Chapter 63
Evaluations on the Applicability of Generic and Modular Image Processing Chains for Quantitative 3D Data Analysis in Clinical Research and Radiographer Training

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ABSTRACT

The introduction of digital imaging and diagnostics facilities has fundamentally changed radiology. Nevertheless, theory of digital image processing and analysis as well as their practical application are still only a subsidiary part in nowadays radiology technician curricula. This work focuses on the evaluation, to what extent the authors' simplified and standardized process model for applying image processing modules in generic domains is suited for radiographer students and medical staff, lacking deeper theoretical knowledge compared to physicians and imaging experts. The semi-automated image processing workflow thereby comprises region growing, live-wire segmentation and filtering steps, all available from MeVisLab prototyping framework. It is shown that the proposed imaging chain is highly applicable for analysis and facilitating medical diagnostics of arbitrary anatomical structures from tomographic data. After compact practical instruction, radiographer students are versed to achieve complex 3D analysis perfectly suited for quantitative analysis in clinical research typically only achievable by use of specialized software.

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1. INTRODUCTION

Although applications for computer-based diagnostics showing enormous potential are slowly but steadily finding their way into clinical routine, their applicability is still limited to specific medical issues. Generic methods and tools for segmentation, analysis and visualization of arbitrary anatomical structures will not be available for clinical practice the next couple of years, if ever, although their fields of applications are highly important. Each precise quantitative assessment of geometric properties like position, size and extent of anatomical structures necessitates previously performed segmentations. Segmentations can be applied to the task of surgery planning, e.g. liver lobe resection (Zwettler, Backfrieder, Swoboda, & Pfeifer, 2009). The complementary information from different imaging modalities allows for differential diagnosis in various contexts, e.g. the registration of *MRI* and *CT* volumes yields high resolution morphology combined with the functional images of nuclear medicine modalities as modern *PET* or *SPECT*. Several approaches exist to utilize detailed morphology for quantitative assessment of metabolic information from emission tomography (Beyer, Schwenzer, Bisdas, Claussen, & Pichler, 2010). Intra patient registration and proper segmentation facilitate accurate tumor staging, the comprehensible documentation of time-related progress in disease or evaluation of the therapy success (Kuhnigk, Dicken, Bornemann, Bakai, Wormanns, Krass, & Peitgen 2006). In the modern field of surgical planning and intra-surgical navigation, segmentation approaches are deeply manifested to introduce patient-specific models to virtual reality environments (Wulf, Vitt, Gehl, & Busch, 2001). Accurate three dimensional models are of growing importance for surgical training (Stone, 2011; Fürst & Schrempf 2012).

In clinical practice often rather simple but robust procedures are used for segmentation of particular organs and anatomical structures, like region growing (Gonzalez & Wintz, 1987) or live-wire contour definition (Barrett & Mortensen 1997; Schenk & Prause 2001), but these methods are semi-automatic and thus time consuming. Although requiring rarely any a priori knowledge and thus favoring generic segmentation, utilizing these strategies only rather awkwardly shaped structures with homogeneous intensities can be successfully processed. Thus, these methods are not directly applicable for medical applications but are of high relevance whenever preparing manual reference segmentations for model-driven segmentation approaches.

Utilizing deformable models (McInerney & Terzopoulos 1996) and incorporating a priori knowledge, particular structures with low anatomical variability can be precisely segmented. Deformable models as general tools for segmentation are not applicable, as the model parameters are highly dependent to the target morphology. Thus, small structures with only low intensity variability remain still hard to segment. Statistical Shape Models (Cootes, Taylor, Cooper, & Graham 1992) benefit from the automated assessment of parameters based on reference segmentations in the sense of training an a priori model, but the problems of shape overlay and topological changes still exist. Furthermore, modeling very thin and sparsely connected structures with respect to low imaging resolution or partial volume effects cannot be achieved by utilizing geometric shape modeling. Active appearance models introduce statistical properties of the target structure expected intensity profile additionally to common geometric model preparation (Cootes, Edwards, & Taylor 1998). Level sets (Osher & Sethian 1988) can handle changes in topology and anatomical variability but complex parameterization needs adjustment to the particular segmentation task.

General medical segmentation tasks can currently only be achieved by building up complex image processing chains utilizing rapid prototyping techniques. These individually adjusted segmentation tasks

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