

Ph.D. @CSE, IITH



Table of Contents

Theoretical Computer Science @IITH

Computer Systems Research @IITH

Artificial Intelligence/Machine Learning Research @IITH

Collaborations

Publication Venues

Infrastructure

Fellowships

Life @CSE, IITH

CSE PhD Alumni

How to Apply?

Theoretical Computer Science @IITH

Cryptography

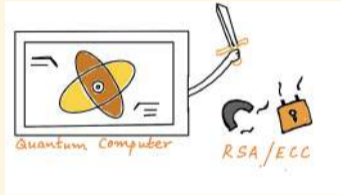
- ▶ How to **efficiently authenticate** a vehicle **without revealing private information** in fast moving traffic? Lightweight cryptography!



Cryptography

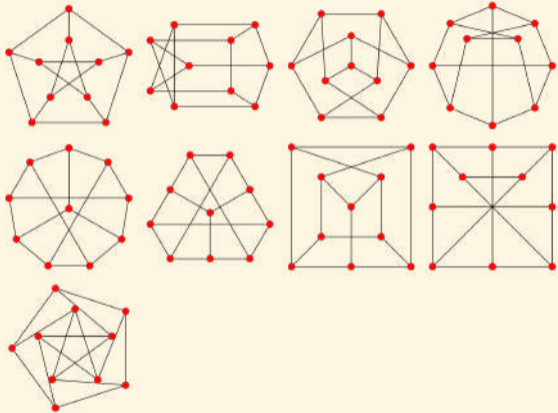
- ▶ A quantum computer can break most of the encryption schemes of today. What are the options for crypto, post-quantum?

Quantum crypto, Lattice crypto, etc.



- ▶ Hardware/Software aspects of quantum cryptography.
- ▶ Privacy preserving mechanisms over blockchains.

Combinatorics

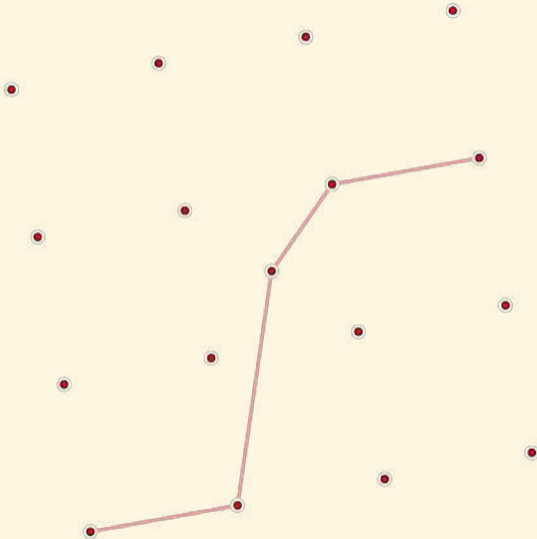


Are they the same graph?

Graph Isomorphism Problem

(Image Courtesy: Wolfram Mathworld)

Combinatorics



Erdős Szekeres Problem:
What is the longest
increasing/decreasing sequence
here?

Combinatorics

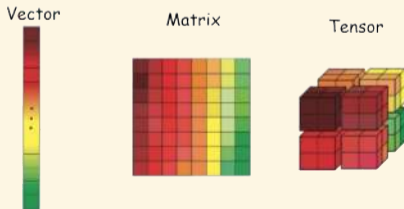
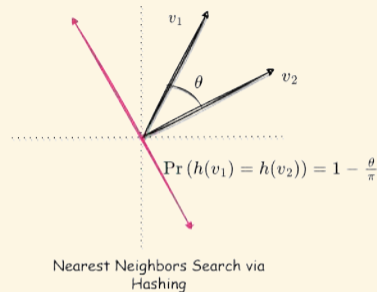
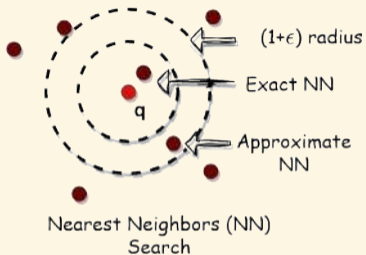


Second Neighborhood Problem:

Posed by Paul Seymour (1990):

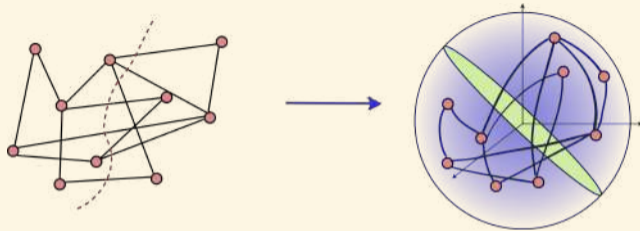
In a **social network** described by such a graph, is there always someone who has at least as many friends-of-friends as friends?

Algorithms



- ▶ Locality Sensitive Hashing (LSH) [Indyk, Motwani '98] suggest approximate nearest neighbour search algorithm for vectors.
- ▶ Major open problem is to propose (approximate) nearest neighbour search algorithms for tensors!

Algorithms



Max-Cut problem:

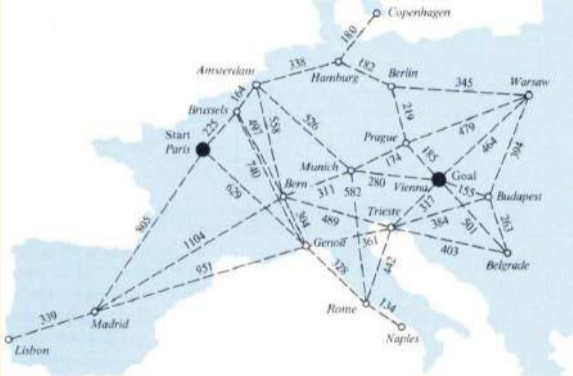
Partition a set of people into two parts such that **interaction** across parts is **maximized**.

[Goemans-Williamson '95]:

Embedding the graph **into a sphere**, and **cutting the sphere** into two halves to find the partition gives a **good approximation**.

Major open problem to find a better solution!

Complexity Theory



Travelling Salesman Problem:
Given: cost of travelling between every pair of cities, and a cost c .

Is there a **tour with cost $\leq c$** that visits every vertex exactly once and ends in the starting vertex?

Complexity Theory



Zero Knowledge Proofs:
Can you **prove** that you have found Waldo
without revealing where he is?

Theoretical Computer Science Faculty



Maria Francis

Cryptography, Computational Algebra



Rogers Mathew

Combinatorics



M. V. Panduranga Rao

Quantum Computing



Nitin Saurabh

Computational Complexity, Quantum Computing



Rakesh Venkat

Algorithms, Complexity Theory



Subrahmanyam Kalyanasundaram

Computational Complexity



Aravind N.R.

Graph Theory, Algorithms, Combinatorics



Rameshwar Pratap

Algorithms, Machine Learning



Manaswi Paraashar

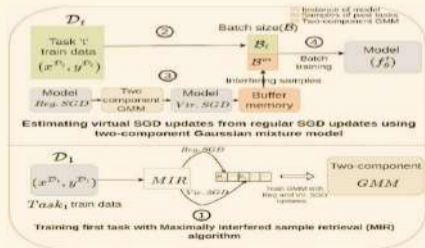
Quantum Computing

Computer Systems Research @IITH

Networks and Security



- ▶ Mobile Wireless Networks (5G and Beyond Networks)
- ▶ Software-defined Networking and Network Functions Virtualization
- ▶ Hybrid Cloud and Programmable Data Planes
- ▶ V2X and Mobile Edge for Autonomous Navigation
- ▶ Network Security Cyber Forensics





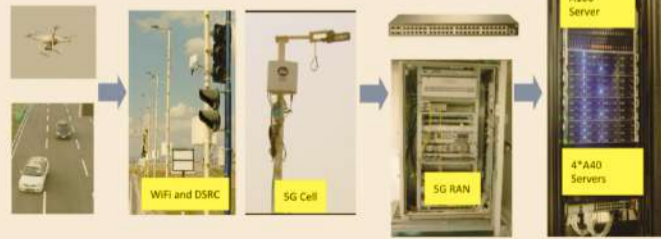
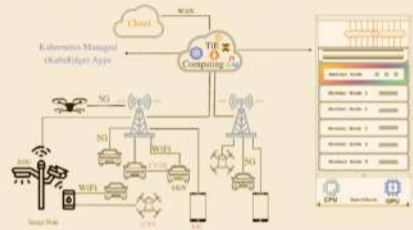
Edge Cloud for Autonomous Navigation Applications

Goal: Bring compute and storage closer to the data source



TiHAN testbed for Research & Technology development of Autonomous Navigation and Data Acquisition Systems

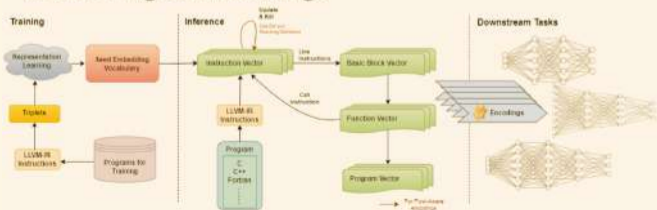
TiE Architecture



Compilers

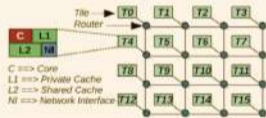
- ▶ Program Analysis and Compilers using Machine Learning
- ▶ Polyhedral Compilation
- ▶ Compiler Optimization Techniques for CPUs and GPUs
- ▶ High-performance GPU Algorithms for Scalable Graph Analysis
- ▶ Data Race Checking and Parallel Code Compliance Standards

IR2Vec - Program Embeddings



Computer Architecture

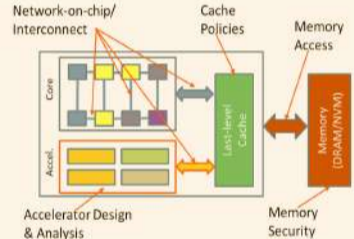
- ▶ Thermal Management for 3D Architectures
- ▶ Memory Security
- ▶ Cache, Interconnects Memory Access Policies
- ▶ Resource Sharing in Heterogeneous Architectures
- ▶ Non-volatile Memories



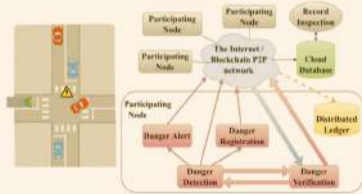
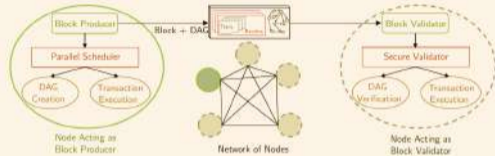
A Chipmultiprocessor (CMP) with tiled architecture.



A Chipmultiprocessor (CMP) with non-tiled architecture.



Distributed Systems



Collective Intelligence by AI-Blockchain Interplay

- ▶ Blockchains and its applications to Security and Smart Contracts
- ▶ Large-Scale Graph Analytics
- ▶ Efficient Consensus Protocols
- ▶ Distributed and Federated Learning
- ▶ Lock-Free Programming

Open Source Efforts

- ▶ Contribution to OAI 5G Core
- ▶ LTE Energy Module for NS-3
- ▶ Contributions to open-source compiler infrastructures: LLVM, MLIR, Polly, ISL
- ▶ Benchmarks for DNN optimizations
- ▶ Program Embeddings Infrastructures (IR2Vec, MIR2Vec, VEXIR2Vec*) + Applications
- ▶ Dataset for document generation task in Python notebooks (18,378 data points consisting of a pair of Python code and precise documentation)

Systems Research Faculty



Antony Franklin

Wireless Networks, Mobile Networks



Ashish Mishra

Formal Methods, Programming Languages



Sathya Peri

Distributed Systems



Praveen Tammana

Systems, Networking, Network Security



Ramakrishna Upadrasta

Compiler, Compilers Optimizations



Bheemarjuna Reddy Tamma

Networks, Network Security



Kotaro Kataoka

Internet, Blockchain



Jyothi Vedurada

Compilers, High-Performance Computing



Rajesh Kedia

Computer Architecture, Embedded Systems



Shirshendu Das

Computer Architecture, Hardware Security

Systems Research Faculty



Anupam Sanghi

Database Systems



Abhijit Das

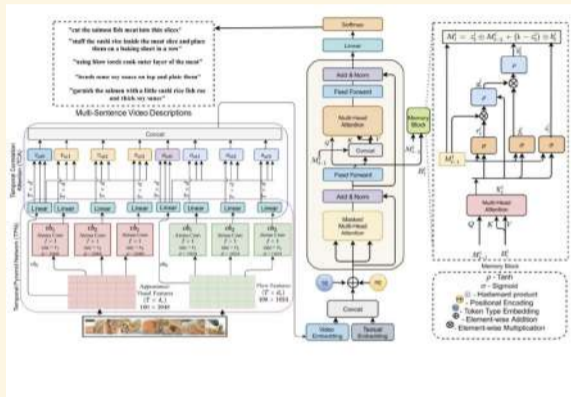
Computer Architecture

Artificial Intelligence/Machine Learning Research @IITH

Deep Learning Architecture and Training

► Explore

- New architectures and models
- New training methods and loss functions
- Newer inputs



Generative AI

- ▶ AI to create a wide variety of data, such as images, videos, audio, text and 3D models
- ▶ GenAI learns patterns from existing data and uses that knowledge to generate new and unique data.
 - ▶ GenAI applications: ChatGPT, DeepBrain, Synthesia,...

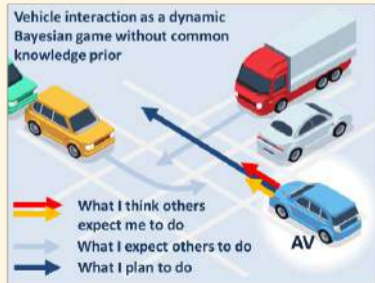
“ A cat and a female character in a spaceship exploring a hidden galaxy. With detailed backgrounds, expressive characters, including magical elements, illustration made by hand. ”



Image Generation

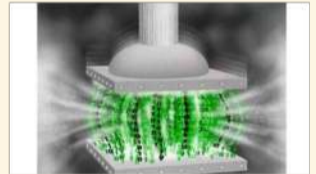
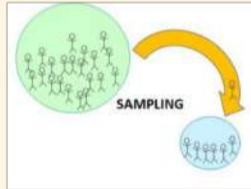
Bayesian Learning

- ▶ Use Bayesian Learning for building Safe AI applications
- ▶ High risk real-world applications, such as autonomous vehicles and healthcare
- ▶ Bayesian Deep Learning provides better decision making by handling uncertainty, robustness and considering domain knowledge



Algorithms for Massive Datasets

- ▶ Developing algorithms for handling large dimensionality and large volume of datasets
 - ▶ **High-dimensional:** text vocabulary, pixels in image
 - ▶ **Large volume:** millions of documents and images
- ▶ Develop efficient distributed algorithms – Hadoop/MapReduce
- ▶ Use Sketching/Sampling to turn “Big Data into tiny data”



Computer Vision

- ▶ Action recognition, emotion recognition and video analytics
- ▶ Autonomous vehicle technology
- ▶ Aerial imagery analysis and image captioning
- ▶ Medical imaging



Vision for Drones

- ▶ **Challenge:** Handling objects of different sizes
- ▶ **Applications:** Surveillance, Search and Rescue, Infrastructure Inspection, Crop Health Monitoring, Land Cover Mapping, Traffic Management
- ▶ Detecting drones from drones



NLP: Dialog Systems

- ▶ Computer system intended to converse with a human.
- ▶ Uses one or more of text, speech, graphics, gestures, etc., to communicate between human and system
- ▶ Build scalable and explainable dialog systems

U_0 : Can you help me find some attractions in the **east** part of town?

B_0 : { (attraction, **area**, **east**) }

S_1 : Definitely! My favorite place in the east is the **Funky Fun House**. It's funky and fun!

U_1 : Can I have the number please?

B_1 : { (attraction, **area**, **east**), (attraction, **name**, **Funky Fun House**) }

S_2 : It's 01223304705. Do you need anything else?

U_2 : Yeah, I need a restaurant. They need to serve **Indian** food and be in the **same area** as Funky Fun House.

B_2 : { (attraction, **area**, **east**), (attraction, **name**, **Funky Fun House**), (restaurant, **area**, **east**), (restaurant, **food**, **Indian**) }

S_3 : There are 4 Indian restaurants in the area. Two are moderately priced and two are expensive. Can I ask what price range you would like?

U_3 : I would prefer one in the **moderate** price range.

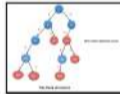
B_3 : { (attraction, **area**, **east**), (attraction, **name**, **Funky Fun House**), (restaurant, **area**, **east**), (restaurant, **food**, **Indian**), (restaurant, **price**, **moderate**) }

NLP: Personalized Autosuggest

- ▶ Personalized query autocompletion for short and unseen prefixes.



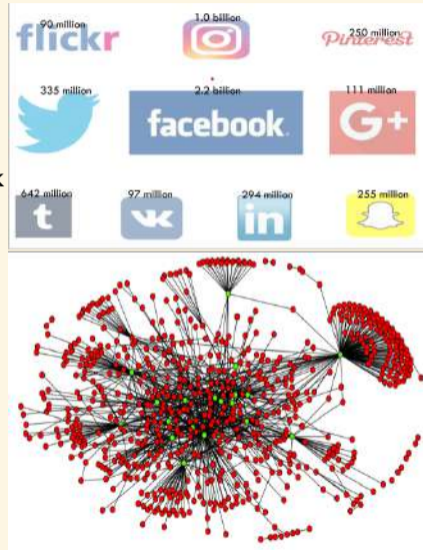
Let previous n queries (earliest to latest order) in the current session s be $\{q_1, q_2, \dots, q_n\}$. Current query is q , and p is the query prefix typed so far.



Generate top- N query completions conditioned on current query prefix p , additional trie context e , and session information s i.e., $P_{\theta}(q | p; e; s)$

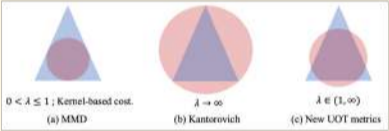
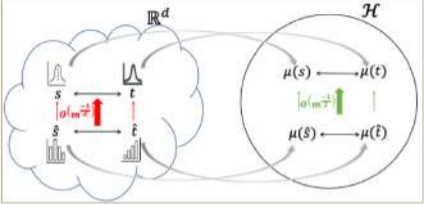
Social Media Analytics

- ▶ Information diffusion in social network
- ▶ Summarize social media content
- ▶ Categorize content
 - ▶ Spam vs non-spam
 - ▶ Quality of posts and replies
- ▶ Content routing



Applied Learning Theory

- ▶ Kernel methods
- ▶ Statistical learning theory
- ▶ Optimization
- ▶ Generative AI



$x \sim p$				
$\tilde{T}(x, z_1)$				
$\tilde{T}(x, z_2)$				
$\tilde{T}(x, z_3)$				

Machine Learning Faculty



C Krishna Mohan

Video Content Analysis, Machine Learning,
Sparsity Based Methods, Deep Learning



Manish Singh

Databases, Data Mining, Information Retrieval



Sobhan Babu

Big Data Analytics, Graph Theory and Applied
Algorithms



Srijith P.K.

Bayesian Data Analysis, Probabilistic Machine
Learning, Survival Analysis and Text Analytics



Saketha Nath Jagarlapudi

Machine Learning



Maunendra Desarkar

Recommender Systems, Information Retrieval



Vineeth N. Balasubramanian

Machine Learning, Computer Vision



Sandipan Dandapat

Natural Language Processing Generative AI

Collaborations

Industry



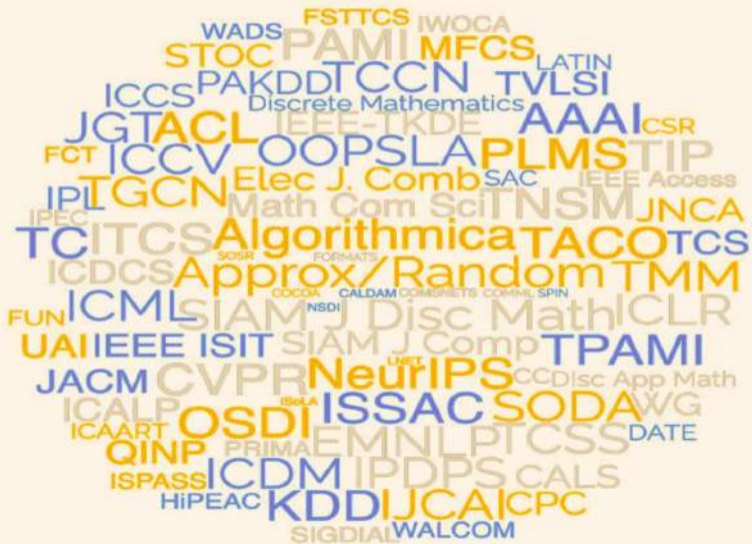
International



National



Publication Venues



Infrastructure

- ▶ Large number of servers (with CPU and GPU) available through SLURM and MAAS infrastructure
- ▶ High Performance Computing (HPC) cluster available under the National Supercomputing Mission
- ▶ OpenStack-based private cloud for Virtual Machines (VMs)
- ▶ A large range of IoT and embedded processors and FPGA boards
- ▶ State-of-the-art DGX Servers
- ▶ High-end network switches such as 3.2 Tbps Intel Tofino Programmable Switch
- ▶ Labs with dedicated workstation for every Ph.D. scholar, with 24x7 access



Fellowships

- ▶ Ministry of Education (MoE) fellowships
- ▶ Sponsored research project fellowships
- ▶ Joint Ph.D. fellowships with IDBRT Hyderabad, Swinburne University Australia, and Deakin University Australia
- ▶ Industry fellowships such as Google, TCS, Intel fellowships
- ▶ PM Research Fellowship (PMRF)
- ▶ Visvesvaraya Fellowship
- ▶ Financial assistance for Ph.D. students to present their research papers in international and national venues

Life @CSE, IITH

- ▶ PhD seminar talks:
[CSE Ph.D Seminar Talks IIT-Hyderabad](#)
- ▶ Several international and national computer science conferences held @IITH, e.g. ACML 2022, CALDAM 2020, etc.
- ▶ Research Scholars Day



CSE PhD Alumni

Alumni in PostDoc positions

Technion
IIT Kanpur
IMSc, Chennai A*STAR
Verisk AI Research
Monash University CSHL
University of Augsburg
University of Cambridge
University of Manchester
UTSA Harvard University MIT
Shizuoka University
Aalto University
Aalborg MBZUAI, UAE
Lip6 Paris

Alumni in Industry

DRDO
Celona HCL
Salesforce ASCI
Supraoracles
Rakutan Mobiles
Samsung Research
Adobe Research
IIAI Jio Platforms
NPCI Qualcomm
Intel Amazon
DELL

Alumni in Academia

IIT Dharwad
NIT Calicut
NIT Rourkela IIT Indore
SSIPMT-Raipur IIT Bhilai
Monash University
Shivnadar University
University of Hyderabad
Woosong University
JNU
JNTU Amrita University
IIT Tirupati IITDM Kurnool
BITS Pilani NIT Nagpur
IIT Palakkad
IIIT Kottayam

How to Apply?

- ▶ We have two regular rounds of admissions with deadlines typically around second weeks of April and November. *We also sometimes have special rounds of admissions in between the regular rounds.*
- ▶ All calls for admissions with the details on how to apply will be updated here: [CSE Ph.D Admissions](#). Do check out the sections on “Eligibility criteria” and “How to prepare for the interviews?” on the same page.
- ▶ For any queries, please reach out to phd.admissions@cse.iith.ac.in.