Image Processing with Applications and Learning
Spring 2023, Math563

Instructor: Dr. Nikolay Metodiev Sirakov
Department of Mathematics, TAMU-Commerce
Room: Bin329
Meets 1/17/2023 through 5/12/2023, Day, Time: TR: 6PM-8:30PM

Instructor: Dr. Nikolay Metodiev Sirakov
Office Hours: M 2:45PM- 4:45PM
W 2:45PM- 4:45PM
Th 5PM-6PM
Friday research meetings
Others by appointment

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Textbook: Digital Image Processing, 3rd Edition, by Rafael C. Gonzalez, Richard E. Woods, Prentice Hull, 2008, 0-13-168728-x, 978-0-13-168728-8

A book which provides IP algorithms (not a text book): Digital Image Processing Using Matlab, by Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, Prentice Hull, 2004, ISBN 0-13-008519-7

A helpful book (NOT a text book): Linear Algebra and Optimization for Machine Learning, ISBN 978-3-030-40343-0 ISBN 978-3-030-40344-7 (eBook), ©Springer Nature Switzerland AG 2020

For class enhancement materials and lectures, please visit:

http://faculty.tamuc.edu/nsirakov/Teaching/Image%20Processing%20With%20Applications.aspx

Objectives: Students will be able to learn, understand and perform Image enhancement applying mathematical methods in the spatial (1st 2nd derivatives, laplacian and the gradient) and frequency domains (Fourier transformations); Image Restoration; Transformation; the students will learn the fields of application; the students will develop skills for working with image processing (IP) algorithms and tools; the students will know how to develop and code IP algorithms; students will learn how to write research reports and papers as well as how to present them.

Student Learning Outcomes (SLO):
(1) Students will be able to work with main definitions, metrics, image statistics, and new technologies in the field.
(2) Students will be able to utilize basic image transformation methods: zooming, Bi-linear and Bi-cubic interpolation, arithmetic, order and local statistics, fuzzy logic, averaging, log, power, histogram processing;
(3) Students will be able to utilize Image Enhancement Methods for smoothing/sharpening in space domain: convolution, correlation, Laplacian, Gradient and their derivatives.
(4) Students will be able to utilize Fourier transforms, properties, Fast Fourier transform, inverse, main algorithm, the Convolution and Correlation Theorems, Laplacian and low/high pass, band pass/band reject filters in frequency domain.
(5) Students will be able to utilize Image Degradation and noise modeling, Basic color models; color image processing and transformation.
(6) Students will conduct independent project development, which encompasses: survey, theoretical work, coding, writing, conducting experiments and presenting reports.
As an additional activity (out of the course) for the interested and best prepared students an introduction may be given to the most recent Image Analysis methods.

Prerequisites: MATH 2414 Min Grade C

Helpful Skills: *Calculus of two variables;*
Any of the languages: Python, MathLab, Mathematica, C++, Java

List of Lectures

1. Intro to IP: Definitions, Main Problems, Advanced Technologies, Imaging Modalities. Visual Perception, Image Sensing and Acquisition.
2. Representing Digital Images. Zooming. Bilinear and Bi-cubic interpolations. Basic relationships, connectivity, regions and boundaries.
3. Arithmetic/Logic Operations: Image Subtraction; Image Averaging. Projects assignment.
4. Gray Level transformations: Log; Power-Law; Piecewise-Linear.
5. Histograms: Processing; Equalization; Matching.
6. Local statistics for enhancement. Image averaging.
7. Spatial Filters. Convolution, Correlation, Smoothing, Sharpening.
8. Use of Second Derivative for Image Enhancement – The Laplacian.
9. Use of First Derivative for Image Enhancement – The Gradient.
10. Fuzzy sets and membership functions to IP.
11. The 1D Fourier Transform and its Inverse.
12. The 2D Fourier Transform and their Inverse. Properties- shifting, periodicity.
13. Filtering in the Frequency Domain. Low-pass and High-pass Filters.
14. The Laplacian in the Frequency Domain. Un-sharpening Masking.
15. The Convolution and Correlation Theorems.
16. The Fast Fourier Transform. Calculation complexity.
17. Theoretical foundations of NN, architectures.
18. Activation, weights changing functions. Hyperparameters. Training, validation, testing.
19. Convolutional Neural Networks basics. Projects reports submission.
20. Gradient Descent learning method- theoretical view. Return of the reviewed project reports.

Calendar: *1st week*-Lectures 1and 2; *2nd week*- Lectures 3 and 4; *3rd week*- Lecture 5; *4th &5th weeks* - Lectures 5, 6 and 7; *6th and 7th weeks* - Lectures 8 and 9; *8th weeks* - Lectures 10 and 11; *9th week*- Lecture 12; 10th week- Lectures 13 and 14; *11th week* - Lectures 15 and 16; 12th – Lecture 17, Guides for writing report and designing a presentation; *13th week*- Lecture 18; *14th week*- Lectures 19, 20; *15th week* – Giving back the report revisions, Lecture 21, reminder regarding Guides for writing report and designing a presentation.

COURSE EVALUATION

Basis for Evaluation:

Mid Term Exam	- 26%
HW	- 20%
Lab Work	- 12 %
Project	- 22%
Project Presentation and revision	- 20%

Grading Policy:

A:	100%- 90%
B:	89% - 80%
C:	79% - 70%
D:	69% - 60%
F:	Less than 59 %

The professor reserves the rights to reward students for continuous hard work.

Additional Activities: Experiments; Home Practice Problems**;** Extra Credit Problems

Final Test : Math563	**Date:** Tuesday, May 9th	**Time:** 6PM-9:30PM

COURSE POLICIES

In-class activity: *Problems to be solved during the class period.*
HW: *problems, which involve theoretical and practical skills above the average level.*

Mid term comprehensive exam: *Is to be given around mid-semester. It will take 2/3 of a class period.*

Lab Work – conducting experiments with given software and images by the teacher. Short report will be required.

Makeup: *Except in the case of a formal institutional excuse, no individual makeup test or HW or Lab Work will be permitted***.**

Project (most likely group): *closed itself innovative problem, whose development includes: survey of the present state of the art; development of a theoretical model; numerical analysis of the implementation; algorithm design and coding; performing experiment and deriving conclusions.*

Cheating: ***test and quizzes results will be canceled in case of cheating, extra credit grades may be taken off as well.***

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The road that will lead you to find a good job is the road of coding, learning, and developing yourself through accumulating a new knowledge.

Commerce, Texas
December 25, 2022 **Dr. Nikolay Metodiev Sirakov**