Master Course Description

No: EE 574

Title: IMAGE ANALYSIS

Credits: 3

Catalog Description: Image Spaces, Variational Optimization, Variational Image Processing (restoration and denoising), Curves (representations, characterizations and evolution), Medial Axis Transform, Surfaces (representations, characterizations and evolution), Interface Propagation Techniques (Level Sets), Statistical Image Analysis (PCA, ICA)

Coordinator: Burak Acar, Assistant Professor of Electrical Engineering

Goals: Its goals are to *i)* to review basic contemporary mathematical tools for image processing, *ii)* to introduce up-to-date algorithms on which active research is still being conducted, *iii)* to present the underlying ideas and theoretical background for these algorithms, *iv)* to discuss specific algorithms in more detail with an emphasis on their implementations, *v)* to develop practical skills for their implementation through applications and *vi)* to develop skills to conduct a complete research including the literature survey, problem solving and publication.

Learning Objectives:

The course is designed for the 1st and 2nd year graduate students and senior undergraduate students. It is based on mathematical approaches to several image (2D/3D) analysis problems such as *i)* restoration/denoising, *ii)* segmentation, *iii)* characterization/identification. At the end of this course, the students are expected to develop skills regarding the special image processing tasks listed in the 'Catalog Description'. Specifically, they will:

1. be introduced to the concept of variational image processing and its application to enhancement, denoising and segmentation problems
2. be introduced to interface propagation methods and its applications to segmentation and identification
3. learn stochastic modelling of 2D/3D images/objects (such as Active Shape and Appearance Models)
4. have developed skills to run a complete research project
5. have learned and practiced how to present their research in speech and text

Textbook: No single textbook is used. All communication will be done over the internet.

Reference Texts:

1. Aubert & Kornprobst, *Mathematical Problems in Image Processing,* Springer, 2000
2. Sethian, *Level-Set Methods and Fast Marching Methods,* Cambridge University Press, 1999
3. Sapiro, *Geometric Partial Differential Equations and Image Analysis,* Cambridge University Press
4. Osher & Fedkiw, *Level-Set Methods and Dynamic Implicit Surfaces, Springer, 2003*

5. Do Carmo, *Differential geometry of curves and surfaces, Prentice-Hall, 1976*
6. Van Brunt, *The Calculus of Variations, Springer, 2004*
7. Several scientific papers and tutorials will be distributed via the web page.

Prerequisites by Topic:

1. Introductory image processing
2. Linear algebra
3. Numerical methods
4. Programming skills

Topics:

- Image Spaces
- Variational Optimization
- Variational Image Processing
- Curves: Representation, Characterization and Evolution
- Medial Axis
- Surfaces: Representation, Characterization and Evolution
- Statistical Image Analysis: PCA, ICA

Course Structure: The class meets for three lectures a week, each consisting of two 50-minute sessions. The students are required to select a research topic related to the course material, conduct a survey and write a survey paper in the first half of the semester. They will then propose to solve a practical problem using the techniques they have made a survey of. The result of the second part of their project will be presented in the form of a research paper and oral presentation. Both papers will be written in a scientific paper format in accordance with IEEE guidelines. The presentations will be done in a conference presentation format.

Computer Resources: The scientific papers and tutorials on which most of the course will be based, will be distributed through the course's webpage.

Laboratory Resources: None.

Grading:

1. Survey paper & presentation (35%)
2. Final project paper (45%)
3. Final project oral presentation (20%)

Outcome Coverage:

(a) Apply math, science and engineering knowledge. The soul aim of the course is not only to introduce the students the conventional and the current image processing techniques but also to discuss the underlying theories and the implementation issues. The collection of this information is anticipated to give the students the ability to choose the correct approach and the ability to apply them. The project based evaluation of their success serves to this end.

(e) *Identify, formulate and solve engineering problems.* In parallel with item a, the course will give the students the ability to see real life problems in terms of the knowledge they have and transform the problem into an analytical framework and apply their knowledge to solve it.

(g) *Ability to communicate effectively.* The group project groups will improve their ability to collaborate effectively. Furthermore, the presentation requirements for their projects will improve their ability to communicate their work in the scientific and the industrial community.

(i) *Recognition of the need for and the ability to engage in life-long learning.* The bulk of the course material is selected from active research areas and rather recent scientific papers. Thus the students will develop an understanding of the necessity to stay up-to-date in order to be competitive.

(j) *Knowledge of contemporary issues.* As it has been stated in item i, most of the course topics are selected from contemporary issues.

(k) *Use the techniques, skills and modern engineering tools necessary for engineering practice.* The projects will not only be graded on a theoretical basis but also on the quality of the end product. This depends on the students' ability to use current engineering tools. Some of the tools that will be / can be used for this include Matlab, Visual C++, VTK (Visualization Tool Kit), CG (C for Graphics).

Prepared By: Burak Acar

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