Augmented Reality Promises Mentally and Physically Stressful Training in Real Places

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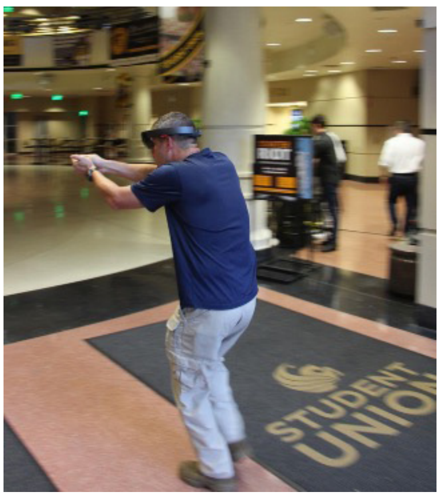

In-situ training, that which takes place in real environments, is common in the healthcare, defense, and law enforcement professions. Defense and law enforcement training share several common characteristics, primarily that the training is meant to be realistically stressful, both mentally and physically.

Compared with defense, law enforcement, in general, and university law enforcement, in particular, is unique in that universities comprise relatively dense populations of young adults in a formative and vulnerable stage of their lives. They might be experiencing high stress, unbridled stress relief of, and wide swings of emotion including depression and anger. Dangerous events can play out on an individual basis, (e.g., a lone student in a dormitory room), or in places with high concentrations of people such as libraries, student unions, and sports venues. Such venues are well suited to in-situ training because officers are likely to be acting operationally in those very same places. As such, training to act to preserve lives and property can be very specific to the physical structures and the nature of their use. Constructive in-situ training in real places traditionally includes carefully choreographed scenarios involving real human role players (e.g., the perpetrators, bystanders, and first responders) and simulated weapons/munitions. Such training events can be costly and disruptive.

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The virtual nature of Augmented Reality or AR (see side bar "What is Augmented Reality?") seems to offer a compelling alternative to conventional physical in-situ training. Specifically, AR seems to offer the promise of a flexible, engaging, and increasingly realistic alternative. This has long been recognized by the military, which has been pursuing the development and use of AR-related technology as far back as the 1960s, for both training and operational use. The Office of Naval Research (ONR) has been on the forefront of the related research and for decades has supported university and corporate research and development through research grants and contracts. As part of a grant from ONR, AR researchers at the University of Central Florida (UCF) partnered with the UCF Police Department to explore some of the potential of AR for training law enforcement officers in a university context.

The basic idea of an AR training scenario is that trainees looking through head-worn display "goggles" would see virtual versions of some key objects and people within the existing physical space. For example, in the side bar "What is Augmented Reality?" the user sees a virtual shooter wielding a handgun and victims laying on the floor that are not physically present.

For this experiment, the preliminary scenario consisted of a virtual shooter experience inside the main atrium of the Student Union building on the UCF campus. After a quick pre-briefing, officers donned and adjusted the AR head-worn display and went through a short calibration process to match the displayed stereo imagery to the distance between their eyes. The officers each started the scenario inside a set of doors from the outside, as if they had just entered the building. They were immediately presented with a virtual bystander cowering in fear nearby with multiple virtual victims lying on the floor toward the center of the room. The officers proceeded to enter the real space, navigated real obstacles such as counters, columns, and stairs, and searched for and interacted with three possible virtual shooters throughout the entire scenario. The virtual assailants had some simple instructor-initiated responses, such

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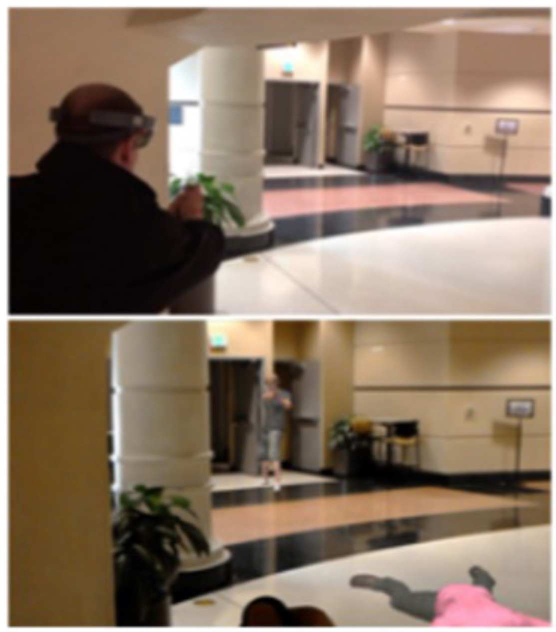
as surrendering, assuming a more prone position, or firing a handgun at the officer, with various accompanying speaking or shouting. Officers participating in the experiment had a small handheld clicker device which they could use to "fire" a virtual sidearm at the assailants, if they decided it was necessary.

There are many difficult technical challenges related to realizing a dynamic AR experience such as this. One key technical challenge is achieving accurate alignment or registration of the virtual and real objects in the same physical space, such as making a virtual bystander appear to be standing on a specific physical spot on the ground, even while officers are moving around. Another technical challenge is having real physical objects such as columns, correctly occlude (visually block) virtual content that is behind them. Because all virtual content is overlaid in front of the officer's view of the real space via the head-worn display, any parts of virtual objects that should appear occluded by real objects need to be identified and omitted (not drawn). For example, a virtual shooter that should be seen by the officer as hiding "behind" a physical column should be drawn such that only those parts of the shooter that would not be blocked by the column are drawn. To achieve this, an accurate invisible virtual model of the physical room is created that is then precisely registered with the physical space throughout the AR experience (see sidebar "Blending Virtual Objects into a Real Space"). Both registration and physically accurate occlusion worked well with this AR experience implementation inside the Student Union space.

The specific AR scenario was not intended to be fully fleshed out as a training scenario, but rather as a formative proof-of-concept experience designed to get some initial feedback from real police officers presented with a potentially threatening situation involving virtual characters. For example, while the scenario included some aspects of decision making related to when an officer decided to fire a sidearm, it did not incorporate any marksmanship component—if a weapon was fired at all, it was assumed to hit. After each officer experienced the AR scenario, comments were collected about various aspects of the AR system to get a preliminary sense for which things were perceived as important to providing a realistically stressful AR experience in the real physical environment.

What is Augmented Reality?

Augmented Reality (AR) is a variation of Virtual Reality (VR). In both paradigms, a user typically uses a head-worn display ("goggles" or "glasses") and both sees and hears virtual (computer graphics) objects and people. In the case of VR, the user is completely immersed in a virtual world and cannot see the real world. In contrast, AR visually and aurally superimposes virtual objects and people over one's view of the real world. AR does not replace reality, it supplements reality.



A user wearing an AR head-worn display and the user's view of the augmented physical space.

Feedback from Police Officers

The article reports the findings from one in-situ training, in which six UCF police officers participated in the AR experience, and provided valuable feedback and new insights in a variety of areas. Three of those areas are: realistic behavior of the virtual humans in the simulated scenario as well as any real humans also in the physical space, weapon realism for the officer's sidearm and how it feels, reacts, and interacts with the virtual simulation, and the importance of supporting some specific interactivity between an officer and the virtual scenario content that was not present in this initial simplified prototype experience.

They stressed the importance of having the correct feel, including the weight, shape, appearance, and physical responsiveness of a simulated firearm for what is intended to be a very realistic and stressful experience.

Some officers quickly noticed deficiencies or limitations related to the plausibility of the behavior of the

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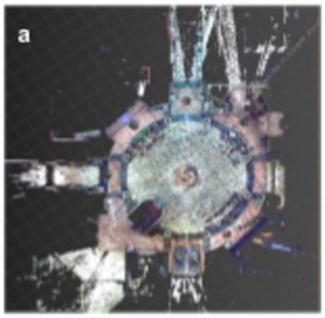
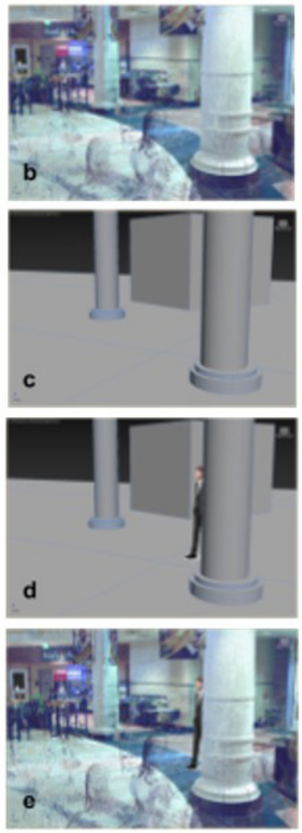
Blending Virtual Objects into a Real Space





A laser scanner was used over two days to generate a collection of millions of 3D points defining the interior of the atrium in the UCF Student Union (**a** and **b**). Using the dense points as a reference, computationally light weight proxies were created (**c**), which can be used with existing computer graphics rendering (**d**) allowing virtual content to appear to be correctly blocked by physical structures to users of the AR system (**e**).

virtual humans in the active assailant scenario. Many officers expressed a desire for the virtual humans to exhibit more realistic awareness of the surrounding activity and resulting intelligent reactive behavior. In one instance, a shooter was right behind an officer for a period of time, yet never acted until the officer turned around. The officer immediately perceived this behavior as unrealistic, as a real shooter would have taken some action when the officer approached (e.g., fleeing, attacking, or hiding). The active shooters were effectively more comparable to "pop-up" threat targets—good for prompting an immediate reaction and response, but very quickly losing credibility as a "real" threat. Officers also noted that subtle activities, sounds, or other effects in their surroundings usually give them continual cues about the presence, movement, location, state, etc., of a nearby person; without any realistic complex behavior, many of these subtle cues were missing. Implausible victim and bystander behavior, and the number of fleeing bystanders, were also cited as a factor impacting the sense of real danger during the AR experience. Interestingly, some of these issues were associated with the real bystanders as well. For example, the researchers who were running the experiment were visible but did not exhibit realistic reactions to the virtual threats nor the officers.

Simulating Firearms in an AR Scenario

Many comments from the officers were related to the control, responsiveness, and physical form factor of the handheld clicker device used for the simulated firearm. They stressed the importance of having the correct feel, including the weight, shape, appearance, and physical responsiveness of a simulated firearm for what is intended to be a very realistic and stressful experience. The handheld clicker, which is akin to a small computer mouse, was an unrealistic proxy for a weapon. This mismatch had a negative impact on the officers' perceived sense of danger and urgency, and hence their behaviors. Likewise, officers rely on audio cues, both as direct feedback when firing their own weapon and to help localize and identify an assailant's weapon. In this implementation, gunshots from the officer's firearm and the active shooter's handgun were largely indistinguishable, which—when combined with some unpredictable delay in the simulated sound—led to some confusion about which weapon was firing. Further, there were several perceived accidental weapon discharges, which could have been a hardware issue (e.g., the sensitivity of the physical clicker device while engaged in the scenario), a software issue (e.g., a delay in processing a click event), a misperceived audio cue (e.g., a lack of spatially localized audio such that shots fired at the officer were aurally indistinguishable from shots fired by the officer), or an actual accidental discharge.

Finally, there were several instances in which officers wanted to "control" the weapon of a virtual shooter—the officers were unsure what the virtual assailants were capable of doing with respect to negotiation or surrender. For example, while researchers had programmed the ability for one shooter to kneel and place his handgun on the ground next to him, the officers did not have the ability to pick up, kick away, or otherwise secure the weapon, leading to an apparent standoff where the officer felt unable to continue searching, because the nearby "unsecured" weapon appeared to render the shooter a continuing threat.

Promising Feedback for Future Research and Use

Despite the simplified scenario and limited interaction options, the law enforcement officers who went through the AR scenario were generally positive about the experience, with several expressing an appreciation for the potential of AR for in-situ training. While the fidelity and sensory realism of such AR experiences are currently limited compared with existing dedicated physical training equipment and facilities, recent AR technological developments have the long-term potential for enabling useful complementary experiences. As sensory realism in AR advances, training programs should be able to leverage the inherent benefits of AR as a training tool, such as being less disruptive or destructive, allowing for precise, repeatable control

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over the behavior of virtual entities, while being able to flexibly expose officers to a significantly wider range of threat types and assailant appearances, including variations to cognitive abilities, race, ethnicity, gender, and age.

Overall, there are many aspects of the AR experience that can be improved with new and better technology. For example, existing specialized training sidearms—which provide extremely realistic feel and feedback—could be modified to interface directly with the simulation software, and additional sensors could be employed on the weapon interface and in the physical space to simulate more complex aim and weapon interactivity such as simulated virtual effects when hitting real or virtual objects. There also remain plenty of areas for future research or work, including exploring the range of potentially impactful AR training scenarios, for everything from more complex active threats than what can be simulated in a traditional simulator, to sexual assault investigations, to traffic control, or writing a citation.

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