VISION AND INERTIAL-BASED IMAGE MAPPING FOR CAPSULE ENDOSCOPY [1]

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Introduction

Capsule Endoscopy is a non-invasive procedure for Gastro-intestinal (GI) diagnosis. It does not require sedation and it is comfortable and well tolerated by patient. However, the problem with such procedure is that a huge number of images is collected, which require time to investigate and diagnose and the capsule movement is not controlled leading, in some cases, to inaccurate diagnosis.

In this project we investigate:

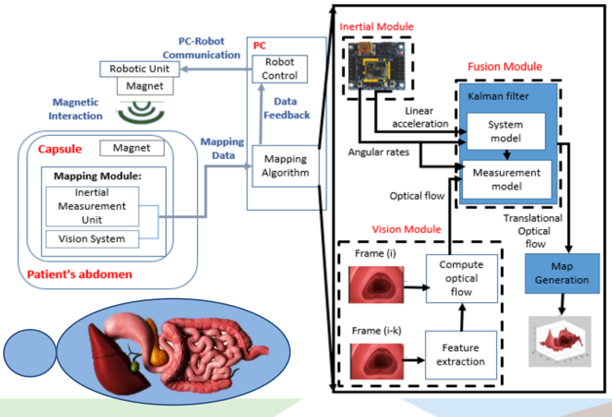
(a) Methods for mapping images from a capsule-based endoscope, using visual and inertial-based data fusion [2] to obtain a 3D map of the lumen from 2D capsule images,

And

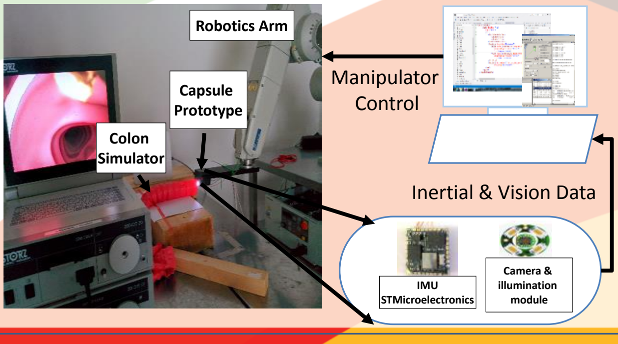
(a) Methods for autonomous locomotion and navigation of the capsule for optimal inspection.

Overall System Architecture:

The overall system consists of a 6-DoF robotic arm equipped with an external permanent magnet (EPM), a capsule device that includes an internal permanent magnet (IPM) that interacts with the external magnet as well as mapping algorithm. The movement of the capsule is guaranteed by the magnetic field interaction between the EPM, attached to the robotic arm, and the IPM, integrated inside the capsule [3].



Experimental Setup:

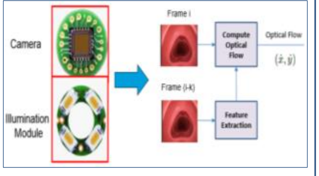


System Components:

The mapping module is divided into three main modules:

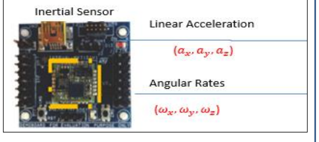
i) Vision Module:

The main function of the vision module is to approximate the capsule motion parameters based on motion changes extracted from the images by computing the optical flow.



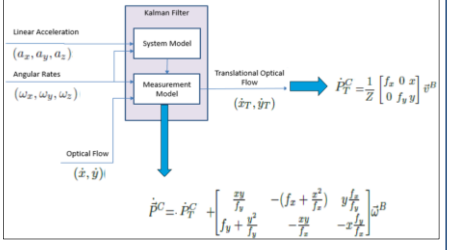
ii) Autonomous Navigation Module:

The inertial module consists of 9-axis motion sensing system, a 3-axis digital gyroscope and a logic unit to measure the orientation and acceleration of the capsule.



iii) The Fusion Module:

A non-linear Kalman Filter algorithm is used to estimate the translational optical flow from the angular velocities and the computed optical flow. the optical flow is divided into two main parts:

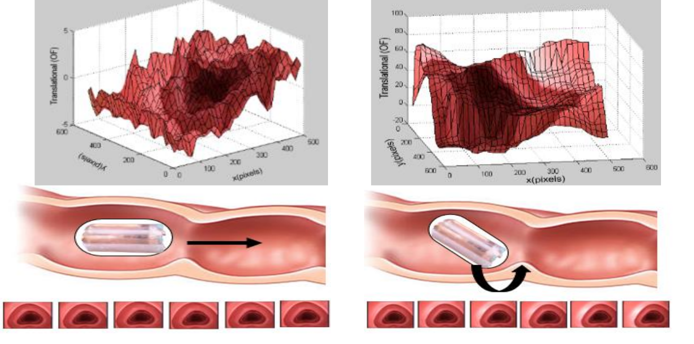


i) **a translational part** that depends on body linear velocities and image depth

ii) **a rotational part** that depends on angular rates.

Therefore, the optical flow measurements and the angular rate data were used to estimate the translational optical flow, which in turn can give the depth and map sequence.

Experimental Results:



(a) Translational motion (b) Rotational motion

References:

[1] Y. Abu-Kheil, G. Ciuti, M. Mura, J. Dias, P. Dario, and L. Seneviratne, "Vision and inertial-based image mapping for capsule endoscopy," in 2015 International Conference on Information and Communication Technology Research (ICTRC), May 2015, pp. 84-87.

[2] J. Lobo, J. F. Ferreira, and J. Dias, "Bioinspired visuovestibular artificial perception system for independent motion segmentation," in *Second International Cognitive Vision Workshop, 9th European Conference on Computer Vision (ECCV)*, Graz, Austria., 2006.

[3] G. Ciuti, P. Valdastri, A. Menciassi, and P. Dario, "Robotic magnetic steering and locomotion of capsule endoscope for diagnostic and surgical endoluminal procedures," *Robotica*, vol. 28, pp. 199–207, March 2010.