Medical informatics, biometry and epidemiology are closely related disciplines that contribute essentially to improvements in health care, public health and biomedical research. In medical informatics advanced methods and tools are developed for the management and processing of patient data and knowledge triggered by ongoing innovations in computer science, e.g. cloud computing and data mining. eHealth as a subdiscipline refers especially to communication, integration and collaboration solutions with the aim of sharing and reuse of patient data, e.g. medical device integration or secondary use of EHR data in clinical research. Furthermore, the high importance of medical images in diagnostic and therapy, new and improved imaging modalities as well as the high complexity and enormous increase of medical image data in clinical routine has reinforced the need for the development of efficient and optimized medical image computing methods. Hence, medical image computing has been established as a highly innovative field in medical informatics [1–6]. Although many medical image computing methods and systems are yet applied in practice, their grade of automation, accuracy, reproducibility and robustness has to be increased to meet the requirements in clinical routine. In biometry and epidemiology there is an ongoing demand for developing and applying new statistical methods for analyzing medical data as well as improving clinical trials and public health applications. As a prerequisite the original data should be provided by suitable medical informatics methods, e.g. with respect to data quality and security aspects [7].

For this issue, selected authors of the 58th Annual Conference of the German Society of Medical Informatics, Biometry and Epidemiology (GMDS) 2013 were invited to submit a manuscript on their latest developments and results for possible publication. The GMDS 2013 was hosted by the Institute of Medical Informatics at the University of Lübeck with 800 participants from computer science, biometry, epidemiology, documentation, medicine, and industry. The invitation was based on the outstanding presentation and the blinded peer review process of the conference. After international reviewing of the journal submissions, seven excellent papers were assembled to present research results in the field of medical informatics, biometry and epidemiology in Germany. In this issue, recent developments in medical image computing, platform design for eHealth applications, public health research and statistical test theory are presented. The selected papers give an impression of the high variety of methods used in these challenging fields in Germany and show interesting results in different medical applications.

The first four papers [8–11] address problems in the field of medical image computing that has become a key technology in image based medical diagnostics and image-guided therapy. In medical diagnostics, image analysis methods enable the extraction of semantic objects (organs, tumors etc.) and quantitative parameters. An interesting application of medical
image analysis methods is given by Deserno et al. [8]. In the paper they present an automatic image processing pipeline for objective and quantitative evaluation of the conjunctival provocation test (CPT), a diagnostic procedure for the assessment of allergic diseases. Here, photographs of the eyes before and after provocation are analyzed using image analysis methods to quantify the increase of redness of the conjunctiva. The computer based automatic method yields improved results in terms of reproducibility and stability.

In [9] recurrent neural networks are applied to recognize tissues in A-scans generated by optical coherence tomography (OCT). The OCT A-scans from freshly resected human lung tissue specimen were recorded through a customized needle with embedded optical fiber. Special recurrent neural networks called bidirectional long short term memory networks (BLSTM) were trained based on pre-processed image grey values to recognize pulmonary nodules in front of the needle. Classification rates from 67.5% up to 76% were achieved for different training scenarios. Using a patient specific training a sensitivity and specificity of the nodule recognition of up to 0.87 and 0.85 was obtained. The results are promising, however further improvements are necessary to meet the clinical requirements.

The following contributions [10, 11] illustrate how 4D medical image computing methods have opened up new perspectives for patient treatment in radiotherapy. Polzin et al. [10] propose a hybrid intensity- and feature-based registration scheme for non-linear deformable registration of 4D lung CT images; e.g. these images are used in 4D radiotherapy to improve radiation therapy of moving lung tumors during respiration. The approach combines a variational nonlinear intensity-based registration method with an approach for automated landmark correspondence detection in lung CT pairs of different breathing states. Corresponding anatomical landmarks are detected automatically in the two CT data sets and used to improve registration accuracy. Based on ten publicly available end-inspiration/expiration CT scan pairs it is shown that the hybrid registration approach outperforms nonlinear intensity-based registration without landmark usage in terms of registration accuracy.

Wilms et al. [11] address the problem of motion prediction during the irradiation of thoracic and abdominal tumors in presence of respiratory motion. In clinical practice, breathing signals (e.g. spirometry, range images of the moving skin surface) are acquired during the radiation to estimate the breathing state of the patient. In this paper patient-specific correspondence models are used to estimate the sought internal motion from given range images. The correspondence model is established on the base of motion fields – extracted from 4D CT data with non-linear diffeomorphic image registration methods – and the corresponding range images of the patient’s skin. A simulation study based on 28 4D CT data sets is carried out to investigate the motion estimation accuracy based on different multidimensional signals extracted from range images and the influence of noise, the signal dimensionality, and different sampling patterns (points, lines, regions). The results show that the use of multidimensional signals instead of one-dimensional signals significantly improves the motion estimation accuracy.

An example to illustrate the dynamic development in the field of electronic health care is given in [12]. Here, Doods et al. show how a protocol feasibility platform produced by the Electronic Health Records for Clinical Research (EHR4CR) project can be installed and used in accordance with local technical and governance requirements to execute protocol feasibility queries uniformly across national borders in Europe. The platform enables to create feasibility queries, distribute them to eleven university hospitals and retrieve aggregated patient counts of both test data and re-identified EHR data. Especially, terminologymapping of local site codes to central platform codes were used for generating queries with eligibility criteria that can be evaluated by all partners.

Advances in the field of epidemiology and health technology assessment (HTA) are illustrated by Ohlmeier et al. [13]. Here sophisticated statistical methods are applied to healthcare data concerning elective percutaneous coronary interventions (PCIs). Based on data of three statutory health insurances including more than nine million insurance members, a retrospective cohort study between 2005 and 2009 was conducted to compare the outcomes of inpatient and outpatient care. A Cox proportional hazard model was used to assess the influence of the setting of the elective PCI on the risk for complications after the PCI for each outcome separately. The results show that the majority of the analyses revealed no statistically significant effect of the setting of the PCI on the risk of myocardial infarction, stroke and further coronary interventions, whereas a reduced mortality risk was observed for outpatient PCIs. Similar results were obtained in the propensity score analyses.

Finally, Schmidt and Brannath [14] illustrate the development in the field of medical biometry by an approach for improving multiple tests in clinical trials where it is often difficult to obtain informative simultaneous confidence intervals (SCIs). In particular in hierarchical testing, no quantification of effects is possible for the first tested (and most important) hypothesis after its rejection. The main idea of the approach is to split the significance level after rejection of each hypothesis to obtain an informative confidence bound. It is shown theoretically and by an example that the newly generated SCIs always provide information when a hypothesis is rejected. The flexibility in the choice of the weight functions makes the procedure attractive for applications.

Discussion

The selected papers give an impression of the breadth and diversity of new developments in medical informatics, biometry and epidemiology in Germany and illustrate that research in these fields is under rapid development. They illustrate how the interdisciplinary research in these fields contributes to improve healthcare and the healthcare system. On the one hand the papers exemplify how complex medical image data is transformed to image-based information and knowledge to support diagnostics and therapy with high accuracy and robustness. On the other hand recent
developments in the field of infrastructure-related platforms are presented which are needed for developing applications in distributed heterogeneous healthcare system environments. Innovative IT-infrastructures are essential to support quality of healthcare and medical research in practice. Sound statistical methodologies are needed to assess the outcome and efficiency of medical technology and health system interventions in evaluation studies. At the end patients will benefit from well supported healthcare professionals by using suitable software platforms as well as novel decision support methods and tools.

References