Virtual Reality Laboratory

Department of Computer Science

Capability Statement

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Index

Capability Statement of the Department of Computer Science at Bowie State University

Established in 1865, Bowie State University (BSU) is the oldest historically Black institution of higher learning in Maryland and is one of the oldest in the nation. Bowie State University is committed to quality education, offers a comprehensive set of undergraduate and graduate programs and serves over five thousand students. The majority of the students (89%) are African-Americans. The university is fully accredited by the Middle States Association of Colleges and Schools and the Maryland State Department of Education. BSU is part of the University System of Maryland (USM). Institutional objectives in the STEM area have been very clearly delineated by the current administration. Bowie State University has been designated as a **National Center of Academic Excellence in Cyber Defense Education (CAE IA/CD)** through academic year 2020.

The Computer Science department at BSU has offered an accredited undergraduate program in computer science (COSC) and computer technology (CTEC) and a master's program in computer science for approximately 20 years. Further evidence of program quality is the achievement and continuance of full accreditation status recognized by the **Accreditation Board of Engineering & Technology (ABET).** The department has been offering a successful master's degree program in computer science since 1984. Since spring 2007 the department has admitted more than 70 students into its Doctoral program in Computer Science. Since Bowie State University (BSU) is an HBCU, a diverse group of minority and international students are involved in the research projects. The department has graduated 13 Doctoral of Computer Science students.

Bowie State University participates in the Model Institution of Excellence (MIE) program supported by NSF and NASA. This program provides support for activities to attract and retain minority students who will pursue degrees in the SEM areas. Although our primary mission is teaching, applied research is an integral part of every program, especially in SEM. The undergraduate research experiences which are offered to our student assistants can with other supporting components such as mentoring and nurturing analytical thinking, inspire them to pursue graduate studies.

Virtual Reality (VR) Laboratory

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

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 graphics workstations, stereoscopic displays (corner cave, 3D wall), 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:** 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 08/3/2018, Award Amount: $85,000.00
- **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**
  - Custom screen size, 3D glasses
- **3D Wall**
  - WorldViz 3D Wall Touch PRO
- **Head Mounted Display (HMD)**
  - nVisor SX111
  - HTC Vive
  - Hollow Lens
  - Samsung GearVR
  - Z800 Dual Pro Ruggedized
  - Google Glass and Shutter Glasses
  - Oculus Rift Head set + Touch
  - 20 NVIDIA 3D Vision Glasses Kit
- **VR Gloves**
  - Cyber Glove III, Wireless
  - 5DT Data Glove 5 Ultra, RH
  - 5DT Data Glove 5 Ultra, LH
  - 5DT Data Glove Ultra Wireless Kit
- **Motion Detection**
  - 3D Wall Touch Pro cameras
  - Virtual Cube Head Tracker
  - Microsoft Kinect
  - 5DT Motion Builder Driver
- **3D Gaming Desktops**
  - 4 Alienware Aurora-R3

VR SOFTWARE LAB (ROOM 312)

- **Modeling**: 3D StudioMax, Maya, Soft Image, Mudbox, Motion Builder, Blender.
- **VR Programming**: Vizard 5.6, Virtools 5.0, Unity 3D, VRML pad, Microsoft Visual Studio, OpenGL, ARToolkit, ALVAR libraries.
- **3D Gaming Desktops: 18 Alienware Aurora-R4**



VIRTUAL REALITY LABORATORY 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)

Implement and evaluate effectiveness of the Mobile Augmented Reality Application (MARA) for building evacuation.

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. In MARA, mobile devices act as the "magic" lens through which people can see the world annotated or augmented with digital information. Augmented reality content can be viewed in several ways. We show how the mobile AR application is able to display a 3D model of the building and animation of people evacuation using markers and web camera. Our system gives a visual representation of a building in 3D space, allowing people to see where exits are in the building through the use of a smart phone or tablet. Pilot studies were conducted with the system showing its partial success and demonstrated the effectiveness of the application in emergency evacuation. Our computer vision methods give good results when the markers are closer to the camera, but accuracy decreases when the markers are far away from the camera. We are integrating GPS, Google maps, wireless base stations for approximating the position of a person, and real-time video to be integrated into the system. Our proposed Mobile AR application was developed using Unity 3D gaming engine and Vuforia SDK. The study has three contributions

1) A novel mobile application to give visual representation of a building in 3D space.
2) Implement the mobile application using Unity 3D by allowing people to see where exits are in the building.
3) Results of usability evaluation for effectiveness of the mobile application in emergency evacuation.

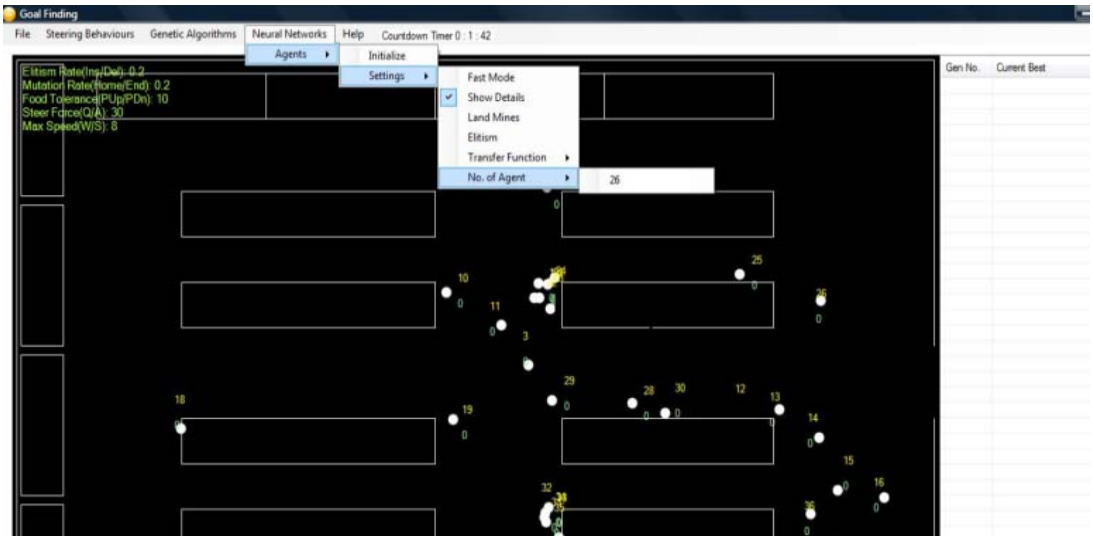
3D representation with agent animation, smoke and fire

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.

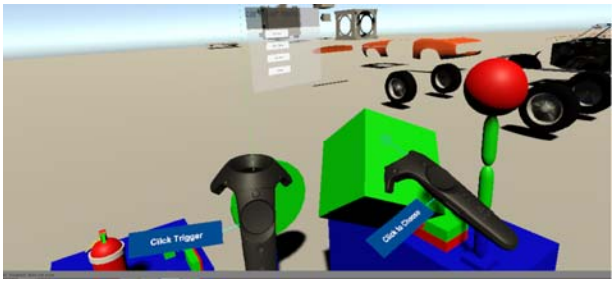
The simulation of human behavior with avatars and agents in virtual reality (VR) has led to an explosion of training and educational research. The use of avatars (user-controlled characters) or agents (computer-controlled characters) may influence the engagements of the user experience for emergency 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.

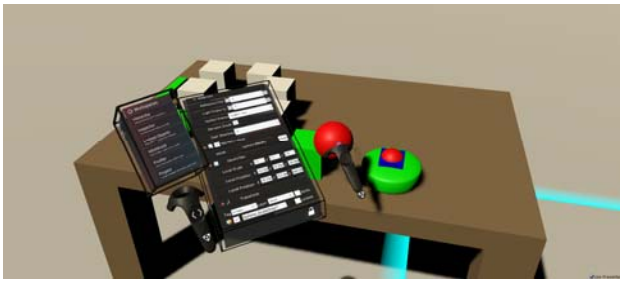
We have used game creation as a metaphor for creating an experimental setup to study human behavior in a megacity for emergency response, decision-making strategies, and what-if scenarios. Our proposed collaborative VR environment includes both immersive and non-immersive environments. The participant 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.

VR Assembly using HTC Vive in a CVE

Collaborator: Thomas G.Grubb, NASA, Ground Software Systems Branch, Greenbelt, MD 20771

The goal of the VR Assembly project is to create a collaborative virtual environment (CVE) for concept design and assembly in VR from a database of pre-defined "parts", enabling engineers and scientists to work in a shared VR environment. The project will contain a data base of a set of physical primitive and off-the-shelf, plug and play parts with reduced detail CAD files. The users will be able to drag and drop the CAD files from the menu to the VR environment for design collaboration.





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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. Recently in 2016, he has 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.