

# AI for Consumer Electronics - Has Come a Long Way but has a Long Way to Go

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I welcome the readers to the third issue of year 2020, the May 2020 issue, of the IEEE Consumer Electronics Magazine (MCE). The current issue is dedicated to Intelligent Consumer Electronics. The presents many article covering various AI technologies which can be applied to Consumer Electronics.

It reminds me that IEEE MCE has covered intelligent electronics, smart electronics kind articles in some of its past issues. In addition, I guest edited a special issue on smart electronics in IEEE Potentials. In Jan 2019 issue of IEEE Potentials, I defined smart electronics as the class C E systems that are envisioned to be Energy-Smart, Security-Smart, and Response-Smart. I advocated that these 3 key aspects and design trade-offs among them is the crucial for the next generation CE. In fact, in my booked titled “Nanoelectronic Mixed-Signal Systems” published in 2015, I presented a broad perspective for design trade-offs of CE systems under the theme “Design of Excellence (DFX)” or ‘Design of X (DFX)’. In DFX, “X” refers to a subset of characteristics/figures-of-merit (FoMs), such as energy, speed, security, and safety, making it Design for Energy, Design for Speed, or Design for Security. Design for Security is essentially the Security and Privacy by Design (SPbD) which was the theme of March 2020 issue of IEEE MCE. We dedicated cover of April 2017 issue of IEEE MCE to deep learning aka deep neural network (DNN). In September 2019 issue of IEEE MCE, we addressed edge-AI, in which AI at the edge devices (close to the user) was highlighted. The current issue (May 2020) of IEEE MCE further advances these efforts on AI. AI is the superset covering machine learning (ML), expert system, and computational intelligence. A subset of AI is machine learning (ML) and a subset of ML is deep learning (DL). Computational intelligence includes artificial neural network (ANN), and a subset of which is deep neural network (DNN).

AI is integrated in consumer electronics (which is characterized by mass production and direct consumed by individual users) in various forms. At a system or Cyber-Physical System (CPS) level, AI is part of various CPS like smart cars (part of transportation CPS or T-CPS), smart healthcare (healthcare CPS or H-CPS), smart energy (energy CPS or E-CPS), smart grid (also part of E-CPS). At the edge devices like edge data centers (EDCs) or microcenters can have AI capabilities. The end devices like, Amazon Alexa and Google Assistant, are examples of intelligent virtual assistant (IVA) or intelligent personal assistant (IPA). Similarly, CE devices like TV and speakers have some form of built-in AI. At the sensor level AI integration is difficult due to lack of computational capability, but with light-weight AI is not far-fetched.

AI is highly data dependent. AI/ML has many issues/challenges including: (1) high energy requirements, (2) high computational resource requirements, (3) large amount of data requirements, (4) underfitting/overfitting issue, (5) class imbalance issue, (6) fake data issue, and (7) AI security. Both DNN modeling/training/learning and DNN model execution need energy consumption. DNN training needs multicore processors and batch processing as DNN considers many training parameters, such as the size, the learning rate, and initial weights. Running or execution of DNN models also need

computational resources (hardware) and energy consumption. These are handled by cloud-AI and edge-AI with different trade-offs. Thus, different hardware accelerators are being designed targeting both edge-AI and cloud-AI. For example, Google TPU, Nvidia DGX, and Xilinx Virtex, are targeted for cloud-AI. Similarly, edge-TPU, Nvidia Drive, Xilinx Zynq, are targeted for edge-AI. Various forms of hardware including, Graphics Processing Unit (GPU), Field-Programmable Gate Array (FPGA), Application Specific Integrated Circuits (ASIC), Field-Programmable System-On-Chip (FPGSoC), and neuromorphic, are designed for efficient AI processing. AI security is critical in systems like smart car. The AI research and development for hardware, software, training algorithms, are on-going, and will continue.

## **FEATURE ARTICLES**

*Preserving Data Privacy via Federated Learning: Challenges and Solutions:* This article discusses privacy challenges and potential solutions in the distributed learning environment.

*Adaptive Temporal Frame Interpolation Algorithm for Frame Rate Up-Conversion in Digital Video:* This article presents an efficient and adaptive temporal frame interpolation algorithm for frame-rate up-conversion of digital video.

*Blacklist vs. Whitelist-based Ransomware Solutions:* This article presents a whitelist-based method to prevent ransomware which is a global cybersecurity threat.

## **COLUMNS**

*Bits Vs. Electrons -- Rewiring my House ... and the World:* This article presents use of software and hardware to create new opportunities in the available infrastructure for optimal usage.

*The Art of Storage -- How Much Memory Do Cell Phones Need:* This article presents a perspective of optimal requirement of nonvolatile storage in smart phones with from a NAND flash perspective.

*Standards Corner -- Key Technologies Enabling Competitive Advantage:* This article presents parameters needed to characterize CE technologies.

*Professional Development Corner -- AI - A Game Changer, or A Solution Looking for a Problem:* This article presents critical thought on AI technology.

## **CE SOCIOECONOMIC IMPACTS**

*Social Robots in Special Education -- Creating Dynamic Interactions for Optimal Experience:* This article presents the potential positive effects of multi-robot assisted therapies.

## **SPECIAL SECTION**

A special section titled “Artificial Intelligence in Consumer Electronics” presents selected articles to cover the scope. I would like to thank the guest editors Lia Morra, Fabrizio Lamberti, and Saraju P. Mohanty for all their hard work for this strong special section which will be an excellent reading for CE community as well as other researchers around the globe.

Another special section titled “VLSI for Next Generation CE” presents a different set of articles. I would like to thank the guest editors, Nikolaos Voros, Michael Huebner, Mircea Stan, and Georgios Keramidas for their strong support for this special section.

## **LOOKING FORWARD**

I hope this issue dedicated to intelligent consume electronics becomes a good reading for a wider set of CE community to advance their knowledge. CE magazine will continue the trend of covering more themes for our enthusiastic readers in future issues on the latest hot topics with the active support of the editorial board, active reviewers, and authors, around the globe.

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