The Edward S. Rogers Sr. Department of Electrical & Computer Engineering
UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE & ENGINEERING

ECE 1512 Digital Image Processing and Applications

Spring 2019

Course outline

Revised December 1, 2018

2019 Theme: `Digital Image Processing in the era of Machine Learning'

Instructor: Kostas Plataniotis, Bahen, 40 St George Str., Room 4140
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Office hours: Monday 10:00 am – 11.00 am (or by appointement)

Brief Bio : Konstantinos N. (Kostas) Plataniotis is a Professor with the ECE Department, and the Bell Canada Chair in Multimedia, at the University of Toronto. He is the founder and inaugural Director-Research for the Identity, Privacy and Security Institute (IPSI) at the University of Toronto and he has served as the Director for the Knowledge Media Design Institute (KMDI) at the University of Toronto from January 2010 to July 2012. His research interests are: adaptive systems, estimation, knowledge and digital media design, biometrics, image & signal processing, communications systems and pattern recognition. Among his publications in these fields are the recent books *WLAN positioning systems* (2012) and *Multi-linear subspace learning: Reduction of multidimensional data* (2013). Dr. Plataniotis is a registered professional engineer in Ontario, Fellow of the IEEE and Fellow of the Engineering Institute of Canada. He has served as the Editor-in-Chief of the IEEE Signal Processing Letters, and as Technical Co-Chair of the IEEE 2013 International Conference in Acoustics, Speech and Signal Processing. He was the IEEE Signal Processing Society Vice President for Membership (2014 -2016), the General Co-Chair for GlobalSIP 2017, and General Co-Chair for the IEEE 2018 International Conference in Image Processing. He serves as General Co-Chair for the IEEE 2021 International Conference on Acoustics, Speech and Signal Processing.

Course : This is an introductory level course for graduate students or practitioners to gain knowledge and hand-on experiences in image processing and applications. The application foci will be on supervised machine learning and convolution neural networks. The course will explore the connection between digital image processing and machine learning. Topics include: Introduction to 2-D signal analysis, 2-D transforms, image filtering, edge detection, segmentation, color imaging, color feature extraction, image coding, convolutional neural networks, explainable machine learning, and applications.

Place & Time: BA4164, Monday 11:00 am – 14:00 pm, (Starting Monday January 7, 2019)

Text: No specific text will be assigned. Class Notes and lecture handouts have been posted online (see ECE1512 Q web page).

Recommended Books:

- [GW] R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd Edition, ISBN: 978-0-168728-8, 2008, [Chapters: 1, 3-6, 9, 10].
- [GBC] I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016, https://www.deeplearningbook.org, [Chapters: 5-9].
- [LDL] Li, Ze-Nian, Drew, Mark S., Liu, Jiangchuan, Fundamentals of Multimedia, Springer Verlag, ISBN: ISBN 978-3-319-05289-2, 2014, [Chapters: 9-11] (NEW).
- [PV] K.N. Plataniotis, A.N. Venetsanopoulos, Color Image Processing and Applications, Springer Verlag, Berlin, ISBN 3-540-66953-1, August 2000 (material available to registered students).
- [LP] R. Lukac and K.N. Plataniotis, Color Image Processing: Methods and Applications, CRC Press, ISBN 0-8493-9774-X, October 2006, (material available to registered students).

ECE1512: Composition of the Final Mark

	• Homework 1, 15%: Assigned Monday, January 21, 2019; will have two weeks to complete.
	• Homework 2, 15% - Reading Assignment – Explainable convolutional neural networks - Assigned Monday, February 11, 2019; will have two weeks to complete
	• Homework 3, 15%: Assigned Monday, February 25, 2019; will have THREE weeks to complete – Special assignment on Image Processing for Autonomous Vehicles.
	• Participation in discussions during talks & project presentations: 5%.
	• Proposal for the end of term project: 5% (should include one page summary overview and description of the data sets to be used): Due on Monday, February 11, 2019.
	• Project (groups up to three students): 45% marked on the basis of a submitted report, simulation results and/or code submitted, and in-class presentation. Final reports are due on MONDAY, APRIL 1, 2019.

Tentative Course plan

January 7: Lecture 1
Lecture Notes: ECE1512_Chapter_01_Introduction.pdf (from GW_Chapter1)
Lecture Notes: ECE1512_Chapter_01_Introductiion. Pdf (from GBC_Chapter1)

January 14: Lecture 2
Lecture Notes: ECe1512_Chapter_03a_Intensity Transformations_(Point Processing) (from GW_Chapter3)
Lecture Notes: ECE1512_Chapter_03b_Intensity Transformations_(Histogram Processing) (from GW_Chapter3)

January 21: Lecture 3
Lecture Notes: ECE1512_Chapter_04a_FrequencyFiltering Fundamentals (from GW_Chapter4)
Lecture Notes: ECE1512_Chapter_04b_Frequency Filtering (from GW_Chapter4)

January 28: Lecture 4
Lecture Notes: ECE1512_Chapter_05_MachineLearningBasics (from GBC_Chapter5)
Lecture Notes: ECE1512_Chapter_06_Deepfeedforwardnets (from GBC_Chapter6)

February 4: Lecture 5
Lecture Notes: ECE1512_Chapter_07_Regularizationfornets (from GBC_Chapter7)
Lecture Notes: ECE1512_Chapter_09_Convolutionalnets (from GBC_Chapter9)
Lecture Notes: ECE1512_Chapter_11_PracticalMethodologies (from GBC_Chapter11)

February 11: Lecture 6
Lecture Notes: ECE1512-Explainable Artificial Intelligence (IEEE ICIP2018 tutorial notes)

February 18: No Class – Ontario Family Day

February 25: Lecture 8
Lecture Notes: ECE1512_Chapter_05_ImageRestoration_(Noise Removal) (from GW_Chapter5)
Lecture Notes : ECE1512_Chapter_06_ColourImageProcessing (from GW_Chapter6)

March 4: Lecture 9

Lecture Notes: Chapter_10a_Segmentation_(Edge Detection) (from GW_Chapter10)
Lecture Notes: Chapter_10a_Segmentation_(Edge Thresholding) (from GW_Chapter10)

March 11: Lecture 10
Student work - Assignment 3 – Collaborative

March 18: Lecture 11
Course Project Preparation - Self Study

March 25: Lecture 12
Lecture Notes: ECE1512-JPEGStandard (from LDL_Chapter9)
Lecture Notes: ECE1512_IntroductiontoVideoCompression (from LDL_Chapter10)

April 1: Last Lecture (double lecture)
Presentation of Course Projects - special assigned room.

Practical Info:

1. End of term projects could be relevant to the students' graduate work. Students are encouraged to select a topic that will advance their research. An end of term report, with no more than 20 pages, in IEEE draft style format, plus code is due on Monday, April 1, 2019. Quality should be suitable for a conference presentation. Towards the end of the semester students will be asked to deliver a 5-10 minutes presentation or prepare a "research poster" where they will explain the problem and the proposed solution (final results could be "work in progress" at the time of the presentation).

2. The instructor welcomes your comments on the course at any time. Please use the "course tools" section of the web page to provide feedback. Feel free to send comments -- in the past, the instructor has obtained helpful remarks that allow him to make improvements mid-course. The ECE Department and the COMM group want to maximize the value of this course for everyone and welcome your input, positive or negative. A formal evaluation of the course will be performed in at the end of the semester.

Required Format for Submitting Assignment Reports:

Assignment reports be kept short, and be organized in a uniform manner to simplify grading. The following format achieves these objectives.

Page 1. Cover Page. Typed:

- Homework title
- Course number
- Student's name
- Student ID
- Date due
- Date handed in

Page 2. Pertinent discussion. One to three pages (max). This section should include the techniques used and the principal equations (if any) implemented.

Page 3 (or 5). Discussion of results. Two to five pages (max). A discussion of results should include major findings in terms of the project objectives, and make clear reference to any result generated.

Layout. The entire report must be in standard sheet size format (8.5 x 11 inches in the U.S.) The report should be submitted as PDF email attachment, or uploaded through the web portal. The PDF file name should strictly follow the naming convention listed below:

ECE1512_AssignmentNumber-by-STUDENTNAME