Automated detection of cecal intubation with variable bowel preparation using a deep convolutional neural network

Low DJ, Hong Z, Jugnundan S, Mukerjee A, Grover SC

Introduction: Colonoscopy completion reduces post-colonoscopy colorectal cancer. As a result, there have been attempts at implementing artificial intelligence to automate the detection of cecal intubation. However, the utilization of these algorithms has not been demonstrated under variable bowel preparation. We present an automated computer-assisted method using a deep convolutional neural network to detect colonoscopy completion with varying bowel preparation.

Methods: We extracted 13, 513 images of cecum (6,847) and non-cecum images (6666). Images of the cecum included the appendiceal orifice and triradiate cecal folds. Non-cecum images included images of the colon (excluding cecum), red outs, fuzzy images, fluid levels, etc. The Boston Bowel Preparation Scale (BBPS) was applied to the dataset. Non-cecum BBPS unclassifiable images were defined as images in which BBPS scores could not be codified (fuzzy, red outs, fluid levels, etc). In total, 13, 222 images (6559 cecum and 6663 non-cecum) were used in the dataset, which was split into 11, 900 images for training and validation, and 1,322 images for testing. We developed a convolutional neural network (CNN) with a DenseNet architecture pre-trained on ImageNet as a feature extractor on our data and trained a classifier uniquely tailored for identification of cecum and non-cecum images under varying bowel preparation, using binary cross entropy loss. We used Adam optimiser with an initial learning rate of $3x10^{-4}$ and a scheduler to decay the learning rate of each parameter group by 0.1 every 7 epochs.

Results: The proposed model was able to correctly classify cecum and non-cecum with variable bowel preparation with an overall accuracy of 94%. The sensitivity, specificity, positive predictive value, and negative predictive value of the model was 0.96, 0.92, 0.92 and 0.96, respectively. The test dataset contained 656 images of cecum, including 355 BBPS 1 (54%), 255 BBPS 2 (39%) and 46 BBPS 3 (7%) images. There were 666 images of non-cecum, including 81 BBPS 1 (12%), 315 BBPS 2 (47%), and 116 BBPS 3(17%), and 154 BBPS unclassifiable images (23%). The cecum was correctly identified in 97%, 95%, and 96% of BBPS 1, 2 and 3 images, respectively. Non-cecum was correctly identified in 84%, 90%, 98%, and 96% of BBPS 1, 2, 3, and unclassifiable images, respectively.

Conclusion: We present an automated computer-assisted detection method of colonoscopy completion with variable bowel preparation using a deep convolutional network. The algorithm has a high overall accuracy (94%) for detection of the cecum and non-cecum. The algorithm continues to perform well despite variable BBPS scores. However, further studies need to be conducted to evaluate its usability in real-time colonoscopy.