Image Processing with Elements of Learning
Spring 2026, Math563

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Department of Mathematics, TAMU-Commerce
Room: *Building:* Education South, Sowers *Room:* 133
Meets 1/12/2026 **through** 5/8/2026, **Day, Time**: M: 6PM-8:30PM

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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 textbook): 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

The teacher's notes of a lecture will be posted in D2L before the lecture. Some lectures and proofs go beyond the book and the notes. Hence participating in the lectures is useful and necessary.

Objectives: Students will be able to learn, understand and perform Image enhancement applying mathematical methods in the spatial (1st, 2nd derivatives, Laplace and the Gradient operators) and frequency (Fourier transformations) domains; Image Noise, Convolution, and Correlation; the students will learn the fields of their application including neural networks (NN); the students will develop skills to work with image processing (IP) algorithms and tools; the students will know basic concepts of machine learning (ML) and NNs; 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 know the basic concepts of Machine Learning and the Gradient Descend learning method as well as the use of convolutions by convolutional NNs (CNNs).
(6) Students will conduct independent project development, which encompasses: survey, theoretical work, coding, writing, conducting experiments and presenting reports.
As an additional activity (upon time permission) the Instructor will teach ML concepts that help avoid the NN convergence to a local minimum .

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. Neural Networks-Some Historical Facts, Architecture, Activation Functions, Weights Updating Functions, Perception.
4. Activation, weight changing functions. Hyperparameters. Training, validation, testing.
5. Arithmetic/Logic Operations: Image Subtraction; Image Averaging. Projects assignment.
6. Gray Level transformations: Log; Power-Law; Piecewise-Linear.
7. Histograms: Processing; Equalization; Matching.
8. Local statistics for enhancement. Image averaging.
9. Spatial Filters. Convolution, Correlation, Smoothing, Sharpening.
10. Use of Second Derivative for Image Enhancement – Laplace operator.
11. Use of First Derivative for Image Enhancement – Gradient operator.
12. Fuzzy sets and membership functions to IP – upon time permission.
13. The 1D and 2D Fourier Transform and their Inverse. Properties- shifting, periodicity.
14. Filtering in the Frequency Domain. Low-pass and High-pass Filters.
15. The Laplacian in the Frequency Domain. Un-sharpening Masking.
16. The Convolution and Correlation Theorems.
17. The Fast Fourier Transform. Calculation complexity.
18. Convolutional Neural Networks (NN) basics.
19. Optimization for ML.
20. Newton's method for ML – *incase of time permission.*
21. Projects reports submission.
22. Gradient Descent learning method- theoretical view.

Calendar: *1st week*-Lectures 1and 2; *2nd week*- Lectures 3 and 4; *3rd week*- Lecture 5, Assign the students projects; *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, Collect students reports; *15th week* – Give back the reviewed students reports.

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 Presentation	Math563	**Date:** Monday May 4th	**Time:** 6PM-8:30PM

COURSE POLICIES

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 – the students will conduct experiments with given, by the teacher, software and images. Short report will be required.

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

Project (could be group or solo): *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, quizzes results will be canceled in case of cheating, extra credit grades may be taken off as well.

AI use policy TAMUC acknowledges that there are legitimate uses of Artificial Intelligence, ChatBots, or other software that has the capacity to generate text, or suggest replacements for text beyond individual words, as determined by the instructor of the course. Any use of such software must be documented. Any undocumented use of such software constitutes an instance of academic dishonesty (plagiarism). Individual instructors may disallow entirely the use of such software for individual assignments or for the entire course. Students should be aware of such requirements and follow their instructors 'guidelines. If no instructions are provided the student should assume that the use of such software is disallowed. In any case, students are fully responsible for the content of any assignment they submit, regardless of whether they used an AI, in any way. This specifically includes cases in which the AI plagiarized another text or misrepresented sources. 13.99.99.R0.03 Undergrad Academic Dishonesty, 13.99.99.R0.10 Grad Student Academic Dishonesty

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Texas Senate Bill - 11 *(Government Code 411.2031, et al.) authorizes the carrying of a concealed handgun in TAMUC buildings only by persons who have been issued and are in possession of a Texas License to Carry a Handgun. Qualified law enforcement officers or those who are otherwise authorized to carry a concealed handgun in the State of Texas are also permitted to do so. Pursuant to Penal Code (PC) 46.035 and A&M-Commerce Rule 34.06.02.R1, license holders may not carry a concealed handgun in restricted locations. For a list of locations, please refer to http://www.tamuc.edu/aboutUs/policiesProceduresStandardsStatements/rulesProcedures/34SafetyOfEmployeesAndStudents/34.06.02.R1.pdf and/or consult your event organizer). Pursuant to PC 46.035, the open carrying of handguns is prohibited on all TAMUC campuses. Report violations to the University Police Department at 903-886-5868 or 9-1-1.*

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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 14, 2025 **Dr. Nikolay Metodiev Sirakov**