Development of a realistic, patient free colonoscopy training environment using patient data

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Objective
To develop a highly realistic computer based interactive training environment for colonoscopy which produces anatomically correct training scenarios extracted from patient Computed Tomography (CT) images, suitable for training, skills maintenance and certification.

Methods
An aging population coupled with growing colorectal cancer screening programs is likely to increase the demand for colonoscopy services in Australia. Colonoscopy is a difficult procedure to master, requiring several hundred cases to reach expert level, with most training currently occurring on real patients.
Existing computer based colonoscopy simulators, while exhibiting construct validity, rate poorly for anatomical, haptic (force feedback) and visual realism and present an insufficiently large range of case complexity to discriminate between intermediate, experienced and expert endoscopists[1]. Training advantages of using these systems disappears after the first 30 – 80 patient based interventions[2,3] likely due to lack of realism compared to animal based models[4]. Successful training of colonoscopy to a high level of competence requires the experience gained from many interventions and exposure to a wide variety of cases, driven primarily by patient age, body mass and colonic pathology. The primary aim being to teach force minimisation and endoscope loop reducing techniques, where cues are often subtle forces experienced through the clinical endoscope.

We have developed new techniques for development of virtual colons extracted from patient CT images. Novel visualisation techniques have been developed so that blood vessels, surface pathologies and other surface details can be displayed in a simulated colonic environment. A custom haptic device[5] has been developed which allows insertion of a modified clinical colonoscope[6] and provides the rotation and insertion depth of the endoscope to the simulation. Advanced mathematical models of the colon, mesentery and colonoscope have been developed which accurately model organ and tool interactions during interventions and compute forces which can be applied to the inserted endoscope via the custom haptic device. Colon and mesentery models can be tuned to represent the physical properties characteristic for different pathology and patient body types.

Results
A highly realistic computer based colonoscopy system has been developed which provides anatomically and visually accurate colon cases. Feedback from expert clinical collaborators indicates that our system has significant realism improvements over existing computer based simulations. Physically based mathematical models of the colon and colonoscope have demonstrated the ability to form all common endoscope loop formations in the presence of suitable mesentery constraints and work continues on development and integration of haptic hardware. Clinical validation studies are planned in the near future.

Conclusions
We have successfully overcome many computational challenges in development of a system for presenting anatomically and visually accurate training scenarios for colonoscopy, extracted from patient CT images. Evaluation of the system by expert gastroenterologists indicates that significant improvements in realism have been made over existing computer based colonoscopy trainers. Through improvements in visual and haptic realism we aim to provide a training system which is eventually suitable for certification while continuing to reduce the reliance on actual patients for training.

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