"Digital Image Processing and Communication"

Janusz Konrad

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About the students
About the course
Classroom procedures
Academic conduct
Pre-requisites
Goals and expected outcomes

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Course staff

- **Instructor**: Janusz Konrad, Professor, ECE
  - 30+ years of image/video processing & computer vision experience
  - E-mail: `jkonrad@bu.edu`
  - Personal website: `http://sites.bu.edu/jkonrad`
  - Research group website: `http://vip.bu.edu`
- **Teaching Assistant**: None
- **Grader**: Haochuan Hu (MS student)
  - E-mail: `huhc@bu.edu`
  - Re-grade requests through Gradescope;
    other concerns via e-mail

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About you

Based on survey responses:

1. 9 undergraduates, 17 Master's, 5 PhD students
2. 3 students: no "Probability" pre-requisite – almost impossible to do well in this class
3. 3 students: beginners in *Matlab/Python* – very challenging to complete programming assignments (must catch up very quickly since the programming difficulty will rapidly increase)
4. More students are interested in applications than theory of image processing, and majority are interested in ML/DL methods

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Course format

- **Lectures**: Mon-Wed, 12:20-2:05pm, EPC 204 (no cell phone use unless asked for)
- **Homework**: weekly (≈10 in total), due Wednesday at midnight on Gradescope
- **No recitations, no discussion hours** (office hours = discussion hours); all questions need to be asked before/during/after lecture or during office hours
- **Office hours with instructor:** Monday and Wednesday, 6:30-7:30pm (PHO428) – will solve sample problems, discuss lecture material and homeworks
- **Team project**: starts in mid-February, presentations during last 2 lectures
- **Mid-term exam**: after spring break
- **Final exam**: early May (date to be determined)

Must have access to Photonics after 6pm - request PHO 307 at bu.edu/eng/zaius

Reminders:

- Last day to change/add class: Jan. 31
- Last day to drop a course without W: Feb. 22
- Last day to drop a course with W: Mar. 29

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On-line course resources

Blackboard:

- Lecture slides, handouts (derivations, proofs), demos
- Homework assignments and solutions
- Exam preparation material
- Project details
- Course announcements and calendar with deadlines
- Links to pertinent web sites, videos, etc.

Piazza: Discussion forum – monitored daily (accessible from Blackboard)

Gradescope: Homework submission portal (accessible from Blackboard)
A way to interact with the grader (e.g., re-grade requests) + email

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Workload

Homework:

- weekly (except before exams), first homework out tonight and due next week
- analytic part – to test theory presented in lectures
- programming part – to map theory to practice
- solutions due on Gradescope on **Wednesday at midnight**:
  - analytic solutions due as PDF (**student must assign pages to problems**),
  - Matlab/Python source code due as single file (**to be cross-checked for plagiarism**)
- meant for practice – use solutions to refine understanding of material

Office hours with instructor: course material, homeworks, exam preparation, ...

Exams: for the instructor – to test understanding of material by the class;
to do well, must do homeworks well!

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Grading

- **25% = Homeworks**
  About 10 homeworks; **lowest grade discarded**; penalty for late submission; no assignment accepted after solutions released.
- **25% = Project**
  Team project involving algorithm development in *Matlab*, *Python* or *C/C++/C#*; report and presentation; details to follow.
- **25% = Mid-term exam**
  Closed-book exam
- **25% = Final exam**
  Closed-book exam

A doctors note must be provided for a missed exam, otherwise the grade will be 0; no makeup exam.

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No formal textbook

There is no single textbook covering the course material, and the feedback on past textbooks was mixed. You will need to rely on lectures and supplementary material from Blackboard.

For some topics, I am going to use a recent textbook:

A.E. Yagle, F.T. Ulaby, *Image Processing for Engineers*, Michigan Publ., 2018.

available for free from `http://ip.eecs.umich.edu`

Books below may prove useful for some parts of the course (on reserve at the Mugar Library for short-period checkouts):

- J.W. Woods, *Multidimensional Signal, Image and Video Processing and Coding*. Academic Press, 2nd edition, 2011 (hardcopy).
- A. Jain, *Fundamentals of Digital Image Processing*. Information and System Sciences Series, Prentice Hall, 1989 (hardcopy).
- A. Bovik, *Handbook of Image and Video Processing*. Academic Press, 2nd edition, 2005 (hardcopy or E-book through *this link*).

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Matlab (Python?)

Each homework will include a programing component, preferably in *Matlab* (*Image Processing* and *Computer Vision Toolboxes* are essential). *Python* is an option, but I cannot help.

On-campus: you can use workstations in SIGNET (PHO307) and VLSI (PHO305) labs, where all toolboxes are available

Own computer: can run with no network access, but large files to download during installation and solid computer needed

Remotely on SCC (instructions here): nothing to download, works on any computer (Matlab runs on BU SCC), but fast internet access needed

Remotely via Citrix (instructions here, VPN needed): download of a small Citrix app, works on any computer (Matlab runs on BU servers), but fast internet access needed

Matlab Online (instructions here): nothing to download, works on any computer (*Matlab* runs on Mathworks servers) but quite slow and has limitations (see here) although not debilitating for what you will need

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Academic conduct

Collaboration with EC520 classmates is essential in course project, permitted in homeworks, but illegal in exams.

If there is collaboration in homework, each student must turn in their own work (solutions, source code, analysis), and list all collaborators at the top of first page.

In homeworks/projects, **you may not use human or automated resources from outside of class**, including outside tutors, web-based help services, generative AI or similar, etc.

However, in some homeworks/projects you may be asked to use generative AI resources in which case you must clearly acknowledge them and describe their use.

The student handbook defines academic misconduct as follows:

Academic misconduct occurs when a student intentionally misrepresents their academic accomplishments or impedes other students chances of being judged fairly for their academic work. Knowingly allowing others to represent your work as theirs is as serious an offense as submitting anothers work as your own.

See the student handbook for procedures followed should academic misconduct be discovered.

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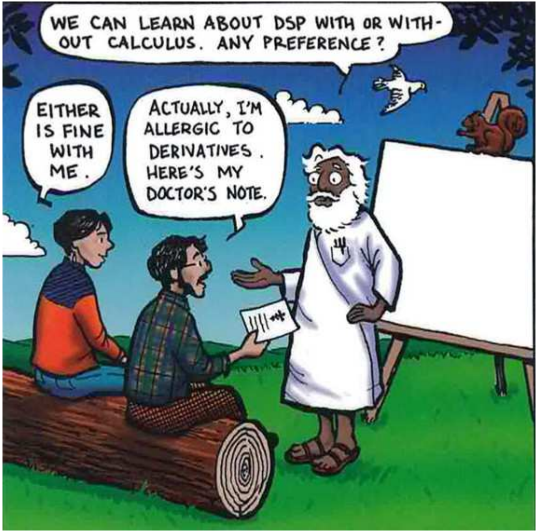
Pre-requisites: Calculus and Linear Algebra



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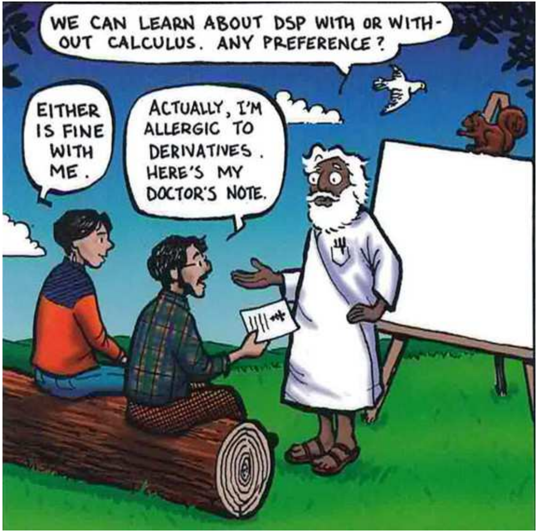

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– **calculus**

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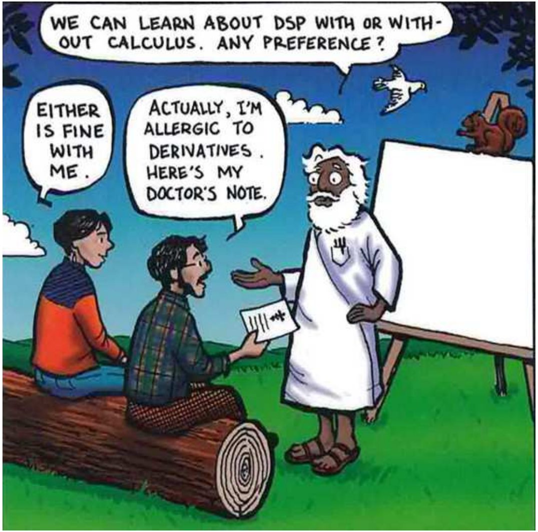

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- **multivariable calculus:**
  - *partial derivative*
  - *directional derivative*
  - *multivariable integral*
  - *gradient, curvature*
  - *...*
- **linear algebra:**

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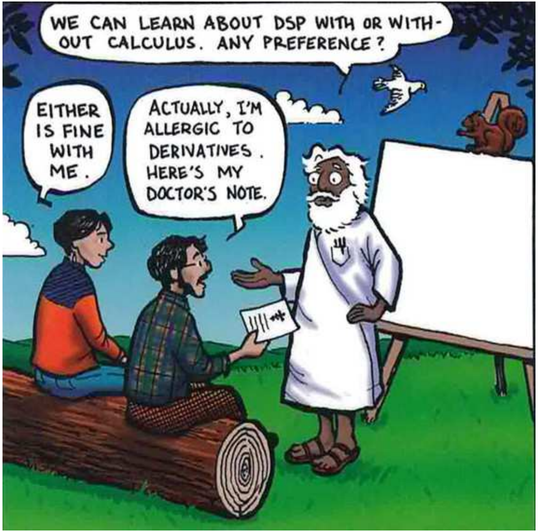

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  - ...
- **linear algebra:**
  - *vector space*
  - *linear transformation*
  - *multivariable integral*
  - *basis, linear combination*
  - *span, subspace*
  - ...

Pre-requisites: 1-D Digital Signal Processing

The following should be very familiar:

1. sampling of continuous-time signals
2. discrete-time signals (even/odd, periodic, exponential)
3. discrete-time systems (linearity, time-invariance, causality, stability, linear difference equation)
4. continuous-time and discrete-time Fourier transform (CTFT and DTFT), discrete Fourier transform (DFT), Z-transform
5. linear, time-invariant (LTI) systems: convolution, frequency-domain analysis
6. finite impulse response (FIR) filters

A good reference are chapters 2,3,4,5,8 from "Discrete-Time Signal Processing" by Oppenheim and Schafer with Buck from Prentice Hall, but many other excellent books exist.

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Pre-requisites: Probability and Random Variables

You should understand the basic concepts in probability and in continuous and discrete random variables:

1. probability: joint, conditional, marginal
2. independence, Bayes theorem
3. concept of a continuous and discrete random variable
4. moments of a random variable (expectation and variance)
5. probability density and probability mass functions
6. cumulative distribution
7. Gaussian and Laplacian distributions
8. minimum mean-squared error estimation

Many excellent books exist; a treatment accessible to engineers can be found in "Probability and Stochastic Processes for Engineers" by Helstrom.

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Goals and expected outcomes of the course

Goals: To provide both the theoretical and practical basis required for the understanding and design of modern image processing, compression and analysis algorithms.

Expected outcomes:

- **acquire a theoretical foundation** necessary for research in image-related fields,
- **gain an in-depth understanding of modern applications** such as:
  - image size manipulation (pinch-to-zoom, drag),
  - image enhancement/reconstruction (denoising, HDR),
  - object detection and recognition (people, cars),
  - image compression (Zoom, FaceTime),
  - ...
- this course **will not focus on machine/deep learning** methods but will discuss them as alternatives to some model-based methods.

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Questions ?

Let's start

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