longteng Kong, Di Huang, Jie Qin, and Yunhong Wang. (2013). "IEEE International Conference on Consumer Electronics, Communications and Networks".

Final Project

Final Project

- A group project, ideally 3-5 students.
- Design and develop DIP-based solution.
- Selectable topic :
 - Smart city / E-govt
 - Health care
 - Education
 - Modern agroindustry
 - Tourism

Final Project

- Assessment aspects :
 - Originality of ideal, proposed method, and urgency of problems – 50%
 - Essay writing – 25%
 - Poster / demo – 15%
 - Presentation – 10%

Proyek Akhir

- Examples (but not limited to) :
 - Brain tumor segmentation and classification.
 - Vehicle type and color detection.
 - Watermelon crop quality classification based on size and texture detection.
 - Porn detection for automatic content censorship.
 - Emotion and micro-expression detection.

Challenge and Bonus (optional)

- Special rewards are available for groups which submitted their work to competition, such as GEMASTIK or either national or international conferences or proceedings.
- The rewards are valid if the students attend the class higher than 80%.
- The rewards are explained by the table below:

Achievement	Special reward
Champion of competition	A
Competition finalist	A-
Accepted by international proceeding	A
Accepted by national proceeding	A-

Thank you and good luck