Editorial. Automation in medicine: from homecare to clinical applications

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Editorial

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Patients are increasingly accompanied by medical technology throughout their daily lives. The technology moved from hospitals and clinics into patients' homes or is worn continuously. Increased miniaturization and integration of sensors and systems has enabled unobtrusive health monitoring at the point-of-care, independent of place and time. Additionally, the integration of information and communication technologies (ICT) into medical systems has enabled direct access to data from remote sensors and the real-time interaction with this data. While such technologies already penetrated the consumer market a few years ago, they are nowadays becoming increasingly important in medical applications. This transition of medical technologies from the clinic to patient homes opens new opportunities and challenges, especially for medical devices based on the automation paradigm. Systems outside the controlled environment are subject to increased noise, and the altered nature of data in quantity and quality requires extra attention. Advancements in sensing and control will make these technologies more robust and market-ready.

In this special issue, we present two contributions on the emerging field of mobile medical technology which are of interest to biomedical automation engineers:

– Markus R. Mutke and Jens Eckstein, "Wearables: Ein Blick aus ärztlicher Perspektive über Möglichkeiten, Herausforderungen und Risiken im Gesundheitswesen"

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– Michael Rapin et al., "Common-mode rejection in the measurement of wearable ECG with cooperative sensors".

This special issue is also dedicated to the 13th AUTOMED Workshop, which was held in Villingen-Schwenningen March 15–16, 2018. This regular workshop provides an excellent forum, especially for young researchers, to present new developments in the important interdisciplinary field of automation in medicine. This involves the development and application of concepts, methods and techniques of modeling, informatics and control of complex biomedical and biological systems, as well as advances in medical technology. The AUTOMED 2018 workshop was jointly organized by the Institute of Technical Medicine (ITeM) at Furtwangen University and the German Technical Committee Automation in Medicine – AUTOMED – a joint technical committee of the VDE society for biomedical engineering (DGMBT) and the VDI/VDE society for measurement and automatic control (GMA). The next AUTOMED workshop will take place in spring 2020 at the University of Lübeck.

This year's workshop in Villingen-Schwenningen was a great opportunity to exchange ideas, discuss exciting problems in the field of biological and medical systems, interact with colleagues, and make new friends. Two keynote lectures were held by Prof. Geoffrey Chase (University of Canterbury) on "Modeling, computers and the future of healthcare" and by Prof. Merryn Tawhai (University of Auckland) on "Patient-specific model-based assessment of lung function in the clinical setting". After the workshop, participants had the opportunity to visit the company Karl Storz SE & Co. KG in Tuttlingen. The proceedings of the event consist of 23 papers. Contributions covering the broad spectrum of application areas in biological and medical systems were selectively invited for this special issue based on previous outstanding conference papers. All papers have been significantly extended prior to passing through the journal's peer review process. Six papers have been finally accepted for publication:

– Fabian Just et al., "Exoskeleton transparency: feedforward compensation vs. disturbance observer"

- Christina Salchow-Hömmen et al., "Automatic control of grasping strength for functional electrical stimulation in forearm movements via electrode arrays"
- Cong Zhou et al., "Structural health monitoring of tissue mechanics for non-invasive diagnosis of breast cancer"
- Christian Herzog (né Hoffmann) et al., "Temperature-controlled laser therapy of the retina via robust adaptive $\mathcal{H}_\infty$-control"
- Mathias Scheel et al., "Application of Kalman filter for breathing effort reconstruction for OSAS patients in breathing therapy"
- Lina M. Beltran Bernal et al., "Optimizing controlled laser cutting of hard tissue (bone)".

Wearable sensors used in clinical and healthcare settings have requirements analog to other medical devices. In their survey, Mutke and Eckstein discuss potential opportunities, challenges and risks when wearables are used for clinical applications. They provide a clinician's perspective on a broad range of aspects, also those which are often overlooked by engineers and developers.

Rapin et al. have developed a technology that improves the integration opportunities for bioelectric amplifiers in wearable devices. Reducing the number of cables and the high integration of the system was achieved through cooperation between the sensors. In the paper presented, a cooperation architecture enables efficient common mode rejection for a 12-lead ECG with active dry electrodes and only two wires connecting all sensors.

When designing therapy exoskeletons, the balanced design of sensors and mechanics as well as control algorithms is critical to achieve high training effectiveness. Just et al. discuss feed-forward compensation and disturbance observer control approaches to generate consistent mechanical transparency across training and therefore compensate unwanted disturbances from the therapy robot such as gravity, friction, spring and cable elasticities, and inertia.

For hand neuro-prostheses activated with functional electrical stimulation, control of grasp force is essential. Salchow-Hömmen et al. have developed a method to track hand motion with inertial measurement units (IMU) to estimate required grasp force. Automatic adaptation of virtual electrodes in an electrode array guarantees a secure grasp for forearm rotation-independent use of the prosthesis.

Zhou et al. present a new non-invasive method for breast cancer diagnosis based on a digital imaging elastotomography (DIET) screening as alternative to mammography. The overall approach can be implemented automatically without requiring a skilled operator, thus reducing the screening cost.

The feasibility of an automatic retinal laser therapy has been investigated by Herzog et al. The newly-developed robust control scheme based on photo-acoustic feedback of the retinal temperature ensures a safe therapy. The control scheme is further extended to adapt to real-time parameter estimates and associated bounds on the uncertainty of each irradiation site.

The work by Scheel et al. is concerned with the improvement of continuous positive airway pressure (CPAP) therapy to treat the obstructive sleep apnea syndrome (OSAS). A model-based approach is presented to estimate the patient's breathing effort during therapy. This information is obtained by a Kalman filter and enables precise control of the mask pressure.

Robot-assisted contactless laser surgery of bones provides less mechanical stress, allows precise functional cuts, and leads to faster healing. The contribution by Beltran Bernal et al. aims at maximizing the efficiency in hard tissue laser ablation furthermore by optimizing the irrigation and lateral movement speed conditions.

We would like to thank the Editor-in-Chief, Ulrich Jumar, for giving us the opportunity to assemble this special issue and all the contributors who accepted our invitation to submit their work in this issue.

Walter Karlen, Thomas Schauer, Knut Möller,
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Guest Editors

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Olaf Simanski studied electrical engineering from 1991–1996 with a specialization in automation at the University of Rostock, where he wrote his dissertation in the field of automation in medicine in 1992. In 2010 he habilitated on the topic "Automatic application of medication in anaesthesia". In 2011, he moved to Wismar University of Applied Sciences where he held a professorship in automation. His research focuses on the application of automation in industry, the maritime sector and medicine.