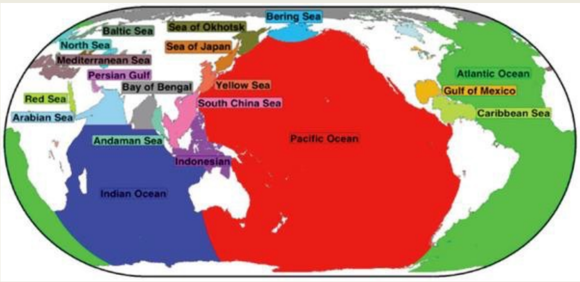
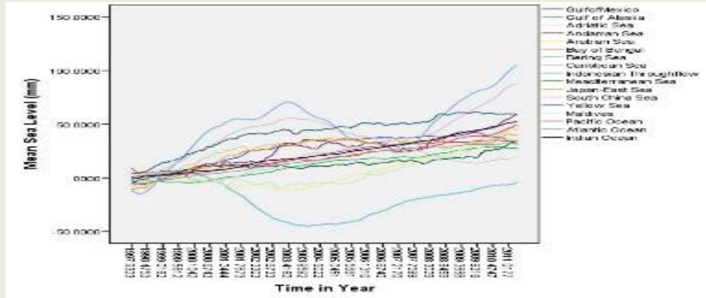
TEXAS A&M UNIVERSITY CORPUS CHRISTI | COLLEGE OF SCIENCE AND ENGINEERING

Applied and Computational Mathematics

Department of Mathematics and Statistics

Analyzing and Predicting Local and Global Sea Level Rise





We have and are analyzing global and local (Unites States Gulf Coast) sea level rise. Analysis is based on the data collected over 25 years by TCOON and NOAA stations along the Gulf Coast and by global stations located at 19 key points all over the world. We are using different statistical and mathematical tools to determine main factors of sea level rise and their connections to the climate change, Geoid, etc.
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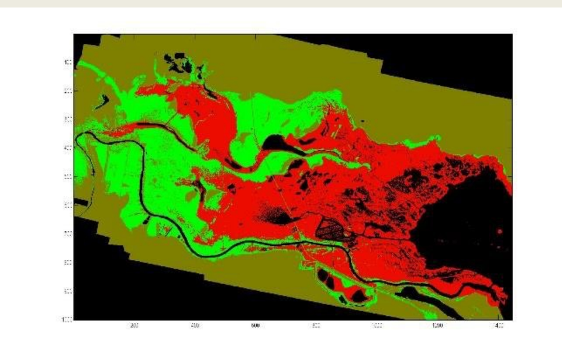
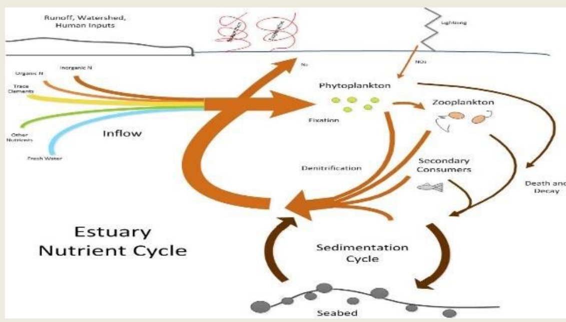
Modeling, Simulation, Visualization of Environmental, Coastal and Marine Systems





We are using tools of mathematics, statistics, and system analysis to understand behavior of complex spatial-temporal environmental, coastal, and marine systems. For instance, learning dynamics of populations of the multi-species food chain could be applied, for example, to problems of marsh preservations through efficient management of freshwater releases. On the other hand, tools of Partial and Ordinary Differential Equations together with the Graph Theory help us to understand circulation of nutrients, phytoplankton, zooplankton, oxygen, carbon, etc. under different conditions in the coastal and marine systems.
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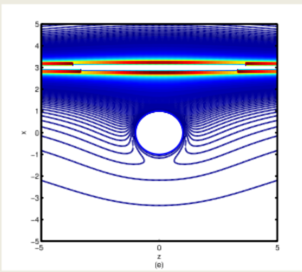
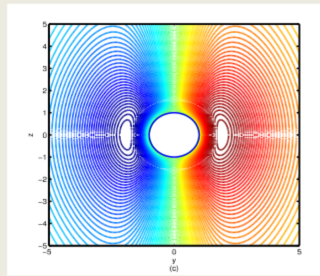
TEXAS A&M UNIVERSITY CORPUS CHRISTI | COLLEGE OF SCIENCE AND ENGINEERING

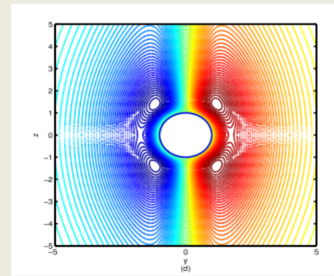
Applied and Computational Mathematics

Department of Mathematics and Statistics

Modeling and Simulation of Fluid Currents in the Vicinity of Islands







Fluid flow simulations due to currents in the vicinity of spherical islands/obstacles. The flow lines generated using differential equations model reveal the evolution of vortex structures and their complex interactions with ocean islands.

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Fluid-Filled Fracture Propagation: Modeling and High-Performance Computation

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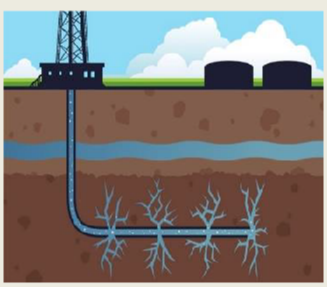

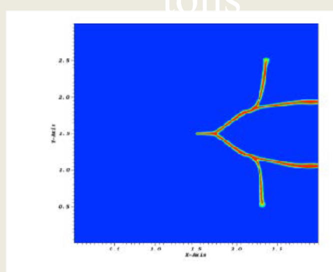

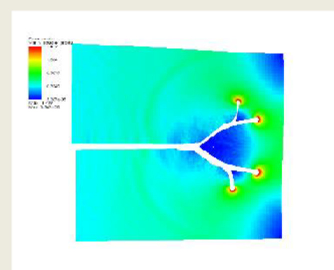

This research program aims to develop novel mathematical and computational models that are capable of describing crack propagation in brittle elastic solids. A challenge is to formulate well posed boundary value problems that can correctly predict underlying physics. In particular, for studying defects and evolution in porous materials and the interaction with fluid flowing in these materials. These types of mechanical interactions are very crucial in many engineering and environmental problems such as fracking, dam/levee fracture, CO2 sequestration, land subside.

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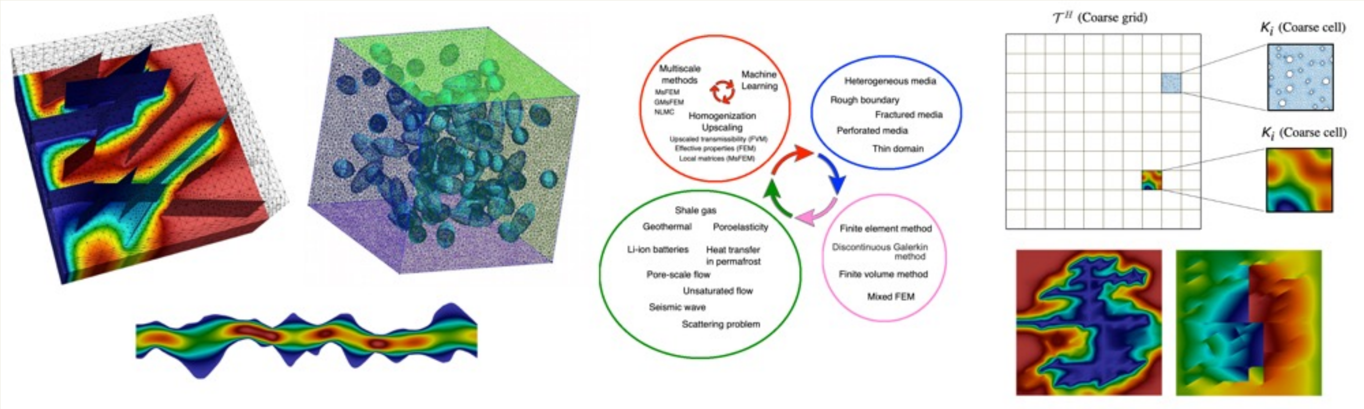
Applied and Computational Mathematics

Department of Mathematics and Statistics

Multiphysics models and methods across scales

This project focus on multiscale multiphysics problems arising from material science, mechanical engineering, geoscience, and subsurface flows. Simulations of such problems in heterogeneous media are challenging due to the multiscale nature of the processes.



- Multiscale multicontinuum models for flow and transport problems in heterogeneous and fractured media.
- Coupled flow and geomechanics processes in heterogeneous media with applications for shale gas production and geothermal reservoirs.
- Multiphase multicomponent reactive transport with application to hydrates reservoirs and CO2-sequestration.
- Multiscale simulations of wave propagations in fractured and heterogeneous media.
- Heat and mass transfer problems with phase-change with applications to hydrates and permafrost regions.
- Multiscale models and methods for thin and perforated domains (pore-scale flows).

Fast and accurate numerical methods are developed based on:

- Finite element and finite volume space approximation techniques on structured and unstructured grids.
- Upscaling, numerical homogenization, and multiscale methods.
- Decoupling techniques for time approximations.
- Deep neural network construction for prediction of the coarse scale parameters

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TEXAS A&M UNIVERSITY CORPUS CHRISTI | COLLEGE OF SCIENCE AND ENGINEERING

Mathematics Education and Teacher Preparation

Department of Mathematics and Statistics

Students Understanding and Difficulties in Selected Topics in School Mathematics

The team of mathematics teacher educators conducts research on students understanding and difficulties in selected topics in K-16 mathematics (e.g. various concepts in school algebra, trigonometry, calculus, differential equations, engineering mathematics education) using inquiry-based teaching and learning methods. Supporting teachers and instructors to develop a scholarship of teaching and learning K-16 mathematics. We also engage in research design and methodology.

POC: J. Dogbey, C. Ekici, G. Tintera https://sci.tamucc.edu/MATH/

Teacher Preparation and Professional Development for In-Service Teachers

We prepare pre-service mathematics teachers using culturally responsive pedagogies through mathematics modeling and integrated STEM practices (e.g., integrating STEM learning with coding, and modeling population dynamics using continuous, discrete, deterministic and stochastic approaches). We provide professional development for in-service mathematics teachers to enhance their mathematics knowledge for teaching, and examine the impact of the professional development activities on teachers' classroom practices and students' achievement.

POC: J. Dogbey, C. Ekici, G. Tintera https://sci.tamucc.edu/MATH/

Curriculum Development and Analysis of Mathematics Textbooks

We conduct research in curriculum analysis and development in mathematics education, and design instructional materials to support mathematics teaching/learning. We also conduct comparative studies.

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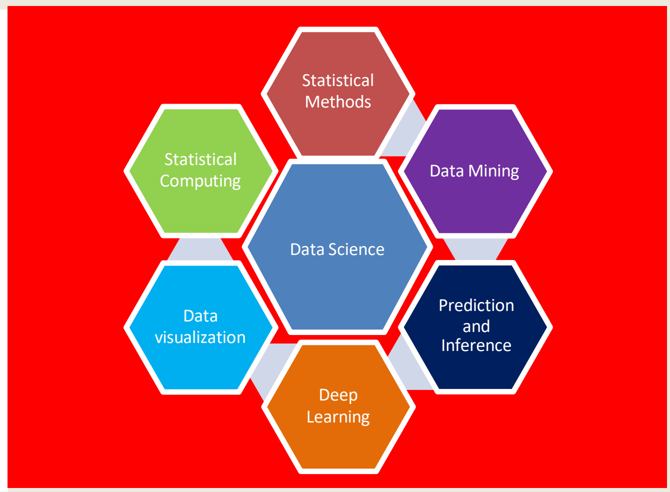
TEXAS A&M UNIVERSITY CORPUS CHRISTI | COLLEGE OF SCIENCE AND ENGINEERING

Data Science

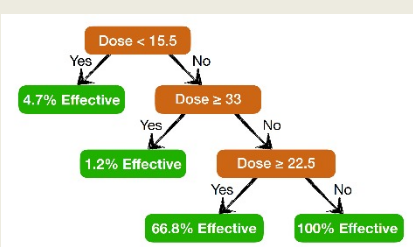
Department of Mathematics and Statistics

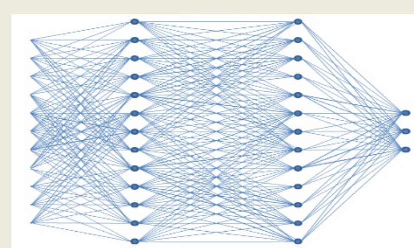
DATA SCIENCE

Data Science is the field of study that combines domain expertise, programming skills, and knowledge of mathematics and statistics in the practice of extracting knowledge and insight from data and effectively communicating the results. It is a truly multidisciplinary field.



- **Bayesian Statistical methods for data science, big data, and analytics;**
- **Statistical machine learning methods:**
  - **- Bayesian Additive Regression Tree**
  - **- Bayesian Regression with undirected Network**
- **Statistical methods for analyzing multiway contingency table for data mining**
- **Machine learning with Stochastic Frontier Model in Econometrics**





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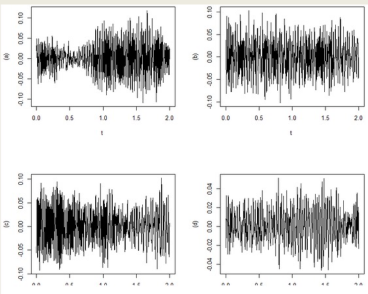
Department of Mathematics and Statistics - Dr. Alexey Sadovski at Alexey.Sadovski@tamucc.edu

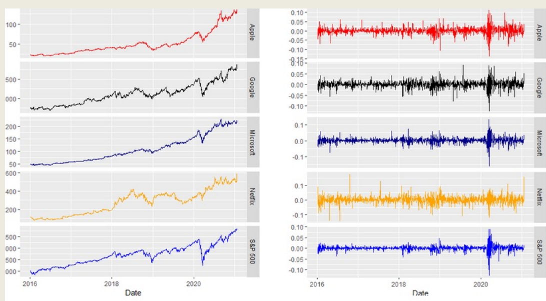
Data Science and Statistics

Time series comparison/Anomaly detection/Time series classification (supervised learning) & clustering (unsupervised learning) in terms of dynamics

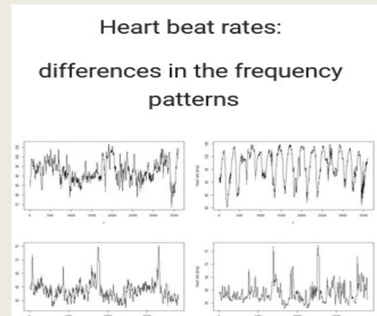
1. Learning from data in both the time & frequency domain
2. Health monitoring from continuous health data from sensors such as wearable devices.
3. Nonlinear dynamics in financial market data



Damage detection of a mechanical system



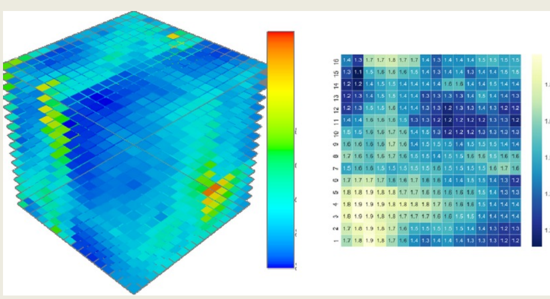
Dynamics similarity measure for nonlinear processes

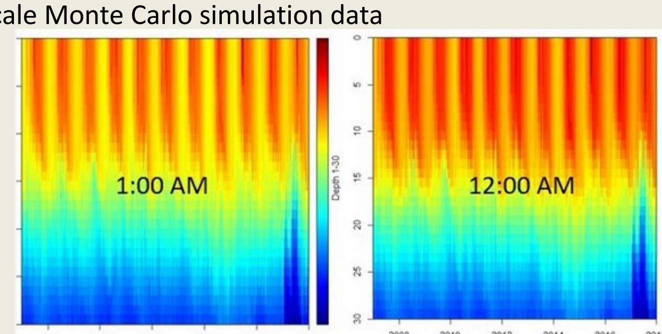


Streaming data: a continuous flow of data

1.Online algorithm for variance/covariance matrix estimation

2.Adaptive spectral variance estimation for large-scale Monte Carlo simulation data





Statistical modeling and data science methods:

Use statistical/data science methods such as data assimilation, and adaptive filtering to analyze a suite of chemical variables from multiple sources (cruises, Wave Glider, In-situ measurements, satellite, etc.) at different temporal and spatial resolutions to understand the temporal and spatial dynamics of pH, Ωarag, and the relationships between environmental factors in the Gulf of Mexico.

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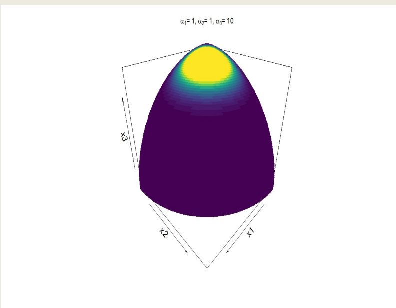
Data Science and Statistics

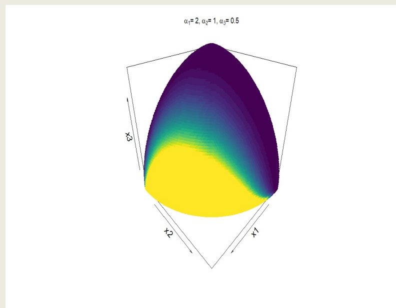
COLLEGE OF SCIENCE AND ENGINEERING

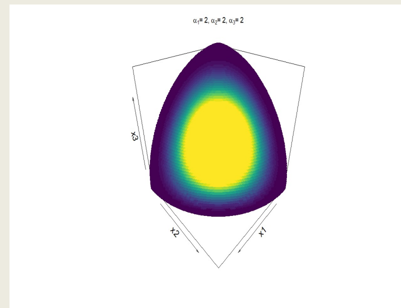
PROBABILITY DISTRIBUTION THEORY

Hyperspherical distributions

1.- Develop suitable probability distributions for the hypersphere
2.- Obtain normalizing constant, distribution properties and moments
3.- Obtain estimators based on classical and Bayesian inferential methods.
4.- Applications in text mining and gene expressions analysis

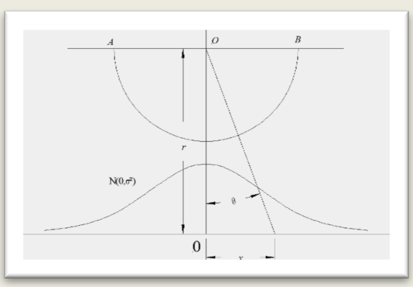


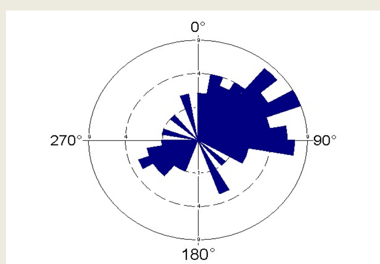


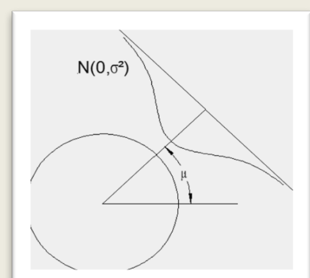


Circular Statistics

1- Develop distributions suitable for analyzing directional data
2- Obtain properties and develop Bayesian and classical inferential methods
3.- Applications for directional data in environmental science, biology, etc.

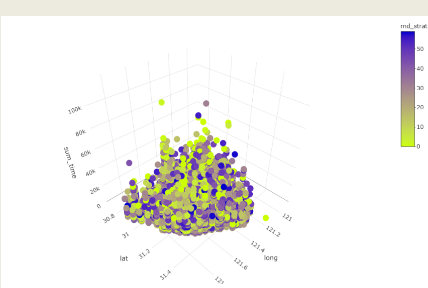


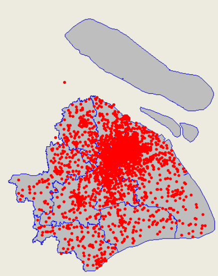


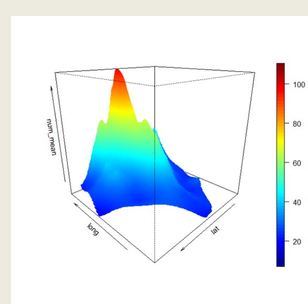


Spatial Statistics

1.- Develop methods for analyzing data correlated in space and time
2.- Applied research in environmental science, biology, medicine, public health and mobile computing







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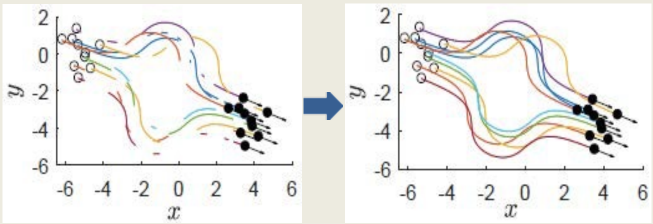
TEXAS A&M UNIVERSITY CORPUS CHRISTI | COLLEGE OF SCIENCE AND ENGINEERING

Machine Learning Research and Modeling with Big Data

Department of Mathematics and Statistics

Reconstruction of Corrupted Trajectories



Tracking of trajectories of collectively moving agents such as fish, birds, and even humans is an active field in computer vision. However, the trajectories produced by multi-object tracking methods might consist of unconstructed segments of trajectories due to natural phenomena such as occlusion, change of illumination, etc. In this project, we utilize mutual interactions and dependencies between the agents to reconstruct the missing segments of the trajectories.

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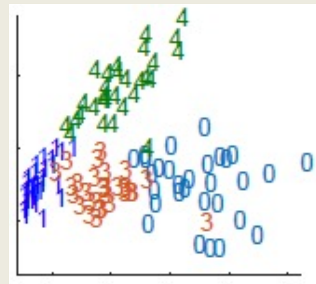
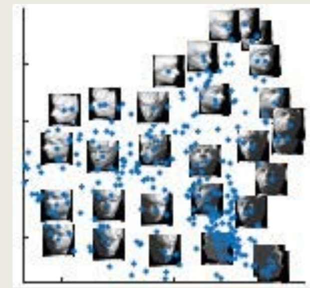
Non-linear Dimensionality Reduction





Nonlinear dimensionality reduction or, equivalently, the approximation of high-dimensional data using a low-dimensional representation is an active area of research. In this project, we present a thematically different approach to detect the existence of a hidden low-dimensional representation of high-dimensional data using matrix completion. Such methods are currently used to solve challenging real-world problems, such as image inpainting, video denoising, and recommender systems.

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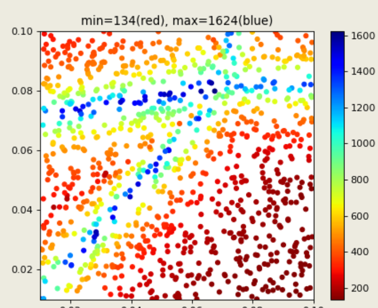
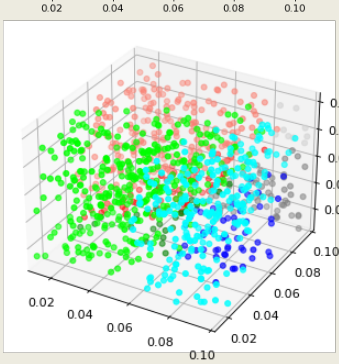
Spatial-temporal Multispecies Models





Understanding the stability of ecosystems is of fundamental importance to ecology. Fundamental mathematical models of such systems are described by a coupled system of ordinary differential equations (ODEs). The Lotka-Volterra Competition model (LVC) is a basic model that describes the dynamics of the species population competing for some shared resource. The LVC model has been applied in many areas, including biological systems, industry, and economics. For example, the model can simulate the marshes ecosystems. In such systems, a temporal dynamic model can represent and describe the behaviors of the entire system. However, real ecosystems interact in different locations, and spatial structure is essential and has an enormous impact on the final equilibrium state,. Systems of the partial differential equations (PDEs) are used to describe spatial-temporal systems. A mathematical model is described by a coupled system of unsteady nonlinear reaction-diffusion equations.

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