

## SYSTEMS SCIENCE AND INFORMATICS UNIT

### 1. TEACHING AND TRAINING

#### 1.1 Degree and Training Courses

Name of Faculty Member	Subjects taught to MSLIS students during April-2011 and July 2012		
	Mar 2011-Jul 2011	Aug 2011-Feb 2012	Mar 2012-Jul 2012
B. S. Daya Sagar	Geographic Information Systems, MSLIS	Information Storage, Retrieval and DBMS, for MSLIS Programme	Geographic Information Systems, MSLIS
			Elements of Mathematics - II (Part-1), MSLIS
Kaushik Majumdar	Elements of Mathematics II, MSLIS	Not Taught Any Subject	Not Teaching Any Subject
	Data structures and Programming Languages, MSLIS		
Saroj Meher	Data and Text Mining, MSLIS	Elements of Mathematics - I	Data and Text Mining, MSLIS
			Elements of Mathematics - II (Part-2), MSLIS

#### 1.2 Ph.D./D.Sc. Degrees

N/A

#### 1.3 International Statistical Education Centre (ISEC)

N/A

#### 1.4 Professional Examination in Statistics

N/A

### 2. CONVOCATION

N/A

### 3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

#### **SSIU Research Activities in Computing in Science and Engineering**

Broad areas of research at SSIU fall under the category 'Computing in Science and Engineering' essentially to address challenges of both basic and applied nature. Towards this the broad objective of SSIU is to pursue high quality research work related to computing in interdisciplinary

science and engineering, systems science and informatics related topics. Currently faculty members of SSIU are pursuing vigorous research programs in Spatial Informatics, Computational Neuroscience, and Computational Intelligence. Goal is to conduct quality research, in the areas of interest to SSIU—that competes for space for publications in journals of repute—involving advanced spatial statistical tools (e.g. mathematical morphology, fractal geometry, fuzzy set theory, rough set theory, neural networks, digital image processing and analysis, signal theory, game theory etc), and applications of such tools in various domains like geospatial, biology and medicine, and several other socially relevant application domains. We aim to develop frameworks to address all the above components to demonstrate their potential utilities in domains such as (but not limited to) geospatial and neuroscience. These areas of research are presently being carried out in two broad research groups: Spatial Informatics Research Group, and Computational Neuroscience Research Group.

B. S. Daya Sagar, Kaushik Majumdar, and Saroj Meher

#### **Generation of zonal map from point data via weighted skeletonization by influence zone**

Data about many variables are available as numerical values at specific geographical locations. A methodology based on mathematical morphology to convert point-specific data into zonal map has been proposed. This methodology relies on weighted skeletonization by zone of influence (WSKIZ) that determines the points of contact of multiple frontlines propagating, from various points spread over the space, at the travelling rates depending upon the variable's strength. This approach has been demonstrated for converting rainfall data available at specific rain gauge locations (points) into a spatially distributed zonal map that suggests zones of equal rainfall.

B. S. Daya Sagar, H. M. Rajashekara, and Partap Vardhan

#### **Derivation of a spatially significant zone within a cluster of zones via dilation distances**

The ability to derive spatially significant zones (e.g. water bodies, zones of influence) within a cluster of zones has interesting applications in understanding commonly sharing physical mechanisms. Using morphological dilation distance technique, we introduce geometrically-based criteria that serve as indicator of the spatial significance of zones within a cluster of zones. This

work focuses on the problem of identifying zones that are 'strategic' in the sense that they are the most central or important based on their proximity to other zones. This technique has been applied on a theme depicting water bodies retrieved from IRS LISS-III satellite image.

B. S. Daya Sagar, N. Rajesh, S. Ashok Vardhan, and Partap Vardhan

### **Directional spatial relationship via origin-specific dilation-distances**

Thematic maps generated from remotely sensed satellite data consists of spatial objects (planar sets) of varied degrees of spatial complexity. We provide an approach to compute origin-specific morphological dilation distances between planar sets to further determine the directional spatial relationship between sets. Origin chosen for a structuring element ( $B$ ) that yields shorter dilation distance than that of the other possible origins of  $B$  determines the directional spatial relationship between  $A_i$  (origin-set) and  $A_j$  (destination set). This approach has been demonstrated on (i) a cluster of spatial sets (states) decomposed from a spatial map depicting country India, and (ii) water bodies traced from SPOT PLA data.

B. S. Daya Sagar.

### **A geometric analysis of time domain signals: from mathematics to medicine**

A novel geometric analysis of time domain signals is being carried out to extract important information from multichannel data. In this approach a rigorous mathematical definition of a signal has been proposed, which is broad based enough to encompass almost all signals in real life. The second order differentiable (difference) structure of signals has been analyzed (Conjecture: For an analog signal defined on a compact interval, the second order derivative may not exist only at a finite number of points). The notion of power in the classical mechanics (completely different from the notion of amplitude based power of the signals) has been extended to time domain signals leading to a novel multichannel information retrieval algorithm. This has been applied on epileptic depth EEG data to gain some novel insights.

Kaushik Majumdar



### **Novel spike-train distance measure**

An efficient spike-train distance measure has been implemented on a large number of simulated neuronal spike trains with added white noise of SNR up to 0.5 (50%). Multiple statistical features from the spike trains have been extracted. With those features a metric on the space of spike trains has been defined. With the help of this metric the new algorithm is working with greater accuracy than the one of the most reliable algorithms known (van Rossum, Neural Computation, 13: 751 - 763, 2001). However it runs slower.

Kaushik Majumdar and Shubhanshu Shekar

### **Class-dependent rough-fuzzy granular space, dispersion index and classification**

In this research work, a new rough-fuzzy model for pattern classification based on granular computing is described. In this model, we propose the formulation of class-dependent granules in fuzzy environment. Fuzzy membership functions are used to represent the feature-wise belonging to different classes, thereby producing fuzzy granulation of the feature space. The fuzzy granules thus generated possess better class discriminatory information that is useful in pattern classification with overlapping classes. Neighborhood rough sets are used in the selection of a subset of granulated features that explore the local/contextual information from neighbor granules. The model thus explores mutually the advantages of class-dependent fuzzy granulation and neighborhood rough set. The superiority of the proposed model to other similar methods is established with seven completely labeled data sets and two partially labeled real remote sensing images collected from satellites.

S. K. Pal, Saroj K. Meher and S. Dutta

### **Rough-wavelet granular space and classification of multispectral remote sensing image**

A new rough-wavelet granular space based model for land cover classification of multispectral remote sensing image, is described in this research contribution. In this model, we propose the formulation of class-dependent (CD) granules in wavelet domain using shift-invariant wavelet transform (WT). Shift-invariant WT is carried out with properly selected wavelet base and decomposition level(s). The transform is used to characterize the feature-wise belonging of

granules to different classes, thereby producing wavelet granulation of the feature space. The wavelet granules thus generated possess better class discriminatory information. The granulated feature space not only analyzes the contextual information in time or frequency domain individually, but also looks into the combined time-frequency domain. These characteristics of the generated CD wavelet granules are very useful in the pattern classification with overlapping classes.

Saroj K. Meher and S. K. Pal

#### **Wavelet-fuzzy-hybridization: feature-extraction and land-cover classification of remote sensing images**

The research work focuses on a wavelet feature based supervised scheme for fuzzy classification of land covers in multispectral remote sensing images. The proposed scheme is developed in the framework of wavelet-fuzzy hybridization, a soft computing approach. The wavelet features obtained from wavelet transform on an image provides spatial and spectral characteristics (i.e., texture information) of pixels and hence can be utilized effectively for improving accuracy in classification, instead of using original spectral features. Four different fuzzy classifiers are considered for this purpose and evaluated using different wavelet features. Wavelet feature based fuzzy classifiers produced consistently better results compared to original spectral feature based methods on various images used in the present investigation.

B. Uma Shankar, Saroj K. Meher and Ashish Ghosh

#### **Efficient detection and counting of moving vehicles with region-level analysis of video frames**

The problem of detecting and counting of moving vehicle (MV) in a road traffic scenario, where background subtraction (BS) plays a vital role, has been discussed. BS in a video sequence is an open problem with many practical applications including camera surveillance system, human-computer interactions, etc. Among the various methods of BS, frame difference method is a simple and most adopted one. However, the performance of frame difference method depends on the proper selection of a set of frames. To meet this problem, an efficient and fast processing approach for detecting and counting of MVs has been described. A region/block-level analysis of frames is performed in this approach, which requires less processing time and provides more



accurate results compared to the conventional pixel-level analysis. Fuzzy flood fill mean shift based segmentation algorithm has been used for this present study, which is robust under the illumination effects; such as shadows, shades, and highlights. In pixel-level analysis, segmentation operation is performed on the difference frame obtained from two test frames and detection of MV is made subsequently.

Saroj K. Meher and M. N. Murty

### **Fuzzy impulse noise detector for efficient image restoration**

This work proposes an efficient restoration model for images corrupted with impulse noise of varying values that follow a random distribution over some dynamic range. The model extracts a set of informative features, uses a fuzzy detector based on product aggregation reasoning rule for noisy pixels detection and noise removal operator for filtration. The fuzzy set-based detector provides a better learning and generalization capability for improved detection. The model thus explores mutually the advantages of both fuzzy detector and noise removal operator. Superiority of the proposed model to other similar methods is established both visually and quantitatively in removing impulse noise from highly corrupted images.

Saroj K. Meher and P. Patel

### **Derivation of spatially significant set via spatial analysis and reasoning (Internally Funded Project-On Going)**

The ability to recognize strategically important set(s) within a cluster has interesting applications in geographical information science (GISci). This project focuses on (i) the problem of identifying spatial entities (e.g. continents, countries, states, cities, sets, water bodies, zones of influence, etc) that are 'strategic' in the sense that they are the most central or important based on their spatial relationships to other entities, (ii) defining geometric-based criteria based on mathematical morphological operators to derive individual zones that may serve as indicators of their strategic importance to other zones that are part of a collection of zones. and (ii) modelling spatial entities based on boundary, distance and contextuality relationships along with other spatial properties that depend upon the properties of size, shape, adjacency between the sets.

B. S. Daya Sagar and N. Rajesh

### **Human depth EEG processing for epilepsy and cognition (Internally Funded Project- On Going)**

Under the ISI funded project depth EEG data of 21 epileptic patients and 5 Schizophrenic + 5 normal controls' scalp EEG data are being analyzed. Seizure offset is being studied in order to understand why do all seizures terminate on their own. A novel hypothesis that seizure changes extracellular pH from  $\sim 7.35$  to  $\sim 6.8$ , which enhances activity of inhibitory neurons and suppresses the activity of excitatory neurons leading to greater focal ECoG channel synchronization towards the end of a seizure, rather than in the midway of its progression has been put forward (paper likely to be accepted in *J. Clin. EEG. Neurosci.*) The Schizophrenia data are being analyzed for auditory hallucination by the newly invented video synchronization method (joint work with NIMHANS).

Kaushik Majumdar and Pradeep

### **Computation in the brain: neuron, synapse, astrocyte interactions in small networks (Externally Funded Project- On Going)**

The recent controversy regarding whether astrocytes modulate synaptic plasticity (Nature, 463: 232 - 236, 2010 and Science, 327: 1250 - 1254, 2010) has been addressed by mathematical modeling and computer simulation. It has been showed both long and short form of plasticity are modulated by astrocytes. The former one was experimentally confirmed by Araque's group in Cajal Institute in Madrid. A close touch was maintained throughout the duration of the work. Two papers came out in *J. Comp. Neurosci.* and *J. Biol. Phys.*

Kaushik Majumdar and Shivendra Tewari

### **Workshop on Advanced Methods in Spatial Data Processing and Analysis (6th-7th March 2012)**

Data for various natural, anthropogenic, and socio-economic phenomena from a wide range of sources are available at multiple spatial and temporal scales. Representation of such data available in continuous and discrete forms in spatial form further invites a host of novel techniques to unravel meaningful spatial information. Such spatial information is useful to develop cogent spatiotemporal models. Some of those novel techniques have been emerged from the fields such



as Granular Computation, Artificial Intelligence, Spatial Statistics, Fuzzy Set Theory, and Mathematical Morphology. This workshop organized during 6-7 March 2012) has provided experiences of pioneering researchers who have been involved in designing, developing and demonstrating the elegant methods in spatial data processing and analysis. This workshop was attended by 45 participants from various parts of India. The invited speakers delivered lectures are from Austria, India, Japan and UK.

Saroj Meher and B. S. Daya Sagar

#### 4. INTERNALLY/EXTERNALLY FUNDED PROJECTS

##### 4.1 Internally funded Plan projects (On-Going)

Sl. No.	Name of the Project	Principal Investigator(s)	Unit(s) Involved
01	Derivation of spatially significant set via spatial analysis and reasoning	B.S. Daya Sagar	SSIU
02	Human depth EEG processing for epilepsy and cognition	Kaushik Kumar Majumdar	SSIU

##### 4.2 Externally Funded Projects (On-Going)

Sl. No.	Name of the Project	A/c No.	Principal Investigator(s)	Unit / Division(s) Involved	Funded by
01	Computation in the brain: neuron, synapse, astrocyte interactions in small networks	218	Kaushik Kumar Majumdar	SSIU	DST

#### 5. CONFERENCES, SYMPOSIA, WORKSHOPS, LECTURES & SEMINARS (organized by the Institute)

##### 5.1 Symposia and Conferences

N/A

##### 5.2 Workshops and Training Programmes

###### 1) WORKSHOP on "ADVANCED METHODS IN SPATIAL DATA PROCESSING AND ANALYSIS".

Systems Science and Informatics Unit, held at ISI - Bangalore, March 06 – 07, 2012. (A Captioned photograph is provided at the end of this document.)



### 5.3 Lectures and Seminars

- 1) Atkinson, Peter, University of Southampton, UK (06.03.2012): Space-time monitoring of Earth Surface Properties: Vegetation Phenology in India.
- 2) Boerner, Wolfgang-Martin, University of Illinois at Chicago, USA. (15.12.2011): Implementation of FULL-POL-SAR in Agriculture, forestry and aquaculture as well as for the detection of natural hazards and natural disaster assessment from air and space for South, East and Pacific Asia – with emphasis on multi-band FULL-POL-SAR image fusion.
- 3) Ghosh, Aurobrata, INRIA, Sophia Antipolis, France (19.4.2011): High order models in diffusion MRI and applications.
- 4) Krishnan, R. N., Indian Institute of Space Science and Technology, Trivendrum, (07.03.2012): Hyperspectral Image Classification.
- 5) Majumdar, Atreyi, Department of Economics, University of Delhi (21.3.2012): Socio-economic implications of international movements of human resource with special reference to a case study of professional Indian immigrants in the U.K.
- 6) Marschallinger, Robert, ÖAW Institute Geographic Information Science, Schillerstr, Austria (07.03.2012): 3D and 4D modeling and simulation across multiple scales in Geosciences.
- 7) Mukhopadhyay, Supratik, Department of Computer Science, Louisiana State University, USA (21.04.2011): A Formal Approach for Developing Reliable Service-based Systems.
- 8) Murthy, K. R. S, National Institute for Advanced Studies (NIAS), Bangalore, (06.03.2012): Commercial Opportunities in Space Imageries and Spatial Information.
- 9) Pinnamaneni, Bhanu, MATRIX VISION Paris Area, France (06.03.2012): Machine Vision Applications using Intelligent camera.
- 10) Rao, Mukund, Expert Consultant (National GIS), Planning Commission, (06.03.2012): World gets SPATIAL – Changing Methods and Processes.
- 11) Ramarao, N, Indian Institute of Space Science and Technology, Trivendrum,

(07.03.2012): Hyperspectral Image Classification.

- 12) Ray, Supratim, Center for Neuroscience, IISc, Bangalore (26.12.2011): Study of attention at multiple scales of neural integration.
- 13) Shevade. Shirish, Indian Institute of Science, Bangalore, (07.03.2012): Support Vector Machines for Structured Prediction Problems.
- 14) Tsumoto, Shusaku, Department of Medical Informatics, Shimane University, Enya-cho, Lzumo, Japan (07.03.2012): Trajectories Mining based on Multiscale Comparison and Clustering.

## 6. PUBLICATIONS OF THE INSTITUTE

N/A

## 7. SCIENTIFIC PAPERS AND PUBLICATIONS

### 7.1 Books Published

N/A

### 7.2 Papers published in journals:

- 1) Majumdar, K., and Vardhan, Pratap: Efficacy of differential operators in brain electrophysiological signal processing: A case study in epilepsy, *IEEE Trans. Neural Systems and Rehabilitation Engineering*, **19 (4)**, 356 – 365, 2011.
- 2) Majumdar, K.: Human scalp EEG processing: various soft computing approaches, *Applied Soft Computing*, **11 (8)**, 4433 – 4447, 2011.
- 3) Lim, S. L., Sagar, B.S.D, Koo, V. C., and Tay, L. T.: Morphological convexity measures for terrestrial basins derived from Digital Elevation Models, *Computers & Geosciences*, **37 (9)**, 1285-1294, 2011.
- 4) Majumdar, K.: Differential operator in seizure detection, *Computers in Biology and Medicine*, **42(1)**, 70 - 74, 2012.
- 5) Rajashekara, HM., Vardhan, Pratap and Sagar, B.S.D.: Generation of zonal map from point data via weighted skeletonization by influence zone, *IEEE Geoscience and Remote Sensing Letters*, **9 (3)**, 403-407, 2012.

- 6) Pal, S.K., Meher, S. K., and Dutta, S.: Class-Dependent Rough-Fuzzy Granular Space, Dispersion Index and Classification, *Pattern Recognition*, **45**, 2690-2707, 2012.
- 7) Meher, S. K., and Pal, S.K.: Rough-Wavelet Granular Space and Classification of Multispectral Remote Sensing Image, *Applied Soft Computing*, **11 (8)**, 5662-5673, 2011.
- 8) Shankar, U, B., Meher, S. K., and Ghosh, A.: Wavelet-Fuzzy-Hybridization: Feature-extraction and Land-cover Classification of Remote Sensing Images, *Applied Soft Computing*, **11 (3)**, 2999-3011, 2011.
- 9) Tewari, S., and Majumdar, K.: A mathematical model of tripartite synapse: Astrocyte induced synaptic plasticity, to appear in *Journal of Biological Physics*, Online Version: DOI: 10.1007/s10867-012-9267-7, 2012
- 10) Tewari, S., and Majumdar, K.: A mathematical model of astrocyte mediated LTP at a single hippocampal synapse, *Journal of Computational Neuroscience*, Online Version: DOI:10.1007/s10827-012-0389-5, 2012.

### 7.3 Papers published in Conference Proceedings:

- 1) Meher, S. K., and Murthy, M.N.: Efficient Detection and Counting of Moving Vehicles with Region-Level Analysis of Video Frames *Proceedings of the International Conference on Soft Computing for Problem Solving (SocProS 2011) December 20-22, 2011, Advances in Intelligent and Soft Computing*, 2012, Volume 131/2012, 29-40, DOI: 10.1007/978-81-322-0491-6\_3.
- 2) Meher, S. K., and Patel, P.: Fuzzy Impulse Noise Detector for Efficient Image Restoration, *IEEE Conference on Recent Advances in Intelligent Computational Systems, RAICS 2011, Trivandrum, India*, 701-705, 2011.

### 7.4 Papers published in books

N/A



**8. VISITING SCIENTISTS (include only non-ISI scientists and arrange the names in alphabetical order of the last name)**

- 1) Atkinson Peter, University of Southampton, UK, March 06 – 11, 2012.
- 2) Boerner Wolfgang-Martin, University of Illinois at Chicago, USA, December 15, 2011.
- 3) Ghosh Aurobrata, INRIA, Sophia Antipolis, France, April 19, 2011.
- 4) Krishnan R.N, Indian Institute of Space Science and Technology, Trivendrum, March 05 – 08, 2012.
- 5) Majumdar Atreyi, Department of Economics, University of Delhi, New Delhi, March 21, 2012.
- 6) Marschallinger Robert, ÖAW Institute Geographic Information Science, Schillerstr, Austria, March 05 – 11, 2012.
- 7) Mukhopadhyay Supratik, Department of Computer Science, Louisiana State Univeristy, USA, April 21, 2011.
- 8) Murthy Sridhara K.R, National Institute for Advanced Studies (NIAS), Bangalore, March 06, 2012.
- 9) Pinnamaneni Bhanu, MATRIX VISION Paris Area, France, March 05 – 08, 2012.
- 10) Rao Mukund, Expert Consultant (National GIS), Planning Commission, March 06, 2012.
- 11) Rama Rao.N, Indian Institute of Space Science and Technology, Trivendrum, March 05 – 08, 2012.
- 12) Ray Supratim, Center for Neuroscience, IISc, Bangalore, December 26, 2011.
- 13) Shevade. Shirish K, Indian Institue of Science, Bangalore, March 03, 2012.
- 14) Tsumoto, Shusaku, Department of Medical Informatics, Shimane University, Enya-cho, Lzumo, Japan, March 05 – 10, 2012.

## 9. HONOURS AND AWARDS

- 1) Sagar, B. S. D.

Awarded: Georges Matheron Award (with Lectureship), 36th International Association for Mathematical Geosciences (IAMG) Conference, Salzburg, September 6, 2011. (Award receiving photograph given at the end of this document)

- 2) Meher, S. K.

Elected: Senior Member of Institute for Electrical and Electronics Engineers (IEEE), USA, 2011.

## 10. SCIENTIFIC ASSIGNMENTS

### 10.1 Editorship

- 1) Sagar, B.S.D. (Editor): Discrete Dynamics in Nature and Society: Multidisciplinary Review and Research Journal (Hindawi Publishers, USA); (Guest Editor): IEEE Journal on Special Topics in Signal Processing, 2012.
- 2) Meher, S, K. (Guest Editor): Applied Soft Computing, 2012.

### 10.2 Scientific Assignments/Academic Visits Abroad

- 1) Sagar, B. S. D.:

(1) ESIEE, Universiti Paris-EST, France, August 31 - September 03, 2011; (2) University of Salzburg, Austria, September 4 – 11, 2011; Delivered Georges Matheron Award Lecture-2011, University of Salzburg, Salzburg, Austria, September 06, 2011, 36th International Association for Mathematical Geosciences Conference, Salzburg, Austria, September 5-11, 2011.

### 10.3 Scientific Assignments/Academic Visits in India

- 1) Majumdar, K.K.:

(1) Delivered lecture in National Brain Research Center, Manesar, Haryana, 31 October to 1 November 2011; (2) participated through videoconference in the curriculum development program for B.Tech. in Systems Science of IIT Jodhpur, 11 - 12 December

2011; (3) Delivered lecture, ISI Chennai, International Conference on Game Theory, Operations Research and Their Applications, January 04 to 08, 2012; (4) Delivered lecture on "EEG based brain computer interface", M. S. Ramayya Institute of Technology, Bangalore, March 27, 2012.

2) Sagar B.S.D.

(1) Member of Doctoral Committee, University of Hyderabad, 2011; (2) Member of Doctoral Committee, Indian Institute of Science, 2011.

3) Meher, S. K.:

(1) Delivered lecture, AICTE sponsored Staff Development Programme on "Future Trends in Industrial Mathematics for Engineers", National Institute of Science and Technology, Berhampur, March 20th to 24th, 2012.

# 11. GENERAL ADMINISTRATION

Faculty members at SSIU:

- |                     |                            |
|---------------------|----------------------------|
| 1. B. S. Daya Sagar | Associate Professor & Head |
| 2. Kaushik Majumdar | Assistant Professor        |
| 3. Saroj Meher      | Assistant Professor        |

## Break of manpower by Gender, Social category and Disability group at SSIU

Total Strength		Physically Handicapped (PH)	Scheduled Caste (SC)	Scheduled Tribe (ST)
Male	03	01	Nil	Nil
Female	Nil	Nil	Nil	Nil
Total	03	01	Nil	Nil

## 12. Lists of members of Academic Council and different committees of the Institute as on 31 March 2012 should be provided by the Dean's Office and CE (A&F)'S Office.

Head, SSIU: Member, Works Advisory Committee, Bangalore