Visual behaviour in laparoscopic surgery using eye-tracking
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Minimally Invasive surgery

Minimally invasive surgery (MIS) is surgery done through small incisions. It is performed using specialised narrow, elongated instruments which the surgeon navigates using visual information relayed to a monitor from a miniature camera.

Shorter hospitalisation has made MIS very popular in recent years. However, for the surgeon there is a requirement of a higher degree of competency due to several constraints, of which the primary is the narrow monoscopic field of view of the operative field.

With advancement in technology, surgery is required to become safer. This can be achieved by better equipment, better training and continuous assessment of surgical competency.

Eye and eye tracking

The fovea is a tiny indentation on the retina and is responsible for the high definition visual acuity of only one to two degrees. Outside the fovea visual acuity drops off dramatically from the centre of focus.

When we try to understand a scene we fixate our eyes on particular areas and move between them. The intrinsic dynamics of eye movements are complex and saccadic eye movements are the most important to consider when studying visual search. The objective of a saccade is to foveate a particular area of interest in a search scene.

Eye tracking is the art of recording saccades and determining fixations.

Aim of the study

To assess how attention and different visual cues are integrated whilst performing laparoscopic tasks.

Methods

A homogeneous group of 7 medical students with no prior laparoscopic experience was used for this study (ethical approval obtained).

All subjects were equally trained on a laparoscopic simulator prior to performing the "real" task.

The "real" task required the participants to grasp a colored section of a simulated blood vessel fixed on plastic skin pad and transect it at a subsequent colored section using laparoscopic instruments (grasper (G) and scissors (S)).

The operative field was recorded using a camera fixed within a box-trainer and live video footage was streamed via a computer onto a 2D video screen. The two targets on the simulated blood vessel and both tool tips were differently coloured as to allow the automatic extraction and tracking of these 4 features from the recorded video footage.

Gaze positions were recorded during the procedure using a Tobii ET-1750 video based infra-red eye tracker capturing the position of gaze in the work plane (screen) at up to 38 samples per second (1 degree accuracy).

Data Analysis

The instrument tip (A), the target anatomy (B) and the feature space in between (C) represented the areas of interest (AOI). For a detailed analysis of visual search and hand/eye strategy, the surgical task was decomposed into two steps: vessel grasping (task 1) and vessel transection (task 2).

Each AOI was defined by different colours and automatically tracked by colour segmentation by hue-saturation space filtering.

The co-ordinates of each AOI were combined with the gaze data and using developed software we determined which AOI foveal vision (taken as 2° visual angle) was centered on. In order to extrapolate intrinsic information of each individual’s dynamic eye movements, Markov modeling was used to investigate the sequence of temporal fixations.

Results

Mean transition probabilities for the participants performing the surgical task. Transitions between the vessel and instrument were the clear method adopted. There are further saccades between the vessel, instrument and surrounding feature space. Decomposed mean transition probabilities for the group for task 1 and 2. Data clearly illustrates the similarities in strategy for both task one and two.

Discussion and conclusions

- We present a framework for extracting visual search behaviour in laparoscopic novices by analysing the eye movements and transitions between areas of interest for a simple laparoscopic task.
- Temporal analysis of eye movements has highlighted strong intra-individual disparities reflecting different abilities in performing the same surgical task.
- Future work will focus on investigating such behaviour in experts and determining any associations with competency.