Introduction

Medical image computing techniques have become more and more important in medicine and medical informatics. Nowadays, image computing and visualization techniques are applied in daily routine. However, further improved high-level image processing methods are needed to analyse and visualise anatomical and pathological image structures in a user-oriented way, especially if a large number of images for one patient are available containing spatial, anatomical and functional information. Moreover, with recent imaging techniques 4D (= 3D + t) image data can be generated containing information about the spatio-temporal behaviour of tumours and inner organs. This is e.g. of interest in radiology for analysing the dynamic changes of the beating heart (e.g. [1, 2]) or in radiation therapy for measuring respiratory motion of the lungs, lung tumours and inner organs [3]. However, 4D image computing algorithms are developed to generate 4D image data sets at improved levels of quality as well as to analyse, extract and visualize significant information from this huge amount of data.

Medical Image Computing

High-level image computing techniques are needed for future improvements in image-based medical diagnostics and image-guided intervention such as computer-assisted surgery. Hence, it is not surprising that medical image computing is a field of growing importance with an increasing number of articles published annually [4].
To describe recent developments in this field the winners of scientific awards of the German Conferences on Medical Image Processing (BVM) 2005 and 2006 were invited to submit a manuscript about their latest developments and results for this issue. Excellent papers were selected to describe important aspects of recent advances in the field of medical image computing and are assembled in this special issue. The selected papers give an impression of the broad methodical range and depth of new developments in the field of medical image computing. New methods for improved image reconstruction [5, 6], data-driven and model-based image segmentation [7-9], as well as methodical improvements [10, 11] and extended applications [12] of non-linear image registration algorithms are presented together with applications of image analysis methods in different disciplines [13-15].

The impact of new developments in medical image computing on medical diagnostics and computer-assisted therapy can be illustrated by the development of registration algorithms, which have offered new possibilities for the analysis and visualization of multimodal image data sets [16]. Using these algorithms image data from different imaging modalities like radiography, ultrasound, computer tomography, magnetic resonance imaging, functional magnetic resonance imaging, positron emission tomography etc. can be matched and presented in a common coordinate system of a reference body. Hence, the spatial, anatomical, and functional image information usually distributed over a huge number of images can be visualized in one common 3D scene showing key anatomical structures, pathological changes of tissue, functional brain regions, and their spatial correlation to each other. These new image computing methods enable new insights into the patient’s image data improving medical diagnostics and patient treatment. Furthermore, especially non-linear registration algorithms have opened up new opportunities. They can be used to estimate and quantify organ motion in 4D image data [17] or for atlas-based segmentation, where a predefined segmentation of a reference data set, called atlas, is transferred to an unsegmented patient data set using the computed displacement field (e.g. [18]). In [5] non-linear registration algorithms are used for improved reconstruction of 4D CT data sets, while in [12] it is shown that image interpolation of spatial and temporal image sequences can be improved significantly using non-linear registration techniques. In [10] and [11] new methodical improvements and new approaches in non-linear registration methods are presented to improve the robustness and quality of non-linear image registration. The high computational requirements and computation times of non-linear 3D-3D registration algorithms can be reduced significantly by using multi-scale techniques, parallelisation, and grid computing techniques [19].

A further challenge in medical image computing is the automated segmentation of medical images and image sequences. In this issue a new data-driven approach for the segmentation of volumetric image data is described [7]. Moreover, organ models can be used to increase the degree of atomisation in organ segmentation processes. These approaches are highly promising, because they support the segmentation of organs in cases, where a pure data-driven segmentation would not work in a proper and satisfactorily robust manner. A new approach for the generation of statistical organ models to improve organ-specific segmentation is presented in [8]. In [9] a geometric model of the heart is used to facilitate the segmentation of heart structures and to significantly reduce the amount of interactive segmentation time.

Finally, image analysis methods are essential for medical image computing. These methods were developed and optimised to facilitate and extend the analysis of medical images (or data) and to extract significant quantitative parameters describing characteristic image or object features. In this issue new approaches for the computer-assisted analysis of ultrasound [13], microscopic [14], and CT images [15] are presented as examples of the development in this challenging field.

Conclusions

The development of image analysis systems for diagnostic support (e.g. [1]) or therapy planning and intervention (e.g. [20]) is a complex interdisciplinary process. On the one hand image computing methods have to be developed to support the physician during the diagnostic and therapeutic process, on the other hand methods of different scientific fields like image processing, computer graphics, pattern recognition, mathematics, simulation, and robotics have to be adapted and used in combination.

The papers selected in this issue give an impression of new trends and developments in the field of medical image computing. The image computing methods presented enable new insights into the patient’s image data and have the potential to significantly improve medical diagnostics and patient treatment in the future.

References


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