



# Indian Institute of Technology Kanpur



Department of Computer Science & Engineering  
Session: 2021-2022



## About us:

Indian Institute of Technology Kanpur was the first Institute in India to start Computer Science education. The initial "computer-related" courses were started at IIT Kanpur in August 1963 on an IBM 1620 system installed in the nation's first "computer classroom," a novelty then even in many North American and European universities. Gradually, the Institute drew upon some of the brightest young Indians in Computer Science to serve on its faculty and initiated an independent academic program in 1971, leading to Ph.D. and M. Tech. degrees. The undergraduate program started later, with the first batch graduating in 1983. The department was formally established in 1984. Many of the nation's leading experts, educationists and consultants in computer science today are the alumni of this department. Currently, the department has a faculty of 33 whose interests span almost all areas of Computer Science.



The department admits about 100 students every year in the B.Tech. program, 12 students in the MS program and 80 students in the M.Tech program. Some students convert their B.Tech. program into dual degree program, which results in students getting both a B.Tech and an M.Tech. degree at the end of 5 years. There are about 15 students registered in Ph.D. program at a time. The department has recently started M.S. program, which is mainly focussed in research in various domains of Computer Science. There is one software engineer and five other staff attached to the laboratory facilities. Besides, there are a number of research engineers working in various sponsored projects.

## Message from the Head:

The Computer Science and Engineering department is at the forefront of producing academic and industrial leaders. The academic curriculum of this department is designed to build a strong foundation of computing in the students. The curriculum also features emerging and advanced topics of computing so that the students remain up to date about the bleeding edge of the most-happening technologies. Our students are well prepared to take on engineering as well as strategic visionary roles in the industry. Many of our students are doing extremely well in global companies in the areas of core computing as well as in financial software companies, algorithmic trading companies, and E-commerce industry. Many students have contributed and built startup industries around the world. Our department is a premier place from where to hire your next engineer, your next leader, and your next technology visionary. On behalf of the department, I welcome all to visit us and find a unique stimulating environment where your next hire is being nurtured for success.

**Dr. Mainak Chaudhuri**  
**Head, Computer Science and Engineering Department**  
**Indian Institute of Technology, Kanpur**

# Recent Research and Developments:

Researchers at the CSE department have achieved many milestones. Their research and initiatives have opened up new horizons.

## **Interdisciplinary Center For Cyber Security And Cyber Defence**

DST has sanctioned 14.43 crores (~2.2 millions USD) for the Interdisciplinary Center for Cyber Security and Cyber Defense of Critical Infrastructure. Prof. Sandeep Shukla and Prof. Manindra Agrawal will lead the group. This is the first center, set up in India, to pursue cyber security of critical infrastructure.

## **JEE Seat Allocation : An Algorithmic Perspective**

Prof. Surender Baswana proposed an algorithmic perspective for JEE seat allocation for CFTIs. This approach ensures each candidate submits a single choice list over all available programs and receives no more than a single seat from the system, based on the choices and the ranks in the relevant merit lists.

## **Primality Testing In Polynomial Time**

One of the major problems in computational number theory was solved by Prof. Manindra Agrawal, Prof. Nitin Saxena. The problem was whether a number could be tested for primality in polynomial time.

## **Identity Testing, Dependence Testing, Root Finding**

One of the major problems in algebraic complexity is that of polynomial identity testing. A large number of special cases have been solved jointly by the research group of Prof. Nitin Saxena. The quest for a general solution is still on. The group also has famous complexity results in the related questions of algebraic dependence testing and finding roots of polynomials.

## **Development Of National Air Quality Index (NAQI) For Indian Cities**

The National Air Quality Index (NAQI) translates individual air pollutant concentrations into a single number that reflects the status of air quality in simple terms. The scientific basis of developing AQI is the attainment of air quality standards and pollutant dose-response relationships. This was developed by Prof. Arnab Bhattacharya.

## **MOOC And Agropedia Software Models**

MOOCs provide affordable and flexible way to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Agropedia, a software as a service model, can be used to rapidly build agriculture portals for different communities.

## **Prutor : A Cloud Based Web Application**

Prutor is a cloud-based web application that provides instant and useful feedback to students while solving programming problems. Prutor provides a view of the students' approach to solving programming problems, regardless of programming environments.

## **Smart Card Technology Development**

A standard for smart card operating system has been developed which is used by the government of India for all their smart card based applications. A smart card operating system has also been implemented which is compliant to this standard. This technology is in the process of being commercialized.

## **Language Technology**

Some path breaking contributions have been made in Indian language coding (ISCII), keyboard design, transliteration, OCR machine translation, Linux ware, NLP, Indian scripts on Linux, Web content creation and search. Some of our landmark achievement is : GIST multilingual technology, AGLABHARTI & ANUBHARTI MACHINE aided translation strategies and popular web sites such as Gita-supersite.

## **Multipurpose Multimodal Human Identification System**

The primary aim is to design a robust system which is capable of handling problems like security, personal, verification/identification etc. The various traits that are considered are Face, Iris, Signature, Fingerprints and Ear.

## **Medical Application**

The medical applications group supported by media lab Asia developed a portable mobile model of printing healthcare delivery which uses ICT and digital devices to contact remotely located individuals requiring medical attention with doctors. The 'Sehat Saathi' software was one of the software for telemedicine.





## CSE Lab Facilities:

### Network

The CSE lab is equipped with a 1 gbps switched network with a tree topology. All systems (servers & clients) are equipped with 1 gbps NICs. A CISCO Catalyst 3750G Series Layer-3 switch acts as a backbone switch. The lab is connected to the campus network through a router. The connectivity between CSE and the institute Computer Center is through fiber optic cable. A total of 50 switches (24 ports each) each having 1 gbps speed cover the both CSE buildings. Department has two server rooms which are full with different kinds of servers. These server rooms also have specific project based servers & systems.

### Cloud

Recently CSE lab has deployed one cloud "Vyomkesh" which has currently 20 compute nodes having dual Xeon 6 core CPUs with 48 GB RAM each. It supports 240 physical (480 logical) cores with 960 GB RAM. Soon capacity will be enhanced.

### Hardware Lab

The hardware lab in the CSE department is the state of the art lab equipped for embedded computing. The lab provides several FPGA based stations for hardware programmability.

### SCADA Cyber Security Test Bed

A flexible SCADA test bed has been installed of Schneider made industrial hardware and software to provide a facility for research scientists and engineers investigating cyber security of critical infrastructure. This test bed replicates of power distribution automation for both three phase and single phase power supply. This test bed is equipped with real field devices such as energy meters, protection relays, modular control system, IRIG-B based GPS time sync unit, IEC-61850 compliant Ethernet switches, unified threat management hardware, industrial grade HMI, SCADA system etc.

### Robotics Lab

Vicon Vero Motion Capture System for indoor robot localization has been installed in this Lab.

### Sun Grid

Sun grid has been established in the department with funding from Sun Microsystems, USA. The grid has 20 workstation based on Opteron (64 bit AMD processor) and it is available to all the users who want to do research and explore the area of High Performance Technical Computing. The department is recognized as the "Sun Regional Academic and Research Partner for Excellence in Grid Computing".

# Research Areas and Faculties:

The department provides an excellent research platform, and nurtures and challenges students to solve real-world research problems.

## Algorithms And Data Structures

**Faculty :** Dr. Raghunath Tewari, Dr. Sanjeev Saxena, Dr. Sumit Ganguly, Dr. Surender Baswana

We are a group of faculty and students working on exciting problems on the recently very popular areas in algorithms and data structures including dynamic graph algorithms, fault tolerance, streaming algorithms, computational geometry, graph theory and space bounded algorithms. The groups has been carrying out excellent research. In the last 5 years (2014-2018), the group has published 5 ICALP papers including one best student paper in 2016, 1 paper in STOC, 3 papers in SODA. ACM Distinguished Dissertation Award for the year 2019 was also awarded to a PhD thesis in algorithms at IIT Kanpur.

## Computational Biology And Bioinformatics

**Faculty :** Dr. Hamim Zafar

Modern biology is in the middle of a paradigm shift where computation is an essential taskforce for understanding biological systems.

Computational biology is a broad discipline that aims to develop novel computational methods utilizing elements from a wide range of mathematical and computational fields for building models for diverse types of experimental data and understanding biological systems. The Computational Biology group at IIT Kanpur focuses on the design of scalable computational techniques backed by probabilistic modeling and statistical inference methods for understanding the biology of cancer and processes in single cells. Using their computational frameworks, the group tries to understand how cancer cells evolve, elucidate the heterogeneity in cancer tissue, and identify potential drug targets.

## Computer Architecture And Operating Systems

**Faculty :** Dr. Debadatta Mishra, Dr. Mainak Chaudhuri, Dr. Rajat Moona

The Computer Architecture and Operating Systems group focuses on all aspects of modern computing systems: processor, memory, storage, and interaction with the operating systems. Some of the active topics of interests are the following: better processor design with speculative techniques, memory hierarchy optimizations in the form of hardware prefetching, cache/DRAM content management, and cache coherence protocols for client and server systems. The group works on security issues related to modern processor, memory systems, and operating systems, in the form of side/covert channel attacks and their mitigations.

## Cyber-Physical Systems

**Faculty :** Dr. Indranil Saha , Dr. Sandeep Shukla

In this age of automation, usage of complex safety-critical systems are increasingly high in industries like hardware, automobiles, avionics, space etc. This is a major task to ensure correctness and completeness to get a reliable controller of such systems. The CPS Group at the CSE Department of IIT Kanpur is working on developing principled approaches for robust implementation of cyber-physical systems. The group is working on several exciting problems in the area of CPS, more specifically in distributed multi-robot systems and internet-of-things. The focus of this group is to develop cyber-physical systems with correctness guarantee through the application of formal verification/synthesis techniques.

## Formal Methods

**Faculty :** Dr. Indranil Saha, Dr. Sandeep Shukla

Formal methods are an area of computer science where we use automated mathematical reasoning techniques to analyze programs. This analysis could be used to prove a program has certain correctness properties -- for example, that it does deadlock, or that it does not have a buffer overflow vulnerability, or to automatically find violations of these correctness properties. Our formal methods groups combines expertise in robotics, cyber security and formal methods to solve real-world verification problems.

## Cyber Security

**Faculty :** Dr. Manindra Agrawal, Dr. Rajat Moona, Dr. Sandeep Shukla

Today, cyber-Security is not just a computer science issue but a national security issue. Terrorist organizations like ISIS use digital platforms to recruit fighters while many countries including China, Russia, Israel and the United States have cyber-attacked rival nations. Like many other nations, India's national critical infrastructures are ripe targets for cyber-attacks. At IIT Kanpur, leveraging the expertise in multiple areas of Computer Science and Engineering, we initiated such a comprehensive program within our center for cyber-security. We have a multi-disciplinary national project to carry out research, training and education in cyber security of the national cyber space including information infrastructure, and other critical infrastructures such as banking, power grid, industrial manufacturing, defense tactical communication networks, and various information assets of the country. Our approach is multi-pronged and multi-layer -- defense-in-depth strategy. Starting from crypto algorithms, protocols, till the systems. We also use machine learning for anomaly detection to fight persistent threats in the critical infrastructure.

## Databases, Big Data And Data Mining

**Faculty :** Dr. Arnab Bhattacharya, Dr. Sumit Ganguly

Databases are ubiquitous and form the backbones of almost all the modern systems.

While traditional databases are relational, the NoSQL paradigm has proved itself useful in various applications and situations, especially in the realm of big data. The research in this field encompasses data analytics, data processing, indexing, querying, searching and information retrieval. It also includes data mining in the form of graphs, text, multimedia, strings, etc. With proliferation of data emerging from heterogeneous sources, data analytics is being considered as the key tool for business growth and understanding the physical world.

## Hardware Security

**Faculty:** Dr. Urbi Chatterjee

The department has very recently started exploring the area of hardware security that encompasses requirements of secure hardware design for novel cryptographic algorithms in FPGA/ ASIC, hardware design principles for real-time, low power embedded systems, side-channel (power, EM, and timing) and fault attacks and countermeasures, hardware fingerprinting with physically unclonable functions, hardware Trojan Horse design and detections, hardware IP Protection, protocol design principles to bridge the gap between the hardware primitives and their secure use in applications, FPGA based hardware accelerator for AI and its security aspects such as privacy leakages, adversarial attacks etc. Currently, we are focusing on developing a testbed to integrate unconventional hardware security primitives with Micro-Air vehicles to realize a privacy-preserving anonymous authentication scheme for trusted data communication with the ground control system.

## High Performance Computing

**Faculty :** Dr. Preeti Malakar, Dr. Swarnendu Biswas

Parallel programming is ubiquitous in today's multicore era and is a necessity to exploit performance from multicore architectures. However, massive parallelism entails significant hardware and software challenges. High performance computing is used to solve many real-world scientific problems. With the ever-growing compute capabilities, complex memory hierarchies, and varied network topologies, writing efficient and scalable parallel code is a significant challenge. The group focuses on several challenging problems in this area, such as topology-aware mapping, communication-aware job scheduling, and effective parallelization strategies. In today's era of big data, high performance computing can significantly speed up big data related computations and analysis. However, the challenge lies in big data I/O. The group also focuses on solving parallel I/O bottlenecks.

## Software Architecture

**Faculty:** Dr. T. V. Prabhakar

In the era of Internet-scale applications, the success of a software application greatly depends on its quality attributes such as performance and scalability. To ensure the quality attributes desired by an application, the architect has to design a suitable architecture -- which is a very complex task. The contemporary computing platforms such as mobile and cloud alleviate the problem due to the partitioning of quality concerns and architectural implications of the characteristics of these platforms.



## Machine Learning And Data Science

**Faculty :** Dr. Arnab Bhattacharya, Dr. Hamim Zafar, Dr. Nisheeth Srivastava, Dr. Piyush Rai, Dr. Priyanka Bagade, Dr. Purushottam Kar, Dr. Swaprava Nath, Dr. Vinay P. Namboodiri

This is an area where the department has had a recent surge in terms of strength, as well as diversity. We cover nearly all the challenging areas of machine learning (ML) and computer vision. Research in ML focuses on probabilistic machine learning, deep learning, optimisation, statistical learning theory, natural language processing etc. Research in computer vision is mostly on language and facial analysis, graphics, human attributes prediction, pose estimation, and action/activity prediction. We also conduct research in human-centered computing, human factors in computing, and computational cognitive science to bring AI algorithms closer to humans both conceptually and instrumentally. An emerging area of research in AI is computational social choice that uses tools from CS and Economics to help humans take provably efficient decisions. Our department has faculty and students working in this interdisciplinary area. Another interdisciplinary area of research in machine learning that is covered in the department is Computational Biology where the group develops novel probabilistic models and inference algorithms for understanding biological systems. Results from this research group are frequently reported in ICML, NIPS, AAI, IJCAI, AISTATS, CVPR, AAMAS, WINE, Games and Economic Behavior etc.

## Programming Languages And Compilers

**Faculty :** Dr. Amey Karkare, Dr. Subhajit Roy, Dr. Swarnendu Biswas

The department has a focused interest on the theory and applications of programming languages, program analysis and compilers research. The main research areas are compilers, data flow analysis, heap analysis, formal techniques for automated debugging, program verification and synthesis, software testing, static and dynamic program analysis, concurrency, high-performance compiler optimizations, and GPU algorithms. Of particular interest is a recent project being executed by Prof. Amey Karkare, Prof. Subhajit Roy and Dr. Sumit Gulwani (adjunct faculty, MSR Redmond) on developing intelligent tutoring systems that are designed to adaptively guide students who are learning programming or other tools and tasks for the first time. The project has been successfully piloted with the introductory programming course at IIT Kanpur which graduates more than 800 students each year.

## Systems Security

**Faculty :** Dr. Debadatta Mishra, Dr. Sandeep Shukla

Our group has expertise in the use of formal methods to build provably secure systems. Recent research includes work on provably secure enclave platforms which can enable secure computing in the cloud and the provably secure defenses against transient execution attacks like Spectre and Meltdown. The group also focuses on security issues related to Computer Architecture, Operating Systems, and Computer Networks. Side-channel

attacks at caches and processor, side-channel attack proofs, formal guarantees, crypto engineering to vulnerability analysis of systems and application layer software, network and web security, cloud security through virtual machine hardening. The group currently is funded by semiconductor research consortium (SRC), and UP defense corridor projects.

## Theoretical Computer Science

**Faculty :** Dr. Anil Seth, Dr. Manindra Agrawal, Dr. Nitin Saxena, Dr. Raghunath Tewari, Dr. Rajat Mittal, Dr. Satyadev Nandakumar, Dr. Sumit Ganguly, Dr. Sunil Simon, Dr. Swaprava Nath

The department continues to be one of the best places to engage in cutting edge research in all areas of complexity theory, logic, game theory etc. Our graduate students and alumni have performed marvelously at arriving at path-breaking results on the very fundamentals of computer science. Recent achievements include a best student paper award at ICALP 2016 (the best paper award was also won by CSE IITK alumni), 3 papers at the premier venue STOC 2016, 3 acceptances at MFCS 2016, 2 at STOC 2018, and acceptances almost every year at CCC/ICALP/ISSAC/STACS/FSTTCS. Thrust areas in the department include streaming algorithms (Prof. Sumit Ganguly), information theory (Prof. Satyadev Nandakumar), quantum algorithms and complexity (Prof. Rajat Mittal), game theory (Prof. Sunil Simon, Prof. Swaprava Nath), logic (Prof. Anil Seth), computational complexity theory (Prof. Manindra Agrawal, Prof. Nitin Saxena, Prof. Raghunath Tewari), and number theory/ algebraic algorithms/ algebraic complexity (Prof. Nitin Saxena).



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