Improving Surgical Training Phantoms by Hyperrealism

Deep Unpaired Image-to-Image Translation from Real Surgeries

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Current 'dry lab' surgical phantom simulators are a valuable tool for surgeons which allows them to improve their dexterity and skill with surgical instruments. These phantoms mimic the haptic and shape of organs of interest, but lack a realistic visual appearance. In this work, we present an innovative application in which representations learned from real intraoperative endoscopic sequences are transferred to a surgical phantom scenario. The term *hyperrealism* is introduced in this field, which we regard as a novel subform of surgical augmented reality for approaches that involve real-time object transfigurations. For related tasks in the computer vision community, unpaired cycle-consistent Generative Adversarial Networks (GANs) have shown excellent results on still RGB images. Though, application of this approach to continuous video frames can result in flickering, which turned out to be especially prominent for this application. Therefore, we propose an extension of cycle-consistent GANs, named *tempCycleGAN*, to improve temporal consistency. The novel method is evaluated on captures of a silicone phantom for training endoscopic reconstructive mitral valve procedures. Synthesized videos show highly realistic results with regard to 1) replacement of the silicone appearance of the phantom valve by intraoperative tissue texture, while 2) explicitly keeping crucial features in the scene, such as instruments, sutures and prostheses. Compared to the original CycleGAN approach, tempCycleGAN efficiently removes flickering between frames. The overall approach is expected to change the future design of surgical training simulators since the generated sequences clearly demonstrate the feasibility to enable a considerably more realistic training experience for minimally-invasive procedures. The work was presented at MICCAI 2018 [1]. A supplemental video is available here[1].

References

1. Engelhardt S, De Simone R, Full PM, et al. Improving surgical training phantoms by hyperrealism: deep unpaired image-to-image translation from real surgeries. Proc MICCAI. 2018; p. 747–755.

[1] https://youtu.be/qugAYpK-Z4M