

Chapter 14

Applications of Image Processing in Laparoscopic Surgeries: An Overview

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ABSTRACT

Laparoscopy is a minimally-invasive surgery using a few small incisions on the patient's body to insert the tools and telescope and conduct the surgical operation. Laparoscopic video processing can be used to extract valuable knowledge and help the surgeons. We discuss the present and possible future role of processing laparoscopic videos. The various applications are categorized for image processing algorithms in laparoscopic surgeries including preprocessing video frames by laparoscopic image enhancement, telescope related applications (telescope position estimation, telescope motion estimation and compensation), surgical instrument related applications (surgical instrument detection and tracking), soft tissue related applications (soft tissue segmentation and deformation tracking) and high level applications such as safe actions in laparoscopic videos, summarization of laparoscopic videos, surgical task recognition and extracting knowledge using fusion techniques. Some different methods have been proposed previously for each of the mentioned applications using image processing.

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INTRODUCTION

The general perspective of the chapter is considering different applications of processing laparoscopic videos to extract the valuable knowledge. The main scope is considering the applications of image processing for laparoscopic videos. For this purpose, only the previous studies proposing methods for processing RGB videos of laparoscopic/endoscopic surgeries are considered. 3D videos like RGB-D images and videos augmented by supplementary data from the external sensors or other types of images such as MRI are not in the scope of this study.

The rest of the paper is organized as follows. Section 2 reviews the applications of image mining in laparoscopy. In section 3, the datasets being used in the previous studies are listed and the discussion is presented in section 4. Finally, section 5 summarizes and concludes the paper.

BACKGROUND

Laparoscopy lies in the category of endoscopic interventions. During the endoscopic interventions, a camera called endoscope is inserted into the patient body to display the internal organs. Endoscopes are divided into two categories including flexible endoscope used for inspecting the esophagus, stomach, small bowel, colon and airways; and rigid endoscope used for a variety of minimal invasive surgeries (i.e., laparoscopy, arthroscopy, endoscopic neurosurgery). The endoscopes have various sizes with a tiny video camera at the tip (Oh et al., 2007). The endoscope in the laparoscopic surgeries is called telescope.

Laparoscopy is a minimally-invasive procedure with a few small incisions on the patient's body. Therefore, the hospital stay and recovery time for the patients after the laparoscopic surgeries is shorter than the open surgeries for similar surgical operations.

The first laparoscopic surgery was performed about 100 years ago on dogs. The first laparoscopic surgery on human was about 30 years ago. Till now, many advancements in laparoscopy have been occurred by introducing robotics and new instruments. It leads to less invasive surgeries (Cwach & Kavoussi, 2016).

The surgical tools and the telescope are inserted through the incisions to conduct an operation. The telescope displays the internal organs and can record the surgery as a laparoscopic video (Uecker, Wang, Lee, & Wang, 1995).

Laparoscopy is widely used for diagnosis and treatment of many diseases (Yu et al., 2015). It has many advantages such as reduced patient trauma, reduced pain, decreased rates of infection and sepsis, small scars, reduced hospitalization with improved prognosis, lower rate of returning to the operating room, reduced need for blood transfusion and a quicker recovery (Amodeo, L., J.V., E., & H.R., 2009; Grasso, Finin, Zhu, Joshi, & Yesha, 2009; S. L. Lee et al., 2010; Semerjian, Zettervall, Amdur, Jarrett, & Vaziri, 2015).

But, this procedure has some drawbacks such as a limited view because of two-dimensional imaging, challenging eye-hand coordination, absence of tactile feedback (Schols, Bouvy, Dam, & Stassen, 2013) and surface view of the organs (Ma°rvik et al., 2004).

Many types of surgical operations can be performed by laparoscopic procedure. For example, laparoscopic partial nephrectomy (LPN) is a standard therapy method for renal carcinomas (Baumhauer et al., 2008). Laparoscopic cholecystectomy is a surgical procedure to remove the gall bladder (Sánchez-González et al., 2011). Some other surgeries that can be performed via laparoscopic procedure in reduced

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