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IVEM: Interfaces de Visión para Entornos Médicos TIC2003-00654

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Abstract

Computer Vision will be in a near future a key technology in our living and/or working environment. This project explores two uses of computer vision in this context: (a) the recognition of people and things to determine the context and the intention of an interaction, and (b) the use of automatic image analysis techniques for advanced visualization. In order to design and validate the developed technologies from a user-centered point of view, we have chosen a specific scenario and use case. The scenario is located in a medical environment: the intervention room in the Hemodynamics department of a hospital. This scenario has two interesting characteristics: there is an intensive use of multimedia digital information (generated on-line and off-line), and users cannot access information using the classical metaphors.
Keywords: Computer Vision, Face Recognition, Visualization, Medical Imaging.

1 Project Objectives

IVEM is a 3 year project, with start date 2003-12-01 and end date 2006-11-30. The total project funding is 126.400 Euro. There are 11 people involved in the project (5 PhD and 6 PhD students).

The specific project objectives were grouped around two general objectives corresponding to the research lines of the groups involved in the project:

- To analyze and to understand which are the most important requirements for a computer vision system that is supporting an interaction task that is done by a user that is performing a complex task and has a serious limitation for using the classical interaction techniques, and to develop a set of prototypes based on vision interfaces that allow the access to information in a natural way,

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- To propose advanced methods to extract and fuse multimodal medical information, and to design and develop an advanced system to visualize information about the patient (during an intervention) to perceive it in a natural and intuitive way.

These proposed objectives were (following reviewers' recommendations) slightly modified at the beginning of the project. Basically, changes have affected the use and validation of the developed technologies in the real medical environment. We have continued our research in the first objective but we have limited its application in a complex scenery. On the other hand, we have concentrated our efforts on the second objective, where research has been done in close collaboration with users.

1.1 Face detection and recognition

A long-term goal in computer-human interaction research is to approach the naturalness of human-human interaction. Automatic face detection and recognition is a critical component in this domain. For example, person and face detection allow applications to be aware when there is a person near the computer. However, research in this field is still young and relatively few robust applications exist. In this project we propose to advance the understanding of this problem along two research lines:

- (Scientific objective) To develop new classification methods and architectures for robust real-time face detection and classification in non controlled environments.
- (Scientific objective) To explore new visual cues for person identification in friendly environments.
- (Technological objective) To develop demonstration prototypes and to test the methods following a strict methodology and using a large set of data.

1.2 Analysis of IVUS images for intraoperative control

IVUS is a powerful new imaging modality for analysis and diagnosis of coronary vessels. In this modality, we obtain a cross-sectional view of the artery by inserting a catheter into it. The structure and composition of atherosclerotic plaques play important roles in coronary artery disease study and in the outcomes of coronary interventions. In Figure 1(a) we can see an IVUS image with the catheter in its center represented by a circle with high intensity and a point (the tip) in its center. Around the catheter there is the blood in the lumen of the vessel. In this picture there are two kinds of biological structures: the adventitia tissue, represented by a big region of high intensity and fine texture, and two calcium plaques, represented by thin regions of intensity equal to or greater than the adventitia and with dark regions beyond it. We can also see in Figure 2.b the operation room where IVUS images are used to control interventions.

Our objectives regarding IVUS image analysis are:

- 3D reconstruction of the coronary vessel. Intravascular ultrasound images are acquired during a pullback of catheter through the vessel, giving an internal view of the vessel. In order to locate IVUS images in space we need a 3D reconstruction of the catheter trajectory by using an alternative imaging technique: X-ray images (angiograms).

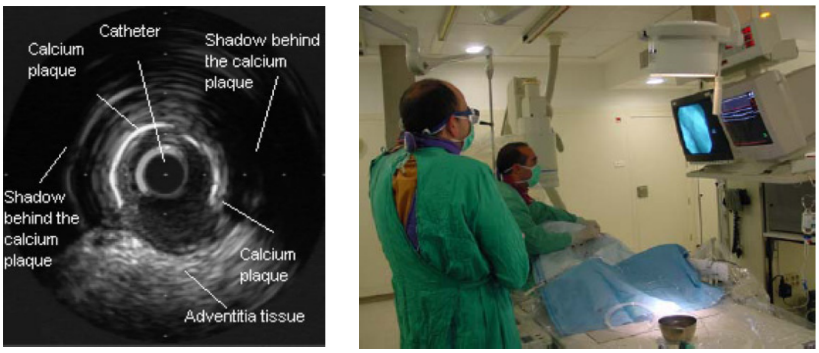

Figure 1: IVUS image and hemodynamics operation room.

- IVUS and Angiography image registration. When observing an intravascular ultrasound stack of images, it is difficult to figure out the image position and extension with regard to the vessel parts and ramifications, and misclassification or misdiagnosis of lesions is possible. The objective is to develop a computer vision technique to fuse the information from angiogram and intravascular ultrasound images defining the correspondence of every ultrasound image with a corresponding point of the vessel in the reconstructed 3D angiogram.

- Automatic segmentation of IVUS images. The composition and structure of the vessel change with age, hypertension, diabetes mellitus and many other factors. Until this moment, it is feasible to discriminate different morphological structures of the vessel as calcium deposits, fatty, fatty fibrous and fibrous materials. Today, it is not completely clear what the vulnerable plaque is. Textural analysis is one of the closest related processes in computer vision to the physicians expertise when dealing with IVUS images; due to the fact that plaque discrimination is performed using, mostly, morphological issues. Visual textural analysis is a difficult, subjective and time-consuming process highly depending on the specialist. Therefore, there is an increasing interest of the medical community in developing automatic tissue characterization procedures of IVUS images.

- Content-based automatic retrieval of IVUS images. The increasing volume of image data in several applications makes it necessary to use efficient and meaningful retrieval systems of images. The poor performance of textual entries for representing this information leads to the necessity of using content-based image retrieval (CBIR) systems.We propose to apply this technique to a database of IntraVascular UltraSound (IVUS) images to be used in during case-based reasoning sessions.

2 Level of Success

In order to assure real conditions and fair evaluation of the developed techniques, we have been collaborating with two external institutions: "Germans Trias i Pujol" Hospital, that is a leading institution in the use of IVUS images, and la Caixa, a savings bank that is interested

in facial recognition for marketing purposes (not security!). In both cases, but specially in the first case, the collaboration has been excellent.

We have organized periodical working sessions with the hemodynamics department of the "Germans Trias i Pujol" Hospital, and we have got access to all their clinical data.

Our work has been presented to the world leading company in IVUS instrumentation: Boston Scientific (MA, USA). We have met two times with Dr. Tat-Jin, director of the Research Division of Boston Scientific in order to evaluate our work for technology transfer. We have signed a non-disclosure agreement and they are testing our software in order to evaluate potential benefits for their instruments. They have also provided, with no cost, the latest available technology to test our developments.

During the development of the project we have started two new collaborations: the *Hospital del Valle de Hebrón de Barcelona* and *Institut Cartogràfic de Catalunya*. In both cases the main interest is to use the developed technologies in their specific problems. In the first case we are analyzing wireless capsule endoscopy images in order to characterize intestinal motility. In the second case the objective is to develop a real time traffic sign recognition system for mobile mapping. In both cases we have signed a contract for technology transfer.

The main scientific achievements can be summarized in the following points:

- From a theoretical point of view, our main achievements are concentrated in the field of pattern recognition. We have proposed a new methodology, based on boosting, for nearest neighbor classification [3, 5, 17, 21, 35, 36, 37]. We have also continued our research on the use of Independent Component Analysis for classification [4, 7].

- We have continued our research on face detection, tracking and recognition. Our group has been invited to participate in the Face Recognition Grand Challenge [1], organized by the National Institute of Standards of the EEUU. FRGC will develop new face recognition techniques and develop prototype systems while increasing performance by an order of magnitude. The FRGC is open to face recognition researchers and developers in companies, academia, and research institutions. We have presented our results in the FRGC Workshop [28] and our paper was finalist for the FRGC Award.

- We have proposed to the face recognition community a new research line that has not been explored until now: the use of external face features for face classification, that has been applied to face verification, face recognition and gender recognition [6, 16, 20, 27, 32, 33, 34].

- We have continued our research in the processing of IntraVascular UltraSound (IVUS) images. We have developed a new system to segment these images in order to automatically classify different tissues [22, 23, 24].

- We have developed a new method to analyze vascular dynamics in order to eliminate artifacts from longitudinal visualization and to do a 3D reconstruction and multimodel image fusion [8, 9, 12, 14, 38, 25, 39].

- We have added a new image modality (CT) to validate the fusion between IVUS and angiography [31].

[1] http://www.frvt.org/FRGC/

- We have developed a content-based IVIS image retrieval system [11, 13, 15, 26, 40].
- We have succesfully tested the intraoperative system in real interventions.
- Finally, we have applied the developed techniques to other problems: wireless capsule endoscopy [10, 29, 30], and real time detection of traffic signals [18, 19].

3 Results

During the last two years, three young researchers of our group have obtained the PhD degree: David Guillamet, *Statistical Local Appearence Models for Object Recognition*; Debora Gil, *Geometric Differential Operators for Shape Modelling*; and Oriol Pujol, *A Semi-Supervised Statistical Framework and Generative Snakes for IVUS Analysis*.

In the last two years the scientific production of the group has been the following one: Books: 2; Journals: 15; Conference Proceedings: 23 (some of them as book chapters).

Our research group has organized during this period three scientific events:

- The 3erd International Conference on Functional Imaging and Modeling of the Heart, June 2-4, 2005, in Barcelona [2].
- The 2ond Advanced Pattern Recognition and Medical Imaging Workshop in Bellaterra (Barcelona), September, 2005.
- The 7th Catalan Conference on Artificial Intelligence (CCIA'2004), October, 21-22, 2004, in Barcelona [1].

We also have continued our research collaborations (that have resulted in joint publications in almost all the cases) with several groups:

- Dra. L. Kuncheva, School of Informatics, University of Wales. We have been working in multiple classifier systems. Two members of our group have visited her laboratory for several months.
- Dr. J. Salas, Instituto Politécnico Nacional (IPN) of México in Querétaro, México. We have been working in motion detection and analysis for wireless capsule endoscopy images. Dr. Salas is spending a sabatical year in our laboratory.
- Dr. M. Bressan. Xerox Research Center Europe, Grenoble, France. We have been working in the development of face recognition systems.

In September 2004 we presented a Marie Curie RTN Proposal to the UE. This proposal (with 15 partners) was leaded by the University of Wales (UK), the Lincoln University (UK) and our university. The objective of the proposal, that was called INSIGHT, was to develop an excellence network to support research in the area of pattern recognition and medical imaging. The proposal was not accepted, but this year will be presented again after some changes.

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In 2007, I joined the Applied Mathematics and Analysis Department at the University of Barcelona (UB) as Full Professor, where I teach an introductory course on Algorithms and advanced courses on Collective Intelligence and Computer Vision for Human and Object Recognition. From April 2011 I am serving as Head of the Applied Mathematics and Analysis Department, UB.Â In 2007, I joined the Applied Mathematics and Analysis Department at the University of Barcelona (UB) as Full Professor, where I teach an introductory course on Algorithms and advanced courses on Collective Intelligence and Computer Vision for Human and Object Recognition. From April 2011 I am serving as Head of the Applied Mathematics and Analysis Department, UB. Jornada de Seguimiento de Proyectos en TecnologÃas InformÃ¡ticas, 2003 Programa Nacional de TecnologÃas de la InformaciÃ³n y las Comunicaciones TecnologÃa Software Avanzada para la IngenierÃa del Software.Â Download "TecnologÃa Software Avanzada para la IngenierÃa del Software de la Sociedad de la InformaciÃ³n (TAISSI) TIC2001-3530-C02". Error: Download Document. Computer Vision will be in a near future a key technology in our living and/or working environment. This project explores two uses of computer vision in this context: (a) the recognition of people and things to determine the context and the intention of an interaction, and (b) the use of automatic image analysis techniques for advanced visualization. In order to design and validate the developed technologies from a user-centered point of view, we have chosen a specific scenario and use caseâ€¦