



**Two-Week DST Summer School on "Mathematical Morphology in Geosciences"  
24<sup>th</sup> March – 08<sup>th</sup> April 2015**

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**A Brief Report on the Two-Week DST Summer School on "Mathematical Morphology in Geosciences (24 March - 08 April 2015)"**

A Two-Week DST Summer School on "Mathematical Morphology in Geosciences" was held at the Systems Science and Informatics Unit (SSIU), Indian Statistical Institute-Bangalore Centre, India during 24 March and 08 April 2015. This summer school was fully sponsored by the Earth Science (ES) wing of Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India. This event that targeted to provide training and manpower development was also supported by the Bangalore Section IEEE Geoscience and Remote Sensing Society (GRSS) Chapter.

A restricted twenty five number of participants (Photo 1) selected to attend this school (see Appendix-1) include young research scholars, who have been pursuing doctoral studies, and young faculty members. These participants are drawn from the Indian Institute of Technology-Kharagpur, Indian Institute of Technology-Roorkee, Indian Institute of Technology-Gandhinagar, National Institute of Technology-Rourkela, Maharaja Sayajirao University of Baroda, Mangalore University, Pondyicherry University, Anna University, Jawaharlal Technological University-Kakinada, Delhi University, Jawaharlal Nehru University-Delhi, Wadia Institute of Himalayan Geology, Indian Statistical Institute-Bangalore, Central University of Karnataka.



Photo 1

Professor N. S. N. Sastry, Head of Indian statistical institute-Bangalore Centre has welcomed the participants on the first day of the summer school. Chairman of Programme Assessment Committee (PAC) for ES-SERB-DST, Professor Subimal Sinha-Roy delivered inaugural lecture (Photo 2) on "Quantitative Geomorphology in Earth Surface Processes and Tectonic Analyses" on 24 March 2015. This lecture was followed by an "Overview on DST Summer School on Mathematical Morphology in Geosciences" delivered by Prof. B. S. Daya Sagar, Coordinator of the Summer School (Photo 3). A total of sixty hours of lectures (see Appendix-2 for Lecture Topics and Time Schedule) on tightly-connected topics on 'Mathematical Morphology in Geosciences' categorized into seven parts (see



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Appendix-3) were delivered by Daya Sagar, and a panel of experts (Photo 4) that include B. L. Deekshatulu, Bhabatosh Chanda, Chakravarthy Bhagvati, Bhanu Prasad, Saroj Meher, and young researchers Sravan, Aditya, Paratp Vardhan, and Raghvendra Sharma. The seven parts of the lectures that span sixty hours of lectures (see Appendix-2 for Lecture Topics and Time Schedule) include:

Part-I: Binary and Greyscale Mathematical Morphology (360 minutes)

Part-II: Binary and Greyscale Granulometries and Skeletonization (630 minutes)

Part-III: Morphological Decompositions, Morphometric Analysis and Quantitative Characterization (630 minutes)

Part-IV: Morphological distances, Interpolation and Extrapolation, and Quantitative Spatial Reasoning (540 minutes)

Part-V: Case Studies and Demonstrations with Hands-On Activity (360 minutes)

Part-VI: Graph Morphology (90 minutes)

Part-VII: Expert Lectures (900 minutes)



Photo 2



Photo 3

Besides inaugural lecture by S. Sinha-Roy (90 minutes), lectures from Parts I to IV were delivered by B. S. Daya Sagar, demonstrations and hands-on-activity from part V were handled by Raghvendra Sharma and Paratp Vardhan, lecture from part VI was delivered by Sravan and Aditya, and expert lectures from part VII were delivered by B. L. Deekshatulu, Bhabatosh Chanda, Chakravarthy Bhagvati, Bhanu Prasad, Saroj Meher, and Manoranjan Mohanty. On 3rd of April 2015, being a holiday due to Good Friday, all the participants were taken to Mysore to show several places in around Mysore. This one-day tour was enjoyed by the participants as most of these participants represent various parts of India. On the day of valedictory on 8 April 2015, Manoranjan Mohanty, Member Secretary of PAC-ES-SERB-DST delivered a talk on "Research Initiatives in Earth Sciences by Department of Science and Technology" (Photo 5).



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Photo 4



Photo 5



Photo 6

On valedictory, the feedback about the summer school provided by the participants is indeed excellent, and the coordinator of this school is confident that there would be an interesting outcome from the participants during the years to come. Several other photographs were shown in Appendix-5. On the valedictory, all the participants attended (Photo-6) this two-week summer school were awarded certificates of participation.

Acknowledgements: Coordinator of this two-week DST summer school gratefully acknowledges the Science and Engineering Research Board (SERB) of Department of Science and Technology (DST) for generously providing grant, the Director of Indian Statistical Institute, Professor Bimal Roy, the Head of the Indian Statistical Institute-Bangalore Centre, Professor N. S. N. Sastry, the Professor-In-Charge, Professor Dipti Prasad Mukherjee for their support and cooperation that helped smooth running of this summer school. Coordinator gratefully acknowledges the Chairman and member Secretary of the Earth Science wing of SERB-DST Professor Subimal Sinha-Roy and Dr. Manoranjan Mohanty for their encouragement and continued cooperation and support without which this summer



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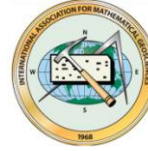
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school would not have taken place. Coordinator also acknowledges the great help received from the experts who delivered lectures, and the high quality of the attended participants for their enthusiasm and interaction to gain new knowledge in "Mathematical Morphology in Geosciences".

Report prepared by

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**Appendix-1**

No.	Name of Participant	Designation	Affiliation
1	K. Saranya	PhD Scholar	Central University of Karnataka
2	N. V. Lakshmi	PhD Scholar	Jawaharlal Technological University-K
3	Ananya Divyadarshini	PhD Scholar	Delhi University
4	Swapna Mahanand	PhD Scholar	Indian Institute of Technology-Kharagpur
5	K. N. Kusuma	Assistant Professor	Pondyicherry University
6	Balasaraswathi P	PhD Scholar	Anna University
7	Shubhra Sharma	PhD Scholar	Wadia Institute of Himalayan Geology
8	Sugandha Panwar	PhD Scholar	Indian Institute of Technology-Roorkee
9	Vijayalakshmi Naik	PhD Scholar	Mangalore University
10	Vinaya Kumari P	PhD Scholar	Mangalore University
11	V. Gopi Krishna Kasyap	PhD Scholar	Jawaharlal Technological University-K
12	Kushal A Chavare	PhD Scholar	Maharaja Sayajirao University of Baroda
13	Ramendra Sahoo	PhD Scholar	Indian Institute of Technology-Gandhinagar
14	Suman K. Choudhury	PhD Scholar	National Institute of Technology-Rourkela
15	Rahul Raman	PhD Scholar	National Institute of Technology-Rourkela
16	L. Vinoth Kumar	PhD Scholar	Anna University
17	V. Kumaran	PhD Scholar	Anna University
18	Amit K Singh	PhD Scholar	Jawaharlal Nehru University-Delhi
19	Sukumar Parida	PhD Scholar	Delhi University
20	Mohd Yawar Ali Khan	PhD Scholar	Indian Institute of Technology-Roorkee
21	S. Anbarasu	PhD Scholar	Anna University
22	Rajendra Mohan Panda	PhD Scholar	Indian Institute of Technology-Kharagpur
23	H. M. Rajashekara	PhD Scholar	Indian Statistical Institute-Bangalore,
24	Akkisetty Bhargav	Student	Indian Statistical Institute-Bangalore,
25	Charakanam Chakradhar	Student	Indian Statistical Institute-Bangalore,



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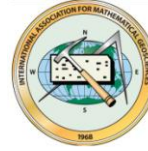
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**Appendix-2**

**24<sup>th</sup> March 2015, Tuesday:**

<b>Time</b>	<b>Title of the Topics</b>	<b>Speaker</b>
10:00-10:45	<b>Registration</b>	
<b>Inaugural Session</b>		
10:45 -11:00	Welcome Address and a few words about Indian Statistical Institute	NSN Sastry Head, ISI-BC
11:00-11:15	A few words about Systems Science and Informatics Unit (SSIU)	B. S. Daya Sagar SSIU, ISI-BC
11:15-11:20	Introducing S. Sinha-Roy	Saroj K. Meher SSIU, ISI-BC
11:25-11:30	Felicitation to S. Sinha-Roy	N. S. N. Sastry
11:30-12:00	<b>Coffee Break</b>	
<b>12:00-13:00</b>	<b>Quantitative Geomorphology in Earth Surface Processes and Tectonic Analyses</b>	<b>Inaugural Talk by Prof. S. Sinha-Roy</b>
13:00-13:30	Interaction	Audience
13:30- 14:30	<b>Lunch Break</b>	
14:30-15:30	Overview on the Summer School	BS Daya Sagar
15:30-16:00	<b>Tea Break</b>	
16:00 -17:15	Potential Applications of Mathematical Morphology-Part-I	P. Bhanu Prasad

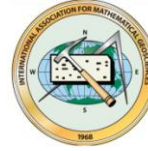


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**LECTURE TITLES WITH TIME SCHEDULES**

Time	Date	Lecture By	Lecture Title
12.00-13.30	24-03-15	<b>S. Sinha-Roy (Inaugural)</b>	<b>Quantitative Geomorphology in Earth Surface Processes and Tectonic Analyses</b>
14.30-16.00	24-03-15	B. S. Daya Sagar	Overview on DST Summer School on "Mathematical Morphology in Geosciences"
16.30-17.30	24-03-15	<b>P. Bhanu Prasad</b>	<b>Potential Applications of Mathematical Morphology-Part-I</b>
10.00-11.30	25-03-15	B. S. Daya Sagar	Minkowski Operations and Mathematical Morphology
12.00-13.30	25-03-15	<b>P. Bhanu Prasad</b>	<b>Potential Applications of Mathematical Morphology-Part-II</b>
14.30-16.00	25-03-15	B. S. Daya Sagar	Fundamental binary mathematical morphology transformations, and Structuring elements (flat and non-flat), symmetric and asymmetric, and their decompositions
16.30-17.30	25-03-15	B. S. Daya Sagar	Multiscale binary mathematical morphological operations, and Geodesic binary morphology
10.00-11.30	26-03-15	B. S. Daya Sagar	Greyscale morphological operations and their multiscale versions
12.00-13.30	26-03-15	B. S. Daya Sagar	Binary granulometries and grayscale granulometries
14.30-16.00	26-03-15	<b>Bhabatosh Chanda</b>	<b>Watershed Transformation: Morphological Segmentation Algorithm-Part-1</b>
16.30-17.30	26-03-15	B. S. Daya Sagar	Alternate sequential Filters (ASF) and ASF-Based granulometries
10.00-11.30	27-03-15	B. S. Daya Sagar	Detection of orientations and directional granulometries, and certain power-laws
12.00-13.30	27-03-15	<b>Bhabatosh Chanda</b>	<b>Watershed Transformation: Morphological Segmentation Algorithm-Part-2</b>
14.30-16.00	27-03-15	B. S. Daya Sagar	Skeletonization and extraction of valley and ridge connectivity networks
16.30-17.30	27-03-15	B. S. Daya Sagar	Grayscale skeletonization and extraction of valley and ridge connectivity networks
	28-03-15 (SATURDAY-HOLIDAY)		



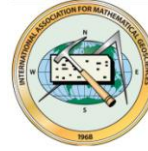
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29-03-15 (SUNDAY-HOLIDAY)			
10.00-11.30	30-03-15	Pratap Vardhan	Implementation of morphological operations through Python and/or MatLab-Part-1
12.00-13.30	30-03-15	Pratap Vardhan	Implementation of morphological operations through Python and/or MatLab-Part-2
14.30-16.00	30-03-15	B. S. Daya Sagar	Fractal-skeletal based Channel Network (F-SCN) models, generation of Fractal Landscapes, allometric Power-law relationships in Hortonian Fractal DEMs
16.30-17.30	30-03-15	B. S. Daya Sagar	Skeletonization by Influence Zones (SKIZ) and Weighted Skeletonization by Influence Zones (WSKIZ). Point-Polygonal conversion, cartograms-Part-1
10.00-11.30	31-03-15	B. S. Daya Sagar	Skeletonization by Influence Zones (SKIZ) and Weighted Skeletonization by Influence Zones (WSKIZ). Point-Polygonal conversion, cartograms-Part-2
12.00-13.30	31-03-15	B. S. Daya Sagar	Morphological shape decomposition and scale invariant but shape-dependent power-laws. Morphometry of networks and non-network spaces via morphological shape decomposition. Hierarchical morphological pruning, travel-time channel networks, convex hulls, convexity measures. Morphological hulls and convexity measures, half-plane closings
14.30-16.00	31-03-15	B. S. Daya Sagar	Morphological Distances and Logical relationships Vs. Quantitative spatial relationships
16.30-17.30	31-03-15	B. S. Daya Sagar	Binary and greyscale morphological interpolations and morphological extrapolations-Part-1
<b>10.00-11.30</b>	<b>01-04-15</b>	<b>Chakravarthy Bhagvati</b>	<b>Road Distress Assessment: Application of Mathematical Morphology</b>
12.00-13.30	01-04-15	B. S. Daya Sagar	Binary and greyscale morphological interpolations and morphological extrapolations-Part-1
14.30-16.00	01-04-15	B. S. Daya Sagar	Binary and greyscale morphological interpolations and morphological extrapolations-Part-2
16.30-17.30	01-04-15	Raghvendra Sharma	Demonstration of spatial interpolations and extrapolations through MatLab- Part-1
<b>10.00-11.30</b>	<b>02-04-15</b>	<b>Saroj K. Meher</b>	<b>Granular computations Part-1</b>
<b>12.00-13.30</b>	<b>02-04-15</b>	<b>Saroj K. Meher</b>	<b>Granular computations Part-1</b>





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14.30-16.00	02-04-15	Raghvendra Sharma	Demonstration of spatial interpolations and extrapolations through MatLab- Part-2
16.30-17.30	02-04-15	B. S. Daya Sagar	Width-function and geodesic spectrum
	03-04-15 (GOOD FRIDAY-HOLIDAY)		
	04-04-15 (SATURDAY-HOLIDAY)		
	05-04-15 (SUNDAY-HOLIDAY)		
<b>10.00-11.30</b>	<b>06-04-15</b>	<b>B. L. Deekshatulu</b>	<b>Intelligent Processing and Applications</b>
12.00-13.30	06-04-15	Sravan Danda and Aditya Challa	Basics Of Graph Morphology
14.30-16.00	06-04-15	B. S. Daya Sagar	Modelling, description and characterization of porous structures via mathematical morphology
16.30-17.30	06-04-15	B. S. Daya Sagar	f-alpha spectra--Opening-Based bisections
10.00-11.30	07-04-15	B. S. Daya Sagar	Logistic Maps and Bifurcation Theory
12.00-13.30	07-04-15	B. S. Daya Sagar	Spatial significance index and Modified Gravity Models for variable-specific classification of zones, pairs of zones, clusters of a spatial system
14.30-16.00	07-04-15	B. S. Daya Sagar	Ranks for pairs of images via grayscale morphological distances
16.30-17.30	07-04-15	B. S. Daya Sagar	Discrete simulations of spatiotemporal dynamics of small water bodies under varied streamflow discharges
<b>10.00-11.30</b>	<b>08-04-15</b>	<b>Manoranjan Mohanty</b>	<b>Research Initiatives in Earth Sciences by Department of Science and Technology</b>
12.00-13.30	08-04-15	B. S. Daya Sagar	Summary of the Sumer School and Seeking Feedback
14.30-15.00	<b>08-04-15 (CONCLUDING SESSION: CERTIFICATE DISTRIBUTION BY DR. MANORANJAN MOHANTY, MEMBER-SECRETARY, PROGRAMME ASSESSMENT COMMITTEE, SERB-ES, DST)</b>		



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**Appendix-3**

**B. S. Daya Sagar**

Lecture: Overview on DST Summer School on "Mathematical Morphology in Geosciences"

**PART-I: Binary and Greyscale Mathematical Morphology**

**B. S. Daya Sagar**

Lecture: Minkowski Operations and Mathematical Morphology

Lecture: Fundamental binary mathematical morphology transformations, and Structuring elements (flat and non-flat), symmetric and asymmetric, and their decompositions

Lecture: Multiscale binary mathematical morphological operations, and Geodesic binary morphology

Lecture: Greyscale morphological operations and their multiscale versions

**PART-II: Binary and Greyscale Granulometries and Skeletonization**

**B. S. Daya Sagar**

Lecture: Binary granulometries and grayscale granulometries

Lecture: Alternate sequential Filters (ASF) and ASF-Based granulometries

Lecture: Detection of orientations and directional granulometries, and certain power-laws

Lecture: Skeletonization and extraction of valley and ridge connectivity networks

Lecture: Grayscale skeletonization and extraction of valley and ridge connectivity networks

Lecture: Skeletonization by Influence Zones (SKIZ) and Weighted Skeletonization by Influence Zones (WSKIZ)

Lecture: Fractal-skeletal based Channel Network (F-SCN) models, generation of Fractal Landscapes, allometric Power-law relationships in Hortonian Fractal DEMs

**PART-III: Morphological Decompositions, Morphometric Analysis and Quantitative Characterization**

**B. S. Daya Sagar**

Lecture: Morphological shape decomposition and scale invariant but shape-dependent power-laws

Lecture: Morphometry of networks and non-network spaces via morphological shape decomposition

Lecture: Morphological hulls and convexity measures, half-plane closings

Lecture: Hierarchical morphological pruning, travel-time channel networks, convex hulls, convexity measures

Lecture: Width-function and geodesic spectrum

Lecture: Modelling, description and characterization of porous structures via mathematical morphology

Lecture: f-alpha spectra--Opening-Based bisections



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### **PART-IV: Morphological distances, Interpolation and Extrapolation, and Quantitative Spatial Reasoning**

**B. S. Daya Sagar**

Lecture: Morphological Distances and Logical relationships Vs. Quantitative spatial relationships

Lecture: Binary and greyscale morphological interpolations and morphological extrapolations

Lecture: Spatial significance index and Modified Gravity Models for variable-specific classification of zones, pairs of zones, clusters of a spatial system

Lecture: Ranks for pairs of images via grayscale morphological distances

Lecture: Discrete simulations of spatio-temporal dynamics of small water bodies under varied streamflow discharges

Lecture: Point-Polygonal conversion, cartograms

### **PART-V: Case Studies and Demonstrations with Hands-On Activity**

**Pratap Vardhan:** Demonstrations: Implementation of morphological operations through Python and/or MatLab

**Raghvendra Sharma:** Demonstrations: Demonstration of spatial interpolations and extrapolations through MatLab

### **PART-VI: Graph Morphology**

**Sravan Danda and Aditya Challa:** Lecture: Basics Of Graph Morphology

### **PART-VII: Expert Lectures**

**Professor S. Sinha-Roy:** Quantitative Geomorphology in Earth Surface Processes and Tectonic Analyses

**Professor B. L. Deekshatulu:** Intelligent Processing and Applications

**Professor Bhabatosh Chanda:** Watershed Transformation: Morphological Segmentation Algorithm-Parts 1 & 2.

**Professor Chakravarthy Bhagvati:** Road Distress Assessment: Application of Mathematical Morphology

**Dr. Bhanu Prasad:** Potential Applications of Mathematical Morphology-Parts 1 & 2

**Dr. Saroj K. Meher:** Granular Computations-Parts 1 & 2

**Dr. Manoranjan Mohanty:** Research Initiatives in Earth Sciences by Department of Science and Technology



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**Appendix-4**





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