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Softeco Sismat - 3D Image Processing and Analysis Laboratory

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Abstract

The activities of Softeco Sismat S.r.l. in the field of Computer Graphics and Vision are described here. The 3D image analysis and processing Laboratory focuses on research activities, carried out thanks to the participation to research projects and aimed at the development of reliable analysis and control systems, in different sectors (the main area of interest being the medical field).

1. The Laboratory

Softeco Sismat S.r.l. is a software company leading the Information and Communication Technology (ICT) sector. Its research and innovation department, through its 3D Image Processing and Analysis Laboratory Group, operates in the field of Computer Graphics and Vision, specially focusing on medical applications (among others) and developing different software solutions as a support of the diagnostic process.

In collaboration with Esaote S.p.A. - world leader in Low-Field Nuclear Magnetic Resonance (MR) for medical applications - Softeco Sismat S.r.l. exploits its consolidated expertise in Image Processing to develop Computer-Aided Diagnosis systems (CADs) for 3D reconstruction, virtual navigation, and measurement of several anatomical districts, starting from medical MR images [PCVV14].

Since 2006 Softeco Sismat is also partner of the Public–Private Laboratory "Imaging non invasivo per diagnostica morfo-funzionale avanzata" ("Non-invasive imaging for advanced morpho-functional diagnostics") (MIUR-DM 18604) which investigates new diagnostic supports in rheumatology and orthopedics, such as the study of spinal column pathologies. The role of Softeco Sismat is focused on the development of new image analysis methods able to go beyond the organ virtual reconstruction, in order to provide objective parameters and better support the diagnostic process.

Softeco Sismat activities in the field of Image Processing include:

- Research in Computer Graphics and Vision.
- Development of medical applications and CAD systems.
- Development of quality control applications.

The expertise of the Laboratory has been achieved during many years of work and through the active participation to many research projects – SIDARMA, IMMERGO-3D, MultiScaleHuman (MSH), CARPUS, MEDIARE, among others.

The activities that have been carried out in the mentioned areas of interest are described in the following.

2. Expertise in Computer Graphics and Vision

Research activities in computer graphics and vision include the proposal and implementation of different image analysis an processing techniques for image filtering, segmentation, registration, and fusion of 3D medical images.

Image segmentation and classification algorithms have been proposed for the identification of anatomical structures in medical images. Different approaches have been investigated and implemented, from thresholding and region growing techniques to interactive level set approaches.

Starting from segmentation results, 3D reconstruction techniques are developed for surface and volume rendering. Additionally, the laboratory has strong expertise in techniques for 3D scene navigation and 3D stereoscopic vision.

Multimodal image registration and fusion techniques, for the advanced visualization of images acquired with different modalities, are being investigated. In particular, a multimodal registration approach, based on point cloud extraction and ICP (Iterative Closest Point), has been proposed for the alignment of MR and US (UltraSound) images of the hand and wrist (MEDIARE project). Additionally, multimodal registration and fusion techniques are being investigated for the fusion of MR, CT (Computer Tomography), and US abdominal and thoracic images (TEDIG project).

The Laboratory focuses on the use of CPU/GPU Computer Graphics Techniques, including the parallel implementation of the aforementioned level set segmentation algorithms [PCV*13].

Finally, computer vision techniques are used for the calculation of quantitative parameters, such as bone erosions in hand and wrist bones, which can be useful as a support of the diagnostic process [PCV*15].

3. Developed applications

The laboratory focuses on the development of different medical applications, as a support of the diagnostc process. The aforementioned techniques have been combined and implemented, through the development of dedicated CAD systems.

First of all, a prototype software for the endo-navigation of knee MR images was implemented (EndoNav).

Moreover, OrthoCAD, owned by Esaote S.p.a., is a software package intended to be used with Esaote Cscan system, approved by the U.S. FDA (Food and Drug Administration). This tool provides the morphometry of the lumbosacral section of the spine, by means of semi-automatic segmentation of MR images, the generation of the relative 3D model and calculation of the significant geometrical properties of the vertebral bodies and spinal canal.

Additionally, a prototype for the analysis of carotid artery (US-CAD) was implemented, which allows the user to perform the segmentation of US images, the reconstruction of the 3D model, and its 3D virtual navigation. Figure 1 shows the various phases of the elaboration.

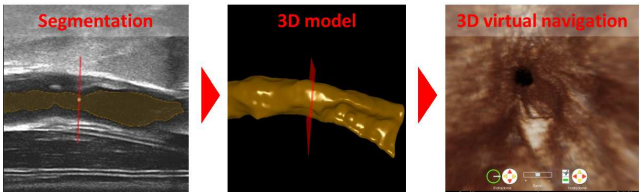

Figure 1: *Analysis of the carotid artery.*

Thanks to the collaboration with the Medical Department (DIMI) of the University of Genoa, RheumaSCORE, a complex CAD system, specialized for the diagnosis and treatment of Rheumatoid Arthritis (RA), has been assembled [PCVV15]. RheumaSCORE offers an interactive tool for the segmentation of carpal and metacarpal bones in MR images, which is based on a parallel implementation of the Geodesic Active Contour approach; moreover, RheumaSCORE allows the 3D visualization and navigation of the detected elements (through volume and surface rendering), the estimate of diagnostic parameters (bone erosion), the storage and management of clinical data, and the visualization of the follow-up of a patient. The user interface is shown in Figure 2. The software is used in the clinical practice by DIMI rheumatologists [TCB*15].

Finally, in the context of the IMMERGO-3D project, a generic tool was developed, for the analysis of images of different districts acquired with different modalities. This software includes various segmentation algorithms and tools (from a simple thresholding technique, to geodesic level set approaches implemented on GPU), surface and volume rendering (GPU based), and stereoscopic vision. A prototype of the software has been released and is currently being used by the partners of the MSH project.

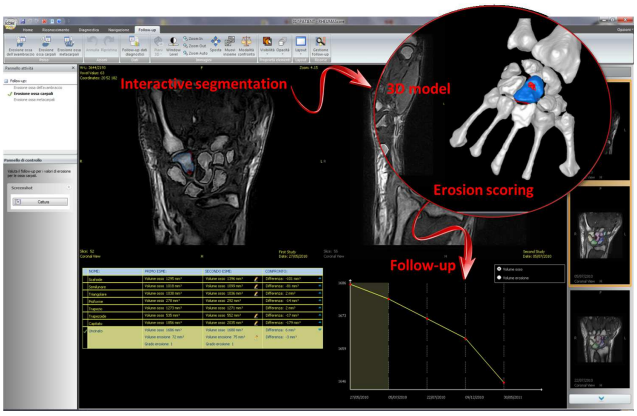

Figure 2: *RheumaSCORE user interface*

Other applications have been implemented over the years, intended for quality control in different fields (e.g., detection of defects in turbine shafts, food quality control, simulation of defects in 3D models of train wagons, etc.). In medicine, image processing approaches have been applied for US helical tomography quality assessment.

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