



Image Processing with Elements of Learning Spring 2023, Math563

Instructor: Dr. Nikolay Metodiev Sirakov
Department of Mathematics, TAMU-Commerce

Room: Bin329

Meets 1/10/2024 through 5/10/2024, **Day, Time:** T: 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

For more information, please visit: URL: <http://faculty.tamuc.edu/nsirakov>

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Textbook: Digital Image Processing, 3rd Edition, by Rafael C. Gonzalez, Richard E. Woods, Prentice Hall, 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 Hall, 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, Laplace and the Gradient operators) and frequency domains (Fourier transformations); Image Noise, Convolution, and Correlation; the students will learn the fields of application; the students will develop skills to work with image processing (IP) algorithms and tools; the students will basic concepts of machine learning (ML) and neural networks (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.
- (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. 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 – Laplace operator.
9. Use of First Derivative for Image Enhancement – Gradient operator.
10. Fuzzy sets and membership functions to IP.
11. The 1D and 2D Fourier Transform and their Inverse. Properties- shifting, periodicity.
12. Filtering in the Frequency Domain. Low-pass and High-pass Filters.
13. The Laplacian in the Frequency Domain. Un-sharpening Masking.
14. The Convolution and Correlation Theorems.
15. The Fast Fourier Transform. Calculation complexity.
16. Theoretical foundations of NN, architectures.
17. Activation, weights changing functions. Hyperparameters. Training, validation, testing.
18. Convolutional Neural Networks (NN) basics. Projects reports submission.
19. Gradient Descent learning method- theoretical view.
20. Critical Points of NNs. Elimination of singularities in NNs Return of the reviewed project reports.

Calendar: *1st week-*Lectures 1 and 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 Test : Math563

Date: Tuesday, May 7th

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 – 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 or 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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Students with Disabilities: The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you have a disability requiring an accommodation, please contact: Office of Student Disability Resources and Services; Texas A&M University-Commerce; Halladay Student Services Building; Room 132 A/D; Phone (903) 886-5150 or (903) 886-5835; Fax (903) 468-8148 StudentDisabilityServices@tamuc.edu

All students enrolled at the U shall follow the tenets of common decency and acceptable behavior conducive to a positive learning environment (See Student's Guide Handbook, Policies and Procedures, Conduct).

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.

Nondiscrimination Notice Texas A&M University-Commerce will comply in the classroom, and in online courses, with all federal and state laws prohibiting discrimination and related retaliation on the basis of race, color, religion, sex, national origin, disability, age, genetic information or veteran status. An environment free from discrimination on the basis of sexual orientation, gender identity, or gender expression will be maintained.

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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, 2023

Dr. Nikolay Metodiev Sirakov