Abstract of the project : *Aberrant Crypt Foci and Human Colorectal Polyps: mathematical modelling and endoscopic image processing* (UTAustin/MAT/0009/2008)

Colon cancer is a type of cancer that forms in the large intestine (colon) or the rectum (end of the colon). Because it often affects both areas it is frequently referred to as Colorectal Cancer (CRC). It is one of the most frequent malignant tumors in the world. In Portugal, it is ranked first in terms of mortality among the five major cancer types (lung, breast, colon, stomach and prostate). Unlike most other malignancies, it is possible to prevent colorectal cancer. This is due to the long period of time elapsed between the appearance of a polyp and the eclosion of the carcinoma, which allows the detection and removal of the benign lesion. The most usual and clinically important polyps are adenomatous polyps (or adenomas), which are common in adults above the age of fifty years. According to international medical guidelines, early detection and removal of adenomatous polyps can prevent CRC and significantly improve the chance of survival. However, many public health issues related to screening of adenomatous polyps, as the periodicity and type of endoscopic evaluations, and the age of first evaluation, are still under discussion, and there is not an agreement about the screening programs. In this context, Aberrant Crypt Foci (ACF) may have a crucial and determinant role. These are clusters of aberrant (deviant from normal) crypts (small pits, which are compartments of cells, in the colon epithelium) that are thought to be the precursors of colorectal cancer. In fact, according to endoscopic studies and animals experiments, ACF precede the eclosion of adenomas. Thus if this claim is proved, it means ACF must be considered part of the adenoma-carcinoma sequence.

This proposed project focuses in the mathematical modelling and endoscopic imaging processing of ACF and polyps. It requires interdisciplinary interactions and close collaboration in complementary areas. The main goal is to assist medical doctors in terms of the diagnosis, the prevention and the treatment of colorectal cancer.

For the modelling part, our intention is to utilize multiscale methods, which involve partial differential equations and level set methods, to simulate the dynamics and shape of ACF and polyps populations. Mathematical simulations will be compared with experimental and clinical results. Such a comparison will lead to critical assessment of the models assumptions and to introduce suitable changes for their enhancement. We believe these models will be able to reproduce some particular aspects of the behavior of the human colon, and to reveal processes/mechanisms that would be impossible to reach with real-life experiments. They will provide some insight into ACF and polyps dynamics/behavior and consequently into CRC carcinogenesis. For the image processing part our aim is to develop computerized and fast algorithms to identify and assess the ACF and polyps patterns, captured in vivo by endoscopy. In particular, PDE (partial differential equation) and variational based image processing methods will be applied. The current methods employed for assessing the ACF and polyps patterns are somewhat subjective. They rely on direct medical observation only and are not standardized nor automated. It is desirable to have a reliable computerized method capable of identifying the ACFs external boundaries and the crypts orifices in their interiors, as well as, the polyps patterns (size, morphology, color, surface, location). In this proposed project, the ACFs images are obtained by magnification chromoscopic colonoscopy, with a fexible endoscope, whereas the polyps images are acquired with a colon capsule endoscope. This latter is a very recent noninvasive tool for colonic evaluation, and consists of a microdevice, which is ingested by a patient and films the interior of the colon wall. The main advantages of such image processing algorithms would be to support the clinical reading and analysis, to improve diagnostic accuracy, to help to standardize colonic crypt and polyp pattern assessment, and to reduce the time needed for analyzing the huge amount of endoscopic images. In this way, these algorithms would facilitate and speed up screening methods towards the CRC prevention.

The study of these research topics started in January 2007 at the Mathematical Department of the University of Coimbra (see http://www.mat.uc.pt/~cmuc/lcm/endoscopic.html), with the collaboration of medical doctors from the Faculty of Medicine of the University of Coimbra and the University Hospital of Coimbra. Later on, in October 2007, we initiated a collaboration with researchers from the Institute for Computational Engineering and Sciences (ICES), in the University of Texas at Austin. These researchers are now members of the team of this project.