“Augmented microscopy: Real-time overlay of bright-field and near-infrared fluorescence images” introduces a prototype of an augmented stereomicroscope with the potential to help surgeons perform microsurgery with a greater degree of accuracy.

Surgical microscopes—highly specialized stereomicroscopes installed on articulated mounts and providing a long working distance and functional enhancements—are widely used in performing certain delicate operations, most notably neurosurgery.

Within the last decade, surgical microscopes (also called *operating microscopes*) have been combined with near-infrared (NIR) fluorescence imaging, in which contrast agents are injected into biological tissue and their fluorescence is picked up in NIR scans. Indocyanine green (ICG), for example, is a contrast agent used in neurovascular surgery to reveal patterns of blood flow; it is also used in cancer treatment, to delineate cancerous tissue from normal tissue.

Established ways of augmenting surgical microscopes with NIR imaging have limitations. For instance, some microscopes used in complex vascular surgeries switch between two different views: the fully optical bright-field (real) view and the fully electronic projection of NIR fluorescence. The two-dimensional NIR image alone lacks the spatial cues that would normally help the surgeon identify anatomical points of reference; the surgeon must visualize how the fluorescence in the NIR image lines up with the respective anatomical structures shown in the bright-field view.

Now researchers at the University of Arizona, with funding from the National Institutes of Health, have built and tested a prototype that produces a simultaneous view of the surgical field (real object) and computer-processed NIR fluorescence (synthetic object), superimposed in real time.

The authors of the paper successfully demonstrated fluorescence angiography with augmented microscopy enhancement (FAAME) in animal models. They anesthetized three-month-old female rats, and surgeons exposed the left carotid artery (the artery that supplies the head and neck with oxygenated blood) under the microscope operating in the bright-field mode. The rats were then injected with ICG solution.

Looking at one of the rats through the eyepiece of the augmented microscope, researchers saw a composite of the real and synthetic images, the fluorescence of ICG presenting in false color to help identify blood vessels, branching points, and the direction of blood flow. The prototype offers a range of magnification between 8x and 56x, and the synthetic image is updated approximately 20 times per second.

The prototype offers advantages over earlier versions of augmented microscopes: by utilizing the optical path of the stereomicroscope, it maintains full three-dimensional stereoscopic vision, which is lost in fully digital display systems. It also retains the imaging environment familiar to surgeons, including key features of surgical microscopes such as real-time magnification and focus adjustments, camera mounting, and multiuser access.

One possible application for this augmented microscope is laser surgery. In the past, surgeons could not see the laser beam through the standard stereomicroscope, or anatomical details in the NIR images. The prototype allows for complete visualization of the treatment beam and the visible environment together.

The researchers also suggest that this technology will be useful in the surgical treatment of brain tumors. Surgeons aggressively removing a tumor run the risk of damaging normal brain tissue and impairing the patient's brain functions; on the other hand, incomplete removal of a tumor results in its immediate relapse in 90% of patients. Being able to simultaneously see the surgical field and the contrast agent within the augmented microscope may allow surgeons to remove these challenging tumors more accurately.

Fig. 1 Schematic of optical pathway in augmented microscope. Current prototype provides augmentation in the right ocular.

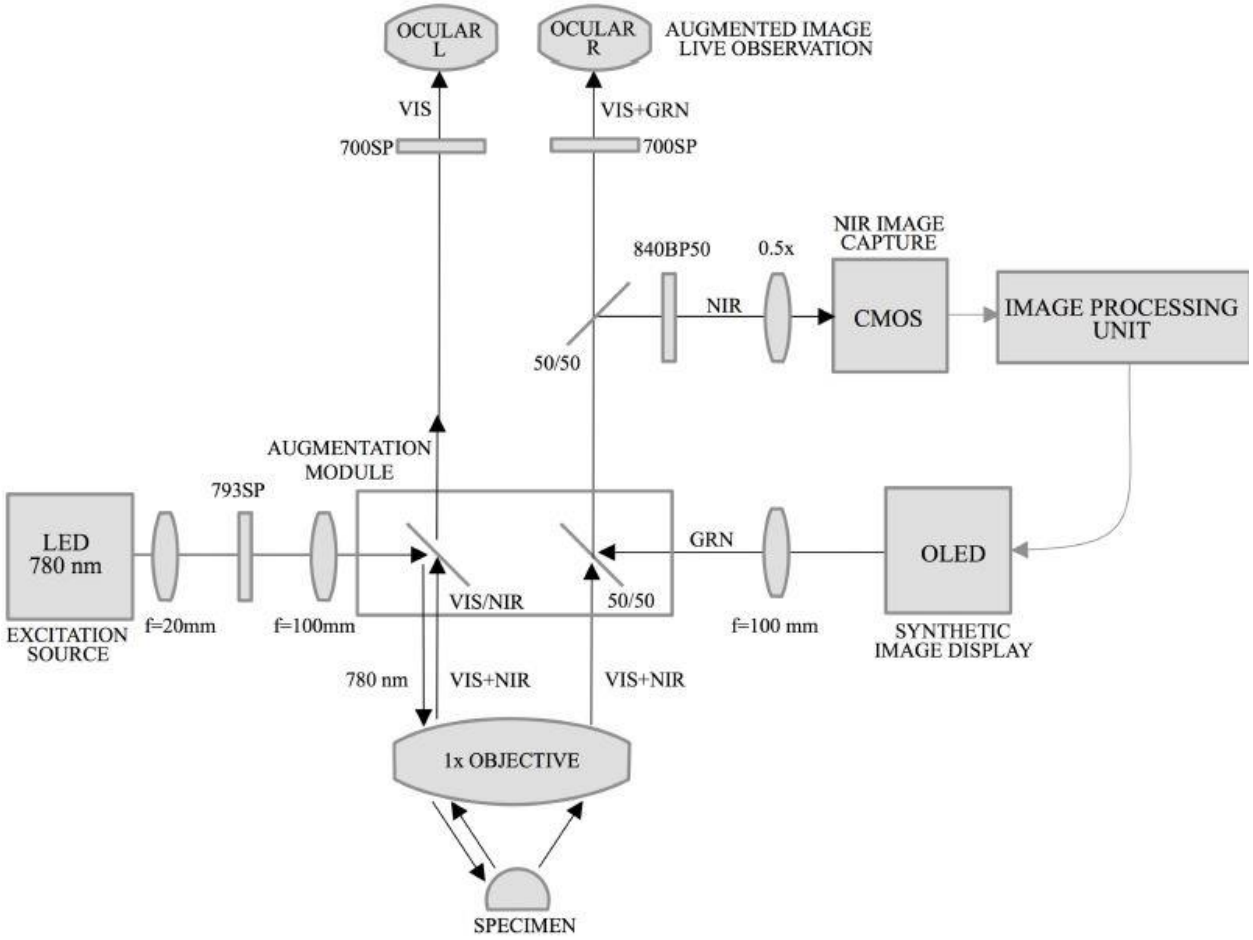


Fig. 2 (a) Augmented microscope system on a stand with extendable arm and motorized telescoping base. (b) Closeup view of microscope with augmentation module.

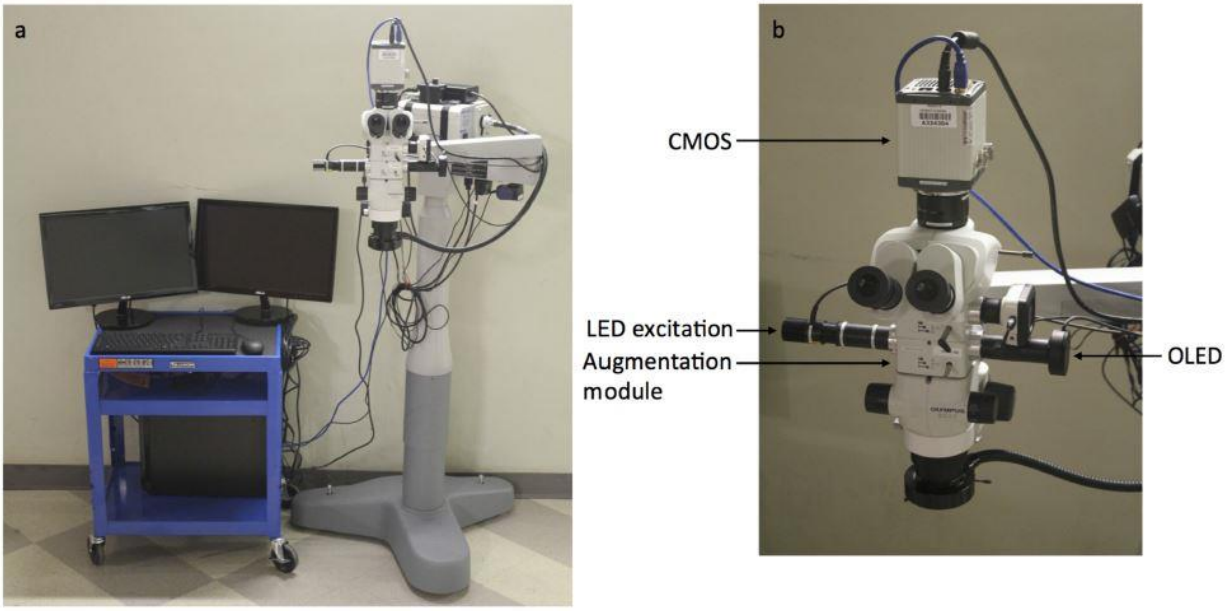



Fig. 6 Custom colored dye solutions with randomly plated ICG solution. (a) Visible view through microscope, (b) NIR view seen on computer monitor, (c) augmented view seen in realtime through the ocular of the augmented microscope.

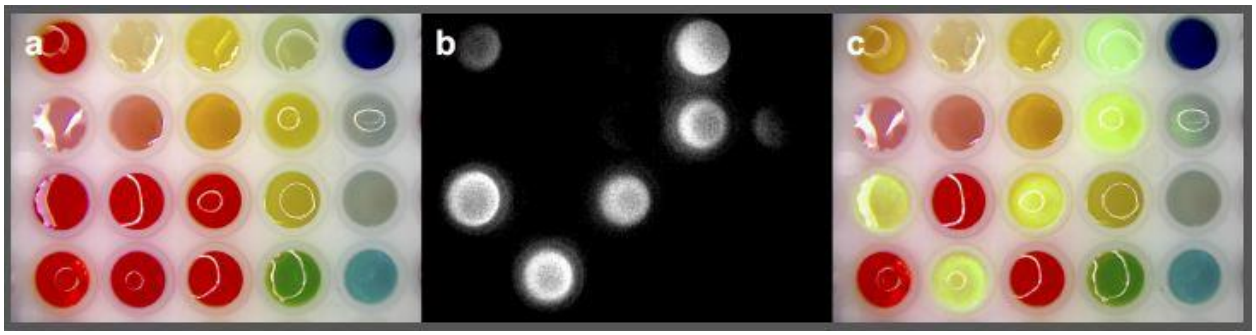


Fig. 7 NIR laser light delivered through hand-held laser wand for demonstration of NIR laser beam guidance by augmented microscope. (a) Visible image conceals location of NIR laser beam, (b) NIR image lacks any spatial information, (c) augmented image visualizes both NIR light and visible spatial ques.

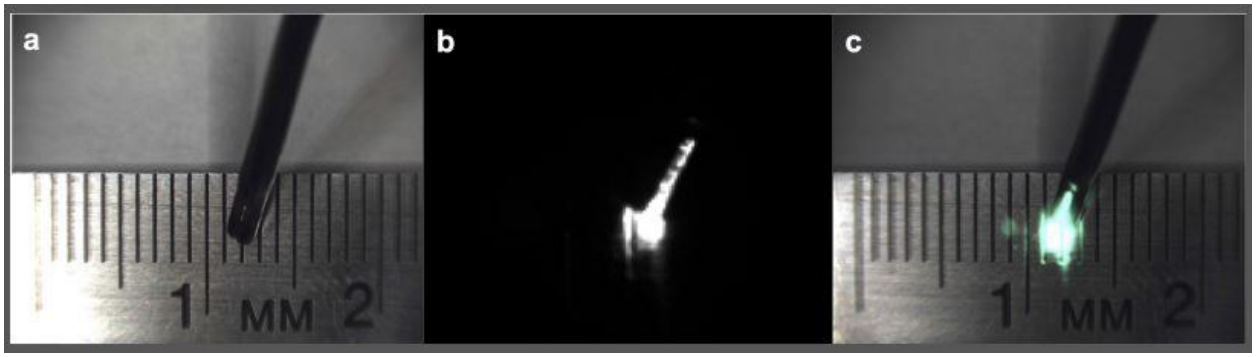
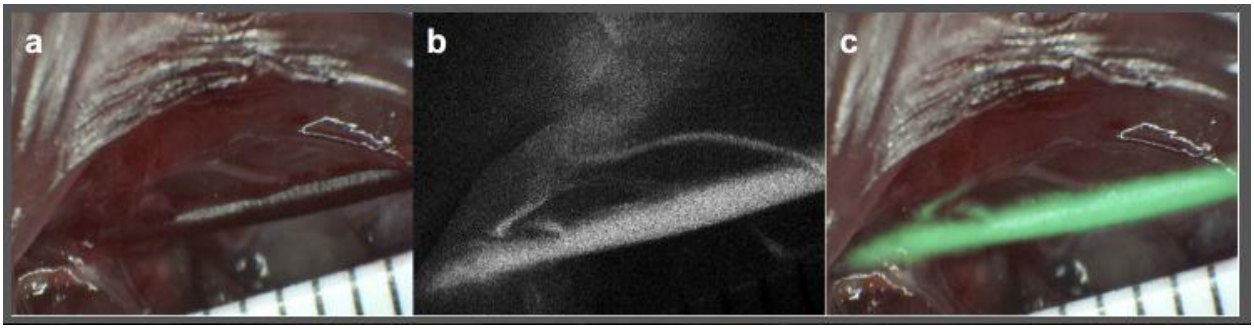



Fig. 8 Left rat carotid artery. (a) visible image, (b) NIR image, (c) augmented image (also shown in Video 1). Ruler increments are 1mm. Spatial differences between simultaneously acquired NIR and augmented images are a result of capturing these images at different microscope ports.




**Please note:** Above is the content I submitted to Amy Nelson, Public Relations Manager for SPIE, based on the full article in the peer-reviewed *Journal of Biomedical Optics*. To see the final press release distributed by SPIE, visit the organization's website at http://spie.org/about-spie/press-room/press-releases/jbo-augmented-microscopy-10-6-2015. — Christine Hosler