
Ph.D. @CSE, IITH

Table of Contents

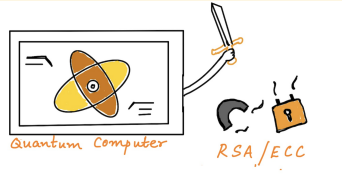
Theoretical Computer Science @IITH

Cryptography

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

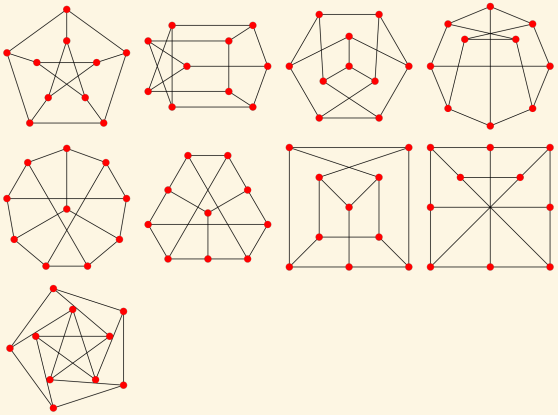
Cryptography

- 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

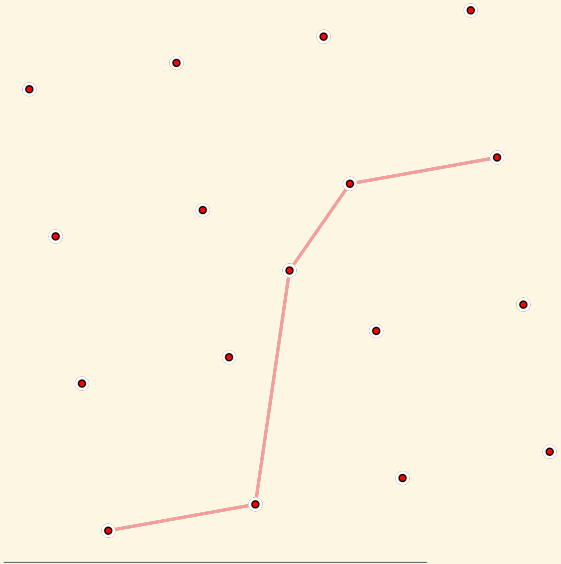


Are they the same graph?

Graph Isomorphism Problem

(Image Courtesy: Wolfram Mathworld)

Combinatorics

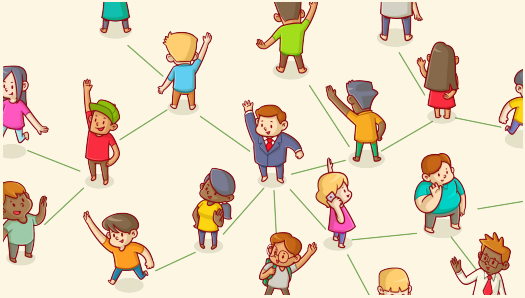


(Image Courtesy: David Eppstein (from Wikipedia))

Erdős Szekeres Problem:

What is the longest increasing/decreasing sequence here?

Combinatorics

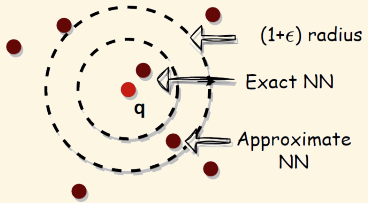


(Image Courtesy: BIG MOUTH for Quanta Magazine)

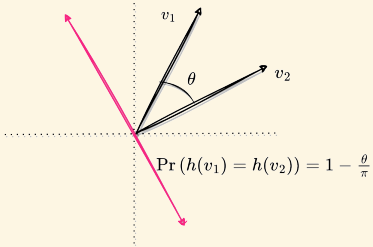
Second Neighborhood Problem:

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



Nearest Neighbors Search via Hashing

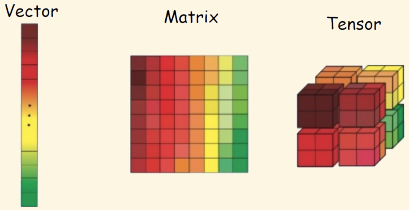
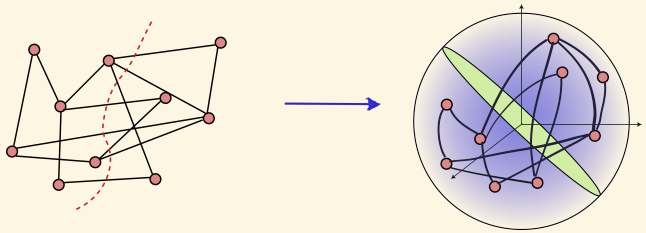


Image courtesy: kdnuggets

- 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



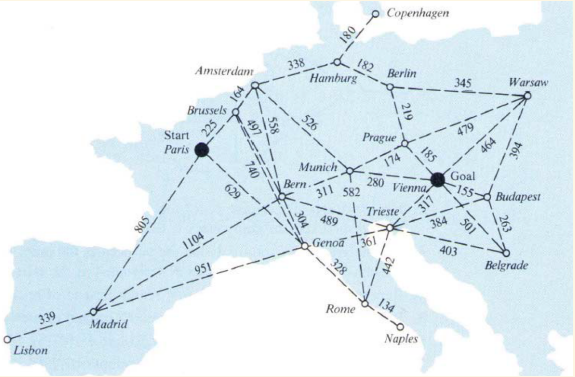
Max-Cut problem:

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!

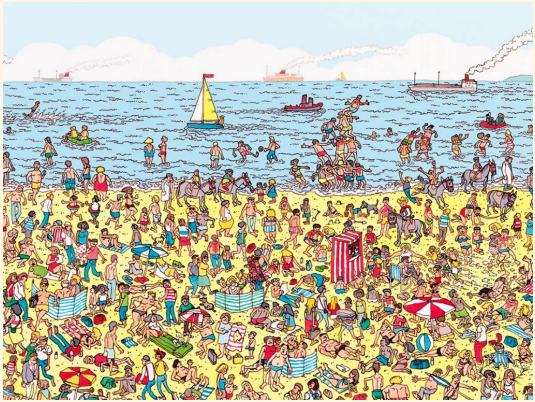
Complexity Theory



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?

Image Courtesies: Media from chegg.com, and linkedin.com

Complexity Theory



Zero Knowledge Proofs:

Can you prove that you have found Waldo without revealing where he is?

Image Courtesies: firstpost.com, and pngitem.com

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

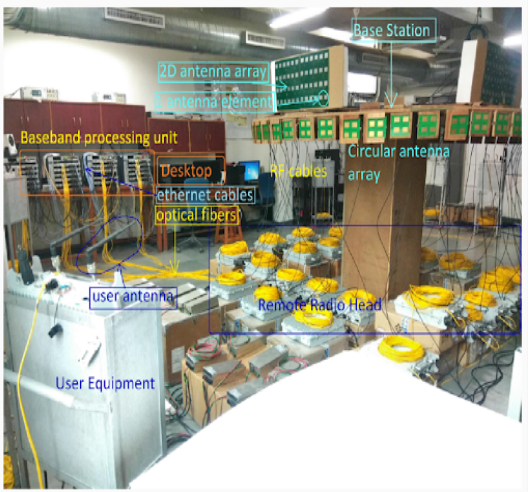
Algorithms, Machine Learning

Manaswi Paraashar

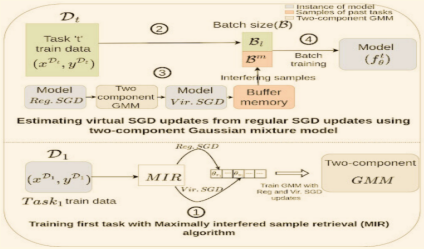
Quantum Computing

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



Department of Science & Technology, Government of India

Edge Cloud for Autonomous Navigation Applications

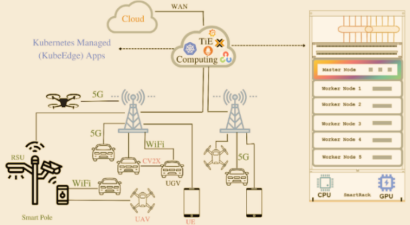
TiHAN IIT HYDERABAD

Indian Institute of Technology Hyderabad

Goal: Bring compute and storage closer to the data source

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

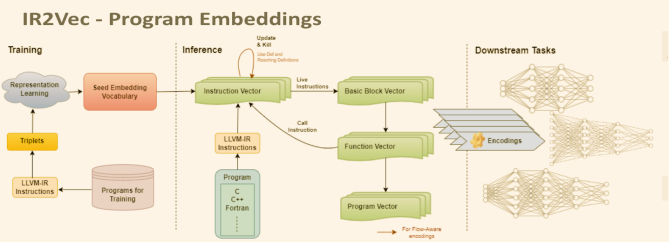
TiE Architecture

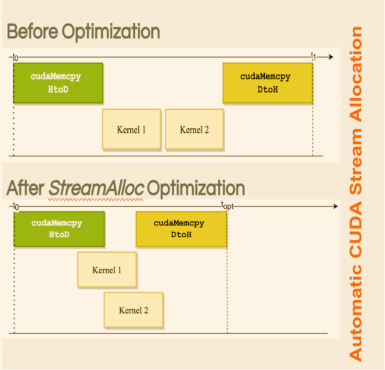


"Experience: Implementation of Edge-Cloud for Autonomous Navigation Applications" IEEE/ACM COMSNETS, Bangalore, India.
Link1, Link 2

Compilers

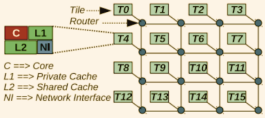
- Program Analysis and Compilers using Machine Learning
- Polyhedral Compilation
- Compiler Optimization Techniques for CPUs and GPUs
- High-performance GPU Algorithms for Scalable Graph Analysis
- Data Race Checking and Parallel Code Compliance Standards



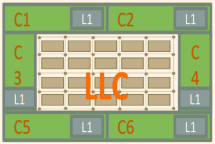


Computer Architecture

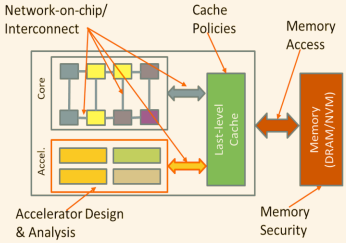
- Thermal Management for 3D Architectures
- Memory Security
- Cache, Interconnects Memory Access Policies
- Resource Sharing in Heterogeneous Architectures
- Non-volatile Memories



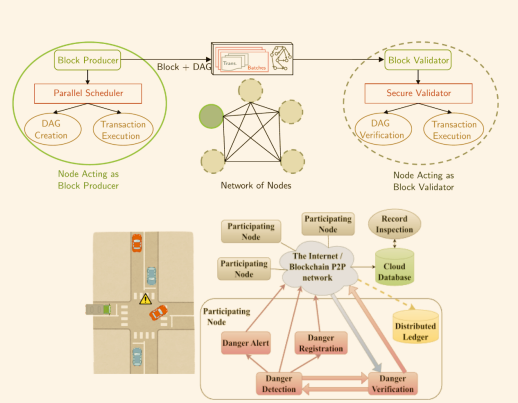
A Chipmultiprocessor (CMP) with tiled architecture.



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

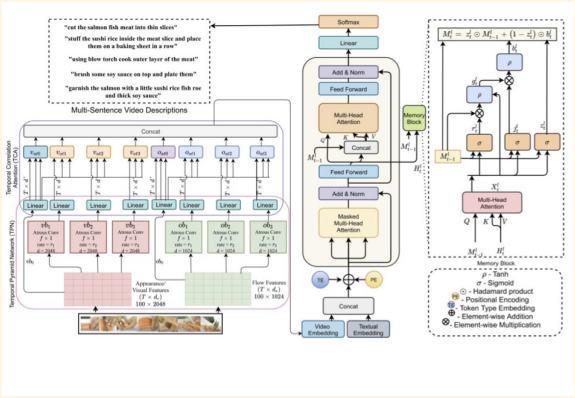
Abhijit Das

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,...

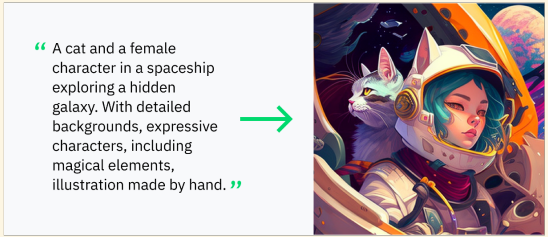
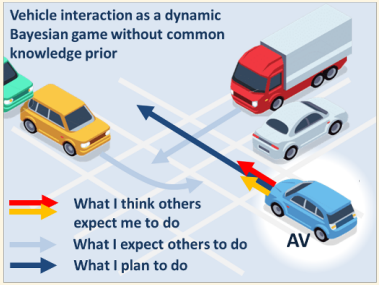


Image Generation

Image Courtesy: generativeai.net

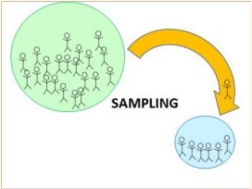
Bayesian Learning

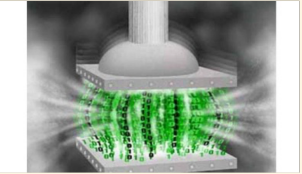
- Use Bayesian Learning for building Safe AI applications
- High risk real-world applications, such as autonomous vehicles and healthcare
- Bayesian Deep Learning provides better decision making by handling uncertainty, robustness and considering domain knowledge



Algorithms for Massive Datasets

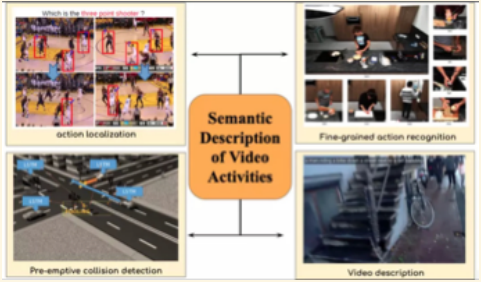
- Developing algorithms for handling large dimensionality and large volume of datasets
  - High-dimensional: text vocabulary, pixels in image
  - Large volume: millions of documents and images
- Develop efficient distributed algorithms – Hadoop/MapReduce
- Use Sketching/Sampling to turn “Big Data into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





Computer Vision

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

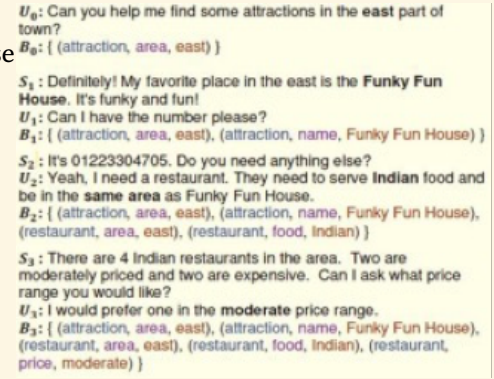


Vision for Drones

- 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

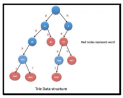
- Computer system intended to converse with a human.
- Uses one or more of text, speech, graphics, gestures, etc., to communicate between human and system
- Build scalable and explainable dialog systems



NLP: Personalized Autosuggest

- Personalized query autocompletion for short and unseen prefixes.

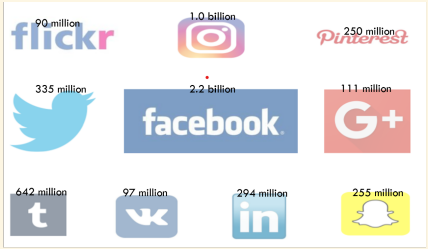
Let previous ***n*** queries (earliest to latest order) in the current **session s** be $\{q_1, q_2, \ldots, q_n\}$. Current **query** is **q**, and **p** is the **query prefix** typed so far.

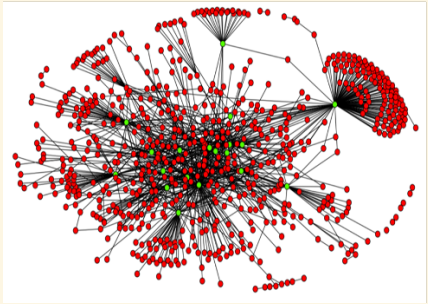


Generate top-**N** query completions conditioned on current **query prefix p**, additional trie context **e**, and session information **s** i.e., $P_\theta(q \mid p; e; s)$

Social Media Analytics

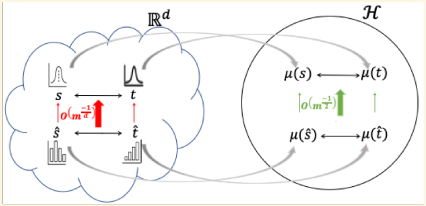
- Information diffusion in social network
- Summarize social media content
- Categorize content
  - Spam vs non-spam
  - Quality of posts and replies
- Content routing

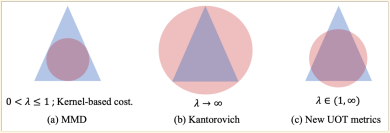




Applied Learning Theory

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





Machine Learning Faculty

C Krishna Mohan

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

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

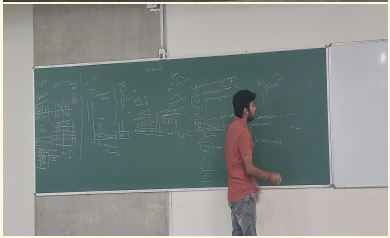
- Large number of servers (with CPU and GPU) available through SLURM and MAAS infrastructure
- High Performance Computing (HPC) cluster available under the National Supercomputing Mission
- OpenStack-based private cloud for Virtual Machines (VMs)
- A large range of IoT and embedded processors and FPGA 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

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.