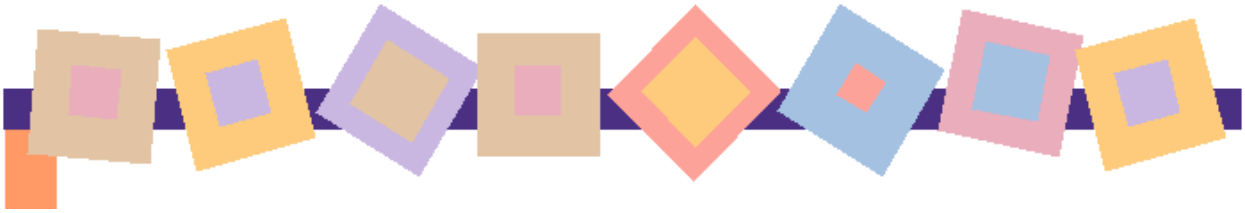

Virtual Reality Laboratory

Department of Computer Science

Capability Statement

Technical point of contact:

Dr. Sharad Sharma
Director, Virtual Reality Laboratory
Department of Computer Science
Bowie State University
Bowie, MD 20715
Tel: 301-860-4502
Facsmile number: 301-860-3979
Email address: *ssharma@bowiestate.edu*
Lab Website: *http://www.cs.bowiestate.edu/sharad/vrlab/index.html.*

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Capability Statement of Virtual Reality (VR) Laboratory

Lab Website: *http://www.cs.bowiestate.edu/sharad/vrlab/*

Virtual Reality (VR) Laboratory is located in room: CSB 312 (Software Lab) and CSB 106 (Hardware Lab). The VR Lab is also used to teach class such as CS 477 (Virtual Reality and its Principles), CS 418 (Computer Graphics), CS 518 (Computer Graphics I), CS 729 (Virtual Reality and its Applications), and CS 829 (Advanced Virtual Reality Systems).

GOAL

The goal of this VR laboratory is to introduce students to Virtual Reality (VR) hardware, software, and provide an opportunity for them to apply this knowledge to applications for education and games. This laboratory applies cutting-edge VR technology currently available in academia and industry. The lab applies research methods from social science and human-computer interaction to address the challenge of including social, emotional, and communication factors into modeling and simulation of crowd behavior.

MISSION

The students and faculty are pioneering the use of VR technology in areas such as evacuation simulation, way finding, battlefield simulation, emergency response, multi user virtual environment (MUVE), augmented reality (AR), and VR classroom environment. We are also exploring agent-based modeling and simulation (ABMS) and multi-agent system (MAS) for evacuation and decision making systems. We study crowd behavior during evacuations due to emergency and terror events. We strongly believe in testing our research with practice and actively seek collaboration with industry.

ACTIVITIES

The lab provides students and researchers with high quality 3D gaming workstations, stereoscopic displays (corner cave, 3D wall), head mounted displays (HTC Vive, HoLo lens, Oculus) motion trackers, 3D input devices, and force feedback devices. Our current research projects focus in areas of Virtual Reality (VR), Augmented Reality (AR), and Software Engineering (SE).

GRANTS

- **ARL Grant:** Avatars to represent human behavior in a Collaborative Virtual Environment, under The U.S. Army Research Laboratory (ARL), Award no.: W911NF1820224, funded by ARL-HRED division under Assessment and Analysis campaign. Award Period: 09/05/2018 to 09/04/2019, Award Amount: $85,000.00.
- **ARL Grant:** Megacity: Avatars in Collaborative Virtual Environment (CVE) approach for Decision Making, under The U.S. Army Research Laboratory (ARL), BAA W911NF-17-S, Award Grant No. 12396753, funded by ARL-HRED division under Assessment and Analysis campaign. Award Period: 08/4/2017 to 02/28/2019, Award Amount: $85,000.00
- **MITRE/ USM, USM/AAC Award,** Collaborative Grant (UMBC/BSU): Inferring Cyber-attacks and Building Resilient Cyber-Physical Systems, Sponsor: MITRE and University System of Maryland (USM), Award Period:1 Oct. 2018 to 30 Sep 2019, Award Amount: $255,000.00

- **NSF**: "A Problem-Based Learning Approach to Teach Gaming and Development of Gaming Instructional Modules to Enhance Student Learning in Lower Level Core Courses". NSF-HRD-1238784, Award Amount: $299,500, Award Period: 2012 to 2017.
- **DHS: Department of Homeland Security, 2011 Scientific Leadership Award**, "Developing Homeland Security Expertise to Support Emergency Evacuation Research", 2011-ST-062-000050, Award Amount: $249, 901.29 Award Period 2011 to 2015.
- **NSF**: "Increasing Expertise of Minority Students by Development of a Virtual and Augmented Reality Laboratory for Research and Education at Bowie State University", NSF-HRD-1137541, Award Amount: $299,489, Period: 2011 to 2014.

VR HARDWARE LAB (ROOM 106)

- **Corner Cave VR System**
  - Tracking and projection System with Custom screen size, 3D glasses
- **3D Wall**
  - WorldViz 3D Wall Touch PRO with tracking system
- **Head Mounted Display (HMD)**
  - nVisor SX111
  - HTC Vive & Oculus Rift Head set + Touch
  - Hollow Lens & Samsung GearVR
  - Z800 Dual Pro Ruggedized
  - Google Glass and Shutter Glasses
  - NVIDIA 3D Vision Glasses Kit
- **VR Gloves**
  - Cyber Glove III, Wireless
  - 5DT Data Glove 5 Ultra, RH
  - 5DT Data Glove 5 Ultra, LH
- **Motion Detection**
  - Advanced VR Motion Tracking: precision position tracking (PPT)
  - VizMove system: 3D Wall Touch Pro cameras
  - Virtual Cube Head Tracker & Microsoft Kinect
- **3D Gaming Desktops**
  - Alienware Aurora-R4

VR SOFTWARE LAB (ROOM 312)

- **Modeling**: 3D StudioMax, Maya, Soft Image, Mudbox, Motion Builder, Blender.
- **VR Programming**: Vizard 6, Virtools 6.0, Vizible, ppt studio, Unity 3D, VRML pad, Microsoft Visual Studio.
- **3D Gaming Desktops: 18 Alienware Aurora-R4**



VIRTUAL REALITY LABORATORY RESEARCH CAPABILITIES

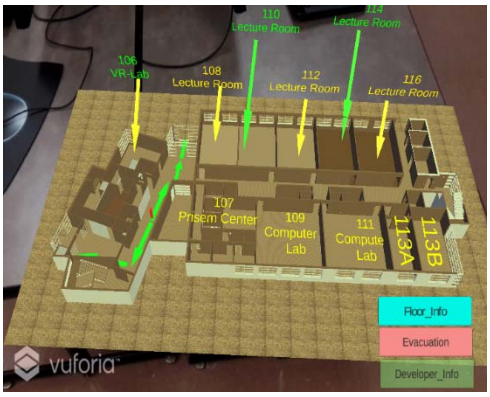
Multi-User Virtual Environment (MUVE) for conducting Evacuation drills using Gaming Metaphor

Virtual Reality (VR) based training and evacuation drills in disaster preparedness have been increasingly recognized as an alternative to traditional real-life drills and table-top exercises. Immersive collaborative VR evacuation drills offer a unique way for training in emergencies. The participants can enter the collaborative VR environment setup on the cloud and participate in the evacuation drill which leads to considerable cost advantages over large-scale real-life exercises. Collaborative VR environment enables an experimental design approach to gather data on human behavior and emergency response. The following evacuation environments have been developed in the lab: (i) Airplane, (ii) Subway (iii) Campus, (iv) School Bus, (v) Building, and (vi) Mega City. Our proposed collaborative VR environment offers flexibility to run multiple scenarios and evacuation drills for disaster preparedness and response. Modeling such an environment is very important because in the real-time emergencies we experience in day-to-day life, there is a need for preparation to extreme events. We have conducted user studies for the MUVE in both Immersive Environment (oculus rift HMD) and Non-Immersive Environment (desktop computer, mouse and keyboard).

Mobile Augmented Reality Application (MARA)

Indoor building evacuation application for emergency response using HoloLens, android phones and tablets

Mobile Augmented Reality Systems (MARS) involves the dynamic overlay of digital information in the user's view through mobile devices, is an increasingly popular technology for enhancing how people interact with and learn about the environment and objects in the physical world. Early hands-on experiences with the Microsoft Hololens augmented/mixed reality device have given promising results for building evacuation applications. Our Hololens application gives a visual representation of a building on campus in 3D space, allowing people to see where exits are in the building. It also gives path to the various exits; shortest path to the exist as well as directions to a safe zone. Our proposed AR application was developed in Unity 3D for Microsoft HoloLens. It is a fast and robust marker detection technique inspired by the use of Vuforia AR library. The application offers users an enhanced evacuation experience by offering enthralling visuals, helping them learn the evacuation path they could use during an emergency situation where evacuation is necessary. The goal of this project is to enhance the evacuation process by ensuring that all building patrons know all of the building exits and how to get to them, which would improve evacuation time and eradicate the injuries and fatalities occurring during indoor crises such as building fires and active shooter events. We believe that AR technologies like HoloLens could be adopted by people for building evacuating during emergencies as it offers enriched experience in navigating large-scale environments. Pilot studies were conducted for the system showing its partial success and demonstrating the effectiveness of the application in an emergency evacuation. Post-test part of the questionnaire measured participant's perceptions of motivation, usability, educational and training effectiveness, and AR applications (HoloLens, Mobile phone, and Tablet) appropriateness.

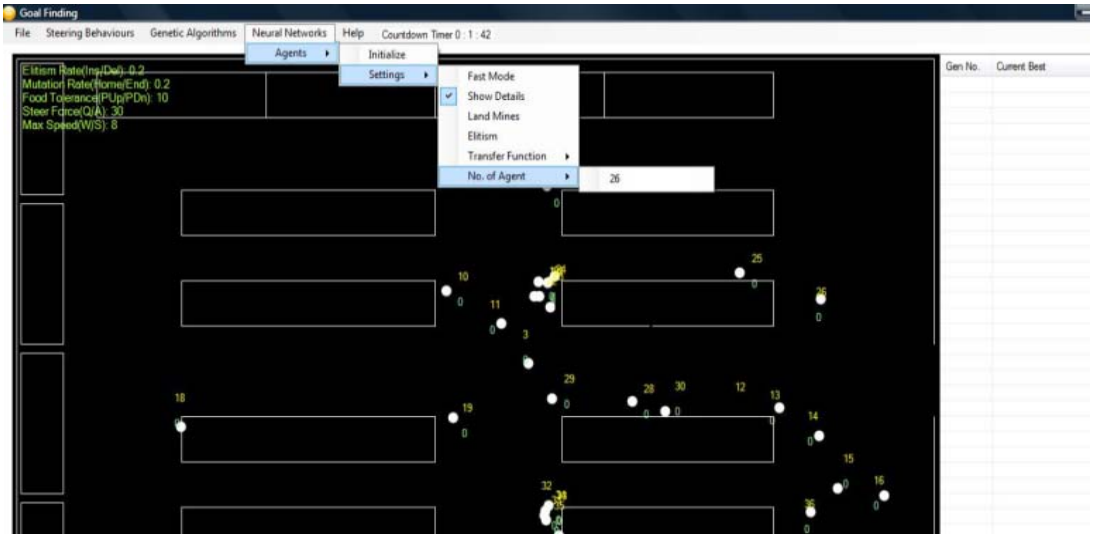


Multi-Agent Systems (MAS)

Simulation and Modeling of human behavior, group behavior, learning behavior, adaptive behavior and emotions during emergency evacuation

This project combines the **genetic algorithm (GA) with neural networks (NNs) and fuzzy logic (FL)** to explore how intelligent agents can learn and adapt their behavior during an evacuation. The adaptive behavior focuses on the specific agents changing their behavior in the environment. We have developed a goal finding evacuation multi- user system using C# to aid in running several **evacuation drills and what-if situations**. We have established a novel intellectual agent with characteristics such as independence, collective ability, cooperativeness, and learning skill which describe their ultimate behavior when moving to attain a goal. This work provides a fuzzy individual model being developed for realistic modeling of human emotional behavior under normal and emergency conditions. It explores the impact of perception and emotions on the human behavior. We have established a novel intelligent agent with characteristics such as independence, collective ability, cooperativeness, and learning, which describes its final behavior. Our hypothesis is that people with similar background, race, ethnicity, sex etc. are more likely to collaborate together and exhibit close affinity in emergency than people with varied background. Agents come from different background with the capability to adapt their behavior under different environment and formulate their response by learning from the environment. The study investigates the following research questions:

1. How can goal finding algorithms be modified to include behaviors like cooperative, learning, and adaptive behavior?
2. How much does the inclusion of uncertainty, stress, and panic in model of emergency evacuations reflect real world human patterns?
3. Does the inclusion of behaviors, emotions, and communication tools allow for improved simulation tools to support emergency evacuation planning?



Virtual Reality Instructional (VRI)/ Game Theme based Instructional (GTI) Modules

The goal of this project is to create course curriculum modules for computer science and mathematics students. Engineering and Mathematic courses are typically considered as difficult by college students and exhibit high failure rate. Due to the complication and abstract nature of computer hardware, it is a challenge for students to understand the principles and concepts related to computer organization. The aim is to create instructional course curriculum modules with more inquiry based problem-solving activities and hand-on experiences based on Gaming and Virtual Reality. We have developed modules for arrays, linked list, loops, memory management, trees, binary search, stacks, queues, etc.

Virtual reality instructional (VRI) modules are widely recognized in academia because they engage students and motivate them to learn by hands-on experience. For this reason, we have developed Game Theme based Instructional (GTI) modules for teaching linked list that can provide a better understanding of the concept than with a traditional instruction approach. The GTI/VRI modules incorporate a proven framework for the evaluation and effectiveness in learning. GTI/VRI module offers a different approach of learning and motivating students to learn more. The result demonstrates the GTI/VRI module can be implemented in the classroom for better learning outcomes.

Collaborative Virtual Reality Environment (CVE) to Improve Patient Experience in Healthcare

Collaborators: Edbert B. Hsu, M.D., M.P.H.
Director of Training, Johns Hopkins Office of Critical Event Preparedness and Response (CEPAR)

Our Collaborative Virtual Reality Environment (CVE) project goal is to improve patient experience in healthcare. We use virtual human technology to create realistic characters as avatars and uses natural language, non-verbal behavior and realistic scenarios for both military and non-military issues to train clinicians. The simulation may be used for both training and educational purposes. The goal of this multi-user VR Environment (MUVR) is to track user efficiency and decision making strategies. Multiple agents are necessary for this environment because it will promote communication, collaboration, and will enhance the decision making process. We are exploring the environment using HTC Vive and Oculus rift touch pro.

Megacity: A Collaborative Virtual Reality Environment for Emergency Response, Training, and Decision Making

Collaborator: Dr. Jock O. Grynovicki, chief of the Complex Ground Systems & Operations Branch of the Human Research Engineering Directorate (HRED) of the Army Research Laboratory (ARL) at Aberdeen Proving Grounds, MD 21005.

The simulation of human behavior with avatars and agents in virtual reality (VR) has led to an explosion of training and educational research. The use of avatars (user-controlled characters) or agents (computer-controlled characters) may influence the engagements of the user experience for emergency response, and training in emergency scenarios. Our proposed collaborative VR megacity environment offers flexibility to run multiple scenarios and evacuation drills for disaster preparedness and response. Modeling such an environment is very important because in the real-time emergencies we experience in day-to-day life, there is a need for preparation to extreme events. These emergencies could be the result of fire, smoke, gunman threat, or a bomb blast in a city block. The collaborative virtual environment (CVE) can act as a platform for training and decision making for SWAT teams, fire responders, and traffic clearance personnel. The novelty of our work lies in modeling behaviors (hostile, non-hostile, selfish, leader-following) for computer-controlled agents so that they can interact with user-controlled agents in a CVE. We have used game creation as a metaphor for creating an experimental setup to study human behavior in a megacity for emergency response, decision-making strategies, and what-if scenarios. Our proposed collaborative VR environment includes both immersive and non-immersive environments. The participant can enter the CVE setup on the cloud and participate in the emergency evacuation drill, which leads to considerable cost advantages over large-scale, real-life exercises.

Emergency Campus Evacuation Drills and Active Shooter Response using Corner Cave, Oculus Rift, and CVE

The mass causality shootings in United States has a great effect on the society. As a result, medical, law enforcement, fire/rescue, swat teams, and EMS (emergency medical services) first responders have each felt the need to respond to such events. With the rise of the active shooter/mass causality events, it has become clear that long-standing practices of law enforcement, fire/rescue, and EMS responses are not optimally aligned to maximize victim survival. It is very important that such events occur in a coordinated manner among all these teams to generate policies that enhance survival of victims at these events. There is a need to synchronize these efforts collectively to minimize these tragedies. After Sept 11, terrorist attack there has been an increased interest in safety, homeland security and the need for accurate, quantitative assessment of people movement in emergencies. *There is a need to address the vulnerability and assessment plans for evacuation scenarios. It is important to plan ahead by targeting groups and identifying specific population. Crowd simulations are powerful tools for visualizing, analyzing, and communicating how a venue will work or testing evacuations scenarios in emergencies.*

Human behavior is difficult to model and simulate due to the high level of uncertainty involved. User controlled agents in Virtual Reality (VR) environment can provide a means for more accurately observing human behaviors during emergency evacuations. We have implemented a multi-user interface to allow multiple user controlled agents to navigate in a virtual environment. Our hypothesis is that the "*sense of presence*" provided by the virtual environment will allow running simulations and conducting evacuation drills without the cost and risk of injury to live actors. The aim of this project is to provide a more accurate and realistic means for assessing human behavior in emergency scenarios using a game setup metaphor. Our work is based on agent based methods, which focus on individual and group behavior. The project focuses on 1) Develop situational awareness through CVE in active shooter response. 2) Enhance realistic training: robots (programmed agents) as teammates and followers (leaderships behavior). 3) Improve soldiers, leaders, and team performance for active shooter event. 4) Management of human-robot teams in mission context (emergency evacuation) through task and role allocation that leads to more effective actions and decision making with in Collaborative Virtual Reality Environment.

Research Areas of Interest

Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Software Engineering (SE), Human-Computer Interaction (HCI), Modeling and Simulation of Emergency Response (M&S), Evacuation, Artificial Intelligence (AI), Agent-Based Modeling (ABM), Multi-Agent Systems (MAS), Collaborative Virtual Environments (CVE), Multi-user Virtual Reality Environments (MUVR), Gaming, Fuzzy Logic, Cyber Physical Systems (CPS), Data Science and Data Visualization.

CONTACT US

Dr. Sharad Sharma
Director, Virtual Reality Laboratory
Associate Professor
Department of Computer Science
14000 Jericho Park Road, Suite 317
Bowie State University, Bowie, MD 20715
Email: ssharma@bowiestate.edu
Ph: (301) 860-4502
Fax: (301) 860-3979
Website: http://cs.bowiestate.edu/sharad/

Short Biography

Dr. Sharad Sharma is the Director of the Virtual Reality Laboratory and Associate Professor in the Department of Computer Science at the Bowie State University. Dr. Sharma's research focus is on modeling and simulation of multi-agent systems for emergency response and decision making strategies. Dr. Sharma's proposed human behavior system integrates both artificial intelligence and fuzzy logic parameters. He has won the "2018 USM (University System of Maryland) Board of Regents "Faculty Award" for Excellence in Scholarship and Research in April 2018. He has also worked on a faculty research fellowship in the Human Research and Engineering Directorate (HRED) division in Army Research Laboratory (ARL) at Aberdeen Proving Ground (APG), Aberdeen, Maryland. He is involved in developing new data and visualization methods for course of action planning, visualization, training, and assessment. He is also exploring socio-cultural issues in Collaborative Virtual Environments (CVE) for emergency response and decision making in dense urban environments.

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