

Research on the Development of Mathematical Morphology-Based Algorithms for Geoscience, Remote Sensing and Geospatial Data Sciences

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Topic 1: Mathematical Morphology in Geoscience, Remote Sensing and Geospatial Data Science: An Overview

Abstract: Data available at multiple spatial/spectral/temporal scales pose numerous challenges to the data scientists. Of late researchers paid wide attention to handling such data acquired through various sensing mechanisms to address intertwined topics—like pattern retrieval, pattern analysis, quantitative reasoning, and simulation and modeling—for better understanding spatiotemporal behaviors of several terrestrial phenomena and processes [1]. Georges Matheron and Jean Serra of the Centre of Mathematical Morphology, Fontainebleau founded Mathematical Morphology (MM) [2]-[5]. Since the birth of MM in the mid-1960s, its applications in a wide-ranging disciplines have illustrated that intuitive researchers can find varied application-domains to extend the applications of MM. Mathematical Morphology is one of the better choices to deal with the aforementioned intertwined topics. Various original algorithms and techniques that are mainly based on mathematical morphology have been developed and demonstrated. This lecture that presents an overview of mathematical morphology and their applications in geosciences, remotely sensed satellite data and Digital Elevation Model (DEM) processing and analysis, as well as geospatial data sciences, would be useful for those with research interests in image processing and analysis, remote sensing and geosciences, geographical information sciences, spatial statistics, and mathematical morphology, mapping of earth-like planetary surfaces, etc. The content of this broad overview of the lecture will be offered in two parts. In the first part, basic morphological transformations would be covered. An overview of the applications of those transformations, covered in the first part, to understand the granulometries, morphological filtering, morphological interpolations and extrapolations would be given with several case studies during the second part.

Topic 2: Processing and Analysis of Digital Elevation Models (DEMs) via Binary and Grayscale Granulometries, Morphological Interpolations, and Morphological Distances

Abstract: Digital Elevation Models (DEMs) that are the main by-products of remotely sensed data acquired via various sensing mechanisms offer rich clues to better understand the terrestrial phenomena and processes. This lecture presents the basics of binary and grayscale mathematical morphology [2]-[5], and their involvement in granulometries, morphological distances, and morphologic interpolations and extrapolations with applications in geosciences, remote sensing, and geospatial data sciences. Classification, clustering, and visualization are important phases of research for any researcher dealing with data relevant to geosciences, remote sensing, and spatial data sciences. This lecture will be offered in three parts. In the first part all the fundamental morphological transformations along with the application of binary and grayscale multivariate granulometries in the classification of watersheds derived from DEMs would be covered. In the second part, the applications of binary and grayscale morphologic interpolations in transforming non-contiguous data into contiguous maps, generating sparse and low spatial resolution DEM data into dense and high spatial resolution DEMs, and morphing of source DEM into target DEM. In the third part of this lecture ranks for pairs of spatial fields (e.g., DEMs) via metric based on grayscale morphological distances to designate every possible pair of DEMs available in a database consisting of a large number of DEMs would be covered.

Bibliography

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B. S. Daya Sagar (M'03-SM'03) is a Full Professor of the Systems Science and Informatics Unit (SSIU) at the Indian Statistical Institute. Sagar received his MSc and Ph.D. degrees in Geoenvironment and Remote Sensing from the Faculty of Engineering, Andhra University, Visakhapatnam, India, in 1991 and 1994 respectively. He is also the first Head of the SSIU. Earlier, he worked in the College of Engineering, Andhra University, and Centre for Remote Imaging Sensing and Processing (CRISP), The National University of Singapore in various positions during 1992-2001. He served as Associate Professor and Researcher in the Faculty of Engineering & Technology (FET), Multimedia University, Malaysia, during 2001-2007. Sagar has made significant contributions to the field of geosciences, with special emphasis on the development of spatial algorithms meant for geo-pattern retrieval, analysis, reasoning, modeling, and visualization by using concepts of mathematical morphology and fractal geometry. He has published over 85 papers in journals and has authored and/or guest-edited 11 books and/or special theme issues for journals. He recently authored a book entitled "Mathematical Morphology in Geomorphology and GISci," CRC Press: Boca Raton, 2013, p. 546. He recently co-edited two special issues on "Filtering and Segmentation with Mathematical Morphology" for IEEE Journal of Selected Topics in Signal Processing (v. 6, no. 7, p. 737-886, 2012), and "Applied Earth Observation and Remote Sensing in India" for IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing (v. 10, no. 12, p. 5149-5328, 2017). His recent book "Handbook of Mathematical Geosciences", Springer Publishers, p. 942, 2018 reached 570000 downloads. He was elected as a member of New York Academy of Sciences in 1995, as a Fellow of Royal Geographical Society in 2000, as a Senior Member of IEEE Geoscience and Remote Sensing Society in 2003, as a Fellow of the Indian Geophysical Union in 2011. He is also a member of the American Geophysical Union since 2004, and a life member of the International Association for Mathematical Geosciences (IAMG). He delivered the "Curzon & Co - Seshachalam Lecture - 2009" at Sarada Ranganathan Endowment Lectures (SRELS), Bangalore, and the "Frank Harary Endowment Lecture - 2019" at International Conference on Discrete Mathematics - 2019 (ICDM-2019). He was awarded the 'Dr. Balakrishna Memorial Award' of the Andhra Pradesh Academy of Sciences in 1995, the Krishnan Medal of the Indian Geophysical Union in 2002, the 'Georges Matheron Award - 2011 with Lectureship' of the IAMG, and the Award of IAMG Certificate of Appreciation - 2018. He is the Founding Chairman of Bangalore Section IEEE GRSS Chapter. He is an IEEE Geoscience and Remote Sensing Society (GRSS) Distinguished Lecturer (DL) for 2020-2022. He is on the Editorial Boards of Computers & Geosciences, Frontiers: Environmental Informatics, and Mathematical Geosciences. He is also the Editor-In-Chief of the Springer Publishers' Encyclopedia of Mathematical Geosciences. For more details about him, the following webpages may be referred at <http://www.isibang.ac.in/~bsdsagar>, https://en.wikipedia/wiki/B._S._Daya_Sagar.

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