Ph.D. @CSE, IITH

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Theoretical Computer Science @IITH

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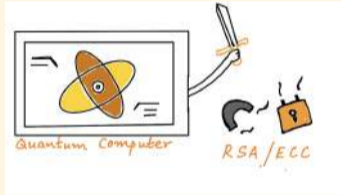
- How to efficiently authenticate a vehicle without revealing private information in fast moving traffic? Lightweight cryptography!

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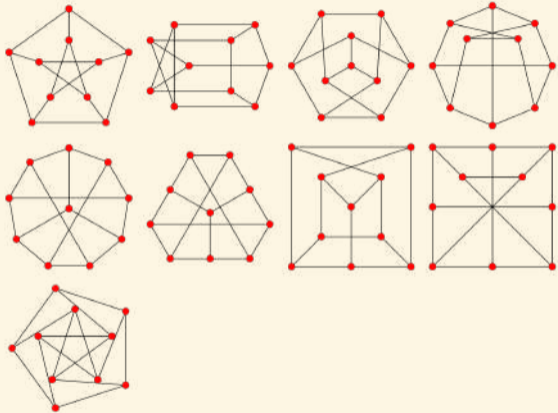
- A quantum computer can break most of the encryption schemes of today. What are the options for crypto, post-quantum?
  Quantum crypto, Lattice crypto, etc.

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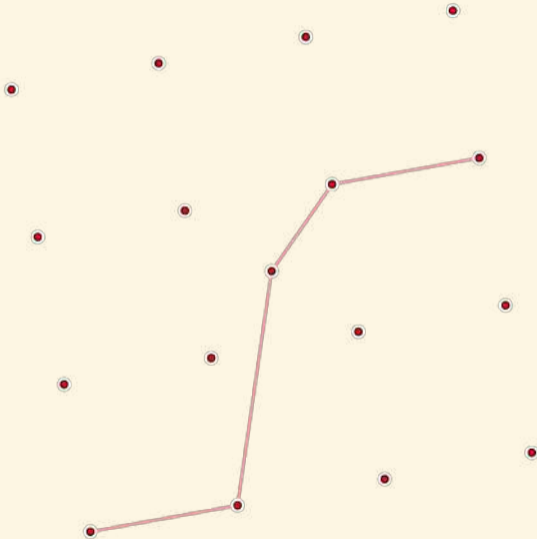- Privacy preserving mechanisms over blockchains.

Combinatorics

Are they the same graph?
Graph Isomorphism Problem

Combinatorics

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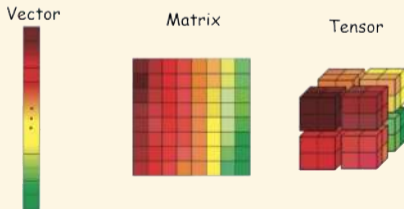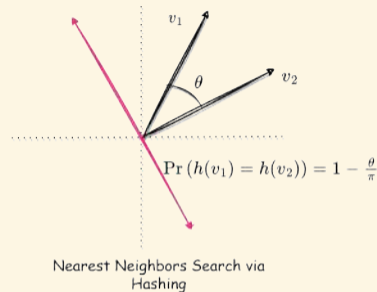increasing/decreasing sequence
here?

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

Nearest Neighbors (NN) Search

$$\Pr\left(h(v_1) = h(v_2)\right) = 1 - \frac{\theta}{\pi}$$

Nearest Neighbors Search via Hashing

Vector   Matrix   Tensor

Image courtesy: kdnuggets
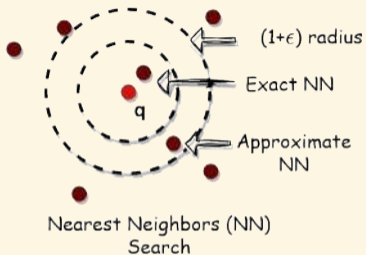
- ▶ Locality Sensitive Hashing (LSH) [Indyk, Motwani '98] suggest approximate nearest neighbour search algorithm for vectors.

- ▶ Major open problem is to propose (approximate) nearest neighbour search algorithms for tensors!

Algorithms
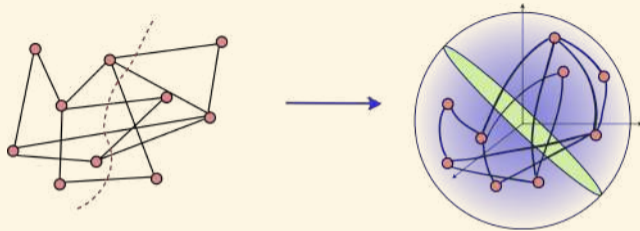
Max-Cut problem:

 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
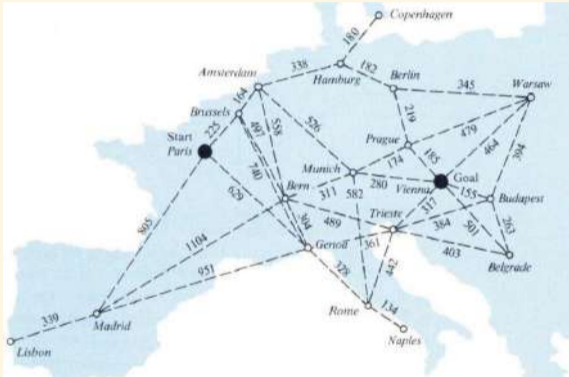
Travelling Salesman Problem:
Given: cost of travelling between
every pair of cities,
and a cost *c*.
Is there a tour with cost $\leq c$ that visits
every vertex exactly once and ends in
the starting vertex?

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

[Subrahmanyam Kalyanasundaram](#)
Computational Complexity

[Rogers Mathew](#)
Combinatorics

[Aravind N.R](#)
Graph Theory, Algorithms, Combinatorics

[M. V. Panduranga Rao](#)
Quantum Computing

[Rameshwar Pratap](#)
Algorithms, Machine Learning

[Nitin Saurabh](#)
Computational Complexity, Algorithms

[Karteek Sreenivasaiah](#)
Computational Complexity, Algorithms

[Rakesh Venkat](#)
Algorithms

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
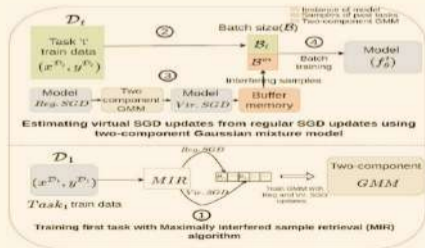
Edge Cloud for Autonomous Navigation Applications

Goal: Bring compute and storage closer to the data source

TiE Architecture

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

WiFi and DSRC

5G Cell

5G RAN

A100 Server

4*A40 Servers

"Experience: Implementation of Edge-Cloud for Autonomous Navigation Applications" IEEE/ACM COMSNETS, Bangalore, India.
Link1, Link 2
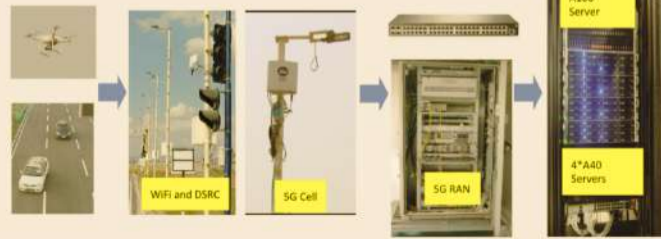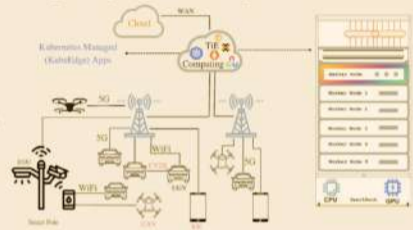
# Compilers

- ▶ 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

Before Optimization

After *StreamAlloc* Optimization

Automatic CUDA Stream Allocation
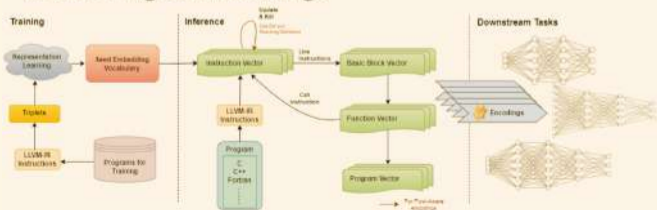
Computer Architecture

- ▶ Thermal Management for 3D Architectures
- ▶ Memory Security
- ▶ Cache, Interconnects Memory Access Policies
- ▶ Resource Sharing in Heterogeneous Architectures
- ▶ Non-volatile Memories
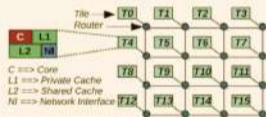
A Chipmultiprocessor (CMP) with tiled architecture.

A Chipmultiprocessor (CMP) with non-tiled architecture.
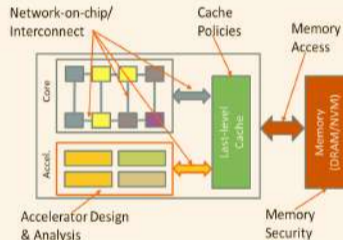
Distributed Systems
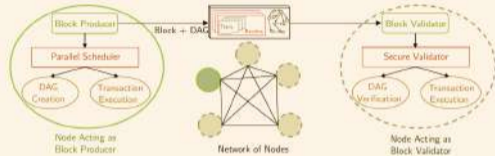
Collective Intelligence by AI-Blockchain Interplay

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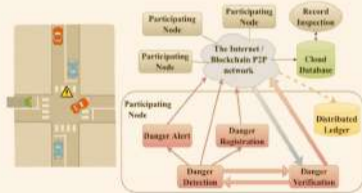- Contributions to open-source compiler infrastructures: LLVM, MLIR, Polly, ISL
- Benchmarks for DNN optimizations
- Program Embeddings Infrastructures (IR2Vec, MIR2Vec, VEXIR2Vec*) + Applications
- Dataset for document generation task in Python notebooks (18,378 data points consisting of a pair of Python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

Systems Research Faculty

Antony Franklin
Wireless Networks, Mobile Networks

Bheemarjuna Reddy Tamma
Networks, Network Security

C. Siva Ram Murthy
Wireless Networks, Distributed Computing

Kotaro Kataoka
Internet, Blockchain

Sathya Peri
Distributed Systems

Jyothi Vedurada
Compilers, High-Performance Computing

Praveen Tammana
Systems, Networking, Network Security

Rajesh Kedia
Computer Architecture, Embedded Systems

Ramakrishna Upadrasta
Compiler, Compilers Optimizations

Shirshendu Das
Computer Architecture, Hardware Security

Artificial Intelligence/Machine Learning Research @IITH

Deep Learning Architecture and Training

- Explore
  - New architectures and models
  - New training methods and loss functions
  - Newer inputs
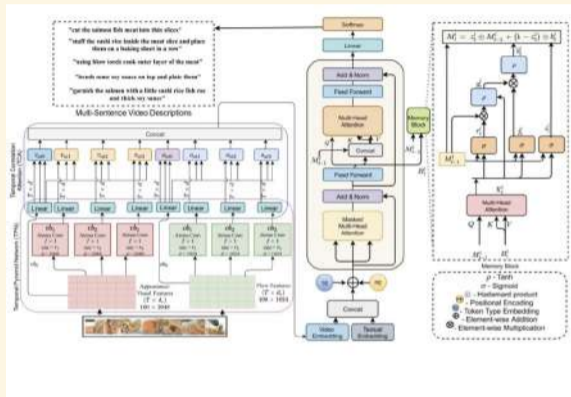
Generative AI

- ▶ 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,…

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

Vehicle interaction as a dynamic Bayesian game without common knowledge prior

What I think others expect me to do
What I expect others to do
What I plan to do

AV
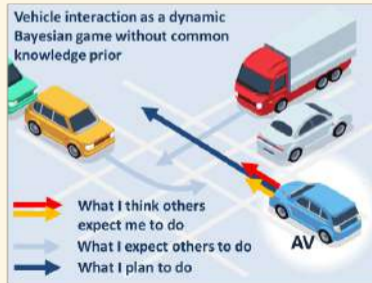
Algorithms for Massive Datasets

- 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"

SAMPLING
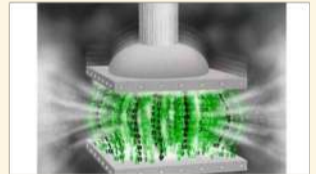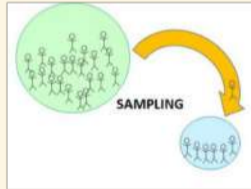
Computer Vision

- ▶ 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 $\{q_1, q_2, \ldots, q_n\}$. Current **query** is q, and p is the **query prefix** typed so far.
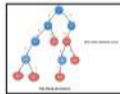
Generate top-N query completions conditioned on current **query prefix p**, additional trie context **e**, and session information **s** i.e., $P_\theta(q \mid p; e; s)$

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
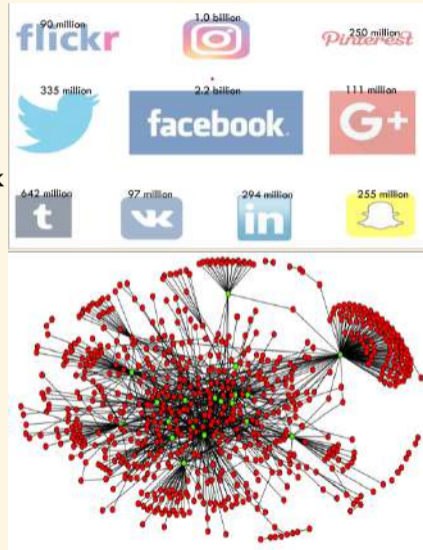
Applied Learning Theory

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

Machine Learning Faculty
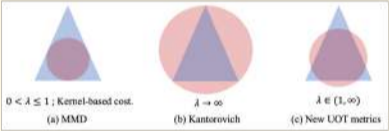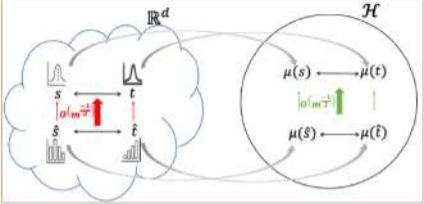
C Krishna Mohan
Video Content Analysis, Machine Learning, Sparsity Based Methods, Deep Learning

Saketha Nath Jagarlapudi
Machine Learning

Manish Singh
Databases, Data Mining, Information Retrieval

Maunendra Desarkar
Recommender Systems, Information Retrieval

Sobhan Babu
Big Data Analytics, Graph Theory and Applied Algorithms

Vineeth N. Balasubramanian
Machine Learning, Computer Vision

Srijith P.K.
Bayesian Data Analysis, Probabilistic Machine Learning, Survival Analysis and Text Analytics

Collaborations

Industry

accenture, QJEANS, Adobe, nasscom, Honeywell, cerebras, Qualcomm, AMD, intel, Innominds, Fujitsu, Microsoft, DENSO

International

University of Haifa / جامعة حيفا, UBC, RICE UNIVERSITY, MIT Massachusetts Institute of Technology, TECHNION Israel Institute of Technology, UMBC, Mohamed bin Zayed University of Artificial Intelligence
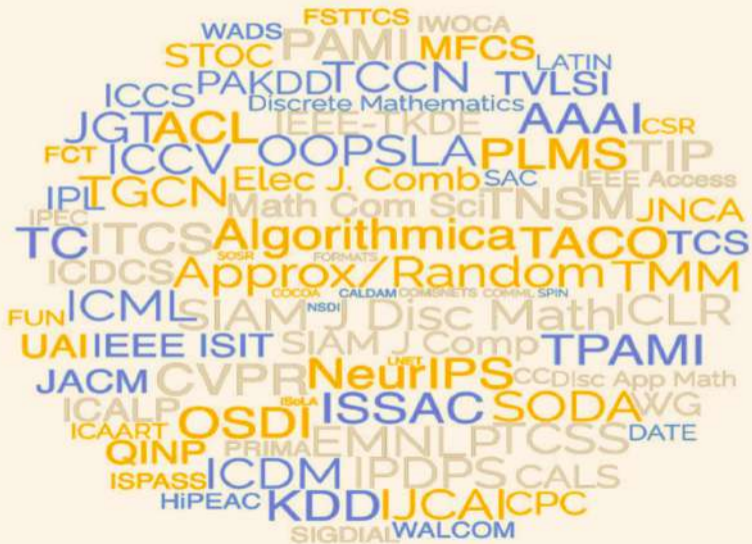
National

IT PALAKKAD

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
JNU Woosong University
JNTU Amrita University
IIT Tirupati IIITDM Kurnool
NIT Nagpur
BITS Pilani IIT Palakkad
IIIT Kottayam

How to Apply?

- We have two regular rounds of admissions with deadlines typically at the end of April and the end of 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.