Rajrup Ghosh

Doctoral Student in Computer Science
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Interests

Research: Volumetric Video, AR/VR Streaming, 3D Capture and Rendering, Immersive Video Delivery, Systems for ML
Related: 3D Computer Vision, Media Delivery, Edge Computing, Cloud Computing

Education

University of Southern California (USC)
Los Angeles, USA

Ph.D. in Computer Science
Aug 2019 - Dec 2025 (exp.)

- **GPA:** 4.0/4.0
- **Position:** Research Assistant in **Networked Systems Laboratory (NSL)**
- **Advisor:** **Prof. Ramesh Govindan**

Indian Institute of Science (IISc)
Bangalore, India

M.TECH. in Computational Science
Aug 2015 - July 2017

- **GPA:** 6.8/8.0, Gold Medalist

Indian Institute of Engineering Science and Technology (IIEST)
Shibpur, India

B.E. in Computer Science and Technology
July 2011 - Apr 2015

- **GPA:** 9.3/10.0

Projects

Immersive Video Project [NSL]
USC, Los Angeles

Live Volumetric Video Streaming
Aug 2021 - present

- ***Point Cloud-based*:**
  - Volumetric videos capture 3D scenes in six degrees of freedom (**6DoF**), often represented as **point clouds**.
  - Developed an end-to-end pipeline to **live-stream** volumetric video over the internet at **30 fps** within **300 ms**.
  - Designed **bandwidth adaptation** for robust streaming in fluctuating network conditions.
  - The system leverages popular streaming technologies such as ***GStreamer***, ***Nvidia Codec SDK***, and ***WebRTC***.
  - **Challenges:** *Real-time encoding/decoding*, *Bandwidth adaptation*, *Low latency*, *Full frame rate*.
- ***Neural-based*:**
  - Live capture and streaming of photo-realistic representation of participants/scenes for **3D Telepresence** application.
  - Using **NeRF/Gaussian Splatting** model to represent each frame of volumetric video.
  - Building the system using modern tools/frameworks such as ***NerfStudio*** and ***Unity***.
  - **Challenges:** *High bandwidth*, *On-the-fly training*, *Inference on headset*, *Real-time rendering*.
- **Applications**: Telepresence, Virtual Classroom, Collaborative Workspace, Telemedicine, AR/VR Multiplayer Gaming.
- This project is a part of **NSF Grant – Multi-perspective Video**.

AR Localization Project [NSL]
USC, Los Angeles

AR Localization Using Gaussian Splatting
May 2024 - present

- Proposed a method to perform **AR localization** by representing a map of an outdoor environment using **Gaussian Splatting (GSplat)**.
- **On-device** (iPhone, iPad, Vision Po) implementation of feature matching, GSplat rendering, and localization.
- Online **appearance adaptation** of the outdoor map in GSplat based on the time-of-day.
- The system is implemented in ***Swift*** using Apple's ***Metal*** library to replicate ***CUDA***-based rasterization.
- **Challenges:** *On-device GSplat rendering*, *Sparse linear optimization*, *Fast Gaussian sorting*

Drone Project [NSL]
USC, Los Angeles

LIDAR-based Fast 3D Reconstruction using Drone, *IMWUT/UbiComp 2023* [Paper]
June 2021 - Dec 2021

- Capture **3D structures** like buildings, airplanes using a drone-mounted **LIDAR** in the form of **point clouds**.
- Formulated **trajectory planning** as an optimization problem to minimize battery consumption, solved using ***Gurobi*** Library.
- Offload heavy computation such as localization using **SLAM** and point cloud registration using ICP to the Cloud.
- Implemented efficient point cloud compression using ***Draco***, adjusting compression ratios based on available bandwidth.

CONIX Project [NSL]

USC, Los Angeles

Accelerating Deep Neural Network Inference

Jan 2020 - May 2021

- ***Scrooge, ACM SoCC 2021*** **[Paper]:**
  - A framework for scheduling data-dependent **DNN** workloads on **Cloud Clusters** that satisfy application SLOs, while minimizing VM cost.
- ***RIM, IoTDI 2021*** **[Paper]:**
  - A framework for placing **DNN** applications on **Edge Clusters** that satisfy throughput and latency, while achieving high GPU utilization.
- These projects are part of **CONIX Research Center**.

Masters Thesis [DREAM:Lab]

IISc, Bangalore

Distributed Scheduling of Event Analytics across Edge and Cloud

Jan 2016 - June 2017

- The thesis focused on efficient static and dynamic **scheduling** of distributed run-time query plans for complex event processing.
- Designed **algorithms** to map user queries on heterogeneous resources such as **Edge devices** (Raspberry Pi) and **Cloud VMs** (Azure).
- **Challenges:** *Compute latency*, *Network bandwidth*, *Battery capacity*
- This project was a part of **IISc Smart Campus Project**.

Selected Publications

Bandwidth-Adaptive Volumetric Video Streaming

Submitted

R. Ghosh, C. Shin, L. Zhang, M. Ye, H. V. Madhyastha, R. Netravali. A. Ortega, S. G. Rao, R. Govindan

- Low-latency live streaming of volumetric videos over the internet with bandwidth adaptation for 6DoF video conferencing.

On-Device Outdoor AR Localization Using Gaussian Splatting

Submitted

W. Pang, **R. Ghosh**, J. Yang, Z. Wei, B. Leong, Y. Wang, R. Govindan

- On-device outdoor AR localization targeted for mobile devices, particularly Apple devices.

AeroTraj: Trajectory Planning for Fast, and Accurate 3D Reconstruction using a Drone-based LiDAR

IMWUT/UbiComp

F. Ahmad, C. Shin, **R. Ghosh**, J. D'Ambrosio, E. Chai, K. Sundaresan, R. Govindan

Sep 2023

- IMWUT - Vol. 7 Issue 3
- UbiComp 2023 - 25th ACM international joint conference on Pervasive and Ubiquitous Computing, **URL:** Paper

Scrooge: A Cost-Effective Deep Learning Inference System

SoCC

Y. Hu, **R. Ghosh**, R. Govindan

1-3 Nov 2021

- SoCC 2021 - 12th ACM Symposium on Cloud Computing, **URL:** Paper

Rim: Offloading Inference to the Edge

IoTDI

Y. Hu, W. Pang, X. Liu, **R. Ghosh**, B. Ko, W. Lee, R. Govindan

18-21 May 2021

- IoTDI 2021 - 6th ACM/IEEE Conference on Internet of Things Design and Implementation, **URL:** Paper

Adaptive Energy-Aware Scheduling of Dynamic Event Analytics across Edge and Cloud Resources

CCGRID

R. Ghosh, S. P. R. Komma, Y. Simmhan

1-4 May 2018

- CCGRID 2018 - 18th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, **URL:** Paper

Distributed Scheduling of Event Analytics across Edge and Cloud

ACM TCPS

R. Ghosh, Y. Simmhan

Sep 2018

- ACM Transactions on Cyber-Physical Systems (TCPS), **URL:** Article

Experiences

Networking Research Group, Microsoft Research

Microsoft Research, Redmond

Research Internship - Krishna Chintalapudi, Nikunj Raghuvanshi, Ranveer Chandra

May 2022 - Aug 2022

- Developed a **VR Supermarket** application where users can have real-life purchase experiences.
- Supermarket provides personalized experience based on user's profile such as customized layouts, advertisements, and music.
- The system is built in ***Unity*** using ***Oculus XR*** and ***Triton Audio Spatialization*** plugin.

DMX Group, Microsoft Research

Microsoft Research, Redmond

Research Internship - Krishna Chintalapudi

June 2020 - Aug 2020

- Greedy layer-by-layer neural network training for tasks such as image classification, detection, and segmentation.
- Developed segmentation-based **person tracking** using body parts-based re-identification.
- Conceptualized automated model training for machine learning systems deployed in production pipelines.

Advanced Technology Lab, Samsung R&D Institute India *Samsung R&D Institute India*

Lead Engineer (Research Position) *July 2017 - July 2019*

- Built **on-device Neural Network**-based solutions for smartphone keyboard applications like Swipe, Auto-correct, and Emoji Prediction.
- Developed applications over **Blockchain** - User Authentication System for smart building and peer-to-peer payment system.
- Developed an **IoT Query Engine** to perform data fusion on home appliance data stored across different SQL and NoSQL datastores.

Crypto Research Lab, IIT Kharagpur *IIT Kharagpur*

Summer Internship - Prof. Dipanwita Roy Chowdhury *Sum. 2013, Sum. 2014*

- Cryptanalysis of a light-weight hash function PHOTON using **fault-based attack** technique similar to Diagonal Faults for AES. A similar technique was applied for a SHA-3 Finalist hash function GROSTL.
- Studied the design and cryptanalysis of SHA-3 standard Keccak Hash Function for reduced round attacks.

Skills

Programming: C, C++, Python, Swift, Android, Java, MATLAB, Golang
Frameworks/Platforms: GStreamer, WebRTC, Open3D, Point Cloud Library (PCL), Draco, Unity, PyTorch, CUDA, Metal, OpenMP, MPI
Development Tools: Visual Studio, Xcode, Android Studio, Eclipse
Databases: Oracle, MySQL, MongoDB

Services

Reviewer: IEEE Vehicular Technology Magazine, Elsevier Computer Communications, Elsevier Computer Networks
Artifact Evaluator: JSys 2024, EuroSys 2025, NDSS 2025, SOSP 2024, NDSS 2024, MLSys 2023, SOSP 2023
Referred Reviewer: NSDI 2024, Mobicom 2023, NSDI 2023, NSDI 2022, Mobicom 2022, SOCC 2021

Achievements

Apr 2022 Nominated for **Outstanding Mentor Award** in the Spring 2022 Viterbi Graduate Mentorship Program.
2019 - Pres. Received **Annenberg Fellowship** for outstanding Ph.D. student joining in Fall 2019.
June 2018 Received **Motorola Gold Medal** for best performance in Master's degree in both academic courses and thesis.
June 2016 **Second** in Microsoft Research IoT Summer School hackathon on innovative IoT applications/projects.
2015 - Pres. Participated in Google APAC 2017 (Best Rank - 412), ACM ICPC 2015.
Jan 2015 Received **INAE (Indian National Academy of Engineering) Fellowship** for performance in internship under an INAE Fellow.

Teaching

CS 551/651: Teaching Assistant for **CS 551/651 - Advanced Computer Networks** in Spring 2022. *Instructor*: Prof. Ramesh Govindan
COS 598a: Guest Lecture at Princeton University for **COS 598a - Machine Learning-Driven Video Systems**. *Instructor*: Prof. Ravi Netravali

Courses

Systems: Operating Systems, Computer Networks, Distributed Systems, High-Performance Computing, Parallel Programming
ML: Advanced Computer Vision, Artificial Intelligence, Data Analytics, Data Analysis and Visualization
Basic: Design and Analysis of Algorithms, Probability & Statistics, Numerical Linear Algebra, Numerical Methods