PhD Brochure

2022-23-I Semester

Department of Computer Science and Engineering

IIT Kanpur

In this picture: a view of the Rajeev Motwani building that houses the CSE department
Picture credit: www.cse.iitk.ac.in/users/admissions/

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In this picture: a view of the iconic tower at the new Student Activity Centre (new SAC)
Picture credit: http://www.iitk.ac.in/inacomm15/

A Message from the Head of Department

It gives me immense pleasure to personally welcome you all to the CSE department of IIT Kanpur. I congratulate you on being selected to one of the best computer science PhD programs in the country. PhD students are at the center of the vibrant research fraternity of our department. The members of our department faculty conduct cutting-edge research in a large number of areas including artificial intelligence, learning systems, machine vision, graphics, security, quantum computing, computational genomics, algorithmics, complexity theory, logic in computing, data analytics and mining, computational game theory, language processing, compilers, computational cognitive science, operating systems, computer networks, machine architecture, robotics, cyber-physical systems, high-performance computing, software architecture, etc..

PhD students enjoy the freedom to choose their research area. The department's research groups actively publish in the best computer science journals and conferences. The expenses for presenting contributed papers at top-tier international conferences are supported by the department. I expect that you will join one of the research groups soon and start contributing to the research output of the department.

To enrich the knowledge base of the PhD students, our department offers a large bouquet of post-graduate courses every semester covering classical as well as emerging areas of computing. I hope you will be able to use these courses to build a strong foundation in the areas of your interest. I welcome you again to the CSE family of IIT Kanpur. I wish you all the best for your doctoral studies here and hope that our journey together will be highly enjoyable and rewarding.

*Mainak Chaudhuri (**head@cse.iitk.ac.in**)*
Head, Dept of CSE, IIT Kanpur

A Message from the DPGC Convenor

It is a matter of immense pleasure for all of us in the department to welcome each of you to the post-graduate program of the oldest, and one of the most prestigious computer science departments in India, the Department of Computer Science and Engineering at the Indian Institute of Technology at Kanpur. The department presents a vibrant intellectual atmosphere, offering courses and research opportunities in the classical fields of computer science as well as exciting emerging fields of computer science and allied areas.

The department offers three post-graduate degrees, namely, M. Tech, M. S.-R. and Ph.D. All these degrees place great emphasis on original research. The members of the department are engaged in bleeding-edge research in a large number of areas including machine learning, artificial intelligence, natural language processing, operating systems, computer architecture, computational genomics, data mining, databases, compilers, robotics and cyber-physical systems, cyber security, high-performance computing, computational game theory, computational cognitive science, computational complexity theory, algorithms.

As DPGC convenor, I would be happy to help you navigate the course structure and to help you with matters of academic requirements. This brochure is a starting point to help you orient yourself in your new environment.

I hope that you will contribute to the department's research output in the near future. I hope that CSE at IIT Kanpur inspires you to gain a broad and deep knowledge in computer science and related areas. All the best for a productive stay, and greater accomplishments in the future.

Surender Baswana ***(dpgc@cse.iitk.ac.in)***

Convener, Department Post-graduate Committee (DPGC), Dept. of CSE, IIT Kanpur

A Message from the CSE Counsellor

I congratulate you for being part of a department with people eager to help and serve you. The department has several initiatives to help students to reach their full potential. The **Department Student Affairs Committee** (DSAC) offers help and advice with academic and personal issues and **student mentors** (from PhD, MTech and MS programs) who offer advice on coursework. You can also participate in this initiative and help your fellow students. We arrange for psychiatric and counseling services on campus if needed. You can meet or call me anytime if something is bothering you. I can guide you in practicing various techniques that will reduce your stress.

I can help you through direct counseling but also point you to psychiatrists, clinical counselors or specialists if specialist interventions are required. Counseling along with medication helps in case of serious mental disorders like bipolar disorder, schizophrenia or depression. Counseling has also helped students overcome their stammering issues. I can offer you counseling on more sensitive matters as well, such as you or a friend facing anxiety, loneliness or depression. Sometimes, students go on battling issues such as anxiety (academics, job, family) or addiction (internet, substance) and hesitate to reach out and share their issues. I assure you that our department policy mandates that your identity be kept confidential and your case details anonymous. I wish that the few years you spend at CSE IITK be the most beautiful and memorable years of your life.

Appointment Process: If you wish to talk or know more about these services, please send me an email or WhatsApp message, or else call me to set up a meeting. You may also visit my office for a walk-in meeting during office hours (see below).

***Tel**: 0512-259-6807, **Mob**: 9695126885*
***Office**: KD218, **Office hours**: 9am-7pm*

Aradhana Yadav (aradhana@cse.iitk.ac.in)
Counsellor, Dept. of CSE, IIT Kanpur

Picture credit: negativespace.co

Useful Links

CSE Department Services:

1. *The CSE Office*: our staff members are super friendly and ever so helpful. You may need their assistance on matters related to stipend, leave and attendance. **Tel**: 0512-259-7638, Mr. Prashant Sahu (office in-charge) **pksahu@cse.iitk.ac.in**
2. *CSE Office Automation (**Kendra**)*: an online system to manage requests for student leave, travel grants, cluster/GPU resources etc. **kendra.cse.iitk.ac.in**

Institute Services:

1. *Office Automation (**Pingala**)*: used for course, thesis registration, fee payment etc. **pingala.iitk.ac.in**
2. *Useful Forms*: **www.iitk.ac.in/dosa/forms**
3. *The PG Manual*: this document has details of rules that govern various aspects of PG programs e.g. leave, defense, course-work **www.iitk.ac.in/doaa/data/pgmanual-02Sep2015.pdf**
4. *The Counselling Service*: this website has several helpful links for new students **www.iitk.ac.in/counsel/**
5. *Anxiety Helpline*: a list of counsellors and other useful contact persons **www.iitk.ac.in/dosa/data/Anxiety-Helpline.pdf**

Student Gymkhana: offers several club and event activities

1. *Academics and Career Council*: **students.iitk.ac.in/anc/**
2. *Games and Sports Council*: **students.iitk.ac.in/sports/**
3. *Films and Media Council*: **fmciitk.weebly.com/**
4. *Science and Technology Council*: **students.iitk.ac.in/snt/**

Picture credit: www.cse.iitk.ac.in/users/admissions/

Know your Department

Research Centers: the CSE department is a leading center for research in cyber-security, cryptography and cyber-physical systems research

1. Interdisciplinary Center for Cyber Security and Cyber Defense of Critical Infrastructures (**C3I**): **security.cse.iitk.ac.in**
2. The National Blockchain Project: **blockchain.cse.iitk.ac.in**

Special Interest Groups (SIG): the CSE department is home to several reading groups in theory, data sciences and systems research. These are largely student-led activities and offer a unique platform to discuss not only your own research, but cutting-edge developments in your area as well.

1. *SIG on Theoretical Aspects of Computer Science (SIGTACS)*: **sigtacs.github.io**
2. *SIGs on Computer Architecture, Operating Systems and Systems Security (CAOS)*: **www.cse.iitk.ac.in/users/skmtr/CAOS.html**

Counselling Initiatives: the department has a *student well-being committee* and arranges for *student mentors* to offer guidance and help students overcome difficulties in course and thesis work. The *department counsellor* offers help and advice to students on a variety of issues including but not restricted to academics. Please see the message from the CSE counsellor earlier in the brochure for contact and appointment details.

Resources for Students: the CSE department encourages liberal use of department resources to allow PhD students to achieve their research goals

1. **Personal Workstation**: every PhD student is allotted a personal workstation, some office storage space and a desktop computer
2. **Compute Infrastructure**: the department has CPU + GPU clusters and students can requisition these resources by making online requests over Kendra.
3. **Travel Support**: for students whose papers get accepted at top tier conferences, the department offers generous travel support. This support typically comes from the Research-I foundation (**www.cse.iitk.ac.in/users/rif/**).
4. **Office Supplies**: PhD students are given access to the department printing services (subject to a monthly quota).
5. **Student Initiatives**: the PhD students in the department organize several activities like welcoming new students, organizing movie screenings (PhD Movie Club) and maintaining a PhD student pantry.

Association for Computing Activities (ACA): ACA is the student body of the CSE department and aims to make the student experience more enjoyable and well-rounded. This is achieved through various events, designed to increase interaction between students and faculty. Some of the events you might be interested in are

1. **Introduction and Farewell**: we welcome you with a party and don't let you leave without a party either.
2. **Summer Schools**: these are organized every year for non-IITK UG students on various topics like machine learning, algorithm design, cyber security etc. These give an excellent opportunity to teach computing fundamentals to beginners.
3. **Programming Contests**: organized over a couple of days, these allow students to engage in friendly competitions.
4. **Happy Hours**: these are organized regularly and include games, sports, trivia quizzes etc., basically free food and fun.

You may contact any ACA coordinator for more information. Contact details and more information can be found at **aca-cse-iitk.github.io**.

Course Work

1. **Selecting Courses**
   How to benefit most from course work
2. **List of PG Courses**
   Courses being offered next semester

In this picture: a view of the RM101 lecture hall in the CSE department
Picture credit: Purushottam Kar

Picture credit: Engin Akyurt www.pexels.com/@enginakyurt

Selecting Courses

Courses are a valuable way of getting a relatively quick but still thorough introduction to an area. Use the coursework component in your PhD program to learn about diverse research areas. These may influence your research and future studies in serendipitous ways.

Credits: each course at IITK offers a certain number of *credits*, most offer 9 credits but courses with labs offer 12 credits, *modular* courses offer 5 credits, etc. Once you register and complete a course by obtaining a non-failing grade, you are awarded all the credits that the course had to offer.

As a part of your PhD program, you are required to complete 36 course credits by doing PG courses. Since most PG courses offer 9 credits, this amounts to 36/9 = 4 courses although one could also have fulfilled this requirement by doing three 12 credit PG courses.

Flexibility: your CSE department offers great flexibility in choosing courses. You may choose to complete all 36 credits in the first semester itself. However, if you feel the need to pace yourself a bit, you may also choose to do, say 27 credits in the first semester and the remaining 9 credits in your second semester.

You are free to choose any PG courses on offer in the CSE department. However, if you find an interesting course being offered by some other department (e.g. EE, MTH) which you feel would be relevant to your research, then upon discussion with the DPGC, you may take up a non-CSE PG course as well.

Extra Courses: your program allows you to enrol for courses even after you have fulfilled the 36 PG credit requirement. These extra credits come with even more flexibilities

1. You may request instructors of these *extra* courses to award you an S/X (satisfactory/unsatisfactory) grade instead of the usual A, B, … *letter* grade. Keep in mind though that accepting this request is up to the instructor's discretion.
2. You may enrol for UG courses as extra courses as well (although in the S/X mode only).

How to benefit most from course work: Courses (online or classroom) are a valuable way of getting a quick introduction to an area, and that too from a person with years of experience in that area. Courses can teach you the tools and tricks of trade of an area in a secure and controlled environment which might otherwise take several years to master.

The future of CSE research lies in inter-disciplinary applications. The avenues that hold most promise, whether they be in AI/ML, cyber-security, robotics, game theory or algorithm design, are mostly cross-disciplinary e.g. applying AI to cyber-security, using principles of game theory in robotics, etc.

You will be in the best position to participate in these cutting edge projects if you are knowledgeable (even if you are not an expert yet) in a broad range of areas and topics.

Use the coursework component in your PhD program to learn about as many different areas as you can. These may influence your research and future studies in serendipitous ways, as well as allow you to showcase yourself as a researcher with cross-disciplinary expertise.

The freedom to do extra courses is very helpful if, for example, a cutting edge course is introduced after you are done with course credits, and you wish to do that course and get credits in order to include it in your resume.

Requesting S/X grade for extra courses can allow you to enjoy the course content without worrying about letter grades but doing so also means that even superb performance would be awarded just an S grade, not A or A*. You may choose to do a UG course (in S/X mode) if you wish to brush up a basic topic, say databases or algorithm design, that is covered in that course.

Auditing Courses: if you simply wish to learn the subject matter in a course without formally registering, then you may request the instructor to let you *audit* that course. Usually this means attending lectures and getting access to course material but not having to appear for exams, submit assignments etc. (for exact details, discuss with the instructor). However, you will not be awarded any credits or grades for audited courses either.

Picture credit: Caio Resende www.pexels.com/@caio

List of PG Courses

Some courses are offered with fair regularity, e.g. once every year, while others may be offered only based on the instructor's availability and interest. Although course lists are always announced in advance on the department website, you may discuss with individual faculty members to get an idea of what courses they may be offering in coming semesters.

We are giving below a list of PG courses being offered next semester. With each course, a short description and contact details of the instructor are also given. To see the list of all courses (UG,PG), on offer, please visit
www.cse.iitk.ac.in/pages/NextCourseTimetable.html
We update this webpage every semester with the list of courses being offered the next semester. Detailed course descriptions are also available either using links on the above webpage, or else the following webpage
www.cse.iitk.ac.in/pages/Courses.html
You are also welcome to contact the instructor of a course to discuss prerequisites or learning objectives of that course. However, before contacting the instructor, please go through the course description on the website first. It is likely that your query will be answered by information present on the website itself.

Making choices: your department offers courses in a wide range of areas. It would be a lost opportunity to not partake of this variety. Keep an open mind while choosing courses and do not restrict yourself based on merely what seems to be popular among your peers. Apart from broadening your scope, you may discover an area you never knew you liked while doing a course!

CS642: Circuit Complexity Theory

Instructor: Raghunath Tewari (rtewari@cse.iitk.ac.in)

Short Description: The course aims at a comprehensive overview of results on circuit complexity classes and their relationship with Turing based classes. The topics to be covered include: the classes NC, NC1, TC0, ACC, AC0, DLOG, NLOG, LogCFL, SC and their characterizations and properties, characterization of the class P by circuits, proof of RL being a subset of SC, lower bounds for AC0, for AC0[m] where m is a prime power, and for TC02.

CS647: Advanced Topics in Algorithms and Data Structures

Instructor: Sanjeev Saxena (ssax@cse.iitk.ac.in)

Short Description: The course deals with advanced algorithm design and analysis including data structures, analysis and lower bound proofs, and amortized complexity of algorithms. Fibonacci heaps and self-adjusting search trees, Splay trees, linking and cutting trees. State-of-the-art algorithms for minimum spanning trees, shortest path problem. Network flows -- preflow-push algorithms, max flow algorithm, and scaling algorithms. Matching, blossoms, Micali-Vazirani algorithm. Lower bound theory for parallel computations.

CS682: Quantum Computing

Instructor: Rajat Mittal (rmittal@cse.iitk.ac.in)

Short Description: The course will cover the following topics ***Foundations***: Hilbert spaces (finite dimensional). Axioms of quantum probability. Quantum vs Classical probability., ***Quantum Computing***: Turing machines, Boolean circuits, Quantum Circuits, Universality. Simon's problem, Phase finding, Shor's algorithm, Grovers algorithm, Probability amplification. Some applications. ***Quantum Information processing***: Quantum error correction. Knill-Laflamme theorem, Stabiliser codes.

CS798C: Post Quantum Cryptography

Instructor: Debapriya Basu Roy (dbroy@cse.iitk.ac.in)

Short Description: Due to the advent of quantum computing, existing public-key cryptographic algorithms like RSA or elliptic curve cryptography will cease to remain secure. This course will focus on different post-quantum secure public-key algorithms, focusing on both key encapsulation and digital signature algorithms. ***Module 1***: Basics of Quantum Computing and Multiplication Algorithms. ***Module 2***: Lattice-based Cryptography, NewHope, Kyber and Saber, NTRU, NTRU Prime, Digital Signature Algorithms Dilithium, Falcon. ***Module 3***: Code Based Cryptography, McEliece, HQC. ***Module 4***: Isogeny Based Cryptography and Signature, SIKE.

Systems

CS610: Programming for Performance
Instructor: Swarnendu Biswas (swarnendu@cse.iitk.ac.in)
Short Description: The course will discuss programming language abstractions and architecture-aware development to help write scalable parallel programs. Topics include performance models, Amdahl's law, architecture basics, memory hierarchy, loop and data transformations, OpenMP, GPGPU programming, CUDA, optimistic parallelization , memory consistency, MPI, transactional memory, etc.

CS637: Embedded and Cyber-physical Systems
Instructor: Indranil Saha (isaha@cse.iitk.ac.in)
Short Description: A cyber-physical system is a collection of interconnected computing devices interacting with the physical world. This course will cover the modeling, implementation and verification of cyber-physical systems such as basics of modeling dynamic behaviors and control, design issues such as sensors and actuators, embedded processors, and analysis and verification via invariants and temporal logic, equivalence and refinement, reachability analysis etc.

CS639: Program Analysis, Verification, and Testing
Instructor: Subhajit Roy (subhajit@cse.iitk.ac.in)
Short Description: ***Dataflow and Interprocedural Analysis***: functional, call-string and graph reachability based approaches, abstract interpretation, weakest precondition, Floyd-Hoare logic, separation logic, ***Software Model Checking***: symbolic execution, state-space reduction, state-less model checking, counter-example guided abstraction refinement, model checking of concurrent programs, ***Program Testing***: automatic test-case generation, directed testing.

CS666: Hardware Security of Internet of Things

Instructor: Urbi Chatterjee (urbic@cse.iitk.ac.in)

Short Description: IoT Building Blocks, Symmetric Key Cryptography, Asymmetric Key Cryptography, Hardware Design, Power Attacks, Fault Attacks, Timing Side Channel, Side Channel on Smart Devices, Physically Unclonable Functions, True Random Number Generator, Hardware Trojan, Security Protocols, PUF Based Authentication, Remote Attestation, Anonymous Authetication.

CS667: Introduction to Internet of Things and Its Industrial Applications

Instructor: Priyanka Bagade (pbagade@cse.iitk.ac.in)

Short Description: Overview of IoT systems. ***IoT system architecture***: Edge devices, sensors, actuators. ***Sensor networks***: WSNs, localization, node mobility, energy efficiency. ***Communication***: MQTT, wifi, Bluetooth, RFID, LoRa, LoRaWAN, security. ***IoT system optimization***: Low power devices, energy harvesting, performance trade-off. ***Deep learning in IoT***: Introduction to deep learning, camera-based IoT applications in healthcare, retail and agriculture. ***Smart and connected devices***: Raspberry-pi, Google home mini, Alexa, Echo show Industrial use cases: smart home and agriculture. ***Case studies***: Smart cities, transportation, manufacturing, automobile.

CS698F: Sensing, Comm., Networking for Smart Wireless Devices
Instructor: Amitangshu Pal (amitangshu@cse.iitk.ac.in)
Short Description: ***Localization***: GPS, RSSI, Time-of-flight (ToF), Time difference of arrival (TDoA), clock synchronization. ***Signal Processing***: DFT, Beamforming, Angle-of-arrival (AoA). ***Motion sensing***: inertial measurement units (IMU) – accelerometer, gyroscope, magnetometer, motion/activity tracking, gesture detection. ***MAC***: (a)synchronous MAC, low-power MAC, IEEE 802.15.4. ***Routing***: Energy aware routing, geographic routing, attribute based routing. ***Device-free sensing***: human presence detection, digital agriculture. ***Dynamic time warping***: basics, posture detection, hand movement tracking.

CS698S: Practical Cyber Security for Cyber Practitioners
Instructor: Sandeep Shukla (sandeeps@cse.iitk.ac.in)
Short Description: ***Introduction***: Cyber Security Operations (CyOps), DevSecOps, MLops, AIops, DevOps, Cyber Operation ***Planning and Analysis***: Planning of a Cyber Security operation in an IT organization vs an OT/ICS. Planning and Risk Analysis. Incident Detection and Characterization, Vulnerability and Consequence Analysis, Incident Response and Recovery, Cloud and API security, Case Studies.

CS738: Advanced Compiler Optimizations
Instructor: Amey Karkare (karkare@cse.iitk.ac.in)
Short Description: Symbol table structure, intermediate representation, run-time support, producing code generators automatically, control and data flow analysis, dependence analysis and dependence graphs, ***Optimizations***: early optimizations, redundancy elimination, loop optimizations, procedure optimizations, register allocation, code scheduling, control flow and low level optimizations, inter-procedural analysis and optimizations, optimization for memory hierarchy.

CS656: Algorithmic Game Theory

Instructor: Sunil Simon (simon@cse.iitk.ac.in)

Short Description: ***Utility theory***: Nash's Theorem, Complexity of computing Nash equilibrium, Monderer-Shapley characterisation, ***Congestion games***: PLS completeness of computing pure strategy equilibria in potential games, ***Graphical games***: Subclasses of games that allow efficient equilibria computation, Efficiency of equilibria (price of stability, price of anarchy), ***Auction theory***: first/second price auction, incentive compatibility, ***Mechanism design***: Groves Mechanism, pivotal mechanism and Bailey Cavallo mechanism. Green-Laffont result, ***Matching***: Matching markets and sponsored search.

CS690: Computational Genomics

Instructor: Hamim Zafar (hamim@cse.iitk.ac.in)

Short Description: Deciphering biological mechanisms via statistical analyses of genome sequence data, algorithms for sequence alignment, HMMs, genome-scale index structures and algorithms for genome alignment and assembly, transcriptomics, cancer genomics, deep Learning in genomics, phylogenetics and phylogenomics.

CS771: Introduction to Machine Learning

Instructor: Purushottam Kar (purushot@cse.iitk.ac.in)

Short Description: ***Preliminaries***: calculus, linear algebra, probability. ***Supervised ML***: decision trees, probabilistic techniques. ***Unsupervised ML***: clustering, dimensionality reduction, generative models. Deep learning, recommendation systems.

CS772: Probabilistic Machine Learning

Instructor: Piyush Rai (piyush@cse.iitk.ac.in)

Short Description: ***Probabilistic modeling***: basic parameter estimation (MLE, MAP), common probability distributions, conjugate priors and exponential family. ***Bayesian learning***: Bayesian linear regression and classification, sparse linear models. ***Latent variable models***: clustering (mixture models), dimensionality reduction (factor analysis, probabilistic PCA, matrix factorization), sequence and time-series modelling (HMMs, linear dynamical systems), structured prediction, Probabilistic graphical models, Approximate Bayesian inference (MCMC, Variational Bayes, Expectation Propagation), Gaussian Processes, Topic models, Deep learning

CS798B: Computational Linguistics for Indian Languages

Instructor: Arnab Bhattacharya (arnabb@cse.iitk.ac.in)

Short Description: Basics of computational linguistics and natural language processing with a focus on Indian languages. Deep learning methods offer impressive performance on resource-rich languages such as English. However, they may fail to explain language features and offer only modest gains on resource-poor languages such as Indian languages. The course will explore Indian language theories in explaining a text e.g. Shabdabodha theories of akanksha, yogyata, etc.

CS798D: Algorithms for Bayesian Networks and Causality

Instructor: Sutanu Gayen (sutanu@cse.iitk.ac.in)

Short Description: ***Probabilistic graphical models***: modelling dependent random variables using graphs, ***Discrete, Gaussian Bayesian networks***: learning graphs from samples, sample complexity bounds, classical, and recent algorithms. ***Causality***: Pearl's graphical approach using Bayesian networks, interventions, identification, causal structure learning. Classical and recent literature and applications.

Thesis Work

1. **Candidature Process**
2. **Plan Your Thesis**
   Make your thesis a rewarding experience
3. **Thesis Areas**
   Research profiles of faculty members

In this picture: a view from inside the Rajeev Motwani building that houses the CSE department
Picture credit: www.cse.iitk.ac.in/users/admissions/

Picture credit: www.iitk.ac.in/doaa/convocation/

Candidature Process

A motivated student has the freedom to start thesis work on day one itself. However, in order to structure the PhD experience in general, the program requires you to complete certain *candidacy* requirements. Do take these seriously but keep research as your primary focus!

Step 1: Course work
Complete 36 PG credits with a CPI of 7.0 or above.

Step 2: Comprehensive examination
Once course work is over, your advisor (you should have identified one by now) would set up a committee of faculty members (3 CSE + 1 non CSE) to offer you a comprehensive exam. The format of this exam is very flexible. You may be asked to review research papers in a certain area (possibly other than your own area), or prepare basic material in some topic or something else, based upon the advice of the committee. Clearing this exam admits you into *candidacy* for the PhD degree.

Step 3: State-of-the-art seminar (SOTA)
Within 6 months of clearing the comprehensive exam, you should present a seminar discussing the latest trends, outstanding problems etc., in your chosen area of research. This is a good time to conduct literature survey and identify research problems around which you would like to structure your own thesis.

Step 4: Research!
Having put these formalities aside, put all your efforts into producing world-class research results.

Picture credit: www.iitk.ac.in/doaa/convocation/

Plan Your Thesis

The goal of the PhD program is to train you as a strong and independent researcher who not only has the technical superiority to solve the most challenging problems, but also the maturity to identify research problems that are hiding in plain sight! The PhD thesis, although a crucial part of the program, is but a side-effect of this training. Focus on developing critical thinking and technical prowess in your thesis work. These will be your best friends in the long run.

A 5 year Plan?: given its duration, it may seem hard to plan for the PhD program. The candidacy process, SOTA do bring some structure but the program still remains largely unstructured. This is not an accident.

The goal of the PhD program is to train you in research. A time-tested way in which we do this is by pairing you with an established researcher (your advisor) so that you may observe and imbibe various steps that go into research such as selecting problems on which to work (and which to leave aside for a while), identifying prior art and strengths and deficiencies thereof, formulating one's own approach, defining one's own metrics of success and failure, learning how to use success to formulate a more challenging goal, as well as how to use failure to give direction to the next steps.

A PhD program is expected to expose you to several cycles of the above steps so that they become ingrained and second nature. Given how amorphous these steps are, and how unpredictable their outcomes, it is unsurprising that the PhD program was designed as extended and largely unstructured.

Below are some words of advice on some things you can do to make this program a rewarding experience.

Select your Advisor: before you begin your thesis work, you need to identify an advisor. Your department offers you great flexibility in this respect.

1. Most students start thesis work by identifying an advisor within one year of joining the PhD program. Remember, you need to identify an advisor to start thesis work.
2. You may opt for *joint* supervision by two advisors. This is useful if, for example, your project is interdisciplinary and requires an ML and a systems advisor, or else an advisor each from CSE and EE. This is also useful if you wish to have an *external* advisor who is not a faculty member at IITK.
3. Your program is liberal in allowing change of advisor in the middle of the program. Such a change needs the permission of the existing as well as the new advisor(s), but is otherwise quite straightforward.

The choice of area and advisor is a crucial one in the PhD program. Take this decision with care after evaluating your interests and your strengths. The field of computer science is evolving rapidly making it likely that after graduating, you may be working in areas significantly different from those you explored in your thesis.

Thus, the training you receive in terms of developing a research mind-set and technical skills during your PhD is more important. Keep an open mind and discuss freely with faculty members as well as your peers.

Be Regular: make it a point to meet your advisor regularly. Lack of progress in the short term is not unusual and actually quite common in research. Do not feel shy or concerned if this happens (your advisor was also a PhD student at one point and knows these phases very well). However, it is very important for you and your advisor to converse regularly so that any systematic factors hindering progress can be quickly identified and removed. Sometimes, your advisor may get occupied with other tasks (courses, projects, etc.) and may not be able to initiate discussions. At such times, you should step up and take charge of making sure that discussions continue to happen regularly.

Short-term Goals: you may want to set short-term (e.g. 1-2 week) targets to pace yourself and roughly quantify the progress you are making. These goals may be about reading certain papers, writing a piece of code, completing an experiment, etc. It is better that you set these targets for yourself rather than have someone like your advisor impose them on you.

If it suits your working style, you may consider setting a slightly longer term (1-2 month) goal of submitting a paper to a good conference or a journal. This external deadline will in turn set short-term deadlines for you automatically. Even if you are not able to eventually submit the paper, you would have still made some timed progress.

Academic Activities: to enrich your PhD program, participate in activities that allow you to explore ideas other than your core research problems. You may join reading groups that discuss latest papers in your general area (ref: list of CSE *Special Interest Groups* earlier in this brochure), contribute to a course as a teaching assistant. You may take tutorials for students, or develop new content. Such activities do require some additional effort but offer several benefits: they keep enthusiasm levels up, prevent monotony from setting in, and may occasionally help your research work directly.

Vacation: every job requires vacations and the PhD program is no exception. Vacations are known to increase focus and productivity so you do not need to feel guilty about going on a short vacation. Skipping vacations altogether may be suboptimal in the long term. Work hard and then be carefree about partying or vacationing hard as well!

Travel: It is a good idea to travel a bit during the PhD program. Usually this means attending conferences, schools and workshops, but also include research visits and internships. If funds are scarce, you may choose to travel domestically more. Travelling allows you to meet new people, get new ideas and fresh perspectives on your current work, and build networks through which you may get postdoc and job offers later.

Support System: the journey within the PhD program is a solitary one and students sometimes face some form of loneliness, especially when progress at work is not upto their expectations. You may want to invest in a group of friends or consider taking up a hobby, whether artistic or sporting. These activities may help keep your spirits up on days when work gets challenging. For example, an accomplishment in your chosen hobby may fill you with self-confidence and enthusiasm, some of which may positively impact your research as well. Be careful to strike a proper balance with these activities, though. Be careful also to lookout for your peers who may be in need for support and encouragement. Be there for them just they would be for you.

Counselling: on rare occasions, your friends and peers, despite their best intentions, may not be able to help you feel better. Should this occur, do not feel shy to seek help. There is no shame in seeking help to make yourself a better person. The CSE department counsellor Ms. Aradhana Yadav (**aradhana@cse.iitk.ac.in**) may offer you helpful advice – drop an email to start a conversation. The institute has a full fledged counselling service as well which you may contact to seek advice and help.
www.iitk.ac.in/counsel/
You should take all steps to make your PhD program a fruitful and rewarding experience.

Picture credit: www.iitk.ac.in/doaa/convocation/

Thesis Areas

Your department is home to leading experts in several core and interdisciplinary areas of computer science. However, the department needs you to be an integral part of its research programs by bringing in fresh ideas, new perspectives and lots of energy.

Although you may currently have a favourite area as you start your PhD program, you will be exposed to several areas during course work as well as your interactions with faculty members and your peers.

Keep an open mind and look out for research areas and problems that genuinely excite you, rather than merely obsessing on areas about which you peers seem excited. Remember, a thesis requires sustained and dedicated work. Excitement that you have borrowed from someone else may not last long!

Links to websites of all faculty members are available at **www.cse.iitk.ac.in/pages/Faculty.html**

To help you, below we have listed some cutting-edge problem areas on which our faculty members are working. This list is neither exhaustive (some members are not listed), nor limiting (you may very well work on problems not mentioned here, in consultation with your advisor). Go through this list with an open mind. If some area catches your eye, visit that faculty member's webpage (links given) for details or drop them an email to start a conversation. Remember, you will have enough time after joining the program to identify an advisor. Use course work as well as personal discussions to find out which area suits you the best.

Theoretical Computer Science

Manindra Agrawal

Education: PhD, IIT Kanpur
Research Interests: Complexity Theory, Computational Number Theory, Cryptography
Webpage: www.cse.iitk.ac.in/users/manindra
Email: manindra@cse.iitk.ac.in

Ongoing Projects:
Cryptographic tools for real life applications

Surender Baswana

Education: PhD, IIT Delhi
Research Interests: Design of efficient algorithms and data structures, use of randomization in algorithms
Webpage: www.cse.iitk.ac.in/users/sbaswana
Email: sbaswana@cse.iitk.ac.in

Dynamic Algorithms and Fault Tolerant Data Structures:
Usually algorithms are designed for graphs assuming that they remain unchanged. But, in real world, the graphs keep changing - new vertices/edges may get inserted and some existing vertices/edges may get deleted. A trivial way to handle such changes is to execute the best "static" algorithm after each change. This is quite a wasteful approach. So the aim of dynamic algorithms is to use clever ideas and data structures for a given graph problem that can be efficiently updated upon any change in the graph.

Rajat Mittal

Education: PhD, Rutgers University
Research Interests: Quantum complexity theory, Computational number theory
Webpage: www.cse.iitk.ac.in/users/rmittal
Email: rmittal@cse.iitk.ac.in

Research Projects:

1. Giving bounds on quantum query complexity to understand the difficulty of solving problems on a quantum computer. We use multiple mathematical tools like semidefinite optimization and approximate degree to get these bounds.
2. Understanding the root structure and algorithms for factorization modulo prime powers. These problems are well studied modulo primes, we would like to extend those results to prime powers.

Satyadev Nandakumar

Education: PhD, Iowa State University
Research Interests: Computability Theory, Kolmogorov Complexity, Dynamical Systems, Fractal Dimension
Webpage: www.cse.iitk.ac.in/users/satyadev
Email: satyadev@cse.iitk.ac.in

Research Projects:

I am interested in Computability Theory and Kolmogorov complexity, especially its interactions with Measure-theoretic probability, Metric number theory, continued fractions, dynamical systems and fractal dimension.

Nitin Saxena

Education: PhD, IIT Kanpur
Research Interests: Circuit Complexity, Algorithmic Algebra/ Number Theory. Applications in Cryptography/ Learning Theory
Webpage: www.cse.iitk.ac.in/users/nitin
Email: nitin@cse.iitk.ac.in

Ongoing Projects:
I'm interested in algebraic structures and the related computational problems. Broadly, two issues interest me:

1. Designing efficient algorithms, and
2. Proving that such algorithms do not exist.

My results of the first kind require, and further enrich, the understanding of a host of mathematical areas (e.g. complexity, learning theory, algebra, geometry, topology, combinatorics). The results of the second kind, interestingly, are related to those of the first kind; especially, in the area of arithmetic circuit complexity. There the question of identity testing has occupied most of my attention. It is a central question in computer science that has seen a surge of results in the last few years, and seems more approachable now than ever before.

Sanjeev Saxena

Education: PhD, Indian Institute of Technology, Delhi
Research Interests: Algorithms, Parallel algorithms, Graph Algorithms, Computational geometry
Webpage: www.cse.iitk.ac.in/users/ssax
Email: ssax@cse.iitk.ac.in

Research Projects:
I work in the areas of algorithms, parallel algorithms, graph algorithms, computational geometry..

Education: PhD, Tata Institute of Fundamental Research
Research Interests: Logic, Models of computation, Automata Theory on infinite objects, Finite model theory
Webpage: www.cse.iitk.ac.in/users/seth
Email: seth@cse.iitk.ac.in

Potential Thesis Areas:
I am Interested in exploring linear logic and its applications to computation.

Education: PhD, The Institute of Mathematical Sciences
Research Interests: Game Theory, Social Choice Theory, Logic
Webpage: www.cse.iitk.ac.in/users/simon
Email: simon@cse.iitk.ac.in

Research Projects:
I am broadly interested in the computational aspects of game theory and social choice theory. These include algorithmic properties of solution concepts as well as structural axiomatization results. I am also interested in the algorithmic analysis of infinite (regular) games that are often used in formal methods, logic and automata theory.

Raghunath Tewari

Education: PhD, University of Nebraska - Lincoln
Research Interests: Computational Complexity Theory, Circuit Complexity, Graph Algorithms
Webpage: www.cse.iitk.ac.in/users/rtewari
Email: rtewari@cse.iitk.ac.in

Research Topics for Prospective Students:

1. Derandomization of the Isolating Lemma.
   This problem has interesting connections with logspace complexity, parallel complexity of perfect matching and polynomial identity testing.
2. Time Space Tradeoffs for Graph Problems such as Reachability.
   This question has connections with other problems in computer science such as the edit distance problem.
3. Catalytic Computation.
   A model of computation with additional auxiliary space that must be reverted back to its initial state at the end of computation.
4. Circuit Complexity of Perfect Matching.
   Can we efficiently parallelize the computation of coming up with a perfect matching in a graph, if one exists?

Systems and Security

Priyanka Bagade

Education: PhD, Arizona State University
Research Interests: Internet of Things, applications of ML/DL/vision in IoT and cyber physical systems, IoT security
Webpage: www.cse.iitk.ac.in/users/pbagade
Email: pbagade@cse.iitk.ac.in

Internet of Things:
Applications of deep learning and machine learning to the real world Internet of Things systems, e.g. electric vehicles, smart homes, agriculture, manufacturing, healthcare etc - design and develop trustworthy cyber physical systems considering their safety, sustainability and security requirements - Digital forensics of medical devices.

Swarnendu Biswas

Education: PhD, Ohio State University
Research Interests: Programming Languages, Compilers and Runtime Systems, Parallel Software Systems
Webpage: www.cse.iitk.ac.in/users/swarnendu
Email: swarnendu@cse.iitk.ac.in

Research Interests and Possible Future Directions:
The high-level goal of our group is to solve research problems to aid in developing efficient and correct parallel software. Our work ranges from static and dynamic program analysis for correctness of multithreaded programs to automated checking for performance problems on CPU, GPU, and heterogeneous architectures. The research work involves applying concepts at the interface of Programming Languages, Compilers and Runtime systems, Operating Systems, and Computer Architecture, and involves building sophisticated prototypes to demonstrate the feasibility of our ideas.

A possible direction of research is to explore ideas in efficient virtual memory support (UVM) for discrete GPUs.

Urbi Chatterjee

Education: PhD, IIT Kharagpur
Research Interests: Hardware Security, Physically Unclonable Functions, Cryptographic Protocol Design, Unmanned Air Vehicle Security
Webpage: www.cse.iitk.ac.in/users/urbic
Email: urbic@cse.iitk.ac.in

Recent Research Problems:

1. Defensive and offensive security for UAVs
   Hirak Mondal and Urbi Chatterjee. Revisiting UAV Authentication Schemes: Practical Attacks on Aviation Infrastructure, AsianHOST 2021.
2. PUF based Authentication and Key exchange Protocols
   a) Urbi Chatterjee, Debdeep Mukhopadhyay, Rajat Subhra Chakraborty: 3PAA: A Private PUF Protocol for Anonymous Authentication, IEEE TIFS 2020.
   b) Urbi Chatterjee, Vidya Govindan, Rajat Sadhukhan, Debdeep Mukhopadhyay, Rajat Subhra Chakraborty, Debashis Mahata, Mukesh M Prabhu: Building PUF based Authentication and Key Exchange Protocol for IoT without Explicit CRPs in Verifier Database, IEEE TDSC 2018.
3. Constructions and Attacks on PUFs
   Durba Chatterjee, Urbi Chatterjee, Debdeep Mukhopadhyay, Aritra Hazra:SACReD: An Attack Framework on SAC Resistant Delay-PUFs leveraging Bias and Reliability Factors, DAC, 2021.
4. Integration of Hardware Security with Blockchain
   a) Chandan Kumar, Urbi Chatterjee, Debdeep Mukhopadhyay: Auto-PUFChain: An Automated Interaction Tool for PUFs and Blockchain in Electronic Supply Chain, AsianHOST 2021.
   b) Soumyadyuti Ghosh, Urbi Chatterjee, Durba Chatterjee, Rumia Masburah, Debdeep Mukhopadhyay, Soumyajit Dey: Demand Manipulation Attack Resilient Privacy Aware Smart Grid Using PUFs and Blockchain, CIMSS@ACNS 2021.

Mainak Chaudhuri

Education: PhD, Cornell University
Research Interests: Design and analysis of memory systems for emerging chip-multiprocessors, Efficient architectural support for shared memory in multi- and many-core systems
Webpage: www.cse.iitk.ac.in/users/mainakc/
Email: mainakc@cse.iitk.ac.in

Recent Research Problems:

1. Isolating core caches from uncore resource management in multi-core processors
   a) Mainak Chaudhuri. Zero Directory Eviction Victim: Unbounded Coherence Directory and Core Cache Isolation. In Proceedings of the 27th IEEE International Symposium on High-Performance Computer Architecture (HPCA), pages 277-290, March 2021.
   b) Mainak Chaudhuri. Zero Inclusion Victim: Isolating Core Caches from Inclusive Last-level Cache Evictions. In Proceedings of the 48th ACM/IEEE Annual International Symposium on Computer Architecture (ISCA), pages 71-84, June 2021.
2. Memory system optimization for bandwidth in multi-core processors
   a) Mainak Chaudhuri, Jayesh Gaur, and Sreenivas Subramoney. Bandwidth-aware Last-level Caching: Efficiently Coordinating Off-chip Read and Write Bandwidth. In Proceedings of the 37th IEEE International Conference on Computer Design (ICCD), pages 109-118, November 2019.
   b) Jayesh Gaur, Mainak Chaudhuri, Pradeep Ramachandran, and Sreenivas Subramoney. Near-optimal Access Partitioning for Memory Hierarchies with Multiple Heterogeneous Bandwidth Sources. In Proceedings of the 23rd IEEE International Symposium on High Performance Computer Architecture (HPCA), pages 13-24, February 2017.

Education: PhD, IIT Bombay
Research Interests: Compilers, Data Flow Analysis, Heap Analysis, Computer Aided Education
Webpage: www.cse.iitk.ac.in/users/karkare
Email: karkare@cse.iitk.ac.in

Research Projects for Prospective Students:
Prutor, an Intelligent Learning and Management System for Programming Courses: For courses having programming component, grading of programming assignments and providing feedback requires significant time and effort. It is a challenge for an instructor to maintain the effectiveness and quality of the grading and feedback. Prutor, created in 2014, is a platform to conduct programming courses. It provides instant and useful feedback to students while solving programming problems. It has several interesting sub-projects, such as Search Engine for Programming Problems, Clustering of Student Submissions for effective Repair and Grading, providing Natural Language Feedback, etc.

In past, I have worked on the Heap Analysis for Functional Languages, and Improving GPU performance. I look forward to interesting applications of Program Analysis.

https://www.cse.iitk.ac.in/users/karkare/prutor/

Preeti Malakar

Education: PhD, IISc Bangalore
Research Interests: Scalable parallel communications, Data movement optimization, Profiling and Performance analysis, Parallel I/O
Webpage: www.cse.iitk.ac.in/users/pmalakar
Email: pmalakar@cse.iitk.ac.in

Potential Thesis Topics:
The world's first exascale system is expected to arrive in a couple of years. Our group focuses on various aspects of supercomputing to improve the performance of large-scale parallel applications, such as weather forecasting. Some potential research projects are:

1. Resource-aware on-the-fly analysis and visualization of large-scale scientific simulations.
2. Develop communication-aware job schedulers for supercomputers.
3. Resource-aware data movement optimization on high performance systems for big data applications.
4. Network- and route-aware parallel I/O optimization.
5. Visual profiling of parallel applications to effectively find communication and I/O performance bottlenecks at large scale.
6. Machine learning-based parallel program performance modeling and analysis.

Debadatta Mishra

Education: PhD, IIT Bombay
Research Interests: Operating Systems, Virtualization and Cloud Computing, Computer Networks, System Security, Operating System-Architecture Interfaces
Webpage: www.cse.iitk.ac.in/users/deba
Email: deba@cse.iitk.ac.in

Research Interests:
Primary focus of our group is to design efficient and secure software abstractions at lowest layer of the software stack which includes operating system and hypervisor. For example, towards building next generation system software for non-volatile memory systems, we are working on research projects to re-design different OS subsystems like file systems, memory management system etc. Our group also work on projects involving security aspects of computer systems. We explore solutions to different security issues using---specialized OS-level techniques (e.g., sandboxes) and cross-layer techniques (e.g., OS-architecture enhancements), with acceptable levels of security-efficiency trade off.

Amitangshu Pal

Education: PhD, The University of North Carolina at Charlotte
Research Interests: Wireless and sensor networks, Sensing and communication for Internet of Things (IoTs), Building IoT solutions for smart cities
Webpage: https://www.cse.iitk.ac.in/users/amitangshu/
Email: amitangshu@cse.iitk.ac.in

Research Overview:
My research interests span a seeming widely diverse set of topics, with the aim of developing adaptive solutions and techniques for building communication and sensing infrastructure for future IoT platforms. To be specific, my interests lie in three broad areas, i.e

a) sensing
b) communication and
c) Networking

For (a) I am interested in building different IoT-based sensing platforms that can be useful for smart healthcare, agriculture, surveillance, transportation etc. For (b) I are exploring communication possibilities in different challenging environments, such as underground, underwater or inside body-area networks etc. These environments are challenging especially because the RF communication does not work in these media, and therefore exploring other possibilities like acoustic, magnetic or visual light based communication are promising. For (c) I explore networking solutions for wireless and optical networks, develop adaptive schemes for rechargeable sensor networks, extend networking solutions in challenging environments such as building disaster recovery networks, explore sensing and networking in underground pipeline environment, develop cyber-physical solutions in the fresh food logistics and smart city context etc. I also study several problems on content centric networks, reconfigurable data centre networks, enterprise networks etc.

Subhajit Roy

Education: PhD, IISc Bangalore
Research Interests: Formal Methods, Artificial Intelligence, Software Engineering and Programming Languages
Webpage: www.cse.iitk.ac.in/users/subhajit
Email: subhajit@cse.iitk.ac.in

Research Agenda:
My interests are in the broad area of Formal Methods, Artificial Intelligence, Software Engineering and Programming Languages. Programs, today, are more than C/C++ code that we knew about --- Software 2.0 is has penetrated deep into today's systems. The cool idea that PL/SE researchers use is that machine learning models are also programs. Our group attempts to design new algorithms and develop automated tools to answer the following questions for both (conventional) programs as well as for machine learnt models:
Analysis: What interesting properties hold on this program/model?
Verification: Is this program correct?
Optimization: Can the program run faster?
Testing: Can we produce an input to make the program fail?
Synthesis: Can we automatically create a program for this given task?
Profiling: What interesting properties frequently hold on this program?
Debugging: What is the bug in the program?
Robustness: Can a small perturbation in the input cause a large deviation in the output?
Interpretability: What does this machine learnt model actually do?
Towards solving these problems, we use formal methods (logic, automata theory, compiler design) and data-driven techniques (machine learning, artificial intelligence, statistics).

Debapriya Basu Roy

Education: PhD, IIT Kharagpur
Research Interests: Post Quantum Cryptography, Advanced side channel analysis, VLSI for Cryptography, FPGA Architecture and Security
Webpage: https://dbroy24.wixsite.com/
Email: dbroy@cse.iitk.ac.in

Potential Thesis Topics:
Implementation of cryptographic algorithms is a challenging problem as most of the cryptographic algorithms are based on computationally intensive mathematical operations. These cryptographic algorithms are often accelerated by dedicated hardware accelerators, implemented either on FPGA or ASIC platforms. However, such hardware or even software implementations of cryptographic algorithm suffers from side channel vulnerability where an adversary can retrieve the secret key of the cryptographic algorithms by observing physical information like power, electromagnetic radiation or time.
Our objective is to develop efficient yet secure implementations of cryptographic algorithms and protocols. In recent years, this field of hardware security has undergone a major metamorphosis due to the advancement of quantum computing that has made public key algorithms like RSA and elliptic curve cryptography vulnerable. In our research, we also focus on post-quantum secure public key algorithms, focusing on both efficiency and side-channel analysis.

Google Scholar : https://scholar.google.co.in/citations?user=bVX8VCoAAAAJ&hl=en
DBLP: https://dblp.org/pid/116/4686.html

Indranil Saha

Education: PhD, University of California Los Angeles
Research Interests: Artificial Intelligence, Formal Methods, Embedded and Cyber-Physical Systems, Robotics, Autonomous Vehicles
Webpage: www.cse.iitk.ac.in/users/isaha
Email: isaha@cse.iitk.ac.in

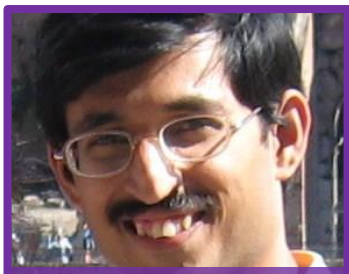
Research Overview:
I am broadly interested in the application of formal methods and artificial intelligence in developing safety-critical cyber-physical systems. A particular focus of my research has been developing planning algorithms, control mechanisms, and software infrastructure for multi-robot systems involving both ground and aerial vehicles. We are also involved in self-driving car research, with the goal of developing a fully autonomous car capable of navigating through an unstructured environment. My lab, located in KD110, is fully equipped for carrying out advanced robotics research.

Sandeep K Shukla

Education: PhD, State University of New York at Albany
Research Interests: Cyber Security, Cyber Physical Systems, Blockchain Technology, Formal Methods
Webpage: https://security.cse.iitk.ac.in
Email: sandeeps@cse.iitk.ac.in

Cyber Security of Critical Infrastructure:
Security Problems in Cyber Physical Critical infrastructure and their solutions at different layers of system architecture such as network, applications, physical Dynamics and control, distribution platform and protocols etc. Blockchain Technology and Applications.

Data Science and AI



Arnab Bhattacharya

Education: PhD, University of California, Santa Barbara
Research Interests: Databases, Data Mining, Information Retrieval, Natural Language Processing
Webpage: www.cse.iitk.ac.in/users/arnabb
Email: arnabb@cse.iitk.ac.in

Interests:
Making computers understand **Indian languages** with or without the use of database querying, data mining, natural language processing, and artificial intelligence.

Sumit Ganguly

Education: PhD, University of Texas at Austin
Research Interests: Data Streaming, Sampling, Sketching, Dimensionality Reduction, Numerical Linear Algebra
Webpage: www.cse.iitk.ac.in/users/sganguly
Email: sganguly@cse.iitk.ac.in

Research Interests:
Approximate Efficient and Randomized Algorithms for Numerical Linear Algebra:
Sketching and Sampling techniques for specific numerical algebra problems.

Sutanu Gayen

Education: PhD, University of Nebraska-Lincoln
Research Interests: Foundations of Machine Learning, Probabilistic Algorithms.
Webpage: www.cse.iitk.ac.in/users/sutanu
Email: sutanu@cse.iitk.ac.in

Research themes:

- [*Distribution testing*] Given random samples from an unknown distribution what is the minimum number of samples needed to decide whether it satisfies certain properties? Is there a computationally efficient algorithm which achieves this minimum number of samples?
- [*Learning high-dimensional distributions with structure*] Given samples from a high-dimensional distribution, which is known to have certain structure (such as limited independence) can we learn it approximately in a small amount of samples and time?
- [*Causal inference*] Under what assumptions, in practical situations, can we learn about the causal effects among random variables using only correlational data? What are the statistical and computational barrier to learn such effects?

Education: PhD, Saarland University
Research Interests: Natural Language Processing, Machine Learning, Computer Vision, Reinforcement Learning, Affective Computing
Webpage: www.cse.iitk.ac.in/users/ashutoshm
Email: ashutoshm@cse.iitk.ac.in

Research Projects for Prospective Students:

I work in a number of areas at the intersection of NLP, ML and CV. On the techniques side, I work on statistical and probabilistic techniques for understanding language including, deep learning models and generative modeling. Some of the applications I am currently exploring are:

1. **Affective Computing**: understanding, modelling and generating human emotions
2. Conversational/Dialog Systems
3. **NLP for Legal Text**: Developing state of the art systems for understanding, processing and generating legal documents. Language and ethics.
4. **Multimodal NLP**: combine different modalities like vision text for interesting applications. Multimodal generative models. This also has an overlap with affective computing.
5. **Real World Agents via RL**: Developing RL agents that can learn about the world by interacting with objects and entities via Interactive Fiction Games (IFG)
6. Sign Language Translation and Generation
7. NLP for Climate Change Policy by creation of Knowledge Platform.
8. Mental Health Monitoring via Wearables.

Education: PhD, Rice University
Research Interests: : Computational Biology, Machine Learning, Bioinformatics
Webpage: https://hamimzafar.wixsite.com/home
Email: hamim@iitk.ac.in

Research Projects for Prospective Students:

I work in the intersection of Machine Learning and Biology. Some of the current projects are

1. Scalable algorithms for mutation detection from large-scale single-cell genomic data.
2. Bayesian machine learning for inferring tumor evolution by integrating complementary data.
3. Probabilistic and Combinatorial cell lineage inference from CRISPR-Cas9 mutations.
4. Probabilistic inference of cell types and differentiation trajectories from single cell multi-omics data.
5. Deep generative models for single-cell multi-omics and spatial transcriptomics.

Visit us at www.cse.iitk.ac.in

Brochure designed by Purushottam Kar on MS PowerPoint
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