Evaluation of Clinical Effectiveness of 3D Digital Endoscopic Image

3차원 디지탈 내시경 영상의 임상적 효용성 평가

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국문요약

본 연구의 목적은 복강경 수술환경에서 2D와 3D 내시경 비디오 영상이 수술에 미치는 영향을 평가하기 위한 연구이며, 이를 위해 3D 내시경 시스템을 구성하고 성능 평가를 수행하였다. 결과적으로 본 연구에서 제안한 3D 방식이 기존의 전자셔터 방식에 의한 3D 영상에 비해 화질과 시야각이 우수하며, 2종류의 모의 수술 실험 비교를 한 결과, 제안한 방식의 디지털 영상을 이용하는 경우가 성능이 가장 우수함을 정량적으로 확인하였다.

Abstract

This paper represents the design of 3D endoscopic video system in order to improve visualization and enhance the ability of the surgeon to perform delicate endoscopic surgery. Minimally invasive techniques have set new standards in all surgical disciplines, as patients may experience less post-operative discomfort, shorter hospitalization, and quicker recuperation. Finally, the aim of the present study was to determine the influence of 2D and 3D video imaging on defined tasks on a laparoscopic trainer.

Key words: 3D endoscopy, Spatially multiplexed imag, 3D digital image

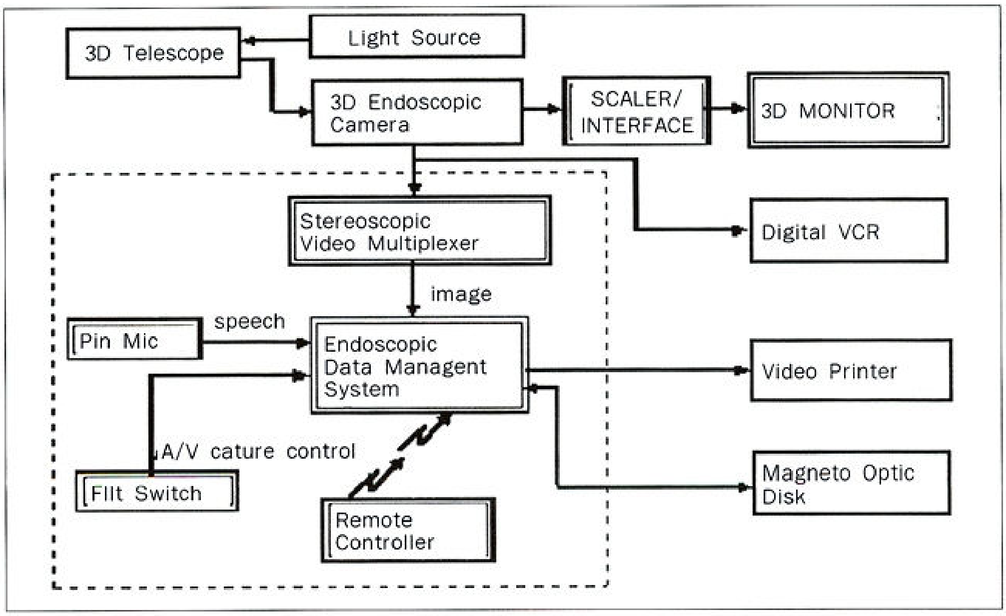

Figure 1. Schematic organization of a complete endoscopic system allowing report generation and image handling

Introduction

Three-dimensional video systems have been recently developed which significantly improve visualization during minimally invasive surgical procedures. The objective of this study was to compare the established 2D, electric shutter-type 3D, and the prototype 3D endoscopic systems for the performance of laparoscopic tasks in an animate situation. The result of experiments shows that the polarization-type stereoscopic display system using TFT-LCD has a wide viewing angle and zone which is necessary for multi-view and it has better image quality and stability of the optical performances than the electric shutter-type does.

3D Digital Endoscopic System

(1) 3D digital image

In the present study, a newly modified electronic 3D endoscopic system was developed for the real-time processing of surgical images and surgeons comments.

Figure 1 shows a schematic organization of a complete endoscopic system. An computerized endoscopic system combines a 3D telescope, 3D endoscope,

xenon light source, a computer for data and image handling linked to a magneto optical disk, a color video printer, a video cassette recorder, a foot switch, a pin microphone, and a high resolution TFT-LCD 3D monitor.

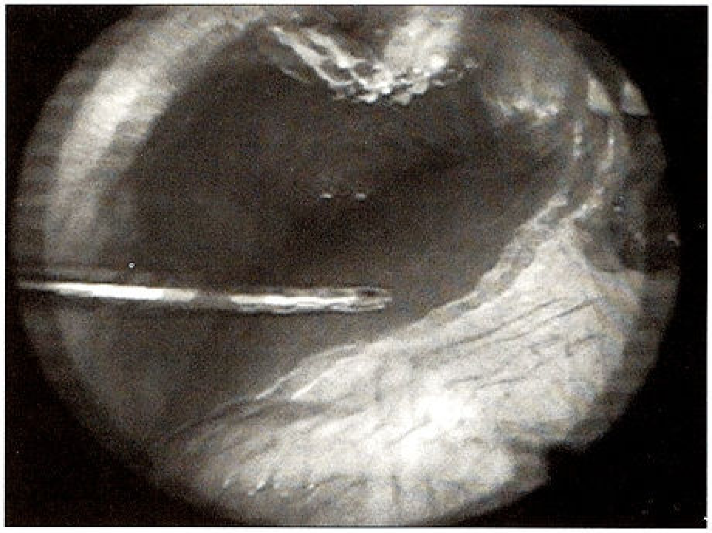

Figure 2. Spatially multiplexed image from an endoscopic stereo pair

To display a 3D image, an image conforming to the SMI (Spatially Multiplexed Image) format is used. When an SMI is displayed, it will appear as full-color 3D image when viewed with polarized glasses. An SMI encodes the right and left images of a stereo pair into a single frame to form a stereo image. The SMI format consists of alternating horizontal lines (rows) for the right and left images (right, left, right, left, etc.). All of the even lines of pixels (starting from 0) contain the right image and all of the odd lines contain the left image. It is used to form this SMI from an endoscopic stereo pair as shown in Figure 2.

(2) The proposed 3D endoscopic display system

We used two 15 TFT-LCD panels for the Polarization-type Stereoscopic Display (SM500TFT-3D) system so that they could display slightly different images independently captured by a two-head camera consisting of the left and right CCD (Charged Couple Device) cameras. A beam splitter (half-mirror) was designed to transmit the S-polarized light from the upper LCD for right eye image and reflect the P-polarized light from the down LCD for left eye image to viewers as shown in Figure 3.

The P and S light from two LCD are linearly polarized and their direction is perpendicular to each other since the direction of the polarized light from the down LCD is shifted by 90 after reflection. Through the polarizing glasses, and then, whose polarization directions are same as P and S, respectively, the right eye sees only the right eye image and the left eye sees the only the left eye image simultaneously. Finally, it gives viewers the spatial information (i.e., depth perception).

(3) The Conventional 3D endoscopic video system

The 3D imaging system used was an active shutter

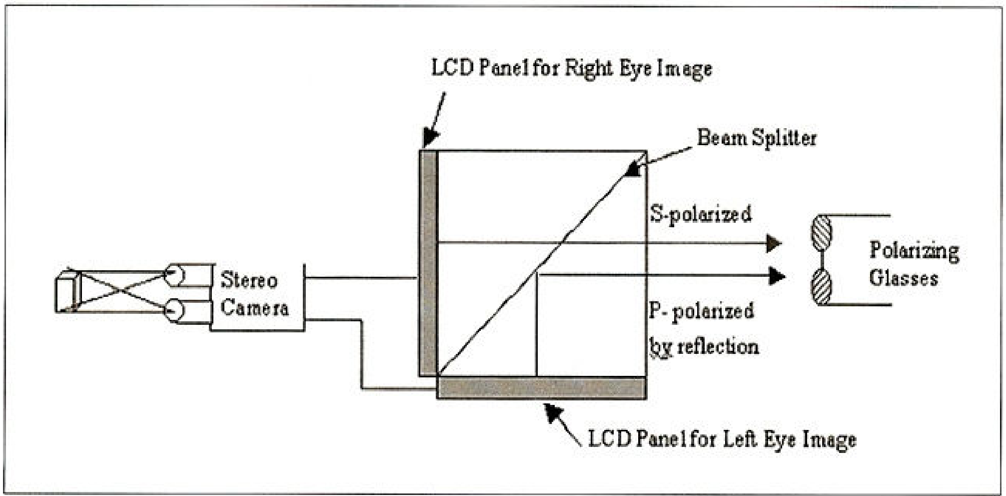

Figure 3. Configuration of SM500 TFT-3D System

system(3D laparoscopic system, Wolf Co. Ltd, Germany)with a 120 Hz 3D converter, active shutter glasses, and a 10mm/0 binocular laparoscope. The system was used both in 2D and 3D mode.

Experimental Methods

Medical student(10 persons) and Laparoscopic surgeons(10 persons) performed two defined tasks using 2D, electric shutter-type 3D, and polarization-type 3D endoscopic imaging. Student and --Surgeons repeated each task 4 times. The camera holder used for for three type exerceses for each participant. Using laparoscopic instrument and trainer(Storz Co. Ltd.), each participant completed the following two tasks(loop pass and suturing).

For the loop pass task, a 2 cm diameter ring was hung 3 cm above the base of the laparoscopic trainer. The object(1cm x 5cm wire paper clip) were then passed from right to left through the ring. For the Suturing task, Suturing was done with a 8cm long 2.0 silk suture with an RB-I curved needle.

Results

Table 1 shows the mean time(second) across experience level by mode of visualization. Each task were compared for student and surgeons(Fig. 4 and Fig.5). The surgeons were significantly faster in 2D and 3D than students. Task 2(suturing) was performed an average 15 % faster using 3D display by two groups($p=0.05$).

Discussions

The numeric advantages of 3D imaging will most likely translate into higher safty and better performance in the clinical use of laparoscopic procedures. The advantages might even be more important in procedures with operating

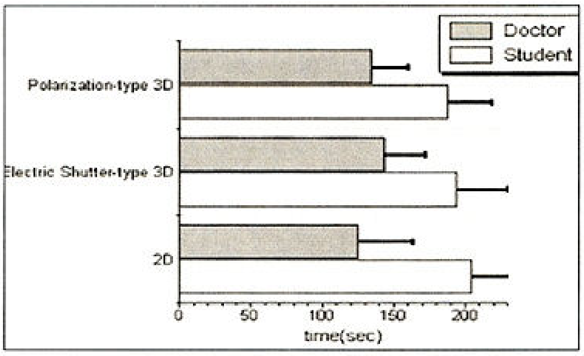

Figure 4. Task performance of loop passing

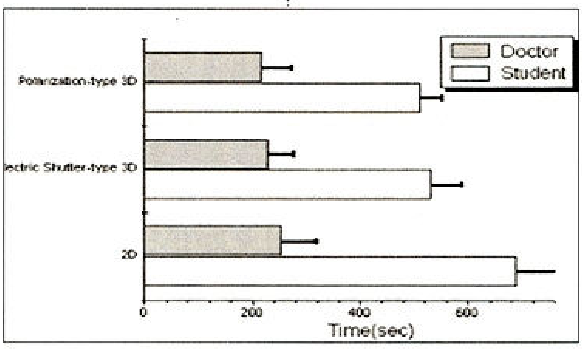

Figure 5. Task performance of suturing

sites of large large spatial depth. The result of experiments shows that the polarization-type stereoscopic display system using TFT-LCD has a wide viewing angle and zone which is necessary for multi-view and it has better image quality and stability of the optical performances than the electric shutter-type does.

In comparison of the polarized and electric shutter-type stereo monitoring system, both have similar accuracy and speed for test of knot-tying and loop pass. But the former is superior in image quality and stability of the performance. There was no significant difference in task performance between 2D and 3D among groups performing simple or difficult tasks, although knot-tying were performed 15 %(p=0.05) faster in 3D by all groups.

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Table 1. Mean time across experience level by mode of visualization(meanSD)

Task	Mode	2D imaging	Electric shutter-type 3D	Polarizarion-type 3D
Task 1:	Student	205±50	195±35	189±29
Loop Passing	Doctor	126±37	144±28	135±26
Task 2:	Student	690±107	532±55	512±38
Suturing	Doctor	257±61	230±47	220±52

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