Wireless Capsule Endoscope Motion Estimate based on Multiscale Elatisc Registration [1]

Isabel N. Figueiredo, Carlos Leal, Luis Pinto
Department of Mathematics, University of Coimbra, Portugal.
isabelf@mat.uc.pt, carlosl@mat.uc.pt, luisp@mat.uc.pt

Pedro N. Figueiredo
Dep. of Gastroenterology, HUC and Faculty of Medicine, University of Coimbra, Portugal.
pnf11@sapo.pt

Richard Tsai
Department of Mathematics, University of Texas at Austin, USA.
ytsai@math.utexas.edu

Abstract

Wireless Capsule Endoscopy (WCE) is an innovative imaging technology that permits physicians to examine all the areas of the Gastrointestinal (GI) tract, especially the small intestine, where traditional invasive endoscopies cannot reach. More than 10 years after being presented for the first time [1], WCE is now becoming widely accepted and utilized. The first device, for the examination of the small intestine, got its approval from the US Food and Drug Administration (FDA) in 2001.

The capsule is a very small device with the size and shape of a vitamin pill. It consists of a miniaturized camera, a light source and a wireless circuit for the acquisition and transmission of signals. In a WCE exam, a patient swallows the capsule, and as it moves through the GI tract, propelled by peristalsis (a contraction of the small intestine muscles that pushes the intestine content to move forward), images are transmitted to a data recorder, worn on a belt outside the body. After about 8 hours, the WCE battery lifetime, the stored images, approximately 50.000 images of the inside of the GI wall, are transferred to a computer workstation for off-line viewing.

Although WCE represents an extremely important advance in medical imaging, a major drawback, that remains unsolved since its invention, is the WCE precise location in the human body during its operating time. This is mainly due to the complex physiologic

[1]This work was partially supported by the project PTDC/MATNAN/0593/2012 and also by CMUC and FCT (Portugal) through European program COMPETE/ FEDER and project PEst-C/MAT/UI0324/2011.

environment and the inherent capsule effects during its movement. We also recall that the WCE passive locomotion (by peristalsis) makes impossible to stop or control the capsule motion. When an abnormality is detected, in the images produced by the capsule, the medical doctors do not know precisely where this abnormality is located and therefore they can not proceed immediately with the appropriate therapy. For instance, concerning an abnormality in the small bowel, the principal medical goal is to know how far is the abnormality from a reference point as for instance, the pylorious (the opening from the stomach into the duodenum) or the ileocecal valve (the valve that separates the small from the large intestine).

Recently, there have been many efforts to develop accurate localization methods for WCE. One proposed technique relies on radio frequency sensors, attached to the patient body, that keep track of signals transmitted by the capsule [2]. Despite some promising results, this method is strongly dependent on the number of external sensors. This external equipment can be very discomforting for the patient. Alternatively, computer vision techniques have been also investigated to estimate the displacement of the capsule [3].

In this work, we present a framework for WCE motion estimation, based on image processing techniques, that proceeds in two main steps. In the first step, and since the intestine is an organ that deforms and bends, we track the motion of the walls of the intestine, in multiple frames, by using a multiscale elastic registration procedure [4]. Then, in a second step, from the previous calculated motion, we estimate the localization and orientation of the capsule using appropriate geometry relations between the imaged intestine walls and the capsule. In the future, a validation of this proposed capsule motion tracking procedure will be considered.

Keywords: Wireless capsule endoscopy (WCE), Multiscale elastic registration, Localization, Motion estimation.

References

[1] G. Iddan, G. Meron, A. Glukhovsky, P. Swain. Wireless capsule endoscopy. Nature, 405(6785):417-417, 2000.

[2] K. Pahlavan, G. Bao, Y. Ye, S. Makarov, U. Khan, P. Swar, D. Cave, A. Karellas, P. Krishnamurthy, K. Sayrafian. Rf localization for wireless video capsule endoscopy. International Journal of Wireless Information Networks, 19(4):326-340, 2012.

[3] E. Spyrou, D. Iakovidis. Video-based measurements for wireless capsule endoscope tracking. Measurement Science and Technology, 25(1), 2014.

[4] J. Modersitzki. FAIR: flexible algorithms for image registration, volume 6. SIAM, 2009.