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A Novel Unsupervised Approach for Minimally-invasive Video Segmentation

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ABSTRACT

Temporal segmentation of laparoscopic video is the first step toward identifying anomalies and interrupts, recognizing actions, annotating video and assessing the surgeons' learning curve. In this paper, a novel approach for temporal segmentation of minimally-invasive videos (MIVS) is proposed. Illumination variation, shadowing, dynamic backgrounds and tissue respiratory motion make it challenging to extract information from laparoscopic videos. These challenges if not properly addressed could increase the errors of data extraction modules. Therefore, in MIVS, several data sets are extracted from laparoscopic videos using different methods to alleviate error effects of data extraction modules on MIVS performance. Each extracted data set is segmented temporally with Genetic Algorithm (GA) after outlier removal. Three different cost functions are examined as objective function of GA. The correlation coefficient is calculated between objective values of the solutions visited by GA and their corresponding performance measures. Performance measures include detection rate, recognition rate and accuracy. Cost functions having negative correlations with all mentioned performance measures are selected. Finally, a multi-objective GA is executed on the data sets to optimize the selected cost functions. MIVS is tested on laparoscopic videos of varicocele and ureteropelvic junction obstruction surgeries collected from hasheminejad kidney center. Experimental results demonstrate that MIVS outperforms the state-of-the-art methods in terms of accuracy, detection rate and recognition rate.

Key words: *Minimally invasive surgery, multi-objective genetic algorithm, surgical instruments, video segmentation*

INTRODUCTION

Laparoscopy or minimally invasive surgery is a surgical procedure which uses a few small incisions.[1] Therefore, it has many advantages over open surgery like shorter recovery time.[2] The surgeon insert laparoscope into the abdominal cavity to see through the laparoscope.[1] The video output of the laparoscope can be recorded. Minimally-invasive video (MIV) can be divided into temporal segments. In previous, several researchers study temporal segmentation of endoscopic/laparoscopic videos.[3-6] These methods aim to segment medical video based on tissue boundaries[4,5] or type of active instruments identified by signals of sensors, that are installed on surgical tools.[3,6] The last class of segmentation methods considers types of active surgical instruments for surgical workflow detection.[3,6]

In this paper, a novel approach for temporal segmentation of MIVS is proposed. MIVS aims to segment the laparoscopic video based on several data sets, describing motion and number of surgical tools.

Extracting data from laparoscopic videos faces various challenges such as illumination variation, shadowing, dynamic backgrounds and tissue respiratory motion. These challenges if not properly addressed could increase the errors of data extraction modules. Therefore, in MIVS, several data sets are extracted from laparoscopic videos using different methods to alleviate error effects of data extraction modules on MIVS performance. Each extracted data set is segmented temporally with Genetic Algorithm (GA) after outlier removal. Three different cost functions are examined as objective function of GA. Moreover, the solutions visited by GA are compared to the solution segmented by human experts and the performance measures are calculated for the visited solutions.

The correlation coefficient is calculated between objective values of the solutions visited by GA and their corresponding performance measures. Performance measures include detection rate, recognition rate and accuracy. Cost functions having negative correlations with all mentioned performance measures are selected. Finally, a

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