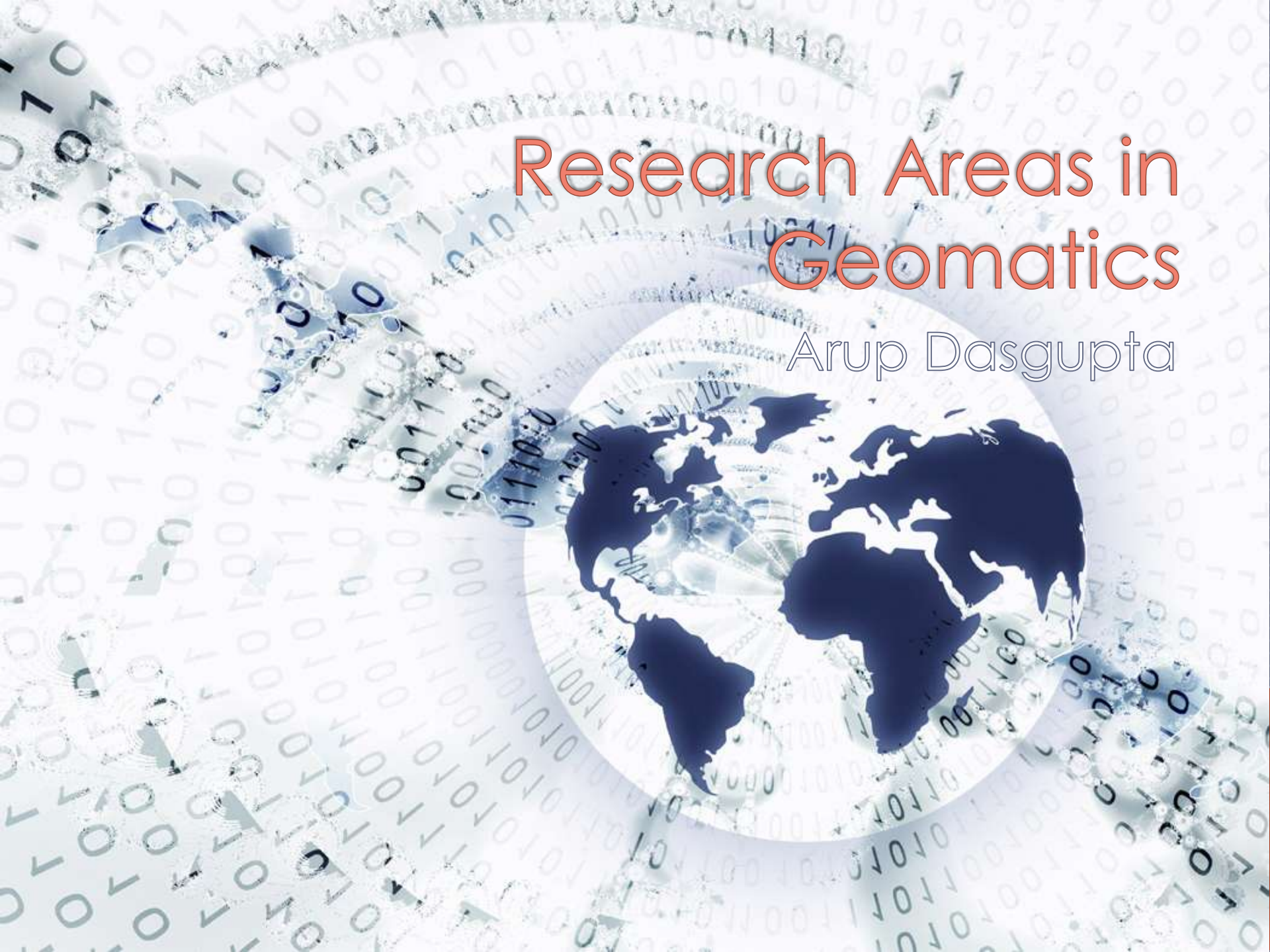


Research Areas in Geomatics

Arup Dasgupta

What is Geomatics

Geomatics is the discipline of gathering, storing, processing, and delivery of **geographical** information, or spatially referenced information

Traditional subjects

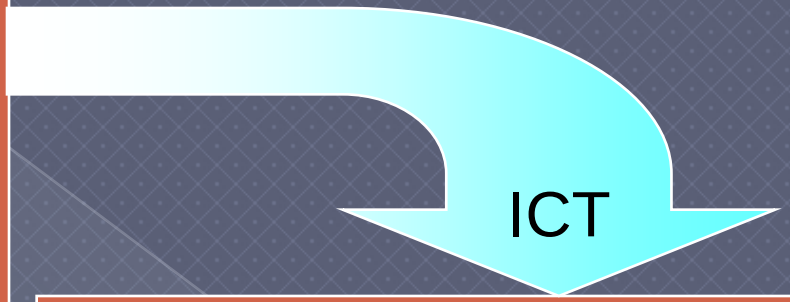
- Geodesy
- Surveying
- Mapping
- Hydrography
- Cartography
- Photogrammetry
- Network Analysis

Why ICT in Geography?

- Geographical information is
  - Large in volume
  - Graphical – maps
  - Time varying
- Geographical data requires special instruments for acquisition, storage and processing
- Geographical data processing is iterative and repetitive
- Geographical visualisation requires 3D capability

ICT and Geomatics

- Geodesy
- Surveying
- Mapping
- Hydrography
- Cartography
- Photogrammetry
- Networks



- Geographic Information Systems
- Wireless Location
- Positioning
- Remote Sensing
- Global Positioning System
- Navigation
- Digital Terrain Modelling

ICT and Spatial Data

- Aerial photography
  - Photo interpretation
  - Stereo-plotting
- Remote Sensing from air and space
  - Digital data
- Data analysis
  - Digital image processing
  - Digital photogrammetry
  - Image interpretation
- GPS for accurate position location
- Total station

Automation of Geoprocessing

- 1970s: CAD adapted to automate map production
- DBMS for data storage
- Merger of CAD and DBMS – AM/FM
- 1980s: GIS emerges
- Integration with remote sensing
- Integration with GPS
  - Location based services
- Integration with Internet -WebGIS

Geography in the New Millenium

- Geography has become
  - Personal
  - Interactive
  - Democratic
- Geography has also become anarchic
  - Incompatible systems
  - Lack of standards and interoperability
- Standardization and Interoperability
  - ISO TC211
  - OGC
  - NSDI

Science of Geomatics

"Geographic Information Science (GIScience) is the basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems. GIScience also examines the impacts of GIS on individuals and society, and the influences of society on GIS. **GIScience re-examines** some of the **most fundamental themes** in traditional spatially oriented fields such as **geography, cartography, and geodesy**, while **incorporating** more recent developments in **cognitive** and **information science**. It also **overlaps** with and **draws from** more specialized research fields such as **computer science, statistics, mathematics, and psychology,** and **contributes** to progress in those fields. It supports research in political science and anthropology, and draws on those fields in studies of geographic information and society."

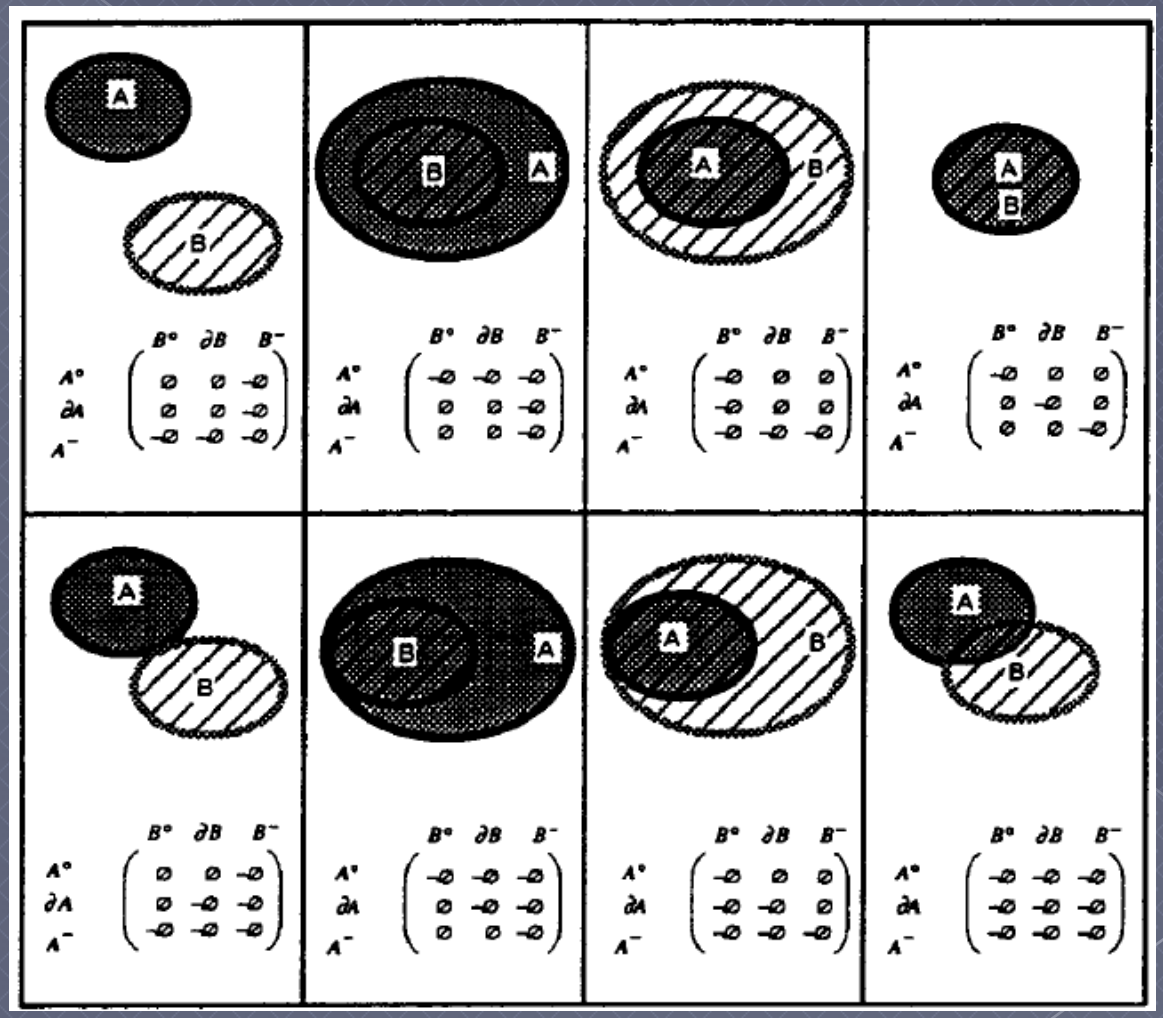
- UCGIS, 1999

Research Areas in Geomatics

- Ontology and Representation
  - Ontology of the geographical domain
  - Representation of geographical phenomena
- Computation
  - Qualitative spatial reasoning
  - Computational geometry
  - Indexing, retrieval and search in geographical databases
  - Spatial statistics
  - Map algebra
- Cognition
  - Cognitive models of geographic phenomena
  - Human interaction with geographical information and technology
- Applications, Institutions and Society
  - Acquisition of geographical data
  - Quality of geographical data
  - Spatial analysis

Example of Ontology of 'Place'

Qualitative Spatial Reasoning



Examples of Computational Geometry

- **Challenge:** To implement Euclidean geometry in a digital environment
- **Map generalisation:** Line simplification
- **Proximity Framework**
  - **Delaunay triangulation**
  - **Voronoi diagram:** Given a set of points, partition the space according to which point is closest.
  - **Closest pair of points:** Given a set of points, find the two with the smallest distance from each other.
  - **Euclidean shortest path:** Connect two points in a Euclidean space (with polyhedral obstacles) by a shortest path.
  - **Polygon triangulation:** Given a polygon, partition its interior into triangles
  - **Line segment intersection:** Find the intersections between a given set of line segments.
- **Convex hull:** Given a set of points, find the smallest convex polyhedron/polygon containing all the points.

Database Management Systems

- Knowledge Discovery and Data Mining
  - Discovering patterns from data stores
- Data Management for Wireless Sensor Networks and RFID
  - Tools for data acquisition and management for tasking sensor 'clouds'. Probabilistic methods for energy-efficient approximation of sensornet queries and distributed triggers, statistical methods to clean noisy data coming from RFID readers.
- Probabilistic Data Management
  - Several real-world applications need to effectively manage large amounts of data that are inherently uncertain, employing sophisticated probabilistic modelling tools to accurately reason about complex correlation/causality patterns in the data.
- Stream Query Processing
  - Traditional data management uses a stored repository of information. Streaming data sources like sensor networks, financial data feeds, and monitors of networks and software services require adaptive processing of multiple queries, fault tolerance, and providing approximate answers in overload situations.

Spatial Statistics and Geocomputation

- Methods to measure Spatial autocorrelation
- Controlling its effects in statistical analysis of spatial units
- Data quality studies
- Map algebra: A different way of looking at geocomputation based on proximity and local operators
- Spatial operations based on Cellular automata

Cognitive Models

- Study of human perception and reasoning about geographic phenomena
- Nature of spatial relationships
- Insights into geographic ontology
- Understand human-computer interaction for GIS

Graphics and Human-Computer Interaction

- Computer Aided Design and Modelling:
- Rendering:
  - Image based rendering. Vision realistic rendering. Computational photography and video.
- Visualization:
  - Scientific and information visualization. Virtual environments, tele-immersive environments
- Animation:
  - Motion capture analysis and synthesis. Physically based simulation.
- Context-aware computing:
  - Activity analysis, Smart Spaces, Location-aware systems, Privacy technologies.
- Perceptual Interfaces:
  - Vision-based interfaces, speech and discourse interfaces.
- Collaboration and Learning:
  - Geographically distributed tele-immersive collaboration.
- Optometry and Human Vision Simulation:
  - Medical imaging, virtual environments for surgical simulation

Scientific Computing

- **Parallel computing**
  - Languages and numerical algorithms for parallel computers
- **Automatic Performance Tuning**
  - Automatic generation of optimized implementations of computational and communication kernels, tuned for particular architectures and work loads.
- **Mesh generation**
  - Automatic generation of triangulated meshes to represent physical and computational domains.
- **Matrix computations**
  - Numerical algorithms and software for fast and accurate numerical linear algebra.
- **Floating point**
  - Extended precision arithmetic. Reliable floating point standards. Architectural and run time implications of floating point standards. Programming language implications of floating point standards.
- **Animation**
- **Computer Algebra**
  - Methods for symbolic mathematical computation.

Security

- Cryptology
- Privacy
- Social implications of security
- Sensor web security
- Security, programming languages, and software engineering
- Human interfaces and security
- Identity and integrity
- Network security
- Research Centers

For more information:

A. R. Dasgupta

Distinguished Professor,

Bhaskaracharya Institute for Space Applications and Geoinformatics,

Gandhinagar 382007

Email: arup@ieee.org

Fax: +91-(79)-23213091

Phone: +91-98253-29382