

MHRD Scheme on Global Initiative on Academic Network (GIAN)

COURSE TITLE: Digital Topology and Geometry in Medical

Imaging: Theory and Application

Date: January 9-14, 2017

Venue: Computer Science and Engineering Department,

Jadavpur University, Kolkata - 700032

Overview :

Digital topology and geometry is an active research field that loosely refers to the use of mathematical topological and geometrical properties and features for images defined in digital grids. It plays important roles in medical imaging research by enriching the scope of target information and by establishing a strong theoretical foundation of a process enhancing its stability, fidelity, and efficiency. Digital topology and geometry in three dimensions have been used in many medical imaging applications involving image segmentation, tracking of tree-like or elongated structures, topology preservation, object representation and modelling, quantitative object morphometry, object correction, etc. Various concepts and methods from digital topology and geometry, including distance maps, component labelling, connected operators, border tracking, Euler characteristic, Voronoi neighbourhood, simple point, neighbourhood analysis, skeletonization, region growing, optimal path, etc. have been applied to medical imaging to solve various important challenges.

The overall goal of the proposed workshop on digital topology and geometry is to highlight – (1) recent research trends and results on digital topology and geometry and (2) presentation of the insights and intuitive ideas behind different fundamental theories, results, and algorithms on digital topology and geometry leading to pathways of their applications to various medical imaging research.

Individual goals of the proposed workshop are – (1) discussion on different fields of digital topology and geometry relevant to medical imaging; (2) presentation of the state of the art methods for relevant topics of digital topology and geometry and discussion of the insights and remaining challenges; and (3) discussion of the roles of different topological and geometrical methods in various medical imaging applications.

The proposed workshop is primarily confined to discussions on three-dimensional image analysis following the convention of mainstream medical imaging techniques. The following topics of digital topology and geometry are to be discussed here – (1) distance transforms and path-propagation; (2) components, connected operators, and neighbourhoods; (3) simple points and local topology; (4) skeletonization; (5) topological approaches to image segmentation; (6) distance transform-based image interpolation; and (7) topology-based object characterization. The common thread among the topics discussed here is that the algorithms are built on digital path connectivity, path propagation, and neighbourhood analysis. Under each topic, the proposed workshop will present – (1) a thorough discussion on the progression of the research fields and contribution by different researchers; (2) a brief outline of the state of the art methods and theories; and (3) related medical imaging applications.

Objectives:

The primary objectives of this unique course on a relatively young and rapidly growing field are as follows:

- i) Exposing participants to the recent research trends and results on digital topology and geometry in the context of medical imaging applications,
- ii) Building in confidence and capability amongst the participants in the application of medical image analysis tools and techniques,
- iii) Providing exposure to practical problems and their solutions, through case studies and live projects in 3-D medical image analysis,
- iv) Enhancing the capability of the participants to identify the need for Indian society, to develop new research programs on medical image analysis, introduce advanced topic in academic program on digital topology and geometry and to initiate/extend research collaborations.

Course details:

Day#1 Monday

Lecture 1 : 10:30 AM to 11:30 AM

Introduction to Digital Topology and Digital Geometry

Lecture 2: 12:00 PM to 1:00 PM

Introduction to the Definitions and Notations; Introduction to Distance Transforms and Path-Propagation

Tutorial 1. 2:00 PM to 4:00 PM

Problem solving session with examples: Distance Transforms and Path-Propagation

Day#2 Tuesday

Lecture 3 : 10:30 AM to 11:30 AM

Components, Connected Operators, and Neighborhoods: Component Labelling, Connected Operators, Surface Tracking, Voronoi Neighborhood, Euler Characteristic

Lecture 4: 12:00 PM to 1:00 PM

Simple Points and Local Topological Numbers; Local Topological Classification

Tutorial 2. 2:00 PM to 4:00 PM

Problem solving session with examples: Component Labelling, Connected Operators, Surface Tracking, Local Topological Classification

Day#3 Wednesday

Lecture 5 : 10:30 AM to 11:30 AM

Introduction to Skeletonization; Digital Geometric Approaches; Parallel Skeletonization

Lecture 6: 12:00 PM to 1:00 PM

Applications of Skeletonization in Medical Imaging; Performance Evaluation

Tutorial 3. 2:00 PM to 4:00 PM

Problem solving session with examples: Skeletonization

Day#4 Thursday

Lecture 7 : 10:30 AM to 11:30 AM

Introduction to Topologic Approaches to Image Segmentation; Region Growing Approaches, Minimal Path Approaches, Watershed Methods

Lecture 8: 12:00 PM to 1:00 PM

Multi-scale Opening of Conjoined Objects: Theory and Applications

Tutorial 4. 2:00 PM to 4:00 PM

Problem solving session with examples: Image Segmentation using Region Growing Approaches, Minimal Path Approaches, Watershed Methods

Day#5 Friday

Lecture 9 : 10:30 AM to 11:30 AM

Distance Transform-Based Image Interpolation

Lecture 10: 12:00 PM to 1:00 PM

Object Characterization: Object Representation; Object Morphometry; Object Correction

Tutorial 5. 2:00 PM to 4:00 PM

Problem solving session with examples: Image Interpolation and Object Characterization

Day#6 Saturday

Break / Examination for students

Teaching Faculty (*detailed CV in Annexure-I*)

Prof. Punam Kumar Saha is a professor of Electrical and Computer Engineering and Radiology at the University of Iowa. He is the director of the Structural Imaging Laboratory at the University of Iowa. He received his Ph.D. degree in 1997 from the Indian Statistical Institute, where he served as a faculty member during 1993-97. In 1997, he joined the University of Pennsylvania as a postdoctoral fellow, where he served as a Research Assistant Professor during 2001-06, and moved to the University of Iowa in 2006. His research interests include image processing, segmentation and analyses, trabecular bone imaging, quantitative structural assessment in medical imaging. He has published over 95 papers in international journals and over 300 papers/abstracts in international conferences, and holds numerous patents related to medical imaging applications. His publications have received an h-index of 42 as per google scholar. He received a Young Scientist award from the Indian Science Congress Association in 1996. He has served as an Associate Editor for Pattern Recognition and Computerized Medical Imaging and Graphics journals; currently, he is an Associate Editor of the IEEE Transactions on Biomedical Engineering and the Pattern Recognition Letters journals. He has served in many international conferences at various levels. He has received several grant awards from the National Institute of Health, USA.

Who can attend:

- Executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories.
- Student students at all levels (BTech/MSc/MTech/PhD) or Faculty from reputed academic institutions and technical institutions.

Registration Fees

Participants from abroad: US \$200

Industry/ Research Organizations: Rs. 5000/-

Academic Institutions: Rs. 2000/-

Students: Rs. 1000/-

The above fee include all instructional materials and laboratory use for tutorials.

Contact Details:

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