MEDIP - PLATFORM INDEPENDENT SOFTWARE SYSTEM FOR MEDICAL IMAGE PROCESSING

Duration of the project: January 2002 – December 2004

Home page of the project: <www.pet.dote.hu/guest/palyazatok/ikta4/projekt.htm>

Co-ordinator:

Department of Information Technology, University of Debrecen, Debrecen, Hungary
Home page: <http://it.math.klte.hu>
Address: H-4010 Debrecen, PO 12, Tel.: (36-52)-512900/2814
Project leader: Kormos János Dr. <kormos@it.math.klte.hu>

Consortium members:

PET Center of University of Debrecen, Debrecen, Hungary
Home page: www.pet.dote.hu
Team leader: Emri Miklós Dr., emri@pet.dote.hu

Mediso Medical Imaging Systems Ltd., Budapest, Hungary
Team leader: Farkas Attila, a.farkas@mediso.hu

Department of Orthopedic Surgery, University of Debrecen, Debrecen, Hungary
Team leader: Csernátóy Zoltán Dr., csz@jaguar.dote.hu

Chair of Radiotherapy, Semmelweis University, Budapest, Hungary
Home page: www.oncol.hu
Team leader: Ésik Olga Dr., esik@oncol.hu

Department of Radiology and Oncotherapy, Semmelweis University, Budapest, Hungary
Team leader: Kári Béla Dr., kari@radi.sote.hu

Keywords: functional library; medical image processing; platform independence; software library; visualization library; volumetric library

1. Introduction

1.1. Project aims

The aim of the project is to develop a software background for our basic and applied research in the field of medical imaging that can be used in clinical routine, as well. The realisation is based on the experience of information technology and medical imaging research university teams and a company specialised on software and hardware developing for nuclear medicine. The aims also reflect some former research and development activities of the participants. Thus some of the participants are well experienced in registration, segmentation and image fusion techniques. These experiences were also considered in the determination of the main purposes.
1.2. Project objectives

The development of the software parts of the project require the solution of several problems that need sophisticated theoretical investigations, as well. The tasks to be solved mainly correspond to digital image processing results, but starting from there, other fields of mathematics and computer science are also should be investigated. Namely, the solutions of the problems need the tools of mathematical morphology, computer geometry, linear programming, probability theory and statistics. The main purpose is the integration of the recent image segmentation, image registration, and image fusion tools as well as the applied computer graphics solutions of GI systems. The multilayered software product consists of three different layers, namely modules for functional tasks of the software, visualisation and graphical user interface. An important point is the marketability of those programs that are (or will be) based on this software library.

1.3. Work description

During the project several test programs and three demonstration software to be created to complete the whole task. The goal of the test programs is to choose the optimal hardware and software environment for the developing phases. Proving the applicability of the complex developing environment, the demonstration programs present solutions for image processing tasks from the fields of orthopaedy, oncology and nuclear medicine. Medical experts are involved into planning and testing the software. Beside software developing, the project contains several basic research tasks, like composing algorithms for segmentation and geometric modelling. Moreover, the implemented algorithms are optimised, as well. Integrating the research results into the software modules is a very important point during the developer process. These results make it possible to create more effective displaying and interactive programs, which indirectly improve the quality of the diagnostic and therapeutic clinical work. Involving Ph.D. and undergraduate students, the development of the system can be continued after the project finished, thus the ability of the software libraries and programs can be improved with respect to the dynamically developing performance of graphic hardware devices. This assures continuos co-operation between a university knowledge base and a technology centre.

2. Software libraries

The functional layer is created by the design models of the standard C++ language. The modelling of multidimensional (2D, 3D, or higher dimensional) parametrized type data structures, and the algorithms needed to handle them, can be given in an abstract way. Thus the image information recorded by different tools (PET, SPECT, MRI, DSA, CT) can be handled uniformly by the help of a 3D image matrix. This approach assures that data storage and algorithms relating to elementary image processing tasks (like image algebra, spatial linear and non-linear transformations, spatial filtering, convolution) can be covered by this base library.

The second main task is the creation of the visualization and 3D interactive computer geometry algorithms. This can be solved by using standard OpenGL software libraries after specifying the supporting hardware and software system. During this development step, the connection between the OpenGL libraries and the storage classes of the functional layer must
be solved. Another sophisticated problem is to create the graphic interface for the interactive selection of the VOI.

The creation of the demonstration programs requires the designation of a user interface. It is recommended to choose such a system, which allows multiplatform development. This problem can be handled by the matching of the designated software package and the developed OpenGL based displaying and interactive software libraries.

3. Research tasks

The creation of the software described in the project requires to perform several theoretical investigations. The solution of these problems can be grouped into the following three main areas:

- **image segmentation procedures based on mathematical morphology basically for CT and MRI inspections to extract ROIs and VOIs of several human tissues.** The demonstration programs show example for bone (mainly the hip joint and femur), brain, and heart/lung extractions. The difficulty of the segmentation task highly depends on the observed human tissue, thus automatic techniques are seldom usable instead of manual ones. To make the segmentation step more reliable, it is recommended to execute some pre-processing. Similarly, to refine the segmentation results some post-processing steps might be useful. As a typical post-processing, morphological operations can be performed to obtain more precise and "natural" final results.

- **composing mathematical (geometric) models for handling different human tissues and simplifying their usability in CAD environment.** The resulted pixel/voxel set of segmentation is usually not sufficient for displaying, thus we render some geometric objects to them. This way the interesting regions can be nicely displayed, moreover, this geometry also can be imported into CAD systems. Thus geometric parameters can be determined, and other investigations (such as finite elements analysis) also can be performed. When a nice visualization or a natural model is desired, then the elements of continuous geometry are used (e.g. B-splines, Coons patches, etc.). On the other hand, if a rough geometric model is sufficient, then discrete geometric objects can be applied.

- **optimizing the algorithms and geometric objects created in the project to improve efficiency.** The models extracted from the images are often extensively detailed, which may causes hardware and also software capacity problems. (For example, the number of nodes of a geometry is often limited by CAD systems.) The reduction of nodes and other geometric elements must be performed in such a way that the usable information is not ruined. The selection of ROIs and VOIs has primary importance in medical image processing applications, thus sometimes it is recommended to apply more segmentation methods, parallel. E.g. automatic techniques can be completed with manual ones, or region growing algorithms by gradient based methods. Moreover, the smoothing of the resulted contour is also recommended in many cases.
4. Milestones and main results

4.1. Milestones
- Surveying conditions and needs, problem specification, initial analysis,
- Model specification, system plans, research design,
- Implementation I. (alpha versions),
- Implementation II. (final versions),
- System tuning, testing, presentation.

4.2. Main results
- Description of programs for creating the development environment,
- Scanning through the literature of segmentation and surface/volume rendering,
- System plan: functional layer,
- System plan: visualization,
- System plan: complex development system,
- Demonstration program plans,
- Image database,
- Development system (alpha version),
- Demonstration programs (alpha version),
- Development system (final version),
- Demonstration programs (final version).