Development of Blood Vessel Search System Using Near-infrared Light for Laparoscopic Surgery

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SUMMARY

Accurate image processing and 3D blood vessel detecting technique is strongly required in the laparoscopic operation with minimally invasive surgery. Our detecting system adopts Near-Infrared (NIR) light and the stereo method. The blood vessel visualization system adopts hemoglobin's absorption characterization of the NIR light. A sharpening process is employed to improve the image quality of original ones taken by laparoscopic system. 2D location of the blood vessel is calculated by the stereo method using luminance distribution. Experimental results of depth obtained by our detecting system showed good agreements with the given depths, and the availability of this system is confirmed.

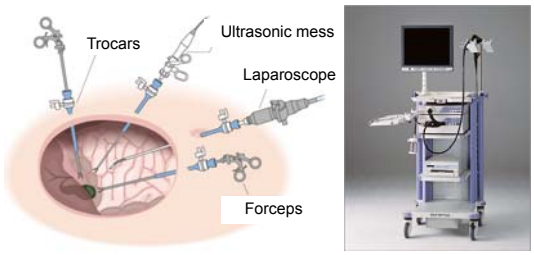


Figure 1. Laparoscopic surgery.

Objective

Development of Integrated system for Visualization of the blood vessel and 3D BVS.

Research theme

(1) Blood vessel visualization using NIR Light and sharpness processing → **Blood vessel visualization system**

(2) Stereo method using NIR LED light and CMOS cameras to detect blood vessel accurately → **3D blood vessel searching system**

Contribution to reduce a blood vessel cutting accident by the human error of the doctor.

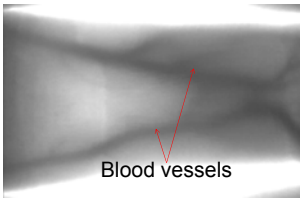
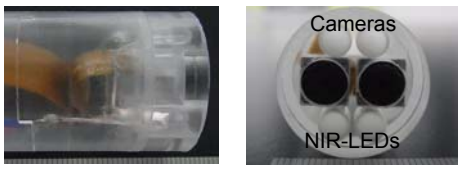


Figure 2. Blood vessel visualization using NIR light

LAPAROSCOPIC SYSTEM & BLOOD VESSEL PHANTOM

Image treatment scheme and Specifications

Measurement method:
Using NIR –LED light (wave length:870 [nm]) and CMOScamera (300 thousand pixels) for peripheral blood vessel.



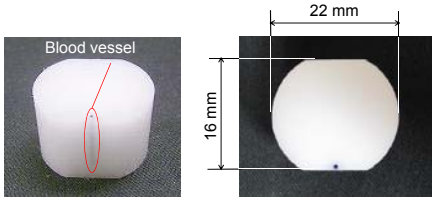
(a) Side of laparoscope (b) Tip of laparoscope

Figure 3. Laparoscopic system.

2 type of blood vessel phantoms

Figure 4. Blood vessel phantom using polycarbonate for 3D VBS.

Figure 5. Blood vessel phantom using intralipid for blood vessel visualization.



(a) Side of phantom (b) Tip of phantom

Figure 4. Phantom for VBS.

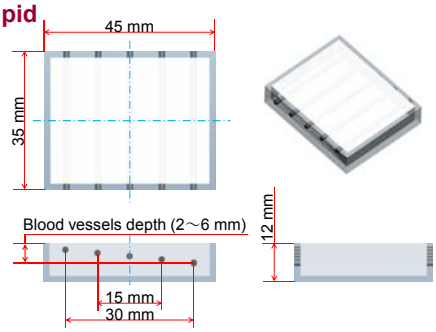


Figure 5. Phantom for blood vessel visualization

BLOOD VESSEL VISUALIZATION

Comparison of 3 type forearm images

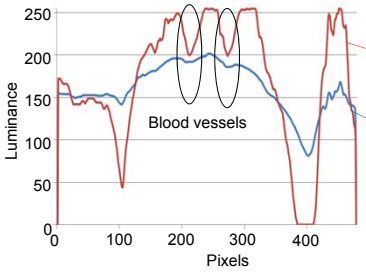
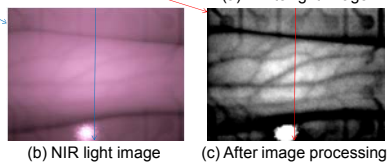
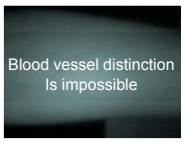


Figure 6. Luminance distribution of forearm images



(b) NIR light image (c) After image processing

Figure 7. Comparison of 3 type forearm images



(a) White light image

Comparison of 3 type phantom images

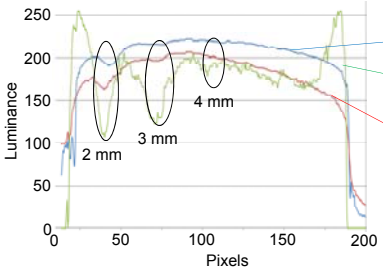
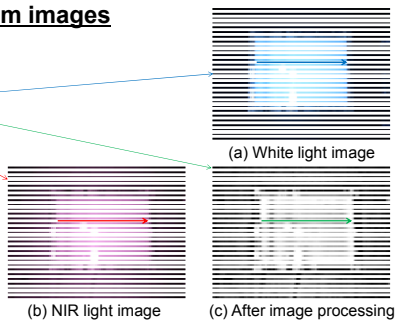


Figure 8. Luminance distribution of phantom images



(b) NIR light image (c) After image processing

Figure 9. Comparison of 3 type phantom images

3D BLOOD VESSEL MEASUREMENT

Confirmed the usefulness of NIR light and image processing

3D blood vessel measurement using laparoscopic system

Real value of 30 to 70 mm was measured 3 times. (Figure 10)

The error at 70mm is very large.

Correction of the measured value using the correction formula.

Detection error was estimated as 80 μm.

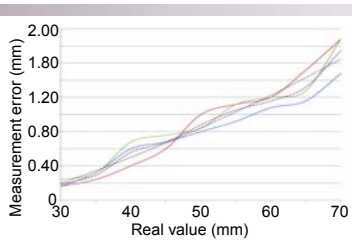


Figure 10. Relationship with real value and measurement error

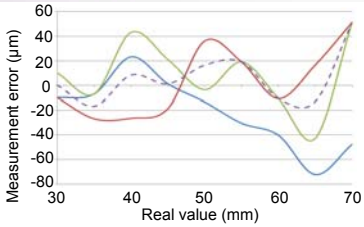


Figure 11. Relationship with real value and correct error

CONCLUSION

Confirmed the usefulness of NIR and image processing in blood vessel visualization

3D BVS detection error was estimated as 80 μm