Aryabrata Basu

Research Statement

"Every great advance in science has issued from a new audacity of imagination." - John Dewey, The Quest for Certainty, 1929

Origins

The year was 1993, and I was excited to visit my uncle Debabrata for he has promised to show me a Personal Computer (PC) with the original Pentium (P5 microarchitecture) microprocessor. As a third-grader, all those specifications meant little except for one aspect of PCs, which is video-games or better known as DOS-Games back then. He showed me all his collection of DOS-Games one by one, and the amazing thing about those games was the human-computer interaction of a video-gaming experience. The notion that a few keystrokes can manipulate virtual characters, vehicles, etc., in real-time still amazes me to this day. This sparked a lifelong appreciation for digital visualization via Computer Graphics. My current research interests have taken me far from those joyful days of video-gaming to creating experiential simulations of places that don't exist or hyper-realistic spaces in an effort to understand human behavior in space-time.

Motivation and Research Philosophy

Virtual Reality (VR), since its inception by Ivan Sutherland in 1968, has rapidly evolved from laboratory-bound experiments to widely accessible, ubiquitous systems. Despite this advancement, persistent usability issues such as simulator sickness, ergonomic discomfort, and technological encumbrance remain barriers to VR's broader acceptance. My research aims to systematically investigate these issues, improving the practical usability of VR through thoughtfully designed, low-encumbrance immersive systems and rigorous user-centric evaluations.

I believe that the future of VR depends on making immersive technologies not only powerful and intuitive but also comfortable and widely accepted by users across various contexts and skill levels.

Previous Work

My previous research focused on developing accessible, portable VR systems through the design and evaluation of the UCAVE framework. This lightweight VR setup utilized a smartphone-based head-mounted display, allowing natural head rotations to interact seamlessly within virtual environments. Through formative user studies, we first investigated the ergonomic impact of perceived tethering on user performance, confirming the benefits of an untethered VR design. Subsequent studies examined environmental factors, revealing improved performance when virtual environments closely matched the physical surroundings—particularly in outdoor settings. Additional research into human

EIT Building Rm 572, 2801 S University Ave, Little Rock, AR 72204
📱 (706) 254 7984 • ✉ abasu@ualr.edu
🌐 ualr.edu/computerscience/aryabrata-basu/ • LinkedIn Profile   1/3

factors demonstrated that previous video-gaming experience significantly influenced VR usability, highlighting biases introduced by familiar interaction devices, such as game controllers.

My dissertation's contributions to the field of VR are as follows:

○ The Ubiquitous Collaborative Activity Virtual Environment (UCAVE), a framework conceptualized with universally accessible technology to enable untethered and portable VR experiences.

○ Designing and evaluating VR user studies in order to further evaluate ergonomic, environmental, human, and technical factors affecting users in immersive VR experiences.

○ Understanding the core impact of deploying immersive VR experiences via HMD technology on user trajectory patterns (behaviors) in solving a spatial navigation problem inside VR.

Collectively, these insights have informed best practices for designing more intuitive and user-friendly VR experiences.

Current Research Endeavors

Building upon previous insights, my current research explores several advanced interdisciplinary applications of immersive technologies, further expanding VR's utility and integration into everyday decision-making and specialized professional training environments.

Persistent Virtual Reality Spaces

Building on previous research into ubiquitous VR systems, my current efforts center around Persistent Virtual Reality Spaces (PVRS). These are immersive environments designed to consistently support user interactions over extended durations, fostering an environment of perceptual comfort and sustained engagement for long-term learning and collaboration. Drawing inspiration from educational philosophies such as Friedrich Froebel's approach, my VR platform integrates structured, experiential learning with intuitive interaction designs that aim to nurture creativity, curiosity, and knowledge retention.

Digital Cardiology and Advanced Medical Visualization

Another significant component of my current research includes developing immersive applications for digital cardiology, particularly focusing on advanced cardiac arterial mapping and visualization. By integrating conformal mapping techniques and immersive 3D visualization, this work aims to significantly enhance diagnostic accuracy and pre-surgical planning, providing healthcare professionals with highly interactive tools to better comprehend complex cardiac anatomy and improve patient outcomes.

Immersive Agriculture Decision Support Systems

In collaboration with interdisciplinary teams, my recent endeavors include leveraging remote sensing and spatiotemporal data visualization to create immersive decision-support systems for agriculture. By integrating satellite-derived crop phenology data, climatic variables, and agricultural management practices, we are developing visualization tools that empower Arkansas's agricultural community to make informed, proactive decisions. This research fosters direct engagement with stakeholders, ensuring practical relevance and impact within the agricultural community.

Real-Time Secure Distributed 3D Mesh Synchronization
My current technical research involves the development of efficient protocols for distributing complex 3D meshes across networked environments using Unity. The focus is on ensuring minimal latency and maximum fidelity through advanced serialization, chunking strategies, and robust encryption standards, particularly AES. This work supports broader aims in cybersecurity and virtual collaboration within industrial and educational contexts.

Cybersecurity Training in Simulated Industrial Environments
Recognizing the increasing need for cybersecurity skills in protecting industrial control systems, I co-lead the design and deployment of realistic, simulated industrial control system environments. These immersive simulations enable professionals and students to effectively practice threat detection, cybersecurity analysis, and response strategies, thereby strengthening workforce readiness in cybersecurity.

Human Spatial Decision-Making in VR
My research also continues to delve deeply into the cognitive aspects of spatial navigation and decision-making in VR. Employing neural networks and advanced machine learning techniques, my team investigates user spatial navigation behaviors and cognitive patterns in complex virtual environments. The goal is to create more effective, personalized training scenarios and educational experiences, enhancing users' spatial awareness, navigational abilities, and decision-making skills over time.

Future Research Goals

Moving forward, my long-term objective is to refine and expand the capabilities of immersive technologies to enhance human cognitive performance, learning outcomes, and overall comfort within persistent virtual reality environments. I aim to leverage advanced machine learning techniques—particularly transformer-based models—to uncover and predict nuanced human behaviors within virtual environments. Additionally, my future work seeks to address persistent usability issues such as cybersickness through innovative hardware and interface design.

Ultimately, by integrating interdisciplinary perspectives, including cognitive psychology, spatial computing, and cybersecurity, I envision developing comprehensive, immersive experiences that bridge the gap between technology and human capabilities, fostering wider acceptance and transformative applications of virtual reality across society.

Closing Statement

The world of Computer Graphics and Human-Computer Interaction has no shortage of challenging and hard problems. I look forward to solving some of them to shepherd public scholarship through meaningful 3D visualization and effective human-computer interaction.

EIT Building Rm 572, 2801 S University Ave, Little Rock, AR 72204
(706) 254 7984 • abasu@ualr.edu
ualr.edu/computerscience/aryabrata-basu/ • LinkedIn Profile 3/3