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Experts Employ a Target-Locking Behaviour in Laparoscopic Surgery

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ABSTRACT

Minimally invasive surgery has gained a lot of attention owing to its advantages, including shorter recovery times and lower blood loss compared to open surgeries. However, this type of surgery requires skills in addition to open surgery due to indirect vision, fulcrum effect of tools, and limited tactile feedback. Minimally invasive surgery requires new levels of eye-hand coordination to perform proficiently. Hence, eye-hand coordination assessment can play an important role in surgical skill assessment and training.

We use motion-tracking and eye-tracking in minimally invasive surgery to investigate the eye-hand coordination pattern of surgeons. Explicitly, we tracked the position of surgical graspers using an OptiTrack motion-capture system (120 Hz) and the position of eyes using a Tobii Pro Nano remote eye-tracker (60 Hz) attached to the bottom of the monitor displaying the surgical site. Having collected this data synchronously, we investigated the synchronously tracked tool motion and eye motion data. Down-sampling of motion-capture data was carried out to equalize the sampling frequency of both measurement systems. Moreover, the tool motion and eye motion data were registered and represented in a single coordinate system using a calibration procedure, which converted motion-capture data to pixels. We analyzed the data recorded from three expert general surgeons and three novices who did not have laparoscopic surgery experiences. They performed an object transfer task in a simulated laparoscopic surgery setting. Once all data were collected, we evaluated the hypothesis that experts and novices employ different eye-hand coordination patterns.

Our analysis revealed that experts moved their gaze to the target in advance of surgical grasper. In comparison, novices primarily focused their gaze on the movement of surgical grasper. Experts had a mean ± standard deviation target-gaze distance and target-tooltip distance of 101 ± 22 and 201 ± 8 pixels, respectively, compared to novices with 195 ± 49 and 290 ± 87 pixels, respectively.

This notable difference is attributed to a higher skill level in the expert group supported by their better motor control strategies. The experts were able to disengage their visual attention from tools to the target. Consequently, they were more confident in their hand movements and able to deliver anticipatory movements, thereby employing a so-called ‘target locking’ strategy instead of the ‘tooltip following’ presented in novices. Different eye-hand coordination patterns found here between experts and novices suggest that we can use this behavioral marker to distinguish the expertise of surgeons in minimally invasive surgery.

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