Guest Editorial of the Special Section on Consumer Electronics With Artificial Intelligence

ARTIFICIAL Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) represent game changer technologies for Consumer Electronics (CE). In fact, they ever more represent the core of most CE products, and they are also changing the way these products are designed and engineered.

As a matter of example, on the one side, AI, ML and DL support the most advanced audio/video systems and their embedded signal processing functionalities, or enable the necessary information handling required in any smart environment powered by Internet of Thing (IoT) and edge computing paradigms. On the other hand, modern solutions for security and privacy, automotive and next-generation vehicles, or entertainment, among others, strongly rely on AI, ML and DL since from their early conception and, afterwards, in any development step. The healthcare field is another emerging and interesting application area for CE and the considered technologies. Indeed, population aging is increasing the burden of national health systems, and researchers all over the world are exploring solutions to boost the prevention, diagnosis, monitoring, treatment, and management of several pathologies. To this end, CE devices are among the most important candidates, since they are equipped with several sensors, allowing an unobtrusive monitoring during daily life. For example, smartwatches and smartphones may be used to monitor movement or other physiological variables, and these data may be further elaborated by custom AI, ML and DL applications or algorithms installed in CE devices in order to provide clinicians and patients with useful reports or even predict of possible dangerous situations.

Based on the above premises, this Special Section on *Consumer Electronics with Artificial Intelligence* focused on innovative methods that have successfully showed possible benefits associated with the use of AI, ML, and DL with CE systems throughout their entire lifecycle. The Special Section was organized by several representative of the Technical Committees of IEEE Consumer Technology Society in these areas (https://ctsoc.ieee.org/technical.html). Overall, 28 submissions were received spanning different CE domains, which were prescreened and reviewed by experts in the fields. At the end of the review process, seven papers were ultimately accepted.

In [A1], the authors present a detailed review and analysis of AI-based algorithms to optimize circuits routing and to solve some important routing problems, which are key for CE products. Currently, the design of circuit routing is performed manually by experts, with great cost in terms of human resources and time. Furthermore, the entire process is error prone and often lead to a not optimal solution. After drawing considerations on how to choose the right algorithm, they propose a hybrid approach using several AI technologies, trying to overcome the limitations found.

The authors of [A2] present a framework able to improve low-resolution ECG signals used for the cardiac arrhythmias (CAs) classification compared to traditional interpolation methods. This outcome can boost the accuracy of next-generation CE devices for health and well-being.

In [A3], the authors propose a data-driven, machine learning technique (named MIXO) to make odometry estimation more accurate and robust by combing outputs gathered by multiple cameras. The proposed technique is realized as a lightweight module that can be smoothly used with different visual odometry algorithms. Real-life data from autonomous vehicles were leveraged to assess the performance of the proposed technique. Improvements in terms of absolute rotational and translation error were observed compared to the use of single cameras, which could have an important impact on the performance of future autonomous vehicles.

[A4] presents a method controlled by a rate-distortion optimization (RDO) decision to add sparse coding as an alternate transform in videos. The method can be used in semi-extreme sparse coding (SESC) setups and leverages the semi-extreme dictionary training (SEDT) process. Moreover, the authors integrated their method into both the High Efficiency Video Coding (HEVC) test model HM-16.18 and the screen content coding (HEVCSCC) test model HM-16.18+SCM-8.7. Results show improvements in terms of Bjontegaard rate difference (BD-rate) when the devised method is compared to the standard, paving the way for next developments in multimedia CE devices.

In [A5], the authors consider the fact that customers of CE devices typically anticipate their perfect performance, which is not always the case. In particular, they focus on air conditioners, and observe that issues may arise if these devices lack an adequate refrigerant supply. In response to this, they present an innovative DL method that predicts the refrigerant quantity beforehand. Their approach, which is applicable to all kinds of air conditioners, leverages a novel algorithm named Domain Adaptive Transformer (DAT). The DAT calculates the refrigerant amount utilizing a transformer encoder and domain adversarial training. It streamlines the model parameters through a modified, lightweight Transformer encoder and incorporates a domain classifier to construct a universally applicable model, unrestricted to specific air conditioner types.

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To validate their proposition, the authors performed real-world experiments, collecting data related to the operational refrigerant amounts. Results demonstrated that predictive capabilities are superior and more accurate than the previous solutions, which led to the commercialization of air conditioners based on this technology. In principle, this approach could be applied to other CE products, limiting the need for expert intervention.

[A6] proposes a new model leveraging the story background for movie description, which is critical to extract complicated contexts from media content for, e.g., entity detection and image/video captioning tasks. Based on analyzing over a hundred movie screenplays, the authors designed neural networks derived from the structure of the movie screenplay. They also manually constructed datasets for training. With the proposed model, multimedia services, including those on CE devices, could provide rich information about movies to users.

Finally, the authors of [A7] focus on an extremely relevant topic for any electronic system, including CE ones, i.e., Non-Intrusive Intrusive Load Monitoring (NILM). Specifically, they present a DL-model designed to capture complex patterns in long sequences of energy data in the industrial domain. The results obtained on publicly available datasets indicate that the proposed model achieves better disaggregation accuracy compared to other state-of-the-art methods.

These papers demonstrate how vibrant is the research regarding AI, ML and DL in the context of CE, and we believe they will help to make readers aware of areas which are worth further investigation. We thank the authors and the reviewers for their contribution to this Special Section. We are grateful to the Editor-in-Chief for having allowed us to serve as Guest Editors and for his guidance throughout the whole process.

Appendix: Related Articles

[A1] Y. Goh, D. Jung, G. Hwang, and J.-M. Chung, "Consumer electronics product manufacturing time reduction and optimization using AI-based PCB and VLSI circuit designing," *IEEE Trans. Consum. Electron.*, early access, Jan. 27, 2023, doi: 10.1109/TCE.2023.3240249.

[A2] T.-M. Chen et al., "SRECG: ECG signal super-resolution framework for portable/wearable devices in cardiac arrhythmias classification," *IEEE Trans. Consum. Electron.*, early access, Jan. 17, 2023, doi: 10.1109/TCE.2023.3237715.

[A3] L. Morra, A. Biondo, N. Poerio, and F. Lamberti, "MIXO: Mixture of experts-based visual odometry for multicamera autonomous systems," *IEEE Trans. Consum. Electron.*, early access, Jan. 20, 2023, doi: 10.1109/TCE.2023.3238655.

[A4] M. G. Schimpf, N. Ling, and Y. Liu, "Compressing of medium-to low-rate transform residuals with semi-extreme sparse coding as an alternate transform in video," *IEEE Trans. Consum. Electron.*, early access, Apr. 18, 2023, doi: 10.1109/TCE.2023.3268061.

[A5] K. Hwang, J. Lee, A. Jalali, and M. Lee, "Predicting the refrigerant amounts across air conditioners with a domain adaptive lightweight transformer," *IEEE Trans. Consum. Electron.*, early access, May 25, 2023, doi: 10.1109/TCE.2023.3278283.

[A6] J.-W. Son, A. Lee, S.-J. Kim, and N. K. Lee, "Movie description model for media retrieval services," *IEEE Trans. Consum. Electron.*, early access, May 22, 2023, doi: 10.1109/TCE.2023.3278704.

[A7] G. F. Angelis et al., "Energformer: A new transformer model for energy disaggregation," *IEEE Trans. Consum. Electron.*, early access, Jan. 18, 2023, doi: 10.1109/TCE.2023.3237862.

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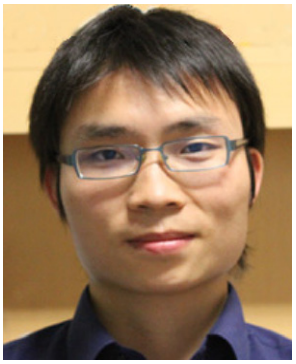

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