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TITLE: Evaluation of an automated lesion detection platform for wireless capsule endoscopy: a novel approach utilizing video-based machine learning temporal relationships.

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Background: Wireless capsule endoscopy (WCE) has dramatically improved detection and evaluation of small bowel pathology. Unfortunately, the reading process is laborious and monotonous—potentially leading to poor attentivity and diminished diagnostic yield. Machine learning has become a viable option for automated reading of WCE videos due to low-cost quick GPUs. As anatomy, image quality/composition, and solid/liquid debris present complex problems for video-based machine learning—groups have utilized static images for their algorithms due to relative ease of implementation. Unfortunately, static images are prone to false positives and misdetections due to the lack of temporal relationships that are crucial in discerning lesions from debris. Our team has developed a novel neural network algorithm for lesion detection that utilizes video sequencing and temporal relationships between frames. The goal of this preliminary report is to assess the performance of this novel algorithm.

Methods:
410 WCE videos (PillCam SB 2/3) were collected between 2014-2018 at our tertiary care medical center. For Cohen's Kappa calculation, 26 sets of video were randomly selected for inclusion. Videos were deidentified and AVMs were found by two independent medical providers, a third was used in case of disagreement, prior to algorithm processing. 12 videos that contained AVMs and were used for the training set (1200 frames). The novel neural network implemented GPU compatible versions of python code in OpenCV (https://opencv.org/) and TensorFlow (https://www.tensorflow.org/) with a two-layer convolutional network feeding into a three-layer LSTM network. Video files were batched into those with and without AVMs (600 frames with; 600 without). Two sets of videos were separated as "hold-out" sets for validation and predictive capability. The videos in the training algorithm were split 65%--35% for internal training and validation. Final validation was them performed using the "hold-out" sets.

Results:
The algorithm yielded a combined Cohen's kappa of 0.6 with a correct prediction of 80.4% on the two "hold-out" sets when compared frame by frame. When the threshold detection of 5 continuous frames indicating an AVM was utilized, the correct identification of AVMs in a data set was 100%. 11/100 frames were detected as false positives and 14/100 frames were detected as false negatives during intermediate steps; however, no false positives or false negatives were noted on final interpretation when evaluated as continuous frames. The total GPU processing time was 45 min for algorithm training and < 30 s for validation sets.

Conclusions:
Our novel video-based algorithm utilizing temporal relationships of frames was successful in detecting AVMs in this study. The algorithm was robust and efficient. Implementation of this

novel algorithm for identification of non-AVM lesions is ongoing and clinical studies for automated/clinician-assisted lesion detection are underway.