A mobile augmented reality application for biomedical research and education

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Abstract

Augmented reality (AR) technology combines a real-world view with computer-generated assets. AR devices range from high-end wearable headsets to smartphone-based applications that can be used with or without inexpensive stereoscopic viewer accessories. Our research and others' work has shown the potential to dramatically change biomedical research, education, and clinical practice.

We implemented a mobile application for 3D visualization of biological structures in AR using the MERGE Cube™ (Merge Labs, Inc.), a 2.75" foam cube. A smartphone camera detects markings on the outer surface of the cube onto which a hologram is projected, thus allowing the user to manipulate the virtual object with their hands.

Our mobile app prototype uses the MERGE Cube software developer kit to display 3D models of biological structures, either on the flat smartphone screen or with a wearable smartphone accessory for stereoscopic viewing. 3D manipulation of these models in AR provides a novel and convenient method for researchers and students to communicate and learn about structural and functional features of biomolecules and viruses.

Our alpha version is developed for the Apple iOS platform, and we are incorporating additional biomedical structures besides influenza virus models and interactive features. Demonstrations of the app thus far have received positive feedback (especially from hundreds of users including teachers, students and researchers during 2018 US Sceince and Engineering Festival), and more extensive user testing is underway with a small number of NIAID research staff. Our intention is to extend the app for Android OS capability and to make it freely available to the public.

Augmented Reality

Augmented reality technology involves the overlay of digital information onto a real-world view, essentially "augmenting" the user's view of their environment.

Left: Example of augmented reality showing a digital 3D heart model on top of a real-world view, captured with the user's smartphone. Right: the Microsoft HoloLens is an example of a more sophisticated AR technology that projects holographic images onto glasses or a visor.

The Merge Cube

The MERGE Cube (© Merge Labs, Inc., www.mergecube.com) is a 4"x4" foam cube that is used to manipulate holographic objects using the camera of a smartphone or tablet device.

A digital 3D image is mapped to unique markings on each face of the cube detected by the camera. As the user moves the cube, the digital object moves correspondingly, and will also shrink and grow as the cube is moved away and toward the device.

The lightweight, 2.72-ounce cube is made a of soft, squishy foam that is attractive as a toy, making it an engaging tool for education. Dozens of apps are available for iOS or Android.

Left: Marking on three faces of the MERGE Cube. Right: The MERGE Cube foam is soft, but quickly returns to its original shape.

The cube is available online and in stores (Amazon, Walmart, Target, etc.). MSRP is $14.99, but it can be purchased for as low as $5.

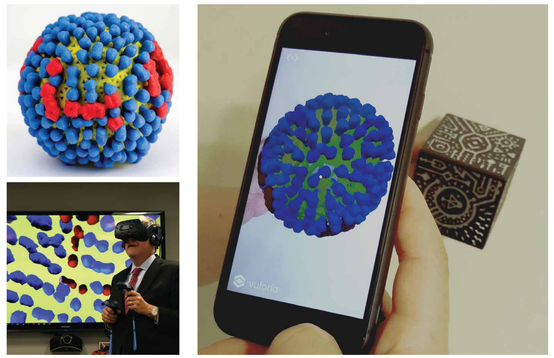
A MERGE Cube app for scientific visualization

Based on our experience with 3D printing, and more recently with immersive virtual reality, we posited that a mobile AR app would be a convenient and more accesible means for experts and lay users to learn and communicate about molecular structures and other bioscientific content.

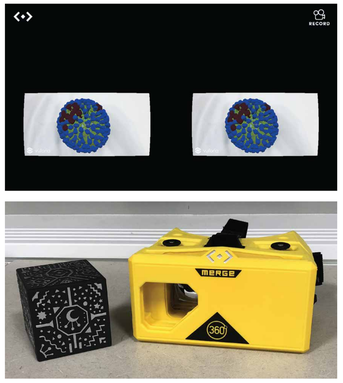
Using the MERGE AR/VR software development kit (SDK) we have created a prototype AR app, compatible with any iOS device (iPhone, iPad and iPod Touch) with iOS 8 or newer for the iOS platform.

Our development environment uses the following software:

- MergeCube SDK v1.2.2
- Unity2017.2
- XCode 9.2
- Vuforia SDK 7.2
- Blender 2.79



Above, the same digital 3D model of an influenza virion created from cryo-electron microscopy data - is represented as a 3D print (top left), in our augmented reality app (right), and in virtual reality (bottom left). Source model was created by Dr. Darrell Hurt (NIH/NIAID) based on data provided by Bernard Heymann (NIH/NCI).



Left: a user points an iPhone at a MERGE Cube using the "phone" mode. The "VR" mode creates a stereoscopic view (above right) that adds depth perception to the experience. It also leaves both of the user's hands free to manipulate the cube. MERGE Cube and MERGEVR Goggles shown at bottom right. The MERGE Cube app can be used with most other consumer-level, affordable, 3D smartphone goggles.

Applications and features

The MERGE Cube is low cost, efficient, learning tool for users of all ages. It was met with positive enthusiasm when we demonstrated the prototype at the USA Science and Engineering Festival in Washington, D.C., in April 2018.

The convenience and portability of our app make it a potentially impactful tool for researchers to communicate their findings. The cube is an attractive alternative to 3D-printed models, which can be heavy or fragile, and the app also allows access to multiple 3D models.

Current and future development includes interactive touch-screen or vision-guided annotations; selecting from a library of models; and pre-processing pipelines to prepare 3D model files.

Left: a young visitor to the USA Science and Engineering Festival manipulate the cube with the smartphone inserted into goggles. (Credit: USA Science & Engineering Festival Sponsor Recap Report. https://bit.ly/2HKf2cy). Right: Dr. Barney Graham (NIAID/VRC) uses a 3D print an influenza receptor to explain the structure during a conference presentation. With our app, he can carry many models with him to a conference, and the smartphone view can be projected to a screen for large demonstrations.

Additional information about Merge Labs products, including the MERGE Cube, smartphone goggles, and the MERGE VR/AR SDK can be found at https://mergevr.com.

Special thanks to Dr. Barney Graham (NIAID Vaccine Research Center), for championing this technology and providing valuable feedback for current and future work.

The digital file of the influenza virion is available for download at https://3dprint.nih.gov/discover/3dpx-000030. The model was created using UCSF Chimera software (https://www.rbvi.ucsf.edu/chimera). Chimera is developed by the Resource for Biocomputing, Visualization, and Informatics at the University of California, San Francisco. Pettersen et al., UCSF Chimera - a visualization system for exploratory research and analysis. J Comput Chem. *2004 Oct 25. 25(13):1605-12.*

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