Photo submitted.

Reaching Across Realities

How Researchers at the University of Arkansas Are Harnessing the Potential of Virtual Reality (VR) to Solve 'Wicked' Problems

BY **DELIA GARCIA**

A recent stroke survivor stands in her living room in rural Arkansas. Sliding virtual reality goggles down over her eyes after she places wired bracelets on her wrists, she is transported to a virtual rehabilitation clinic, where she begins to practice picking up small objects with her hands, slowly rebuilding muscle strength, control, and mobility.

A combat medic stands inside a large training bay. Wearing VR goggles, he crouches down. To an external onlooker, it's not clear what he's doing. A clear image is painted through the lens of virtual reality, however. Through his eyes, he is receiving practical training in saving the life of a wounded soldier. He can feel the force of the precision cut he makes with a virtual scalpel amidst computerized explosions and the whizzing of cyber-bullets.

A CEO is seamlessly transported from her office into a virtual conference room. She steps forward, extending her hand to greet a business colleague who lives half a world away. As they shake hands, separated by miles yet connected through this gesture, she senses the firmness of his grip, a reassuring and friendly squeeze—a customary act of business courtesy.

While the world of neuro-haptic virtual reality hasn't reached this level of sophistication, assistant research professor Andres Pena and doctoral fellow Aliyah Shell are actively bringing it to life at the University of Arkansas' Institute for Integrative and Innovative Research.

"I³R pioneers solutions to wicked problems and brings the future to the now," said Ranu Jung Ph.D., associate vice chancellor at the University of Arkansas and executive director of I³R. "The research that Andres and Aliyah are doing in neuro-haptic feedback has tremendous potential for development of wearable and implantable devices in the HealthTech sector as well as profound implications for the health and well-being of people in Arkansas and beyond."

"The whole idea of neuro-haptics came about from our original research regarding connecting advanced prosthetic limbs via an implant to users so they could feel sensations with their prosthetics," Pena said referring to the ground-breaking innovations pioneered by I³R's biomedical engineering team.

"We were trying to understand how we could provide significant, intuitive information to users so they could better use their prosthetic limbs. The idea of neuro-haptics as a non-invasive approach came about from the need to provide this type of technology to individuals who cannot or do not qualify for surgery."

Neuro-haptics in virtual reality (VR) is a leading-edge innovation that allows users to feel touch sensations within a virtual and augmented environment. In traditional VR, users can hear and see stimuli, but the aspect of touch remains unavailable. ExtendedTouch (xTouch) is a wearable neuro-haptic platform that is designed to enable people to dynamically interact with and feel objects in VR environments. It uses a patented nerve stimulation technique that Pena created for his doctoral studies that may solve this exact issue. The patented technology features combinations of electrodes on the wrist that stimulate the underlying nerves. When these nerve points are stimulated, the sensation of touch can be felt at the fingertips. This form of stimulation is called neuro-haptic feedback. In their current research, Pena and Shell are pairing this technology with virtual reality and exploring the impact of applying xTouch to physical rehabilitation practices.

The University of Arkansas' Women's Giving Circle, which is comprised of alumnae and friends who recognize that women as donors have the capability of making a tremendous impact on the University of Arkansas, its students, faculty and staff, is dedicated to supporting innovative programs and research at the University Arkansas, awarded the research project a $10,000 grant. This funding allowed Pena and Shell to purchase several VR headsets.

"We are so grateful for the generosity of the Women's Giving Circle," Shell said. "Their support has been integral to enabling this advanced research."

The goal of the xTouch project is to allow interaction within a virtual space and apply these interactions in a meaningful way.

"We want to give people an experience of being able to interact with things in an environment without physical restraints or hand restrictors," Shell said explaining that items like gloves and exoskeletons could be cumbersome and impede mobility.

"Wearable technology like this, that allows the hands to move freely, will make it much easier to interact with objects in the virtual environment," she added.

xTouch works by translating interpretable data from the VR headset to the wrist electrodes. Information from interactions in the virtual environment, such as object size and force applied, is captured and used to generate the corresponding stimulation signals.

"Let's say you're grabbing a virtual object," Shell explained, picking up a water bottle. "Based on characteristics that we give the object in the virtual space, we can determine which parameters to send to the system, so that they could match whatever object you're experiencing in the virtual space. This water bottle is a large, solid object. I can give it a command that says, 'Once your hand closes a certain amount around the virtual object, you will begin to feel the sensation as if you were touching it.'"

Pena and Shell envision at least two potential high-impact applications for this leading-edge technology. First is a military application with combat medics. Second is for individuals with conditions or experiences, such as stroke, that lead to neurological deficits. Currently, virtual reality is being used in some physical rehabilitation scenarios, but they lack a critical component.

"One of the things that is missing in existing virtual rehab interventions is touch. With this approach, we would be able to bridge that gap. It doesn't matter if it's simpler than actual touch information that you would get within the real world if the tech is intuitive enough to help a patient internalize a task," Pena said.

Opposite Left, Andres Pena Ph.D. and Aliyah Shell, doctoral fellow, were awarded a $10,000 grant from the University of Arkansas Woman's Giving Circle to support their ExtendedTouch research project.

With the researchers' added neuro-haptic technology, Virtual Reality remains a promising avenue for rehabilitation, training and recreation.

Photo submitted.

Shell drives home the potential impact of the xTouch technology. "During my speech at the Women's Giving Circle awards banquet, I asked the crowd if they knew someone who had had a stroke. Everyone's hands went up," Shell said. "This technology is something that has the potential to directly benefit loved ones."

The potential impact of this technology for Arkansas is substantial. According to the Arkansas Department of Health, an average of 30 Arkansans are hospitalized each day due to stroke. For residents of rural areas where access to rehabilitation clinics may be limited, the potential impact of the xTouch technology is profound, according to Shell.

"Data shows us that there is an unmet need for rehabilitation services," Shell said, citing lack of available services in rural communities and lack of access to trained rehabilitation professionals as some of the challenges.

"Forgoing physical rehabilitation can hinder recovery and negatively impact quality of life. Imagine if we could make it possible for elderly and other people living in rural communities to get the benefit of a rehabilitation clinic from the convenience and comfort of their own home."

While this health sector application shows promise, combat medic training is another important potential application of this technology, according to the researchers.

"Consider the possibilities of using advanced VR technology like xTouch we could simulate an authentic combat experience for the purpose of training military doctors to go out into the field to take care of injuries," Shell said.

A simulated combat experience in a virtual reality setting would enable doctors to feel the tension and sounds of battle in a safer environment, better preparing them to provide quick and effective medical assistance in live combat situations. Ultimately, the addition of touch and haptic feedback could enhance training, which may save lives.

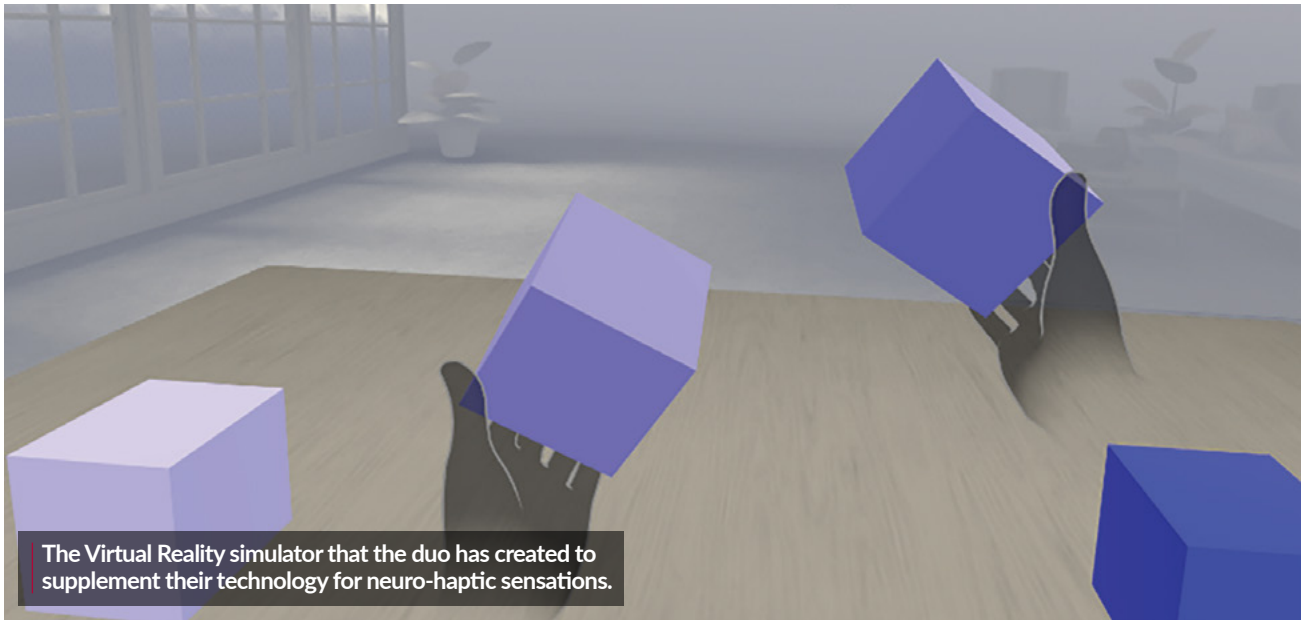
While the potential applications are broad, the research is in its infancy, according to Pena, as they are trying to better understand the mechanisms behind the technology.

"We're doing a lot of brain imaging and trying to understand how the brain processes a virtual versus a real experience," Pena explained.

Shell added, "We're trying to tap into the natural human architecture. We have nerves that are connected to our hands. We target those nerves that already convey information of touch through non-invasive neurostimulation."

Currently, the wrist electrodes provide only basic haptic information, but Pena believes that so much more is possible. The team is working to improve the stability and specificity of the stimulation so that in addition to creating a sensation of touch, the user can differentiate between quality and texture.

"We've published the proof of concept. We are looking to study the effectiveness of these types of interventions and finding out what this technology means in terms of applications. We are also curious about what is happening in someone's brain who is engaged with neuro-haptics, and how we can leverage all that knowledge to help with future interventions," Pena said.



The Virtual Reality simulator that the duo has created to supplement their technology for neuro-haptic sensations.

Photo submitted.

While Pena and Shell might have different backgrounds, their motivations for the project are the same: to help those who need it.

"I have always thought about the lack of accessibility for people in more remote areas," Shell said about her motivation. "My background is engineering, and I have worked at an orthotics and prosthetics clinic. My experience there really drove me to look for some of the discoveries I am searching for now."

Shell discovered her profound fascination with the human brain after analyzing the cranial scans of several 6–18-month-old babies fitted with orthotic helmets to correct for cranial growth deformities known as brachycephaly and plagiocephaly. This experience allowed her to see for the first time the power we have in influencing brain development and sparked her curiosity in neurorehabilitation and the human brain.

Pena credits his family and his upbringing in Venezuela for his altruistic drive saying his family instilled in him "the importance of learning, growing, and helping others."

"I grew up in a very low resource environment. We were forced to think outside the box and figure out how to solve day-to-day problems with what we had on hand. We called it 'MacGyvering' our way through" Pena said with a chuckle. "In my family, we didn't drop something because we didn't know what to do with it. We 'MacGyvered' a practical use for it."

An electrical and biomedical engineer by training, Pena felt he needed something more to achieve the kind of impact he wanted to make on the world.

He drew on his past experience and 'MacGyvered' a solution to fill the gap.

"My background in electrical engineering alone was not enough to do what I wanted, so I learned about biomedical engineering and applied this combined knowledge from two very different fields of engineering to try to make people's lives easier."

Both Pena and Shell are driven to make a positive impact on the world. Their individual paths led them to I³R, a special place driven by purpose where innovations are pioneered and translated into solutions that change people's lives.

"I³R is focused on doing the research as well as commercializing it and getting the technology out there to benefit society. The institute lays a great foundation for us to move xTouch into that space," Shell said.

Pena agreed. "I³R has the same objective we do: translating technology and knowledge for the betterment of humanity. This is the perfect environment for me to translate this knowledge into practical solutions that make a difference," he said.

In the near term, the researchers plan to engage clinical partners around the Northwest Arkansas region to launch human clinical trials as well as secure funding through philanthropic and other contributions, like that provided by the Women's Giving Circle, to continue the research. They anticipate final implementation and rollout of the xTouch technology by 2030.