Division of Interdisciplinary Research, IISc

Interdisciplinary Research

Core research areas:

Urban Infrastructure & Transportation

Nanoscale Materials, Nano Devices and Systems

Management Studies

Energy

Water

Bioengineering

Supercomputing Research

Internet of Things, Distributed Sensing

Computer Systems, Computational Science and Bioinformatics

43

Faculty Members & Scientific Staff

12

Fellowships of Sci & Engg Academies in India

388

PhD/Int PhD students

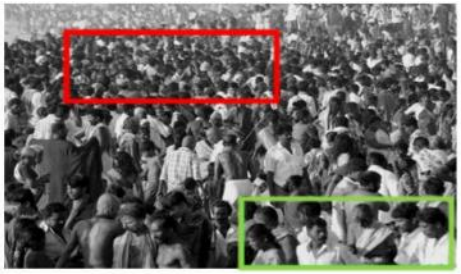
Highlights:

- National Nano Fab: a world-class facility for nano fabrication, testing, and characterisation
- *SahasraT*: Cray XC40 petaflop supercomputer
- Computational and Data Sciences: First such department in India
- SERIIUS: an Indo-US project on high-end energy research (India collaboration coordinated by IISc)
- Robert Bosch Centre for Cyber Physical Systems: One of the first such Centres in the world

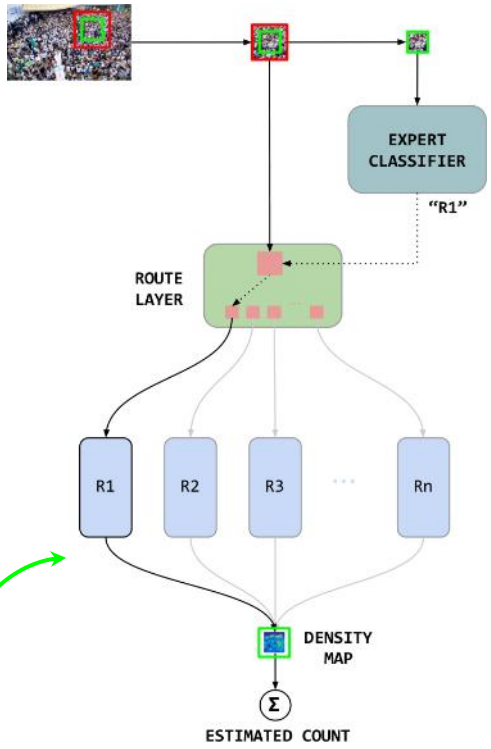
Research Snapshots

Incrementally Growing Neural Network for Crowd Counting

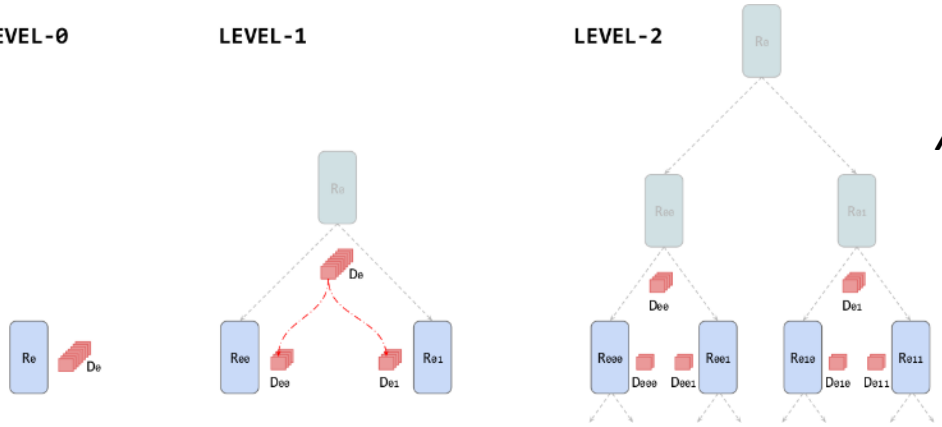
(CVPR 2018)



High variability in appearance of people -> needs multiple experts



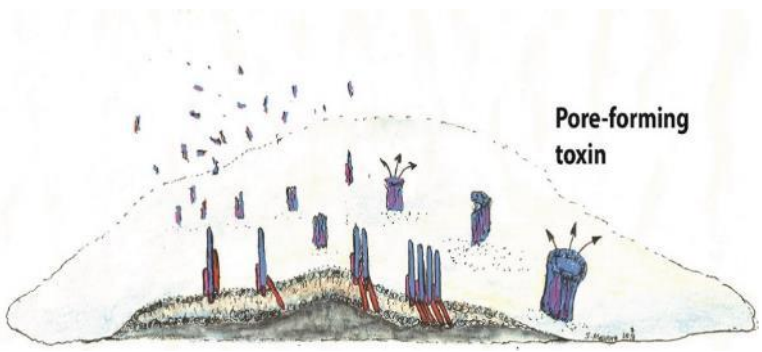
LEVEL-0 LEVEL-1 LEVEL-2



A Growing CNN that automatically adapts to the complexity of data!

Deepak et al. "Divide and Grow: Capturing Huge Diversity in Crowd Images with Incrementally Growing CNN", CVPR'18 (Spotlight)

Research Snapshots

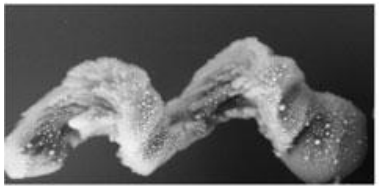


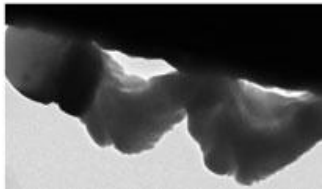
Cholesterol in animal cell membrane facilitates pore formation by bacterial toxin

P Sathyanarayana, S Maurya, A Behera, M Ravichandran, SS Visweswariah, KG Ayappa, and R Roy, "Cholesterol promotes Cytolysin A activity by stabilizing the intermediates during pore formation", **PNAS (2018)**

Plasmonic nanotweezers that can trap and manoeuvre tiny molecules suspended in a fluid

S Ghosh, A Ghosh, "Mobile nanotweezers for active colloidal manipulation"
Science Robotics (2018)





Centre for Nanoscience and Engineering

14,000 sft cleanroom for Nanofabrication

7,000 sft semi cleanroom for Nanocharacterization

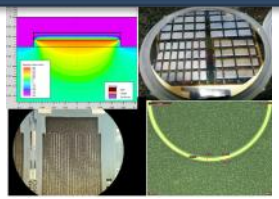
MEMS & IC Packaging

System Engineering Facility (SysEF)

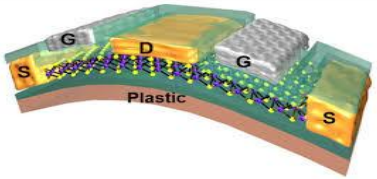
1. MEMS/NEMS/MOEMS
2. Bio Sensors
3. Biophotonics and Bioengineering
4. Optics, Nanostructures and Quantum Fluids
5. Functional Thin Films
6. Gas Sensors
7. Photovoltaics and Energy
8. Polymer Process
9. Neuro Electronics
10. Computational Nanoengineering (CoNe)
11. Photonics Research
12. Non linear Photonics and High power Lasers

Current Research Focus @ CeNSE

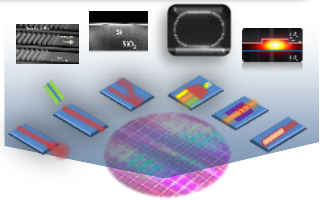
GaN Power Electronics

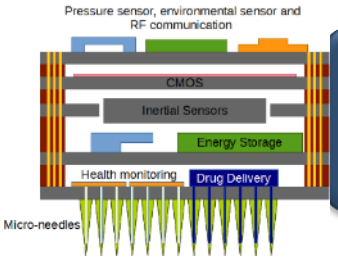


Oxide/Chalcoge-nide Electronics

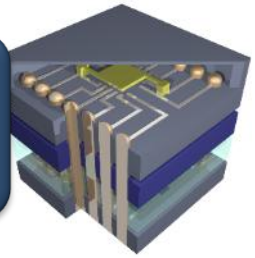


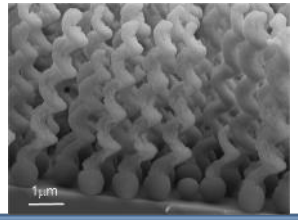
Photonics





3D Systems Scaling



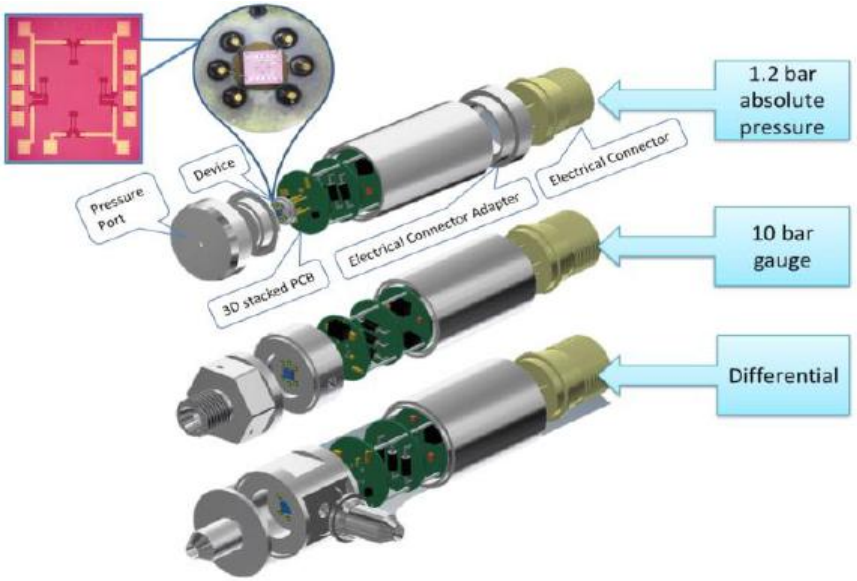


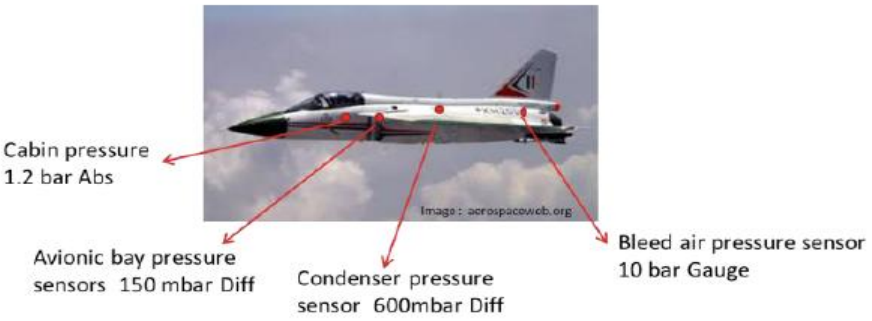
Nano-Bio Healthcare

Photovoltaics & Energy Devices

Nano-Agri, Food, Environment

Impact: MEMS Pressure Sensors for Aerospace





30 Pressure Transducers delivered to Helicopter Division of HAL Bengaluru. Used in Cheetah and Chetak Helicopters for Altitude and Air speed measurement.

Now flying at the high altitudes of Leh!

Impact: Mobile “Lab on Palm”

Only Device in the World for diabetes, liver, kidney, anemia, malnutrition

Time differential glycemic indexing with spot glucose, 2 weeks average glucose (Glycated Albumin) and 3 months average glucose (HbA1c)

January 29, 2018

Tata Trusts announces hub-and-spoke Telemedicine Network; to benefit 10 lakh people in 265 Gram Panchayats

Vijayawada: Tata Trusts today announced a hub-and-spoke Telemedicine Network, covering a population of about 10 lakh people spread over 265 Gram Panchayats in Vijayawada rural parliamentary constituency to supplement the public

In this section

- Events
- Thought leadership
- Media reports
- Publications
- Videos

10 lakh people touched in Andhra Pradesh alone

Computational and Data Sciences

An interdisciplinary engineering department at IISc spanning the research areas of Computational Science and Engineering, and Computer and Data Systems

Besides pursuing cutting edge research, CDS faculty leads several national and international initiatives, and provide industrial consultancy and research services

Computational Science @ CDS

Development of computational models and methods to solve and understand complex problems using advanced numerical and computing capabilities

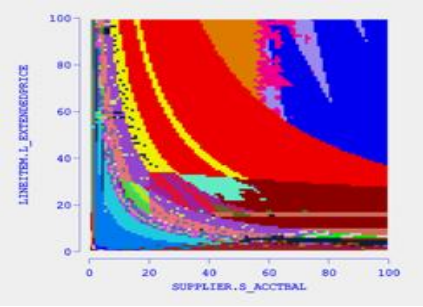
Computer and Data Systems @ CDS

Design, implementation and evaluation of high performance and scalable computer hardware and software systems

Computer and Data Systems

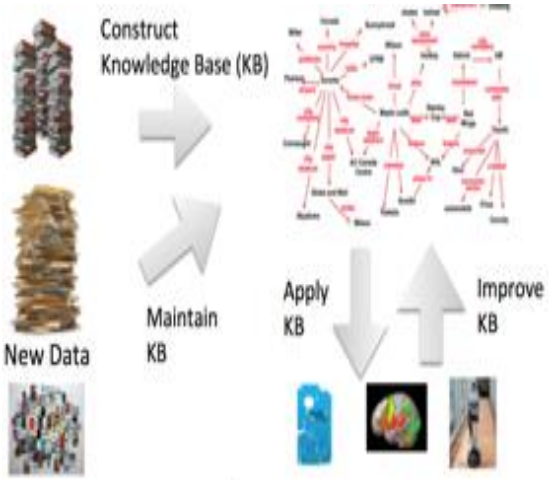
Database Systems

- PICASSO: Visualization tool for analyzing behavior of industrial-strength database query optimizers
- MIRA: Multilingual database system for providing "natural-language-neutral" storage and operators
- MASK: Algorithms for privacy-preserving mining of association rules



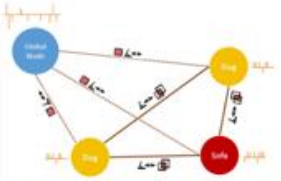
Machine & Language Learning

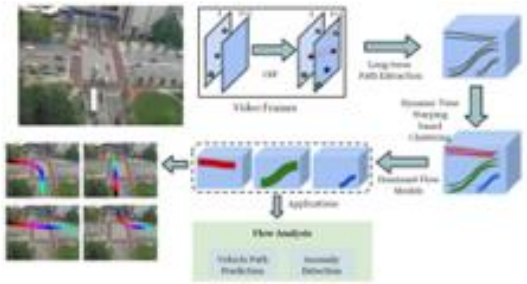
- Representation Learning for Machine Reading
- Knowledge Graph Evaluation Learning at Scale for Machine Reading
- Goal-directed Knowledge Graph Construction
- Deep Learning for Machine Reading



Video Analytics

- Visual Surveillance and Monitoring Object Tracking
- Machine Learning in vision
- Expression Recognition
- Crowd Behaviour Analysis
- Video Indexing and Retrieval
- Compressed Domain Processing

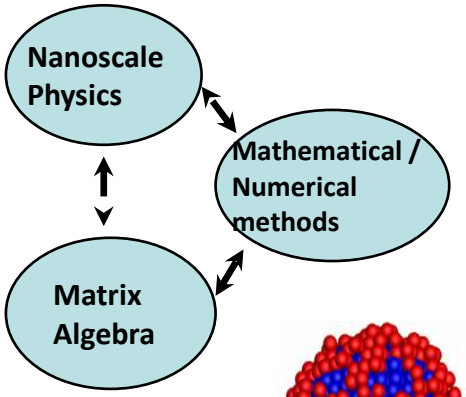


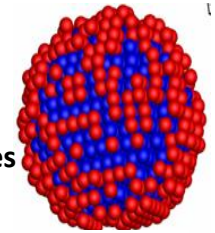


Computational Science & Engineering

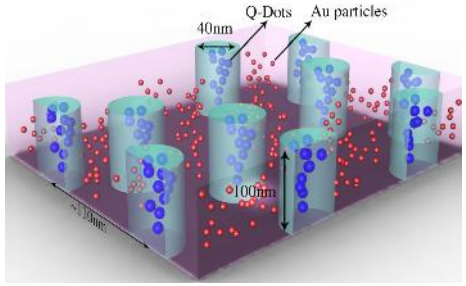
Computational Physics

Numerical Linear Algebra, Photonics, Condensed matter, Computational and Statistical Methods





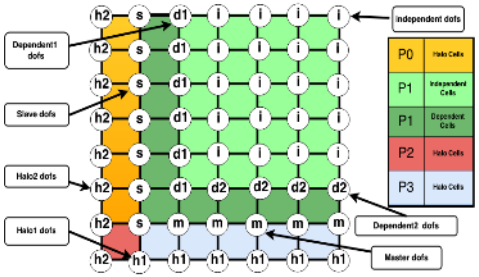
Optical properties of nanoscale composites

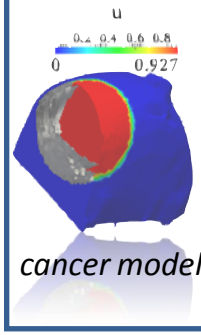


N-body problems in emission

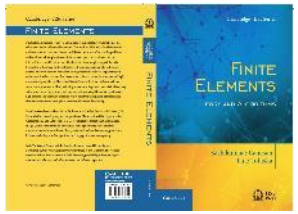
Computational Math

- Finite Element methods for solution of PDEs
- Data-Driven Science, Modeling of Multiphase and turbulent flows with moving boundaries
- ParMooN, an OpenMP and MPI based hybrid parallel finite element software



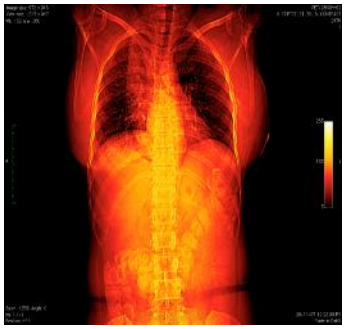


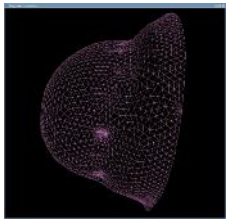
cancer model

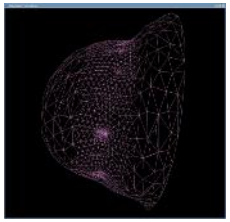


Medical Imaging

Computational methods in medical imaging, multi-modal imaging, medical image reconstruction techniques, diffuse optical tomography, biomechanical modelling, neuroimaging



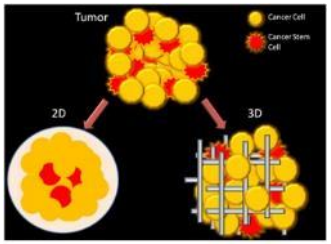


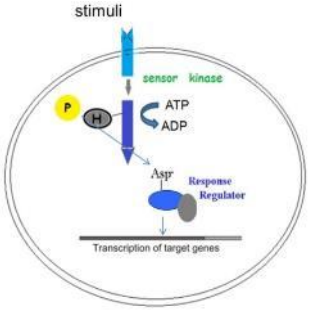


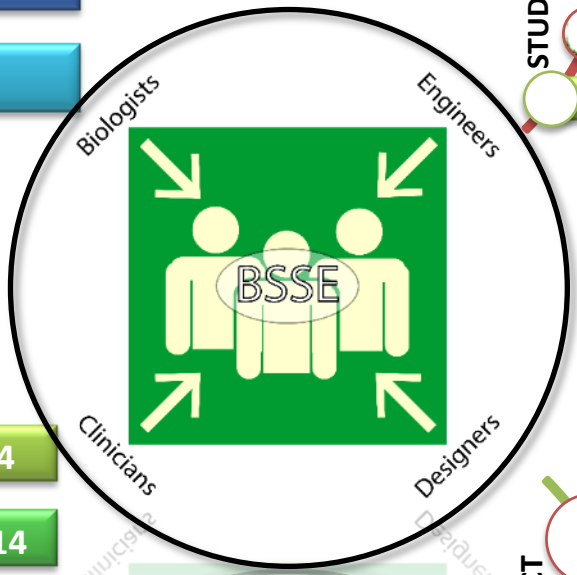
BioSystems Science and Engineering

RESEARCH @ BSSE

- Biomaterials
- Biomechanics
- Computational Bioengineering
- Neuro-Engineering

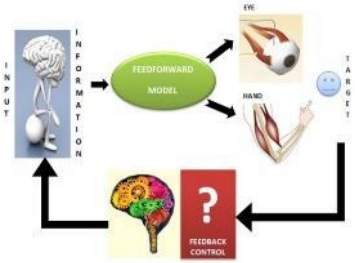






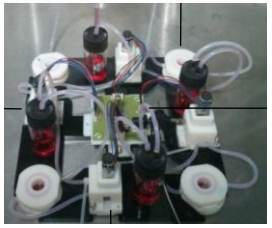
STUDENT COMPOSITION

Biotechnology	15
Electronics/Instrumentation Engg.	6
Mechanical Engg.	3
Materials Science/Plastics Engg.	2
Physics	2
Biomedical Engg.	2
Others	4



PEOPLE @ BSSE

Primary faculty	4
Associate faculty	14
INSPIRE faculty	2
Acad. Prog. faculty	28
Students(completed+current)	9 + 34
Staff	11



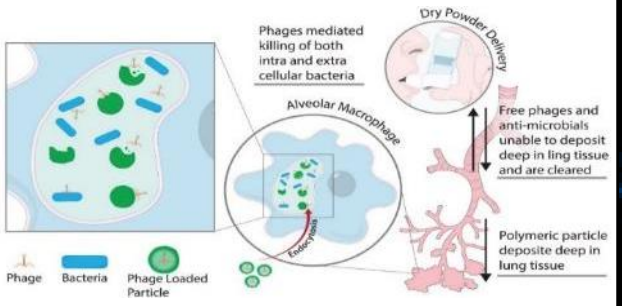
CLINICAL CONNECT

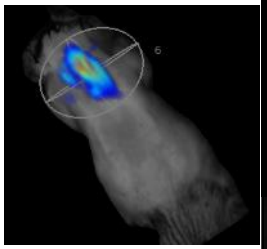
- Bioengineering Summer Training+ Programme
- Medical Research Hub
- Visiting Clinicians
- MoU: CMC Vellore, MSCTR, St. John's, NIMHANS and RGUHS

BioSystems Science and Engineering

Rachit Agarwal

Biomaterials based Nano- and Micro- Technologies

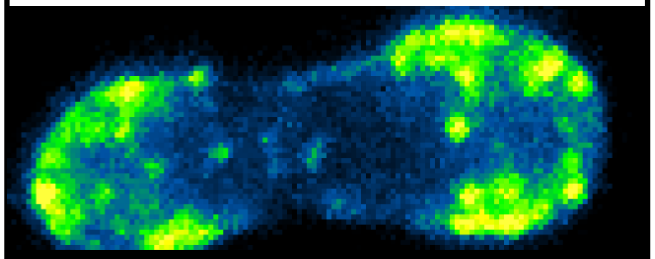




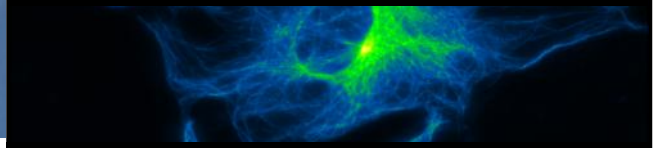
Inhaled bacteriophage-loaded polymeric microparticles ameliorate acute lung infections. Nature BME (2018)

Vaishnavi Ananthanarayanan

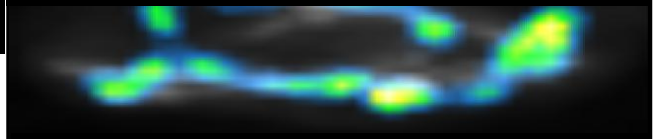
Quantitative Cell Biology using Microscopy and Image Processing



Fission Yeast Myosin I Facilitates PI(4,5)P2 –mediated Anchoring of Cytoplasmic Dynein to the Cortex. PNAS (2017)



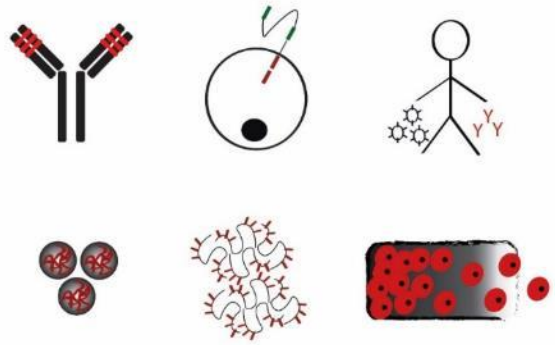
Role of Microtubules in Osteogenic Differentiation of Mesenchymal Stem Cells on 3D Nanofibrous Scaffolds. ACS Biomater. Sci. Eng (2017)



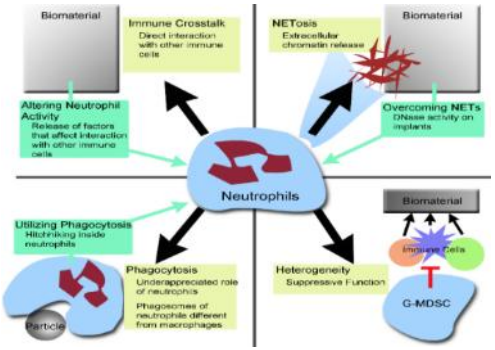
Microtubule dynamics regulates mitochondrial fission. bioRxiv (2017)

Siddharth Jhunjhunwala

Immunoengineering



Strategies and tools being developed to engineer immune responses. J Ind. Insti. Sci. (2018)

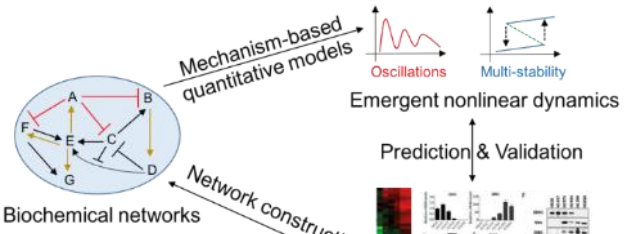


Utilizing biomaterials to study neutrophil biology. ACS Biomater. Sci. Eng. (2017)

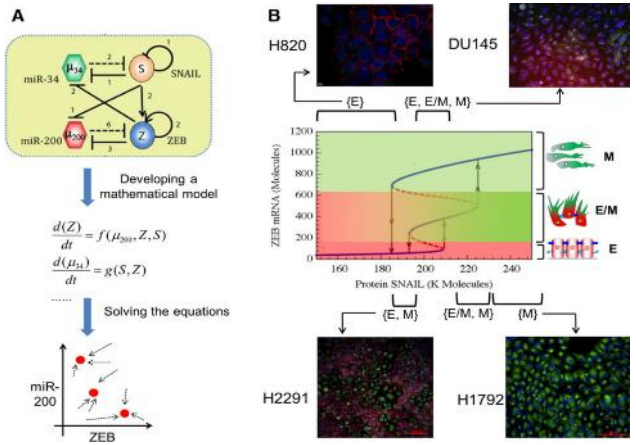
BioSystems Science and Engineering

Mohit Kumar Jolly

Systems Biology of Cancer



An iterative systems biology workflow



Computational models to decode the network dynamics underlying cancer metastasis and therapy resistance (Mol Oncol 2017)

Future Directions

- Biomechanics
- Synthetic Biology
- Tissue Engineering
- Medical Instrumentation
- Digital Healthcare
- Clinical Research
- Neuroengineering
- BioImaging

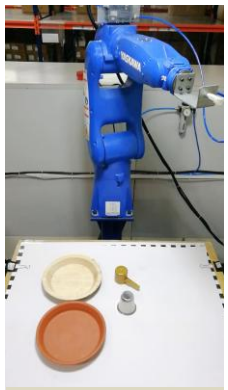
Robert Bosch Centre for Cyber Physical Systems

Pilot: Traffic Video Analytics in Electronics City. (**Min. of Housing Project**)

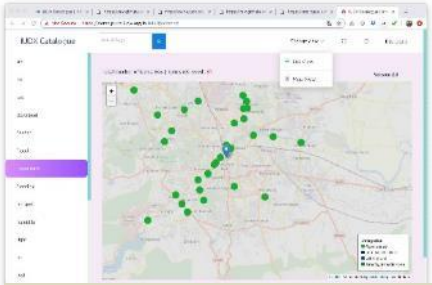
IISc Fabricated AQM Sensor **IUSSTF Project**

Centre developed Quadruped

Cooperative UAVs. **MBZIRC Competition**



Demonstration based learning. **Yaskawa Project**



Pilot: India Urban Data Exchange in Pune Smart City. (**Min. of Housing Project)**

Platforms, Integration & Pilots

Applications: Integration & Demo

Software & Embedded Stack: Design and Validation

IoT and Robotic Devices : Design and Prototyping

IoT Enabled Socio-Technical Systems

Policies and Incentives, Mechanism Design & Games, Statistical & ML techniques, Large-Scale & Real-time Optimization

Autonomous Systems & Robotics

GPS-less SLAM, Robot Systems Engineering, ML for Robot Programming, Algorithms for cooperative robotics, Formal approaches to safety & Security

Facilities and Academics

- About 30 faculty members from across IISc associated with the Centre.
- Interdisciplinary PhD program in CPS started in 2017. Currently 16 PhD students
  - Qualcomm Innovation Fellowship 2019-20 to 2 students.
  - Microsoft Fellowship 2018-19 to 1 student
  - Prime Minister's Fellowship to 2 students.
- Annual International Cyber Physical Systems Symposium (CyPhySS) started in 2017

FACILITIES

Makery:
Robotics and IoT prototyping Lab

- 3D Printers
- Drills/Lathes/CNC
- PCB Prototyping & Assembly
- Instrumentation

Drone Research Park:
Autonomous Drones Research

- Wind Shaping Facility
- Safe Airspace to fly drones
- Drones, Lidars, Radars,…..

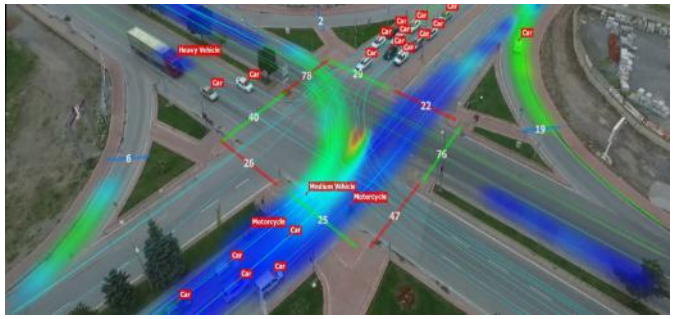
5G V2X Testbed
Connected Autonomous Vehicles Research

- 5G Testbed across the campus
- Instrumented Autonomous Vehicles

CiSTUP: Multidisciplinary Centre for Transportation Research

Contributing to smart and sustainable mobility through…

- Multi-scale mobility sensing, modeling, inference and simulation tools for multimodal transport planning and traffic control
- Projects on prediction and pre-emption of traffic congestion
- Emerging mobility systems
  - Last mile connectivity through IoT/ICT
  - Shared mobility as a service
  - Electric vehicles and transportation (interdependent infrastructure systems)
  - Connected and automated vehicles
- Advanced sensing through IoT, ML, AI
- State-of-the art mobility test bed, modeling labs, simulators, data center



Areas of Interest to CiSTUP

Interdisciplinary Centre for Energy Research - ICER

- A platform to integrate expertise in energy from various disciplines – Mechanical, Electrical, Materials, Physical and Chemical Sciences
- Vibrant industry collaboration
- 12 associate faculty, two visiting faculty
- 48 PhD students

Infrastructure

- A full fledged combustion research facility & laser diagnostic system
- Supercritical CO_2 cycle
- Biomass and coal gasification
- Solar concentrators, storage
- Test loop for hydro turbines
- Smart grid facility
- Field related activity at IISc Challakere campus - solar field

Research @ ICER

Major projects & programs

- Smart grid and hybridization
- Clean coal technology for high ash Indian coal
- **Solid, liquid and gaseous** fuel combustion in gas turbines, internal combustion engines
- **Thermo-chemical conversion of biomass** to gas and advanced fuels like Hydrogen and biofuels
- High efficiency **hydro turbines** for small flow streams

Future areas & programs

- PEM and SOFC fuel cells
- Hydrogen storage
- Energy systems, storage and hybridization
- Building energy and solutions
- Hybrid vehicles; alternate fuels in IC engines
- Combustion emission controls
- Carbon Capture, Utilization and Storage (CCUS)
- Photosynthesis
- Small wind turbines

Major completed projects

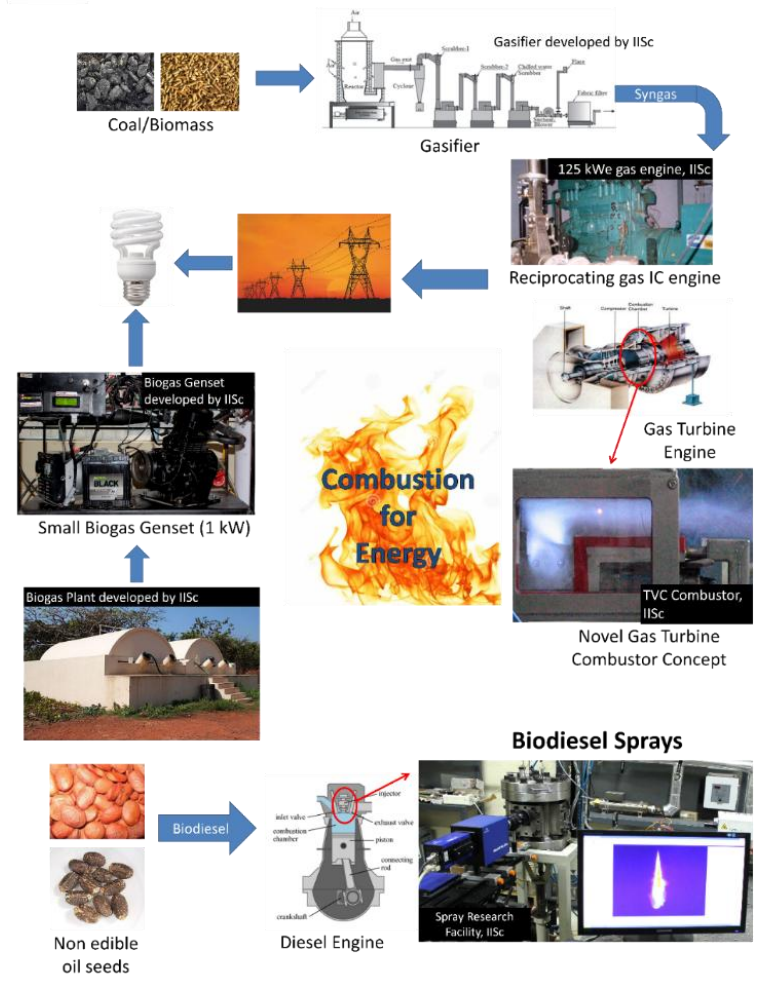
Solar Energy Research Institute for India and the United States (SERIIUS)

Consortium: 33 partners (Universities/ Institutes, National Labs, Industries)

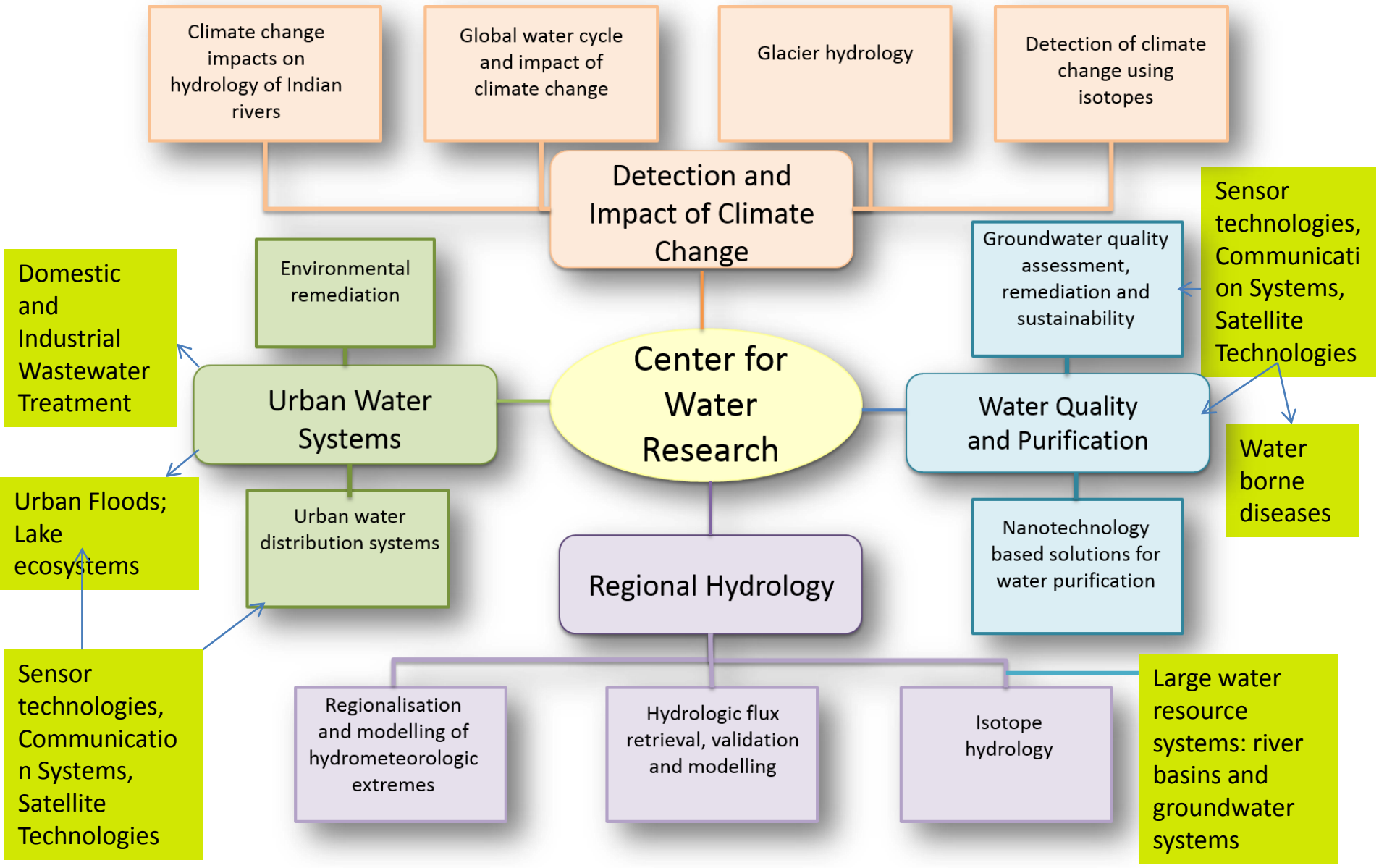
Solar cooling and desalination: Lab prototype

National Centre for Combustion Research and Development (NCCRD)

Multi-faculty involving Experimental and Modeling of combustion devices



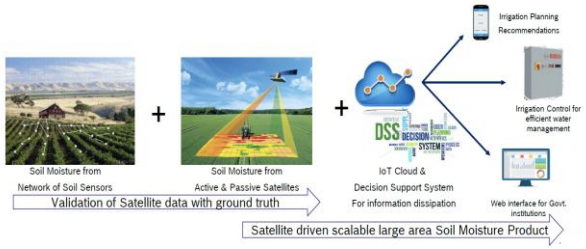
ICWAR: Global to Nano Scales



ICWAR: A Sample of Ongoing Projects

Smart water solutions in agriculture: Integration of Sensors, Satellite & ICT tools

To develop a DSS, which utilizes a framework that combines microwave satellite observations (soil moisture & crop variables) with terrestrial data from network of IoT enabled soil sensors to provide smart solutions for Agriculture with applications into area of Irrigation and water management.



Consortium

Prof. Sekhar Muddu, ICWaR, IISc
Mr. Rajendra Goswami, Robert Bosch
Dr. Sat K. Tomer, Aapah Innovations (SME)

Budget

Rs. 3.38 Crores; 3 Years

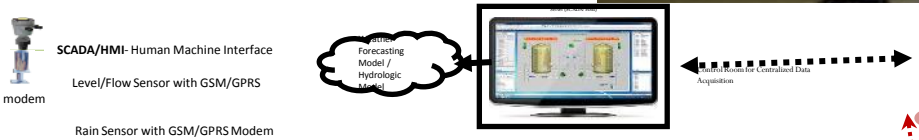
Intelligent Water Supply Network Monitoring and Control for Equitable Distribution of WATER within a Mega City (EQWATER)

Research team:
Prof M. S. Mohan Kumar, ICWaR/RBCCPS, IISc. (PI)
Prof. Bharadwaj Amrutur, ECE/RBCCPS, IISc. (Co-PI)
Prof. Rajesh Sundaresan, ECE/RBCCPS, IISc. (Co-PI)
Prof. Yogesh Simmhan, CDS, IISc (Co-PI)
Prof. R. Parthasarathy, MGMT, IISc (Co-PI)
Prof. Chiranjib Bhattacharyya, CSA, IISc (Co-PI)
Dr. P. N. Ravindra, Executive Engineer, BWSSB (Co-PI)

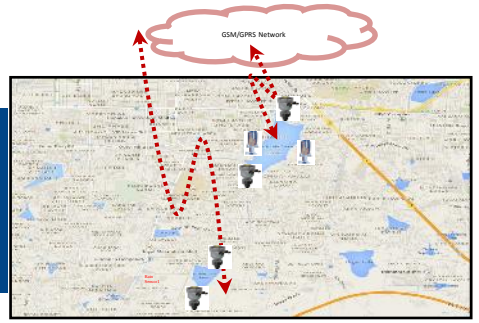
Impacting Research Innovation & Technology **(IMPRINT)**

Budget: Rs 4 crores for 3 years

Urban Floods: Technology Driven Solutions



DST Project (Approved; funds expected in March 2018)
Rs. 7.8 crores; 3 years



Project Partners: ICWaR, KSNDMC, Geokno, Spatika, BBMP

Department of Management Studies

Oldest Management Studies department in the country tracing its origin to 1947 as Section of Economic and Social Sciences

Masters program focussed on Business Analytics and Technology Management

Research @ DoMS

Technology Management and Industrial Economics

Public Policy

Energy Management

Computational Finance

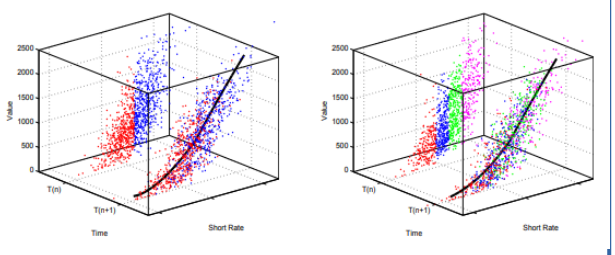
Empirical Finance and Financial Econometrics

Operations Management

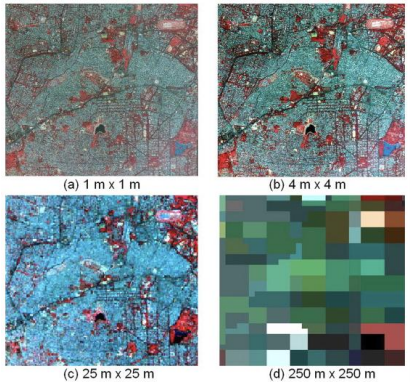
Operations Research

Department of Management Studies

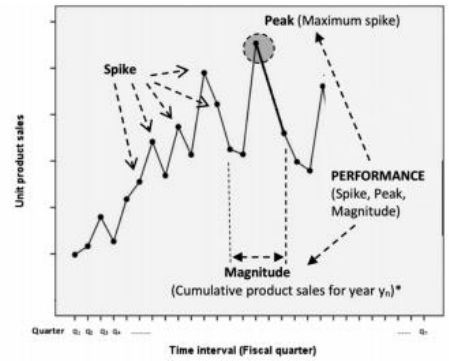
Counterparty Credit Exposures for Interest Rate Derivatives



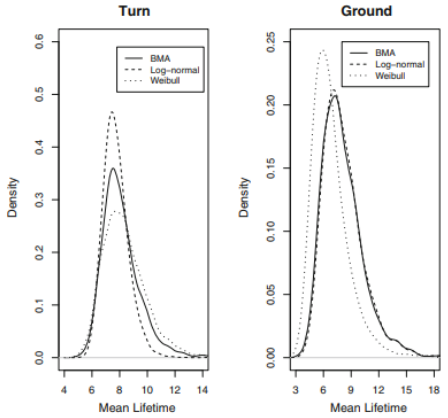
Urban Land Cover Extraction



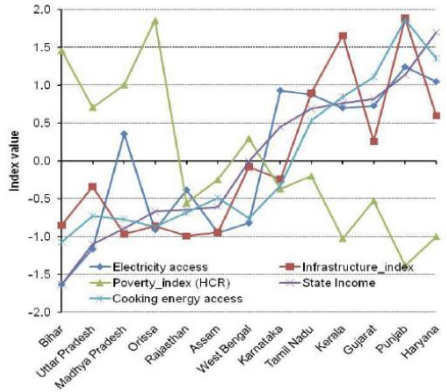
Viral Phenomenon in Product Penetration



Bayesian Accelerated Life Testing



Rural Household Eenergy Access



Rise of IT Services Clusters in India

Indian Institute of Science (IISc), Bangalore