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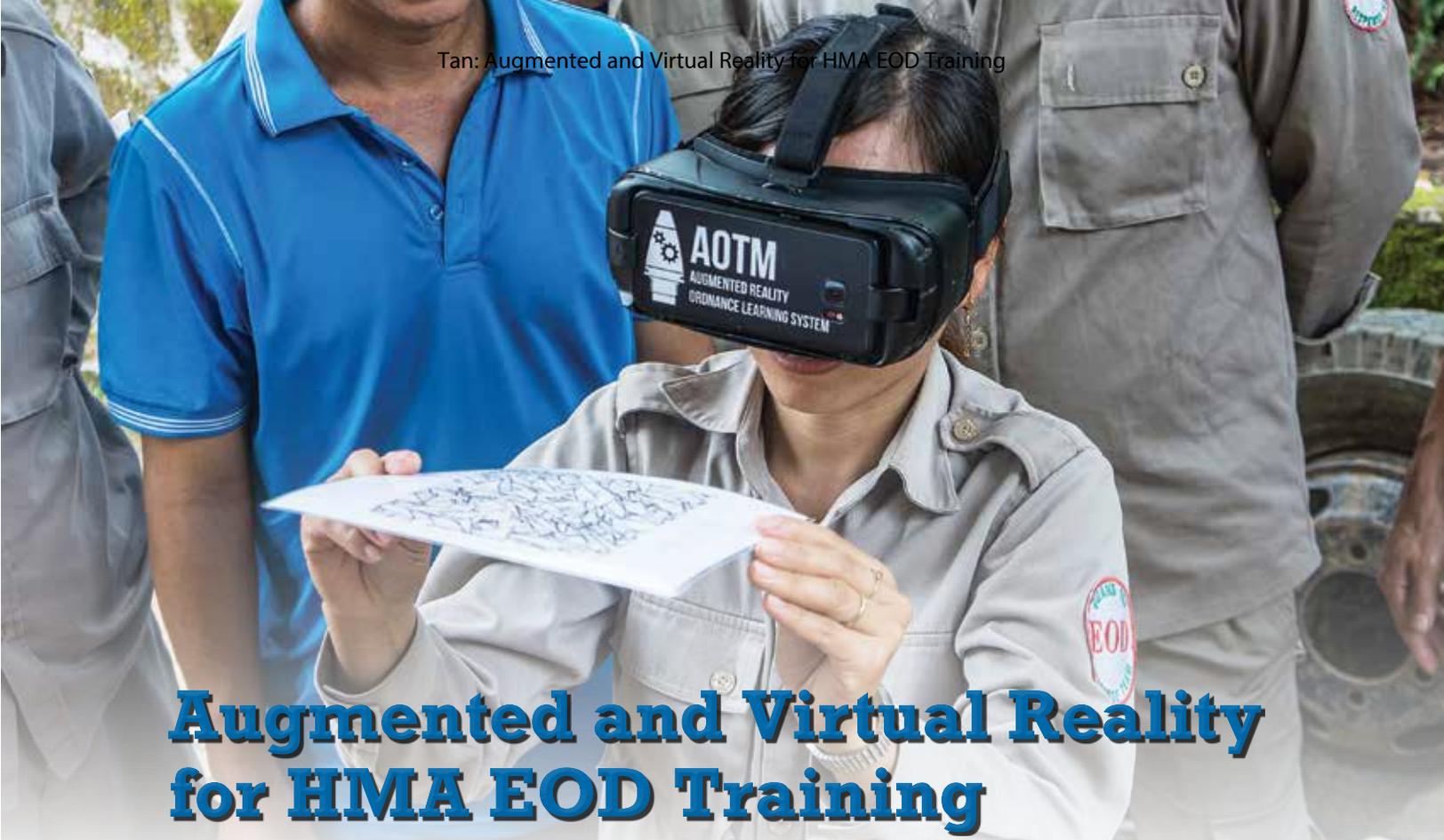
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# Augmented and Virtual Reality for HMA EOD Training

by Allen Dodgson Tan [ Golden West Design Lab ]

In Vietnam, Golden West has deployed the Augmented Reality Ordnance Learning System (AROLS) for use in training the provincial explosive ordnance disposal (EOD) teams. Here an EOD operator is seen reviewing an animation of how a cluster munition functions in the field before taking actions on a live unexploded ordnance (UXO). Through these experiences, we see the potential usefulness of augmented reality (AR) as an operational tool in the near future.

*All images courtesy of the author/Golden West Humanitarian Foundation.*

**A**t the Golden West Design Lab in Phnom Penh, Cambodia, our team has been working on applying augmented (AR) and virtual (VR) reality technologies to explosive ordnance disposal (EOD) for approximately three years with the support of the Office of Weapons Removal and Abatement in the U.S. State Department's Bureau of Political-Military Affairs (PM/WRA). This work grew from our success with the Advanced Ordnance Training Materials (AOTM) program, which produces detailed and functioning training aids of ordnance fuzes using 3D printing technology. The AOTM products were able to provide new training capabilities to programs across the world, and we believed AR and VR might offer similar opportunities.

Similar to how 3D printing has changed the accessibility of physical, engineered products, recent leaps in AR and VR technologies made by Oculus, HTC, Google, Samsung, and others have suddenly made the production of accessible consumer-grade applications possible. With capable platforms available, the challenges to implementation were similar to those we faced with the AOTM product line:

- ◇ identifying clear design constraints that addressed the needs and limitations of the humanitarian mine action (HMA) sector
- ◇ creating blended technical teams capable of producing our products
- ◇ creating the customer support infrastructure required for effective commercialization
- ◇ marketing these technologies to the HMA community

As we have seen with other bespoke HMA solutions, effective commercialization remains one of the most difficult problems to solve. For technologies that make it through the research and development phase successfully, considerable barriers to success remain. We are continuing to improve this process at the Design Lab and our formula has created a second sustainable product: the Augmented Reality Ordnance Learning System (AROLS).

## Use Case

The applications of AR and VR technologies are so far reaching and fundamentally game changing that we can expect some of the same organic spillover into the HMA sector as seen with drone and mobile technologies. These kinds of solutions were not designed specifically for the HMA community but were general advancements in human technology. Given the wide range of possibilities AR and VR offer, they will eventually apply to almost all aspects of what we do. At this early stage, however, our lab is focused on an area where we believe significant room to increase safety and efficiency exists in the near term: EOD operator training.

When we analyze the HMA EOD workflow, there is room for improvement throughout. This begins with initial EOD-technician training, whose quality can vary significantly based on instructor, candidate profile, curriculum, classroom resources, and national standards. Effective areas for intervention through new technologies

are most immediately possible in the classroom resources and in the curriculum. Through the International Mine Action Standards (IMAS), the community works to address the curriculum issue; we focus on classroom resources.

The cause for high variability in EOD classroom resources is mostly obvious. Funding remains the key issue as it relates to a school's ability to purchase or produce expensive inert ordnance training aids. The other issue is that there are inadequate resources for this task.

In EOD, we are required to understand abstract concepts (e.g., explosive effects and the effect of physical forces on fuze mechanisms during the arming and firing sequences). It has always been a challenge to convey these concepts to students from diverse educational backgrounds. The ability to do so often relies solely on the ingenuity of individual instructors. An illustrative example is how some instructors seek to illuminate the concept of centripetal force by spinning a rubber band around a pen. For less readily demonstrable concepts—such as spalling from squash-head projectiles—even the best instructor can find themselves without adequate tools to reach students.

This is where we targeted our first products using AR and VR. By leveraging our lab's unique blend of digital engineers, mechanical engineers, and in-house EOD expertise, AROLS was designed to provide digital solutions to deepen student understanding of fundamental concepts. By providing these products on commercial off-the-shelf (COTS) platforms, we are able to create nearly universal availability, decreasing the gap between training programs of varied resource levels.

## Augmented Reality Ordnance Learning System (AROLS)

With a clear understanding of the limitations of conventional EOD training and the resource constraints of the HMA sector, our team designed our first product to run on Android smartphones: AROLS, a platform that can be purchased and repaired in nearly every corner of the globe. Utilizing a software framework developed by Oculus and Samsung, the GearVR, we created a software package that allows users to visualize the functionality of explosive ordnance fuzes on any table using simple markers.

Employing AROLS, users see static ordnance items and animations of their functioning appear in front of them in photo-realistic renderings, which blend seamlessly into the natural environment. This effect makes the virtual ordnance seem as though it is there, giving an unparalleled realism, which increases the learner's chances of retention. It is the difference between watching a video of a process and actually witnessing it firsthand. This system is currently in use in HMA EOD programs worldwide, though the official launch took place at the GICHD Technology Workshop in November 2019.

### How it Works

Currently AROLS has 121 unique nomenclatures that include 21 highly-detailed animations. The AROLS app can be downloaded from the Google Play Store to any high-end Android device and can be used with or without a VR headset. Once downloaded, the app



This image is not Photoshopped or manipulated in post-production. You are viewing a screenshot from a fourth device looking at the same AROLS marker, using the same equipment as the other three users seen in the photo. The landmine on the table is displaying the same way to all four users. Using small group techniques, users can explore ordnance functioning together.



The newly-released plastic marker cards (right) are portable and durable. The menu cards (left) allow users to select ordnance items to display on the marker cards by simply scanning a QR code instead of searching through a menu. This form of non-language-based user interface enables the system to be readily used by almost anyone with two minutes' training. While marker cards are not required to use the AROLS system, they provide a more reliable user experience and are recommended. They can be purchased separately though the Golden West website for a minimal fee, or users may print them using an ordinary PC printer from a provided PDF file.

must be activated through an annual subscription purchased online requiring an identification card and credit card—steps necessary to ensure that users of potentially sensitive EOD information are identifiable. Once purchased, this app can be used an unlimited number of times on the device, potentially serving a classroom of students with only a few devices.

In addition to the app, users need a *marker card* to put on the table. This marker allows the app to recognize the surface orientation and relative scaling. This is how the software understands where to place the virtual object and what the size needs to be. While other technologies (surface mapping) exist in higher-end devices (e.g., the Microsoft HoloLens), the reliability of these technologies on smartphones remains unacceptable at this time.

We produce a set of marker cards made from durable plastic that can be purchased separately online, or users can download a free printable PDF file. Users in areas without printing accessibility can also use commonly available currency as markers: the U.S.

one-dollar note, the five-euro note, and the British five-pound note. Additional custom markers are possible upon request though we expect a transition away from the marker-based system within the next few years, as systems like Google ARCore become more capable.

## Virtual EOD Training Room

For scenario-driven training, it is the virtual space that offers the most profound opportunities. The virtual world is a blank canvas on which we can create any world or situation. Applying this to HMA EOD, we took a similar approach to the AROLS process and looked for areas where simulation could create significant leaps in student and/or operator capabilities.

The concept we created is the Virtual EOD Training Room. This system utilizes the HTC Vive to deliver a room-scale VR experience allowing users to become fully immersed in a complex training scenario. Most importantly, the system allows instructors to create these scenarios in minutes

using a simple pick and place interface. It is through empowering non-technical users to quickly create these scenarios that we provide a tool capable of adapting to the ever-changing set of tactics, techniques, and procedures required for EOD operators.

An example of this would be an urban post-conflict IED-clearance scenario. In conventional training, this would take place in a parking lot, football pitch, or at best, an expensive specialized military training facility. Fellow team mates would likely be posing as various characters and the operator would be asked to pretend buildings were



A screenshot from a device viewing a 40 mm rifle grenade up close. Objects appear to users as though they are floating on the marker.



An early proof of concept showing how AR can assist users in placing tools. Here you see a mock .50 cal dearmers, which was placed in position for an attack on the mortar fuze using only the AR system for reference. In the near future, tools similar to this will shorten times on target and lower the potential for technical errors during EOD operations.

arranged differently or cars were not where they are. It would be a giant game of make believe where nearly all the critical details and nuance critical to understanding real-life threats were absent.

Utilizing VR, not only are we able to create and build environments that are exactly what the instructor would like to mimic, but we can create the dynamic details critical for EOD scene management. These could include a person on the roof talking on the phone, random crowds of civilians mobbing a scene, or security elements parking too close to suspected IEDs. These are the elements that make operational EOD so difficult, which, until now, have been nearly impossible to replicate in a training environment.

While we have completed the proof-of-concept phase for this system, the development with key customers is still ongoing. Therefore we are only prepared to present this short conceptual overview of the system; however, we remain open to opportunities for partnership. Any interested parties are encouraged to reach out to our lab.

## The Near Future

As we complete AROLS, we look to the next leap in the application of AR. Our ability to create usable products is wholly dependent on the consumer-electronics industry and their ability to deliver suitable platforms for our sector. This means platforms that are not only capable but cost-effective and durable. Fortunately, the AR space is rapidly evolving, and each year we see significant improvements.

The next step for our lab is to move from the training space into the operational space, a move that tracks the development of the technology itself. As AR goggles become more suited to field conditions, we can start applying EOD operational assistance tools to these platforms. We have completed a proof of concept in which a user that is wearing AR goggles can position a dearmers for an attack against a fuze without needing to use handheld measurement tools. The user sees an overlay

of the appropriate tool placement in their vision and is able to match the actual dearmers to that overlay, thereby aligning the shot correctly without tools.

In the next phase of our digital EOD tools, we will link the OrdHUB ordnance technical database to the AR systems. This will allow users to both search and visualize search results through their head-mounted AR displays. The ideal workflow will be a hands-free interface that allows users to identify ordnance by looking at it and then retrieving all relevant information and assistance for tool or disposal charge placement overlaid on the ordnance item. It is through these types of tools that we will eventually create a universal standard for the delivery of EOD services. ©

*For more information about Golden West Design Lab's augmented reality and virtual reality HMA-EOD training, please contact Allen Dodgson Tan at [allen.tan@goldenwesthf.org](mailto:allen.tan@goldenwesthf.org).*

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