Optical coherence tomography-based visual servoing: application to microrobotic minimally invasive surgery*

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1 Medical Context

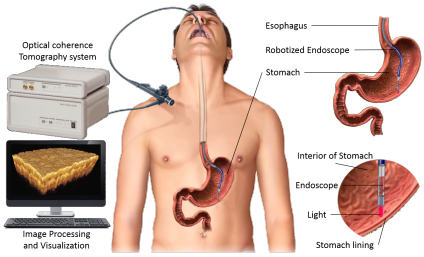

Figure 1: Robotized OCT endoscopy set-up for optical biopsy.

A biopsy is a medical procedure to examine a sample of suspect tissue, especially to detect cancer cells. Therefore, the biopsy can be performed in any part of the body, as the stomach. Moreover, the conventional biopsy procedure is based on the extraction of sample of tissue from a region of suspicion, for a microscopy examination (i.e., *ex-situ*). To perform this, there are several biopsy processes: needle biopsy, endoscopic biopsy, surgical biopsy, etc. However, these biopsies have drawbacks particularly for their poor precision, risk of bleeding, risk of infections, etc. To overcome these shortcomings, the optical biopsy may be the alternative solution. Then, optical coherence tomography (OCT) is quite suitable to achieve a precise optical biopsy. Instead of the conventional biopsy, the OCT device images, as an optical microscope directly (without contact), the suspect tissue (without any removal). Currently, OCT-based optical biopsies are widely used in ophthalmology and dermatology with imposing acquisition systems. In addition, new miniature OCT devices generally based on the use of a fiber bundle increasingly interest clinicians and researchers to go towards intracorporeal optical biopsy (e.g., stomach). It is in this context that this work is a part as shown in Fig. 1.

2 Scientific Objective

Generally, OCT is used to make chronological diagnostics i.e., monitoring the evolution of a suspect tissue. To achieve this, it is necessary to be able to compare the optical biopsies taken from different points of view in different times. It is in this issue that the robotized endoscopy system helps to position with accuracy the OCT probe at the targeted position. Visual servoing is the ideal solution to accomplish this i.e., control the robotized endoscopic system using visual information extracted from the OCT images. In this work, the considered visual information is the wavelet coefficients defined in the spatial domain.

3 Preliminary Results

The obtained preliminary results of the OCT images registration using the wavelet coefficients are more than satisfactory. Have not yet a robotized endoscopy system to validate the visual servoing scheme, we have opted for a virtual visual servoing (can be considered as a numerical registration) to demonstrate the feasibility of the proposed approach. As shown in Fig. 2, the virtual visual servoing approach proves a precise registration of the OCT images, this beside a high difference (illumination) between on the OCT images.

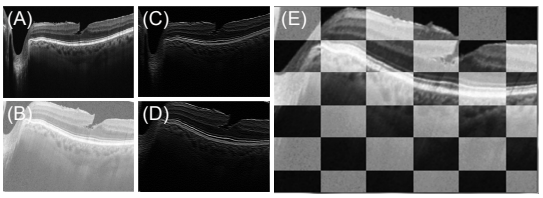

Figure 2: Registration results: (A) reference image, (B) image to be registered, (C) and (D) the corresponding wavelet coefficients, respectively, and (E) the result of the registration.

4 Conclusion

In this work, it was shown the preliminary results of a novel virtual visual servoing method for OCT images registration. The obtained results demonstrate the robustness of the approach beside the presence of high disturbances in the illumination conditions.

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