ACS 2025 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

O-11

Promoting Technology and Collaboration

AI-Empowered Anticipation of Surgical Triplets in Laparoscopic Videos for Enhanced Educational Support

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Background: Context-aware generative systems represent a substantial advancement in surgical education, decision-making, and workflow analysis, also provide significant benefits to AR/VR Surgical Simulation. In this context, we present *SurgAnt*, an AI-driven model specifically developed to predict future surgical triplets. Our project can be found at https://bot-white-g1ve.github.io/DiffAnt/.

Technology Overview: <u>Surgical Triplet</u>: defined as a combination of three surgical components <instrument, verb, target>. This provides deeper insights than other representations such as phases, steps, or events. <u>Surgical Triplet Anticipation</u>: *SurgAnt* utilizes the Diffusion Model as its technical framework to anticipate a sequence of future triplets based on the video observation up to the current time captured by the minimally invasive camera. Diffusion Model is originally a generative model that synthesizes images through a reverse diffusion process. Leveraging diffusion guidance, *SurgAnt* can generate triplet sequences, surpassing the traditional scope of image synthesis. To enhance the model's ability to accurately and stably anticipate future surgical triplets in real-time, we have introduced several novel techniques, including Causal-Convolutions&Attentions, Anticipation-Embedding, and Easy2Hard-Learning.

Potential Application in Surgical Simulation and Education: *SurgAnt* provides a novel system for providing surgical education to trainees which eliminates the need for in-person skilled individuals at the bedside which is a difficult commodity to provide on demand. This technology we also envisage to be utilised as a method for objective critical review/appraisal of procedures that can be performed by surgeons. There is also potential benefit in quality assurance projects for benchmarking surgical technique.

Potential Opportunities to Collaborate: Partnerships with hospitals and healthcare organizations would enable access to extensive datasets of surgical videos and real-time operating room experiences. Collaboration with technology developers in medical devices and software could facilitate the integration of *SurgAnt* into existing surgical simulation systems, leading to the development of comprehensive, embedded solutions.

Surgical Triplet Anticipation

Past — Current — Future

Timeline

Grasper Grasp Gallbladder / Hook Null Null

Hook Null Null

Hook Null Null

Hook, Coagulate Gallbladder

Grasper Grasp Gallbladder / Hook Coagulate Gallbladder

Grasper Grasp Gallbladder / Grasper Grasp Gallbladder