Digital Health: E-Coaching and Remote Monitoring

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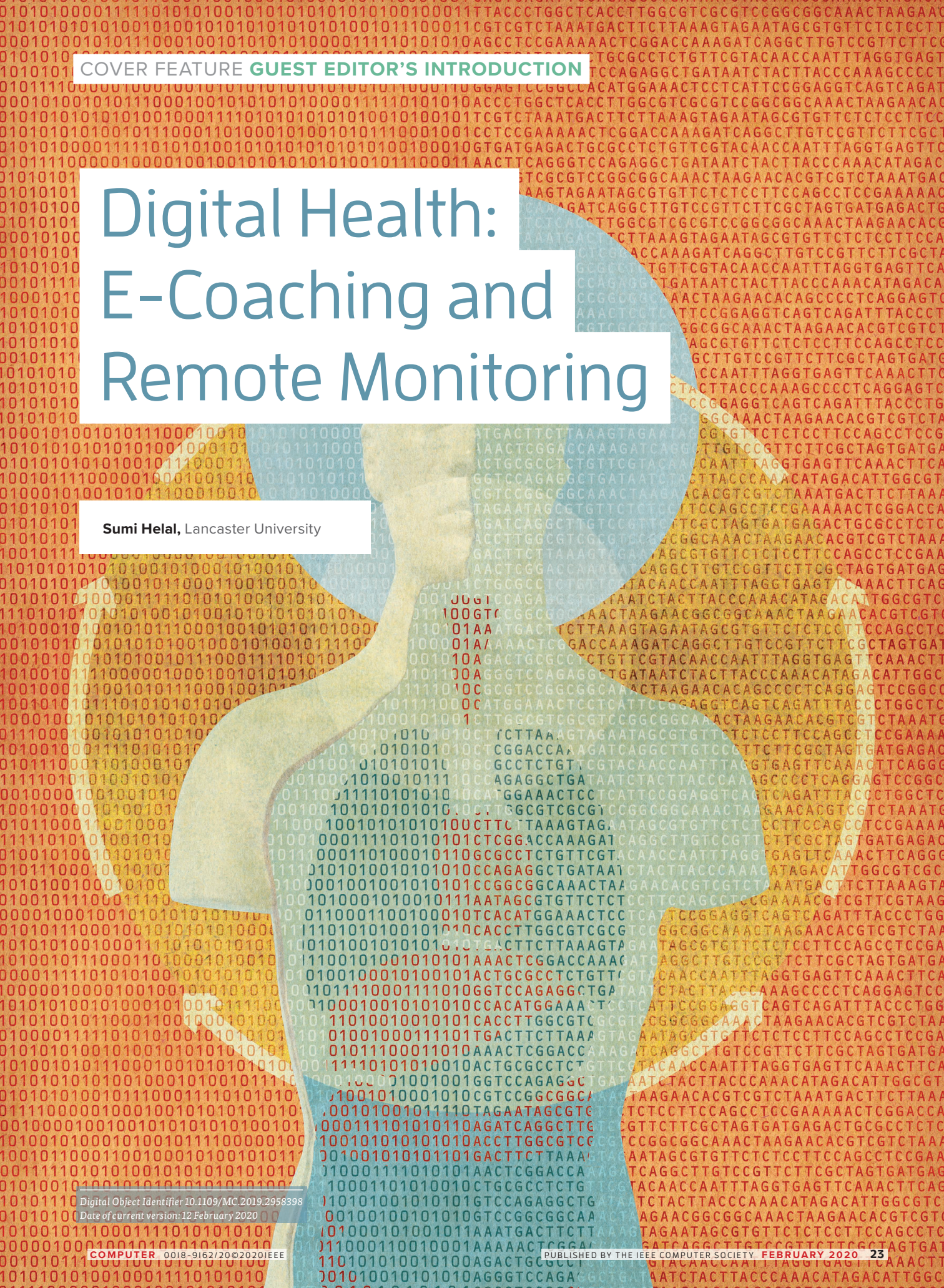

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Digital health technology creates an unprecedented opportunity to improve patient outcomes and quality of life. This theme issue of Computer presents three articles that provide an in-depth study of e-coaching and remote-monitoring technologies in medicine.

Digitizing health care offers great hope to the world, developed and underdeveloped alike, and promises to improve health outcomes, reduce patient suffering, and improve quality of life, all at a lower cost. It also brings the prospect of a new and powerful digital economy with significant savings as we part from the inefficient and wasteful health-care practices of the present and past and reinvest in more health and wellness and less in expensive and late treatments of advanced disease cases for the masses.

It took almost 50 years to develop, mature, and standardize the electronic health record (EHR). With the advent of the Internet and acceptance of standards such as the Fast Health Care Interoperability Resources, the EHR has grown to represent a shiny milestone along the journey toward digitizing health care, and there is more to come that will radically transform medicine and its delivery and economical models. I liken the EHR to the early days of the computer and mainframes, when you had to go to their air-conditioned room to use the equipment. The EHR is similar in that you must visit a doctor, hospital, or lab for your record to be used or updated. It has a sparse net effect of several points of care throughout your lifetime. But the computer became ubiquitous, anytime, anywhere, thanks to the smartphones we attach ourselves to. Amazing wearable technology and even sophisticated personal health devices emerged, and the opportunity to move from health data and records to online systems and continuum-of-care services is loudly knocking.

To cover the emerging and fast-developing research in this area, *Computer* has published a number of special and theme issues with the theme of digital health. The most recent installment, published in the November 2019 issue, focused on active and healthy living. This theme issue, which Editor in Chief Jeffrey Voas invited me to guest edit, includes three articles that examine e-coaching and remote-monitoring technologies, algorithms, and studies.

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In "Virtual Avatar-Based Life Coaching for Children With Autism Spectrum Disorder," Zhao et al. report on a multidisciplinary research study to review a vast body of work that attempts to use virtual avatar-based e-coaching systems to improve the social and communicational skills of children living with autism spectrum disorder (ASD), a neurological and developmental condition that can cause significant social and behavioral challenges. The study does not draw conclusions about the efficacy of virtual avatars for alleviating ASD but, rather, aims to analyze the various elements and types of this approach, hoping to inform future directions, especially by utilizing fully autonomous systems that are portable, inexpensive, and, most importantly, highly customizable.

The article contributes a comprehensive classification of the virtual-avatar system, including avatar types (2D, 3D, with and without animation, and so on), targets (social–emotional, social-cognition abilities, phobias, joint attention, and so on), displays (computer monitors, immersive displays, and virtual-reality goggles), the data collected in response to the avatars' influence, and the timeframe for analyzing the data, among others. The article is timely and appropriate since it calls for scaling up studies by redesigning the approach to go mainstream, which could bring real evidence and a more productive collaboration among ASD clinical researchers and practitioners, computer scientists, and the software developers of the virtual-avatar systems.

In "The Intelligent Medical Platform: A Novel Dialogue-Based Platform for Health-Care Services," by Ali et al., the design and use cases of an e-coaching platform for patients and physicians are presented. The Intelligent Medical Platform (IMP) relies on two workflows, one for knowledge creation (extracting information from medical

data and presenting it to patients and physicians) and the other for knowledge execution (driving dialogue-based e-coaching sessions with patients). The IMP includes several layers: knowledge extraction and engineering, dialogue-based conversation, data acquisition, user-interface adaptability, and system interoperability. The architecture details reveal the heavy use of existing technologies and algorithms.

Two case studies are reported based on thyroid cancer patient data obtained from Seoul National University Bundang Hospital, South Korea. The first study, which was physician centric, addressed IMP knowledge acquisition from 500 randomly selected thyroid cancer patient records and conversion to production rules. The study demonstrated the application of alternative and widely accepted decision-tree algorithms, such as the J48 and chi-square automatic interaction detector. The aim was for physicians to review and approve the learned rules while focusing on the discovered knowledge: a training and e-coaching service for the doctors.

The second case study, which focused on patients, showed how the IMP uses templates to guide dialogues with medical-care recipients, who express their initial symptoms in voice or text. The patients receive responses based on available knowledge as well as a refinement process that uses an incremental-inferencing mechanism based on the sequence of their inquiries. The article's key value relates to showing how data-driven approaches can take e-coaching systems to another level of utility by automating the domain-knowledge extraction and execution, rather than solely involving domain experts to do the programming.

ABOUT THE AUTHOR

SUMI HELAL is a professor and chair in digital health at Lancaster University, United Kingdom. His research interests include smart homes and assistive technology in support of graceful aging and independent living, e-coaching and patient empowerment for active and healthy living, and architectures and programming models for the Internet of Things. Helal received a Ph.D. in computer science from Purdue University. He was the editor in chief of *Computer* from January 2015 to December 2018. Contact him at sumi.helal@gmail.com

Finally, in "An Internet of Things Fog-Assisted Sleep-Deprivation Prediction Framework for Spinal Cord Injury Patients," by Manocha et al., a multitier remote-monitoring system is proposed utilizing fog and cloud computing for data acquisition into the fog layer for a real-time analysis and subsequent deeper analysis in the cloud. The article focuses on algorithms specialized in the domain of sleep deprivation in spinal cord injury patients, but the work could be applicable to other conditions, patients, and disabilities. Fog computing enables responsiveness through swift detection and just-in-time intervention.

The proposed system and its algorithms, which are based on the weighted Bayesian belief network and artificial neural network–backpropagation, focus on learning the causes of sleep deprivation and utilizing that knowledge to detect, in real time, the events (from health and environment sensors—the Internet of Things) that that can update a sleep-deprivation-vulnerability index. Utilizing programmable thresholds, application-level events are raised, also in real time and mainly for caregivers. The article analyzes the proposed approach's responsiveness and prediction accuracy in comparison to other methods and algorithms. It does not report on actual deployments and interdisciplinary studies involving clinical experts, and perhaps this could be a necessary next step to validate the research in real settings.

DATA-DRIVEN APPROACHES CAN TAKE E-COACHING SYSTEMS TO ANOTHER LEVEL OF UTILITY BY AUTOMATING THE DOMAIN-KNOWLEDGE EXTRACTION AND EXECUTION.

I hope you find this theme issue informative and motivating and encourage prospective authors to consider submitting their work in the area of digital health care for future publication in *Computer*.