Gaurav Tarlok Kakkar

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Research Interests

My research interest lies in the intersection of databases and machine learning. Specifically, I am developing a new video database management system - EVA - tailored to efficiently and accurately query videos at scale. My research focuses on improving the resource efficiency, query capabilities, and usability of video database management systems by developing novel query optimization and execution algorithms.

Education

- **Georgia Institute of Technology** — Atlanta, GA
  Ph.D. in Computer Science — *Aug. 2021 – ongoing*
- **Georgia Institute of Technology** — Atlanta, GA
  Master's in Computer Science; **GPA: 4.0/4.0** — *Aug. 2019 – May. 2021*
- **Indian Institute of Technology** — Kanpur, India
  Bachelor of Engineering in Computer Science; **GPA: 9.5/10.0** — *Aug. 2013 – July. 2017*

Publications

- **Gaurav Tarlok Kakkar***, Zhuangdi Xu*, Joy Arulraj, and Umakishore Ramachandran.
  EVA: A Symbolic Approach to Accelerating Exploratory Video Analytics with Materialized Views,
  SIGMOD'22: Proceedings of the 2022 International Conference on Management of Data, June 2022, PA
- **Gaurav Tarlok Kakkar**, Zhuangdi Xu, Prashanth Dintyala, Pramod Chunduri, Anirudh Prabakaran, Suryatej Reddy Vyalla, Jiashen Cao, Jaeho Bang, Abdullah Shah, Sanjana Garg, Aubhro Sengupta, Subrata Mitra, Ali Payani, Yao Lu, Umakishore Ramachandran, Joy Arulraj
  EVA: An End-to-End Exploratory Video Analytics System
  CIDR'23, in review.

Patents

- **GT Kakkar**, M Singh Text Wrap Detection - US Patent 11,151,370 (link)
- M. Rastogi, P. Mehrotra, S. Sinha, **G.Kakkar**. Mapping annotations to ranges of text across documents - US Patent 11,151,307 (link)

- M. Rastogi, P. Mehrotra, S. Sinha, **G.Kakkar**. Digital Annotation And Digital Content Linking Techniques - US Patent 11,048,864 (link)

Experience

A. Research Experience

- **Graduate Research Assistant** GaTech
  Advised by Prof. Arulraj Joy *Aug 2021 - ongoing*

  EVA - A new database management system (DBMS) tailored to efficiently and accurately enable exploratory video analysis at scale. This project focuses on the following problem:

  - **Materialized Views:** EVA automatically materializes and reuses the results of expensive UDFs to facilitate faster exploratory data analysis. It differs from the state-of-the-art reuse algorithms in traditional DBMSs in three ways. First, it focuses on reusing the results of UDFs as opposed to those of sub-plans. Second, it takes a symbolic approach to analyze predicates and identify the degree of overlap between queries. Third, it factors reuse into UDF evaluation cost and uses the updated cost function in critical query optimization decisions like predicate reordering and model selection. Our empirical analysis of EVA demonstrates that it accelerates exploratory video analytics workloads by 4x with a negligible storage overhead (1.001x). The research was presented in SIGMOD 22.
  - **Cascades Optimizer**: EVA has a Cascades-style extensible optimizer implemented from scratch. Since visual queries are often UDF dominant, EVA extends the cascades framework to support new rules tailored for optimizing UDF execution. The optimizer aims to reduce query processing time while meeting user-provided accuracy.
  - **Distributed Execution**: EVA's execution engine leverages heterogeneous computational units (CPUs, GPUs). To support distributed query execution, EVA leverages Ray, a distributed framework. The modular and extensible nature of EVA enables users to write custom UDFs using deep learning frameworks like PyTorch, Tensorflow, etc.

B. Industrial Experience

- **Snowflake** Sunnyvale, USA
  Software Development Intern in **SQL Optimization Team** *Summer'21*

  - Led the research project to drive new query optimizations by analyzing production workloads based on query inter arrival patterns, query types, and execution statistics.
  - Designed architecture to collect and report back the query runtime statistics to the optimization engine to optimize future queries.

- **Google** Sunnyvale, USA
  Software Development Intern in **Cloud SQL** *Summer'20*

  - Led the project to accelerate OLAP (Online Analytical Processing) queries by automatically building columnar cache indexes
  - Improved the query statistics collection engine and building ML driven columnar cache index advisor.

- 5x improvement in query execution time with no manual cost overhead and worked towards US patent.

- **Adobe Systems** Noida, India
  Member of Technical Staff *Jul 2017 - Aug 2019*
  - **Regenerate Layout from PDFs**: Research project
    - Built a multitude of ML algorithms processing together along with Software level heuristics to provide a single click layout generator from an inspiration pdf
    - Implemented a deep learning model, modified Faster RCNN to detect shape agnostic text wrap in a given pdf
    - Tackled challenges viz. detecting white space cover, creating master pages, organizing raw text runs into well defined text frames and intelligently figuring out object styles.

    Key Achievements: Filed patent in US on shape agnostic text wrap detection, implemented document analysis techniques and researched on core text properties.
  - **Import PDF Comments**: Keynote feature shipped with InDesign Max 2019
    - Implemented a novel approach to import and easily track the feedback made on a pdf version of document, solving the most in demand feature request of our million designers
    - Mastered the existing PDF library, to tackle the challenges of associating text or graphics with the annotation.

    Key Achievements: Filed patent in US and mastered PDF Library APIs

- **Adobe Systems** Bangalore, India
  Research Intern in Big Data Experience Lab *May 2016 - July 2016*
  - Generating personalized bundles of products for customers of e-Commerce website that are needs-driven.
  - Formulated a novel approach of incorporated common sense knowledge, Concept net along with data driven insights.
  - Formed candidate set using hierarchical and minimum spanning tree based clustering algorithm over customer centric data enriched by semantic analysis. (slides)

Presentations and Talks

- **EVA: An End-to-End Data System for Querying Videos At Scale**
  Adobe Research, Bangalore, Jan 2022
  Workshop on Video Analytics, Stanford, CA, May 2022
- **A Symbolic Approach to Accelerating Exploratory Video Analytics with Materialized Views**
  ACM SIGMOD, Philadelphia, July 2022
- **Algorithmic approach to mapping annotations to ranges of text across PDF documents**
  Adobe Tech Summit, San Francisco, CA, Feb, 2019
- **Text Wrap in documents and Images using deep learning**
  Lightning Talk at Grace Hopper Celebration, India, Nov 2018

Teachings

A. Teaching Assistant

Semester	Course	Position
Fall 2022	Database System Implementation (Part I)	Head TA
Spring 2022	Database System Implementation (Part II)	Head TA
Spring 2021	Database System Implementation (Part II)	Head TA
Fall 2020	Database System Implementation (Part I)	Head TA
Fall 2019	DDL Data Analytics using Deep Learning	TA

B. Mentor/Student Guide

B.1. Masters

- 2022: Anirudh Prabakaran, Kaushik Ravichandran, Atul Tulsidas Avhad, Ishwarya Sivakumar, Adarsh Honawad
- 2021: Anirudh Prabakaran, Suryatej Reddy, Devshree Bharatia

B.2. Undergraduate

- 2022: Aryan Rajoria, Aubhro Sengupta
- 2021: Vivian De Sa Thiebaut, Abdullah Shah, Lixing Liu, Raj Srivastava

B.3. High School: Technovation

- Motivated a girls team to pursue STEM by mentoring them in app development challenge
- Team qualified for Nationals, aimed to provide Public Service to Minority & LGBTQ+ community

Recognition and Awards

2017 Dr. Elizabeth & Varkey Cherian Award(Best UG project with an impact on campus community)
2017 Academic Excellence Award, IIT Kanpur (awarded to top 7% students in the institute)
2014 Academic Excellence Award, IIT Kanpur (awarded to top 7% students in the institute)
2013 All India Rank 236, IIT-JEE Advanced (among 150,000 candidates).

Relevant Courses

- **Systems**: High Performance Parallel Computing, Advanced Operating Systems, Database Technologies, Computer Architecture, Compiler Design, Computer Networks, Computer Security, Advanced Data Structure and Algorithms

- **ML/Data Science**: Data analysis using Deep Learning, Recent Advances in Computer Vision, Machine Learning Tools and Techniques, Natural Language Processing, Data Visualization and Analysis

Key Projects

- **[ML Systems] Fast Array of Wimpy GPUs (FAWG)** GaTech

  Research Project with Prof. Alexey Tumanov *Sep. 2020 – Jan. 2021*

  - Serve memory-hungry models using model parallelism on cheap wimpy GPUs while meeting the latency SLOs
  - Proactive planner regresses over the batching parameters, model partitions, operator replicas, hardware types, and operator placement to search for a cost-effective model serving plan
  - The reactive planner behaves as a high-frequency tuner to auto-scale to meet tail latency goals in response to changes in the query arrival process.

- **[Computer Vision] Dense Image Captioning with NMS Convnet** IITK, India

  Research Project with Prof. Gaurav Sharma *Aug. 2016 – Nov 2016*

  - Analyzed the work - DenseCap by Andrej Karpathy et. al. - by experimenting with the parameters and design choices of Fully Convolutional Localization Network on Visual Genome dataset
  - To discard the existing test-time non-maximal suppression, used trainable spatial suppression layer from the work - A convnet for non-maximum suppression by Jan Hosang et. al. - to enhance the mAP of DenseCap from 5.698 to 5.76 (report) (slides)

- **[NLP] Automatic Abstract Generation for Research Papers** IITK, India

  Research Project with Prof. Harish Karnick *Aug. 2016 – Nov 2016*

  - Used a conglomerate of Extractive and Abstractive summarization techniques to generate abstracts for research/academic papers.
  - Used Topic Models, TextRank and Latent Semantic Analysis to extract important sentences which were fed into an RNN encoder-decoder network.
  - The model was trained on NIPS research papers and evaluated using the ROUGE metric. (report)

- **[Databases] Cafeteria Automation System** IITK, India

  Under-Graduate Project with Prof. Sumit Ganguly *Jan. 2016 – Dec 2016*

  - Designed a desktop app in C# incorporating mess menu creation, consumption Records, items BOM management, worker Attendance and salary management.
  - Won **Dr. Elizabeth & Varkey Cherian Award - Best UG project** with an impact on campus community.

- As of May 2017, managed over 2,00,000 transactions of worth greater than INR 3.4 million. (slides) (code)

- **[CyberSecurity] Online Identity and Authentication using Blockchain** IITK, India

  Under-Graduate Project with Prof. Sandeep Shukla *Jan. 2017 – Apr 2017*

  - Design a novel protocol over Ethereum that leverages smart contracts and security of distributed ledger technology, to solve the problem of online identity and decentralized authentication while still preserving privacy.
  - Protocol covers all the key aspects viz. account creation(sign-up), account updation (authentication), account updation (authentication involving third party) and credential verification(sign-in). (report)(slides)

- **[Computer Architecture] Load Value Prediction** IITK, India

  Research Project with Prof. Mainak Chaudhuri *Jan. 2017 – Apr 2017*

  - Analyzed SPEC2006 benchmarks for the presence of Value Locality within instruction using different history depths.
  - Implemented a Load Value Prediction Unit to enable instruction level parallelism using PIN tool and analyzed its performance on the SPEC2006 benchmarks. (report)

- **[ML] Real Time Background Foreground Segmentation** IITK, India

  Research Project with Prof. Harish Karnick *Jan. 2016 – Apr 2016*

  - Classifying the input frames from campus surveillance video into foreground and background frames.
  - Achieved an accuracy of 98.37% by implementing the **Codebook algorithm** augmented with the **Sobel-Feldman operator**. (report)

- **[Compiler] End to end Compiler for Go Programming Language** IITK, India

  Course Project with Prof. Subhajit Roy *Jan. 2016 – Apr 2016*

  - Implemented from scratch an entire pipeline of compiler; lexical analyzer, parser, semantic analyzer, conversion to intermediate language(MIPS), code generator.
  - Supported a wide range of Go Language features viz. arrays, nested loops, recursive function calls, type inference, arithmetic/boolean operations

- **[Operating Systems] NachOS** IITK, India

  Course Project with Prof. Mainak Chaudhari *Aug. 2015 – Nov 2015*

  - Extended the standard system call library for NachOS.
  - Implemented scheduling algorithms viz. UNIX scheduling, Round Robin, Non Preemptive and Shortest Job First.
  - Implemented page replacement algorithms viz. Random Page-Allocation, FIFO, LRO and LRU Clock.

Technical Skills

Languages	Python, C++, C, SQL, OpenMP, MPI, Js, Go, Bash, Assembly, HTML, CSS
ML	Tensorflow, Keras, scikit-learn, OpenCV