Editorial
Special Section on Featured Research From the 2nd International Conference on Human-Machine Systems

I. Introduction

THE 2nd IEEE International Conference on Human-Machine Systems (ICHMS 2021) addressed the fundamental issues of measurement and modeling of human-centered phenomena in engineered systems. Given the high caliber of many papers published through the conference, we made a call for papers for a Special Section of IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS (T-HMS).

The regular and rigorous T-HMS review process was applied to all manuscripts with the guest editors for the Special Section (Kaber, Nürnberger, Fortino, and Mendonça) acting as Associate Editors for the journal and all final decisions on manuscripts being made by the current Editor-in Chief (Trajkovic). There were 14 manuscripts that received decisions for various degrees of revision. Seven papers were ultimately accepted for publication in the current Special Section.

II. Summary of Papers

The papers appearing in the current Special Section are summarized as following. We begin with an article by Saenz et al. [A1]. This work contends that interactive robot applications are limited by a lack of safety engineering expertise to ensure human safety in working with cobots. The researchers developed web-based tools to support engineers and users in considering safety risks in cobot applications with utility for persons with different levels of safety knowledge. This article covers several examples of cobot applications and the benefits of applying the web-based toolkit.

We continue with the interactive robotics theme in [A2]. Samper-Escudero et al. focus on exoskeletons, specifically flexible forms that use fabrics and other soft materials to promote joint stability and work production. Unfortunately, body fit issues may occur with such technologies, leading to ineffectiveness in application. The researchers developed a new cable-driven, soft exoskeleton that provides greater anatomical adaptation through deformation of materials to limb states during motion. The suit was found to effectively transfer mobilizing forces to the arm for performing bimanual daily living tasks. The suit also reduced muscular loading and promoted postural endurance.

In [A3], Huang and Pitts contend that automated vehicle driver's visual and auditory attentional resources are usually occupied during driving. They explore the use of vibrotactile displays as interfaces to support takeover processes under off-nominal conditions. They investigated the effectiveness of such displays for cueing takeover requests in a driving simulator study with a Level 3 automated vehicle control scenario. Surrounding vehicle status and recommended maneuvers (lane changes and braking) were conveyed with seat back, seat pan, and a combo display. Results from the study were counter to expectation with the shortest takeover times occurring for a baseline condition with no meaningful pattern to the vibrotactile display. Furthermore, the baseline condition also resulted in the lowest maximum acceleration response (conservative action) relative to the displayed takeover request. These results suggested limited potential utility of vibrotactile displays for complementing visual and auditory display in automated vehicles to facilitate driver takeover actions.

The fourth paper in the Special Section shifts our focus to the use of physiological responses for gaining insights into human cognitive states. In [A4], Du et al. advocates the use of virtual reality (VR) systems for surgeon training in pre and postoperative conditions. Furthermore, this work identifies shortcomings in existing measure of surgeon skill and proposes an electroencephalogram (EEG) rhythm index for distinguishing between novice and expert surgeon skill levels. A VR-based simulation of a neurosurgery cutting task was presented to testers. The EEG rhythm index was compared with other conventional measures of surgeon skill assessment and revealed a 20% increase in novice versus expert surgeon classification accuracy. The authors subsequently applied machine learning (ML) methods (SVM and random forest) for the analysis of EEG energy topographic maps and found a 10% increase in surgeon skill classification relative to other conventional measures. The analyses also included common ML metrics with all demonstrating improvement in skill classification.

The next paper in the Special Section also focuses on physiological responses for gaining insights into human cognitive states. In [A5], Cai et al. examined the utility of combining EEG measures with the electro-oculogram (EOG) measures for classification of human multidimensional emotional states. The authors downselected EEG channels by identifying those containing the greatest degree of mutual emotion information.

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The authors also examined multiple time windows of EEG and EOG data as a basis for optimizing emotional state classification accuracy with little guidance from the existing literature. The classification approach included extracting multiple statistical features as well as entropy measures on the EEG responses as a basis for producing accurate and refined classification models. The authors found that 13 EEG features with EOG feature boosting could accurately predict the emotional states with data collected in 4, 5, 6, and 10 s time windows.

The sixth paper in the Special Section is topically unique relative to the other papers. In [A6], Scarcello et al. address the challenge of evaluating both objective and subjective indicators of environment thermal conditions to optimize control. The authors collected data on user perceptions of comfort based on interactions with a control interface, as well as indoor temperature data and energy consumption levels. A deep reinforcement learning (DRL) algorithm was applied to the dataset to learn and adapt to user comfort requirements. The DRL algorithm included various combinations of rewards in order for the system to optimally emphasize different outcome objectives.

The final paper in the Special Section is presented by Demir et al. [A7]. This work is complementary to other major themes of the conference papers. The authors investigated manipulations of multiple member teams for degrees of agility. Team configurations included human participants working with synthetic agents, randomly assigned coparticipants or experts. The teams were assigned to complete a remotely piloted aircraft systems operation. Results revealed the presence of an expert on teams to produce a tendency for exploration of new strategic alternatives to task performance (target negotiation), whereas when interacting with a synthetic agent or random partner, teams tend to explore established performance strategies that the authors interpreted as successful agility.

III. Conclusion

The 2nd ICHMS was a dense and full hybrid conference program over three days with core contributions organized in a single track format, including special sessions on *Interactive and Wearable Computing Systems*, *Collaborative Intelligent Systems and Applications,* and *Interactive Robotics*. The conference program yielded many high-quality research contributions. Authors were subsequently invited to expand these contributions into full journal papers with substantial additional results. The Special Section presents selected items from the conference having met the rigorous review criteria of T-HMS.

Acknowledgment

The guest editors for the Special Section (Kaber, Nürnberger, Fortino, Mendonça, and Guerrieri) would like to extend sincere thanks to the Editor-in-Chief, Dr. Ljiljana Trajkovic, for all her efforts in facilitating timely reviews of the manuscript submissions and making careful decisions on the manuscripts for publication. We are also grateful for all the reviewers who agreed to technically evaluate manuscript submissions and to ensure high-quality paper publications according to T-HMS standards.

David B. Kaber, *Guest Editor*
University of Florida
Gainesville, FL 32611 USA

Andreas Nürnberger, *Guest Editor*
Otto-von-Guericke University of Magdeburg
Magdeburg, Germany

Giancarlo Fortino, *Guest Editor*
Department of Informatics, Modeling, Electronics, and Systems
University of Calabria (Unical)
Calabria, Italy

David Mendonça, *Guest Editor*
The MITRE Corporation
Bedford, MA, USA

Antonio Guerrieri, *Guest Editor*
Department of Informatics, Modeling, Electronics, and Systems
University of Calabria (Unical)
Calabria, Italy

Appendix
Related Articles

[A1] J. Saenz et al., "An online toolkit for applications featuring collaborative robots across different domains," *IEEE Trans. Human-Mach. Syst.*, early access, Oct. 27, 2022, doi: 10.1109/THMS.2022.3213416.

[A2] J. L. Samper-Escudero, S. Coloma, M. A. Olivares-Mendez, M. Á. S.-U. González, and M. Ferre, "A compact and portable exoskeleton for shoulder and elbow assistance for workers and prospective use in space," *IEEE Trans. Human-Mach. Syst.*, early access, Jul. 11, 2022, doi: 10.1109/THMS.2022.3186874.

[A3] G. Huang and B. J. Pitts, "To inform or to instruct? An evaluation of meaningful vibrotactile patterns to support automated vehicle takeover performance," *IEEE Trans. Human-Mach. Syst.*, early access, Sep. 30, 2022, doi: 10.1109/THMS.2022.3205880.

[A4] J. Du, Y. Tai, F. Li, Z. Chen, X. Ren, and C. Li, "Using beta rhythm from EEG to assess physicians' operative skills in virtual surgical training," *IEEE Trans. Human-Mach. Syst.*, early access, Jan. 27, 2023, doi: 10.1109/THMS.2022.3228214.

[A5] H. Cai, X. Liu, R. Ni, S. Song, and A. Cangelosi, "Emotion recognition through combining EEG and EOG over relevant channels with optimal windowing," *IEEE Trans. Human-Mach. Syst.*, early access, May 26, 2023, doi: 10.1109/THMS.2023.3275626.

[A6] L. Scarcello, F. Cicirelli, A. Guerrieri, C. Mastroianni, G. Spezzano, and A. Vinci, "Pursuing energy saving and thermal comfort with a human-driven DRL approach," *IEEE Trans. Human-Mach. Syst.*, early access, Nov. 7, 2022, doi: 10.1109/THMS.2022.3216365.

[A7] M. Demir, M. Canan, and M. C. Cohen, "Modeling team interaction and decision-making in agile human–Machine teams: Quantum and dynamical systems perspective," *IEEE Trans. Human-Mach. Syst.*, early access, Oct. 27, 2021, doi: 10.1109/THMS.2023.3276744.

David B. Kaber (Fellow, IEEE) received the Ph.D. degree in industrial and systems enginering from Texas Tech University, Lubbock, TX, USA, in 1996.

He is currently the Dean's Leadership Professor and Chair of the Department of Industrial and Systems Engineering, University of Florida (UF), Gainesville, FL, USA. Prior to joining UF, he was a Distinguished Professor of industrial engineering with North Carolina State University, Raleigh, NC, USA, where he was the Director of Research for the Ergonomics Center of North Carolina. His research interests include human–systems engineering with a focus on human–automation interaction, including design and analysis for situation awareness in complex human in-the-loop systems, physical work systems, industrial safety systems, robotic systems, transportation systems, and healthcare.

Prof. Kaber was the previous Editor-in-Chief of the IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS. He is a Fellow of Institute of Industrial Engineers and Human Factors and Ergonomics Society. He is also a Certified Human Factors Professional (BCPE) and a Certified Safety Professional (BCSP).

Andreas Nürnberger (Senior Member, IEEE) received the degree in computer science and economics from the Technical University of Braunschweig, Braunschweig, Germany, in 1996, and the Ph.D. degree in computer science from the Otto-von-Guericke University of Magdeburg, Magdeburg, Germany, in 2001.

From 2001 to 2003, he was a Postdoctoral Fellow with the University of California, Berkeley, Berkeley, CA, USA, in a joint research project with BTexact Technologies, Ipswich, U.K., on adaptive soft computing and visualization techniques for information retrieval systems in the research group of Prof. L. A. Zadeh. Since 2003, he had been a Professor of information retrieval with the Otto von Guericke University Magdeburg (OVGU). Since 2007, he is a Tenured Professor for data and knowledge engineering. His research focusses on adaptivity in human machine systems, considering aspects such as user behavior analysis and intelligent user assistance.

Prof. Nürnberger is an Emmy Noether Fellow of the German Science Foundation.

Giancarlo Fortino (Fellow, IEEE) received the Ph.D. degree in systems and computer engineering from the University of Calabria (Unical), Arcavacata, Italy, in 2000.

He is currently a Full Professor of computer engineering with the Department of Informatics, Modeling, Electronics, and Systems, Unical. He is also a Guest Professor with the Wuhan University of Technology, Wuhan, China, a High-End Expert with the Huazhong University of Science and Technology, Wuhan, and a Senior Research Fellow with the Italian National Research Council ICAR Institute, Calabria, Italy.

He is the Director of the SPEME Laboratory, Unical, as well as the Co-Chair of joint laboratories on the IoT established between Unical and WUT and SMU Chinese universities, respectively. He is the Co-Founder and the CEO of SenSysCal S.r.l., a Unical spinoff focused on innovative IoT systems, and cofounder of BigTech S.r.l., a startup focused on AI-driven systems and Big Data. From 2002 to 2022, he was a Highly Cited Researcher by Clarivate in computer science. He has authored or coauthored more than 600 papers in international journals, conferences, and books. His research interests include wearable computing systems, Internet of Things (IoT), and cyber-security.

Dr. Fortino is also a Member of the IEEE SMCS BoG and Co-Chair of the SMCS TC on IWCD. He is the Chair of the IEEE SMCS Italian Chapter. He is the (Founding) Series Editor of IEEE Press Book Series on Human-Machine Systems and the Springer Internet of Things series, and he is AE of premier IEEE Transactions, such as IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING, IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS, IEEE INTERNET OF THINGS JOURNAL, IEEE SYSTEMS JOURNAL, IEEE TRANSACTIONS ON AFFECTIVE COMPUTING, INFORMATION FUSION, *Journal of Network and Computer Applications*, and *Engineering Applications of Artificial Intelligence*.

David Mendonça (Senior Member, IEEE) received the B.S. degree in English from the University of Massachusetts/Amherst, Amherst, MA, USA, in 1900, the M.S. degree in public policy and managment from Carnegie Mellon University, Pittsburgh, PA, USA, in 1994, and the Ph.D. degree in decision sciences and engineering systems from the Rensselaer Polytechnic Institute, Troy, NY, USA, in 2001.

He is currently a Senior Principal Decision Scientist with MITRE Corporation, Boston, MA, USA. He was a Professor with the Department of Industrial and Systems Engineering and the Department of Cognitive Science, Rensselaer Polytechnic Institute. From 2015 to 2017, he was a Program Director with the National Science Foundation, Alexandria, VA, USA. He was a Visiting Scholar with the University of Lisbon, Lisbon, Portugal, and the Delft University of Technology, Delft, The Netherlands.

Dr. Mendonça is currently a Member of the Board of Governors of the IEEE Systems, Man, and Cybernetics Society and IEEE Boston (Massachusetts) Section.

Antonio Guerrieri (Member, IEEE) received the Ph.D. degree in computer engineering from the University of Calabria (UNICAL), Arcavacata, Italy, in 2012.

He was a Researcher with the Telecom Italia WSN Lab, Berkeley, CA, USA, and with the Clarity Centre, University College Dublin (UCD), Dublin, Ireland. He is currently a Researcher with National Research Council of Italy, Institute for High-Performance Computing and Networking (ICAR-CNR), Quattromiglia, Italy. He has been involved in several research projects and is Cofounder of SenSysCal S.r.l., a UNICAL spinoff focused on innovative IoT systems. He is the coauthor of more than 120 papers in international journals, conferences, and books. His research interests include wireless sensor and actuator networks, building monitoring and control, smart environments, smart objects, and Internet of Things.

Dr. Guerrieri is an Editorial Board Member of several international journals. He is an Adjunct Professor with the Department DIMES, University of Calabria, and, since 2018, he has been the Italian ASN (Scientific National Habilitation) for Associate Professor.