

## MINING COLONOSCOPY VIDEOS TO MEASURE QUALITY OF COLONOSCOPIC PROCEDURES

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### ABSTRACT

Colonoscopy is an endoscopic technique that allows a physician to inspect the inside of the human colon. Colonoscopy is the accepted screening method for detection of colorectal cancer or its precursor lesions, colorectal polyps. Indeed, colonoscopy has contributed to a decline in the number of colorectal cancer related deaths. However, not all cancers or large polyps are detected at the time of colonoscopy, and studies of why this occurs are needed. Currently, there is no objective way to measure in detail what exactly is achieved during the procedure (i.e., quality of the colonoscopic procedure). In this paper, we present new algorithms that analyze a video file created during colonoscopy and derive quality measurements of how the colon mucosa is inspected. The proposed algorithms are unique applications of existing data mining techniques: decision tree and support vector machine classifiers applied to videos from medical domain. The algorithms are to be integrated into a novel system aimed at automatic analysis for quality measures of colonoscopy.

### KEY WORDS

Medical video analysis, data mining, endoscopy, quality control

### 1. Introduction

Colorectal cancer is the second leading cause of cancer-related deaths behind lung cancer in the United States [1]. Colonoscopy is currently the preferred screening modality for prevention of colorectal cancer. A colonoscopic procedure consists of two phases: an *insertion phase* and a *withdrawal phase*. During the insertion phase, a flexible endoscope (a flexible tube with a tiny video camera at the tip) is advanced under direct vision via the anus into the rectum and then gradually into the most proximal part of the colon (signified by the appearance of the appendiceal orifice or the terminal ileum). In the withdrawal phase, the endoscope is gradually withdrawn. Careful mucosa inspection and diagnostic or therapeutic interventions

such as biopsy, polyp removal, etc., are performed in the withdrawal phase. The video camera generates a sequence of images (frames) of the internal mucosa of the colon. These images are displayed on a monitor for real-time manual analysis by the endoscopist. In current practice, images of the entire procedure are not routinely captured for post-procedure review or analysis.

Colonoscopy is performed over 14 million times per year [2]. However, in current practice there is no objective way to measure in detail what exactly is achieved during the procedure although a number of indirect markers of quality have been proposed. These include duration of the withdrawal phase and average number of polyps detected per screening colonoscopy. Thoroughness of inspection of the colon mucosa, i.e., by looking off-axial to the mucosa or behind mucosal folds, currently cannot be measured.

As part of a novel quality measurement system for colonoscopy, we have recently developed (i) a system to automatically capture all images from a colonoscopic procedure into a colonoscopy video file and upload the file to an analysis server; no identifiable patient information is captured; (ii) image analysis techniques to identify diagnostic and therapeutic operations from colonoscopy videos [3]; (iii) image analysis techniques that output objective measures of quality of colonoscopic procedures [4].

In this paper, we introduce new algorithms to obtain estimates of view mode from a colonoscopy video. The view mode is a rough estimator of the distance of the camera at the tip of the endoscope to the most distant colon wall. We classify the view mode into two types: *global inspection* (more distant examination in which more than one side of the colon wall is seen) in Figure 1(a-c) and *close inspection* (close examination of the colon mucosa) in Figure 1(d-f). Both close and global inspections should be present in a good colon examination. Since most commonly used endoscopes are not able to provide measurements of the view mode, we can only obtain these measures through analysis of images in a colonoscopy video.









