

Zhehan Qu

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RESEARCH INTERESTS

AI-assisted safe Augmented Reality (AR) systems, using eye tracking and machine learning for user context sensing, particularly sensing human attention. My research is oriented around building effective deep learning models with eye tracking data to detect suboptimal user attention patterns in AR and to integrate such models into AR systems to provide real-time feedback to users and mitigate potential safety risks by adaptively adjusting AR content. I'm also broadly interested in other aspects of safe AR systems, including but not limited to semantic sensing of the physical environment, securing AR-based human-robot collaboration and edge-assisted AR applications.

EDUCATION

Duke University

Ph.D. Candidate, Computer Science

Aug. 2022 – Present

Durham, NC, USA

- **Selected Courses:** Theory & Algorithms of Machine Learning, Causal Analysis, Edge Computing, Computer Networks
- **GPA:** 4.0/4.0
- **Advisor:** Prof. Maria Gorlatova

Shanghai Jiao Tong University

Bachelor, Computer Science and Engineering (IEEE Honor Class)

Sep. 2018 – June 2022

Shanghai, China

- **Selected Courses:** Algorithms, Discrete Math, Programming Language, Data Science, Natural Language Processing
- **GPA:** 3.8/4.3

RESEARCH EXPERIENCE

Modeling Situational Awareness in AR-Guided CPR

Intelligent Interactive Internet of Things Lab

Oct. 2024 – Present

Duke University

- Designed and implemented an AR application for **AR-Guided cardiopulmonary resuscitation (CPR)**, along with simulated bleeding and vomiting incidents to evaluate **situational awareness** of CPR providers using AR guidance.
- Identified that **slower and shorter saccades** and **longer time fixated on virtual content** were correlated with situational awareness based on whether the incidents were detected and handled properly.
- Designed a **graph neural network** that represents fixations as nodes and spatial-temporal relationships between fixations as edges, achieving **83% accuracy** in predicting situational awareness based on 7s of eye tracking data.
- Paper accepted to **IEEE ISMAR 2025**, a leading conference in the field of augmented and virtual reality.

Analyzing and Predicting the Distraction Potential of Augmented Reality

Intelligent Interactive Internet of Things Lab

July 2023 – Sept. 2025

Duke University

- Developed a **Sudoku helper** application for **AR** and **VR** to study user attention, incorporating step-by-step guidance and controlled visual distractions.
- Conducted a comparative analysis of attention patterns using **eye tracking** in AR and VR, revealing that VR simulations induced a **higher perceptual load** and reduced user focus, while AR increased **cognitive load**, as indicated by **increased fixation duration and decreased fixation rate**.
- Helped to build an AR version of the **Trail Making Test (TMT)** to assess the impact of different distraction types (top-down, bottom-up and spatial), showing that **top-down distractions** (task-relevant) caused the most significant performance degradation, while **bottom-up distractions** (salient but task-irrelevant) had only early-stage effects. Eye tracking data indicated that top-down distractions led to **increased fixation rate** while bottom-up distractions resulted in **lower gaze entropy**, suggesting effective suppression of irrelevant stimuli.

- Trained **time-series Transformers** on eye tracking data to predict the presence of distractors and assess user attentional control.
- Papers were accepted to **IEEE ISMAR 2024** and **ACM VRST 2025**.

Federated Learning with Data Augmentation

Advanced Network Laboratory

July 2020 – May 2022
Shanghai Jiao Tong University

- Focused on **statistical heterogeneity in federated learning (FL)**, aiming to alleviate the problem of **non-IID data**
- Added a data augmentation stage during global training of FL to complement lacking labels on each client to stabilize distribution of data selected each round; locally fine-tune the model before testing on clients

Readability Controlled Open-Domain Question-Answering System on COVID-19

AI+X Project-Based Learning, NLP Program

Feb. 2021 – May 2021
MIT & Touch EdTech

- Built an open-domain **question-answering (QA)** system based on RAG structure, which enables control of the readability of the answer
- Prepend readability scores to sentences to fine-tune BART, the generator part of RAG, following the CTRL manner; modified the retriever of RAG by adding a score of readability match in addition to similarity check
- Collected datasets from Wikipedia and the WHO official websites to build the knowledge base (>3GB) and the dataset of QA pairs (2000+ entries)

Privacy-Preserving Inference in Crowdsourcing Systems

"Participation in Research" Program

Sept. 2019 – Mar. 2020
Shanghai Jiao Tong University

- Worked on a crowdsourcing indoor localization system where privacy of all participants are guaranteed by differential privacy
- Perturb user data to avoid information leakage, while preserving certain degree of accuracy following the idea of differential privacy
- Implemented via java pailiar, full participation of coding

Internship

Gematria Technologies

Intern (Remote)

Sept. 2021 – Jan. 2022
London, U.K.

- Worked on processing news articles with various tools related to **Natural Language Processing**, including NER, co-reference resolution, entity linking and sentiment analysis. The work aimed at discovering the sentiment of a given topic in news reports in a certain time period, and further exploiting the information for predicting trends in the stock market

Teaching

- **COMPSCI 370D**: Teaching Assistant, Intro to AI (1 unit), Spring 2023
- **COMPSCI 371**: Teaching Assistant, Elements of Machine Learning (1 unit), Fall 2023

Professional Activities

Reviewer

- ACM VRST 2025
- ACM UbiComp/ISWC 2025
- ACM Transactions on Sensor Networks 2024

Research Supervision

Ahmad Choudhary, Undergrad, Duke University

Jan. 2025 – April 2025

Fareeda Akewusola, Undergrad, Duke REU Program

May 2024 – July 2024

Ryleigh Byrne, Research Associate, Duke University

Oct. 2023 – April 2024

HONORS

Best Doctoral Consortium Presentation Honorable Mention

Oct. 2024

NSF AI Spring School Applied AI Poster Award

Mar. 2024

Zhiyuan College Honor Scholarship

2019, 2020, 2021

SKILLS

Programming: Python, C#, C++, R

Machine Learning & Deep Learning: TensorFlow, Keras, Scikit-Learn, PyTorch, Hugging Face Transformers

Tools & Frameworks: Unity (MRTK, Magic Leap SDK), Vuforia, Pandas, Pingouin, pymer4, lme4 (R)

Research Methods: Human-Subjects Research, Statistical Analysis (ANOVA, LMMs), User Study Design & Execution

XR Platforms: Microsoft HoloLens 2, Magic Leap 2, HP Omnicept, Apple Vision Pro

Publications

Note: I primarily publish my work in *IEEE International Symposium on Mixed and Augmented Reality (ISMAR)* and *IEEE Virtual Reality and 3D User Interfaces (VR)*, which are the core venues of the XR community. *ACM Symposium on Virtual Reality Software and Technology (VRST)* is also a leading conference in this field. I also publish in *ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN)*, which is a top-tier conference in the field of sensor networks and IoT.

Conference Proceedings

- **[VRST25]** S. Baek, **Z. Qu**, M. Gorlatova, AR-TMT: Investigating the Role of Distraction Type and Attention Control in AR Visual Search. To be presented at ACM VRST, Nov. 2025. Code: <https://github.com/Duke-I3T-Lab/AR-TMT>
- **[ISMAR25a]** **Z. Qu**, T. Hu, C. Fronk, M. Gorlatova, Will You Be Aware? Eye Tracking–Based Modeling of Situational Awareness in Augmented Reality. To be presented at IEEE ISMAR, Oct. 2025.
Video demo: https://www.youtube.com/watch?v=wGF_hvBP-hg; Code: https://github.com/Duke-I3T-Lab/AR_CPR_SA
- **[ISMAR25b]** T. Hu, T. Du, **Z. Qu**, M. Gorlatova, Spatial Sensing Evaluation for Multiple XR Devices. To be presented at IEEE ISMAR, Oct. 2025. Code: https://github.com/Duke-I3T-Lab/XR_Tracking_Evaluation
- **[ISMAR24]** **Z. Qu**, R. Byrne, and M. Gorlatova, “Looking” into Attention Patterns in Extended Reality: An Eye Tracking–Based Study. In Proc. IEEE ISMAR, Oct. 2024.
Video demo: <https://www.youtube.com/watch?v=KJo9mlpy4hQ>; Code: https://github.com/Duke-I3T-Lab/XR_Attention_Sudoku
- **[IPSN24]** L. Duan, Y. Chen, **Z. Qu**, M. McGrath, E. Ehmke, M. Gorlatova, BiGuide: A Bi-Level Data Acquisition Guidance for Object Detection on Mobile Devices. In Proc. ACM/IEEE IPSN, May 2024. **(21.5% acceptance rate)**. **IEEE/ACM IPSN Best Research Artifact Runner-up Award**. Code: <https://github.com/BiGuideCollection/BiGuide>

Workshop Proceedings

- **[IEEEVRW24]** S. Eom, T. Ma, N. Vutakuri, A. Du, **Z. Qu**, J. Jackson, M. Gorlatova, Did You Do Well? Real-Time Personalized Feedback on Catheter Placement in Augmented Reality-Assisted Neurosurgical Training, In Proc. IEEE VR Abstracts and Workshops, Mar. 2024.

Conference Demonstrations

- **[XRSecurity25]** **Z. Qu**, T. Hu, M. Gorlatova, Demo: More Than Just Compressions: Attentional Tunneling in Augmented Reality–Guided Cardiopulmonary Resuscitation. To be presented at the First Workshop on Enhancing Security, Privacy, and Trust in Extended Reality (XR) Systems, Oct. 2025.
Video: <https://www.youtube.com/watch?v=2MfYJF6sW8A>

Poster Presentations

- **[IEEEVRW24]** R. Byrne, **Z. Qu**, C. Fronk, S. Eom, T. Scargill, M. Gorlatova, AR Simulations in VR: The Case for Environmental Awareness, In Proc. IEEE VR Abstracts and Workshops, Mar. 2024.

Doctoral Consortium

- **[ISMAR24] Z. Qu**, Attention-Safe Augmented Reality System with Edge Computing. In Proc. IEEE ISMAR-Adjunct, Oct. 2024. **Best Doctoral Consortium Presentation Honorable Mention.**