Lab for Spatial Informatics
a multi disciplinary research center

Prof. KS Rajan
Dr. RC Prasad
Dr. S Rehana

Research Team:
PhD: 11   MS / DD: 23
Graduated: 28 + 3

Publications:
Books/Journal : 65+
Conference : 175+
GeoSpatial Technology

BROAD DEFINITION: GIS is a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems.

- although many other computer programs can use spatial data (e.g. AutoCAD and statistics packages), GISs include the additional ability to perform spatial operations.

CURRENT STATUS: A field of Science, Technology and Systems that brings the Spatial and temporal context of the data into understanding, visualizing, analyzing, modelling and simulating phenomena that exhibit such characteristics, thus providing a more dynamic view and understanding of these phenomena.
What is GIS?

Source: Longley, Goodchild, Maguire, Rhind [2001]
Spatio-temporal Data

What are its characteristics

◦ Multi-Dimensional
◦ Large Volume
◦ Unknown Parameters/Variables
◦ Limited knowledge of underlying processes – Discovering Science
Spatio-temporal Data Processing

Algorithms and Scale + Multi-disciplinary
- Land use and Agriculture
  - Cropping Systems
- Meteorological phenomena
  - Climatic perturbations
- Urbanization Patterns
- Infrastructure Planning

Image Processing Challenges
- as Spatial and Spectral resolutions improve
Research @ LSI

1. Remote Sensing
2. Geospatial Science and Systems
3. Multi-Disciplinary Research – Spatial Modelling and Simulations
Geo/Spatial Technology landscape

**Data Collection**
- GPS based field surveys
- Satellite Imagery (Optical and Radar)
- LiDAR

**Data Storage and Analytics**
- Spatial Database
- Spatio-Temporal Data Mining

**Processing and Data Manipulation**
- Satellite image processing to Aerial/UAV data processing
  - ML/DL to Object characterisations
- Mapping and Visualization
- Spatial Big Data and Data Analytics - GIS

**Simulation and Modelling**
- Environmental and Land Use Change Modelling
- Traffic Flow models
Spatial Data Generation – Extraction of Real World Objects and Features

2D and 3D Machine Learning, Deep Learning and OBIA

**GLSI Fusion Model – Spectrum Preserving Fusion of Remotely Sensed Images**
- An Image Fusion technique that addresses the challenges of:
  - Varying bands in the images being fused
  - Variety of sources of images being fused
  - Preserving the Spectral responses of input in fused output images
- An Object based Image Fusion technique
- Key Researchers: Mayank Goyal, Ankush Khandelwal and K S Rajan

**Spatial Object Extraction from Very High Resolution Imagery**

- **ROAD EXTRACTION** – ASTM-R Algorithm
  - A minimal seed based learning algorithm that extracts road segments based on spectral and textural features
  - Has ability to manage occlusions (partial or full) of the road
  - Results show more than 75% road area extracted and more than 85% road network correctness
- Key Researchers: Sreekanth Reddy, Vinay Pandit, and K S Rajan

**BUILDING EXTRACTION**
- Use of ICA approach in detecting built-up spaces from VHR images.
- Ability to eliminate natural entities as background.
- Key Researchers: Lipika

**TREE SEGMENTATION**
- Terrestrial Lidar Processing for Tree identification and tree count
- Tree parameters extraction
- Biomass estimation of a forest
- Key Researchers: Suraj Reddy and K S Rajan

**LIDAR Data processing and Object Segmentation**
- **BUILDING SEGMENTATION** Algorithm
  - Based on Geometric and data characteristics
  - Automated Extraction of Building footprints and building walls
- Key Researchers: Gaurav Parida and K S Rajan

**Semi-Automatic Extraction of Buildings using Active Contour Model**
- Chan-Vese segmentation and Object Based Image Analysis
- Works for large and moderate size buildings
- Key Researchers: Sandeep

Authors list: Dr.K.S.Rajan, Mayank Goyal, Sandeep B, Lipika, Sreekanth, Vinay, Suraj Reddy, Gaurav Parida
Generalization of Road Networks for Efficient Path Computation

- In this work a Skeletal Model is proposed to represent a road network by its generalized representation aka skeleton.
- The skeleton, represents the most important or often used edges of the network which is further used to divide the given network into smaller zones, which shall be selectively used in path computation.
- A path computation algorithm is proposed which extracts a significantly smaller part of the road network for path computation.
- Results show that the most optimal network skeleton induced an average error of less than 5% over large distances (over 10kms) while using no more than 30% of the given road network.
- Key Researchers: Rohith Reddy, Mukul Priya, Dr.K.S.Rajan

Performance Evaluation of SQL vs NoSQL for Routing

- Performance evaluation of an existing NoSQL database and SQL database with respect to routing algorithm and evaluate whether or not we can deploy the computations on the client system only.
- For this comparative study, MongoDB is the NoSQL engine while the PostgreSQL is the chosen SQL engine.
- Results suggest that MongoDB performs faster by an average factor of 15x which increases exponentially as the path length and network data size increases in both indexed and non-indexed operations.
- Key Researchers: Sarthak Agarwal, Dr.K.S.Rajan

LSI Viewer

- A simple and robust online geospatial data visualisation system that performs data rendering and user-interactive styling, with a reduced load on the server.
- The performance analysis showed that the time taken to render the vector data using LSI Viewer is comparable to a desktop GIS application over an identical system configuration.
- Key Researchers: Manikanta Kondeti, Dr.K.S.Rajan

GTREE Based GML Compression Model

- Geography markup language (GML) is an XML specification for expressing geographical features.
- The focus of this work is to provide software solutions and services that can compress and decompress GML data.
- The algorithm takes advantage of topological structure and uses a tree-based data structure to store coordinate attribute data achieving lossless compression.
- Key Researchers: Ayush Khandelwal, Dr.K.S.Rajan

LSI STAT

- A web-based spatio-temporal interactive analytical platform that generates dynamic data visualizations based on user-given data.
- In contrast to the current visualization tools, this platform gives users an option to choose charts in combination with maps distributed spatially over the area of interest.
- Key Researchers: Neha Pande, Dr.K.S.Rajan

Authors list: Dr.K.S.Rajan, Manikanta Kondeti, Sarthak Agarwal, Neha Pande, Ayush Khandelwal, Rohith Reddy
Remote Sensing application in terrestrial ecosystem

1. Geospatial modelling approach to develop Forest Fire Danger Index based on the static and dynamic parameters using satellite datasets

2. Mapping Mangrove Species Using Hyperspectral Data: A Case Study of Pichavaram Mangrove Ecosystem, Tamil Nadu

3. Filling the data gaps in Landsat 7 images using Neighborhood similar pixel threshold based Local Binary Pattern approach

4. Prediction of vegetation dynamics using NDVI time series data and LSTM

5. Statistical Noise Removal (SNR) – A Novel Approach Of Removing Noise From The Full Range Field Collected Spectra

6. Spatio – Temporal Variation In Spectral Pattern vis – a – vis Biochemical Parameters Of Selected Species Of Araku Forest, Eastern Ghats

Suresh Babu¹, N.N. Salghuna², Srinivas³, Sushma Reddy⁴, P. Rama Chandra Prasad
Lab for Spatial Informatics, IIIT-H, Hyderabad 500032
LULC change analysis and modeling

INTRODUCTION
- LULC change dynamics is a continuous process. It has direct relation with global climate and environment change.
- Human Role: one third to one half of our planet’s land surfaces have been transformed by human development.
- The understanding of landscape dynamics is essential for sustainable planning of a region, environmental models and framing policies.
- Geospatial Technology (RS and GIS) The correct information about LULC change intensity and drivers that cause it is highly desirable to formulate effective ways to combat the climate change and develop effective mitigation strategies.

AIM
To identify and analyse the biophysical and socio-economic drivers of LULC change
Scenario based modelling to assess future potential LULC change

METHODS
Contributors
- LULC Project Contributors: Dr. K. S. Rajan (+), Dr. R. C. Prasad (++), IIITH
- LULC Western Ghats - Bharath Setturu, Ramachandra T V +
- LULC Godavari river basin – Mohit Kumar +
- LULC KRF, Eastern Ghats – N. N.Salghuna, J Asha Kumari ++
- LULC Vijayawada,A.P.–Vani M. ++
- LULC Krishna river basin – Yeshu Sharma +

RESULTS
- The result of this analysis showed a rapid growth in built-up land between 1990 and 2017 while the periods between 1990 and 2015 witnessed a reduction in the forest class.

Lab for Spatial Informatics (LSI)
INTRODUCTION

• Great river valleys of India have shaped human civilizations throughout history by acting as a lifeline for their growth and sustenance.
• River basin modelling is an essential tool in understanding various aspects that directly or indirectly affect our rivers and inland water bodies.
• Geospatial Technology (RS and GIS) not only provides explicit data but also these platforms are excellent tools to analyze, assess and model river basin and their changes.

AIM

Qualitative and Quantitative hydrological modelling for large inland water bodies.
Modelling future scenarios depending on climate model outputs.

METHODS

DATA TOOL PROCESS
DEM QGIS, ILWIS, SAGA GIS, etc.
Climate data SWAT, HSPF, SPARROW, MODFLOW, SWAT
Ground data Sediment transport, contaminants movement in water body, flood modeling, ground water assessment, etc.
Satellite imagery GOGS, ILWIS, SAGA GIS, etc.

AIM Qualitative and Quantitative hydrological modelling for large inland water bodies. Modelling future scenarios depending on climate model outputs.

RESULTS

Multiple Linear Regression (MLRM) model of estimated and observed river water temperature for training and testing period. Contributed by Dr. Shaik Rehana and Adhi Naresh.

Nutrient flow modelling in Nagarjuna Sagar watershed.

Contributed by Dr. K. S. Rajan and K. Tarun Teja

Chlorophyll -a detection in large inland water bodies. (Taihu, Nagarjuna Sagar, Ba Bae and Manasarovar lake). Contributed by Dr. K.S. Rajan and K. Tarun Teja

The probability of low water quality for (a) current (1988-2005) and (b) Future Scenario (2020-2040) for Tunga-Bhadra river. Contributed by Dr. Shaik Rehana, IIITH and Dr. C.T. Dhanya, IIT Delhi

Open Source Tools

- SWAT
- HEC-HMS
- HEC-RAS
- HEC-GEOhMS
- HFS
- SPARROW
- Fuzzy logic
- QGIS
- GRASS
- SAGA GIS
- BASSINS
- MODFLOW
- WARP

Lab for Spatial Informatics
International Institute of Information Technology, Hyderabad
Climate Extremes & Impacts - Modeling & Assessment

Our Research

- Climate Change prediction
- Statistical Downscaling
- Climate Extremes Analysis
- Hydro-Informatics Data Analysis
- Uncertainty Modelling
- Reservoir Operation, Irrigation Planning
- Drought Characterisation
- Crop Water Requirement Assessment

Modeling Tools and Methods

- QGIS
- QSWAT
- PCRaster
- SWMM
- HEC-HMS
- VIC Model
- QUAL2K
- RClimdex
- Clustering Algorithms
- ANN, RNN, SVM, Random Forests
- Deep Learning
- Machine Learning algorithms
- Statistical Methods
- Optimization

Research Contributions

Precipitation and Temperature Extreme Indices over India

Drought Characterisation using Precipitation and Evapotranspiration over India

Climate Change Impacts on Agriculture over Afghanistan

Drought study - West Godavari district (2008-2012)

Contributors:
- Dr. Shaik Rehana, IIITH; N.T. Monish, IIITH
- Dr. Francisco Munoz-Arriola, University of Nebraska, USA
- Dr. Shaik Rehana, IIITH; Prof. Krishna Reddy, Aapah Innovations, IIITH
- Darpan Baheti, Dr. K.S. Rajan, IIITH

Spatial pattern of trends of temperature and precipitation extreme indices in India: warm spell duration indicator (WSDI), cold spell duration indicator (CSDI) consecutive dry days (CDD), consecutive wet days (CWD), daily temperature range (DTR), very wet days (R95p).