Healthcare Cyber-Physical System (H-CPS) is More Important than Before

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I welcome the readers to the 5th issue of year 2020, the September 2020 issue, of the IEEE Consumer Electronics Magazine (MCE). We are in the middle of the global impact of Corona Virus Disease 2019 (COVID-19) for last several months. The importance of healthcare system is self-evident along with the other essentials, such as electric power system, water supply system, and communication system which help to overcome the difficulties. In the July 2020 issue of MCE, we covered transportation Cyber-Physical System (T-CPS). I am pleased that the current issue is dedicated to Healthcare Cyber-Physical System (H-CPS). The issue presents many articles covering various key aspects of H-CPS. Other important CPS, such as energy CPS (E-CPS) making smart energy/grid and agriculture CPS (A-CPS) making smart agriculture also deserve coverage.

STATE OF THE ART OF THE H-CPS

The Internet-of-Things (IoT) provides 3 Is (Instrumentation, Interconnections, and Intelligence) to Cyber-Physical Systems (CPS) which then makes smart components for smart cities. The 3Cs of CPS is considered as Communicate, Compute, and Control. The 3Cs of IoT are Connect, Compute, and Communicate. Thus, the CPS and IoT terminology are being used interchangeably in the literature, but these are different level of granularity in the system of systems model of smart cities. The healthcare CPS (H-CPS) is built by Internet-of-Medical-Things (IoMT) leading the smart healthcare.

Smart healthcare did not happen from traditional healthcare straightaway. It has gradually evolved from traditional healthcare. In traditional healthcare individual patient has to deal with various entities and stake holders, such as primary care physician (PCP), laboratories, and specialists, who may or may not communicate to give optimal healthcare to the patient. Traditional healthcare is being increased overwhelmed with increased population growth, thus leading to many undesirable consequences including prescription mistakes, suboptimal care, and even infection of the caregiver, physicians, and technicians. In remote places on the planet, receiving adequate healthcare can still be a difficult expectation. The traditional healthcare consequently evolved to telemedicine, connected health (cHealth), electronic health (eHealth), mobile health (mHealth), and smart health (sHealth).

Overall smart healthcare is built with the help of healthcare Cyber-Physical System (H-CPS) that integrates IoMT, electronic health record (EHR) which is essentially ehealth, and artificial intelligence (AI) obtained from sensor data as well as EHR. H-CPS that makes smart healthcare is a combination of various entities including traditional healthcare, biosensors, wearable medical device (WMD), implantable medical device (IMD), information and communication technology (ICT), artificial intelligence (AI), and communications mechanisms like body area network (BAN). Often implantable and wearable medical devices (IWMDs) are referred together as one groups of devices in H-CPS or IoMT. Healthcare CPS (H-CPS) can be architecture can be modeled with 4-layers as: body-area network (BAN), user interface, AI layer, remote-access layer. Traditional healthcare is being

overwhelmed due to the growth of the population and the demand for quality care. Thus, with limited resources and ever-increasing demands, healthcare needs to be intelligent, efficient, and sustainable which H-CPS based smart healthcare can provide.

The 7Ps of smart healthcare are personalized, participatory, perpetual, persuasive, programmable, predictive, and preventive. In the smart healthcare, the users/patients can participate in their healthcare and get personalized care from physicians. The requirements and challenges of H-CPS based smart healthcare include, low power sensors/communication/devices, higher efficiency sensors/devices, small form factor sensors/devices, inter-operability, continuous connectivity, high speed, data and device security, data/personal privacy, and safety. Research and development from academia and industry and underway to address many of these requirements and challenges. MCE has been covering these in many articles from time to time.

FEATURE ARTICLES

A Low-cost Wireless Multi-channel Surface EMG Acquisition System: This article presents a low-cost electromyogram (EMG) acquisition system for high-sampling and multi-channel measurement which can be integrated in IoMT.

Wearable Smart Health Advisors: An IMU-enabled Posture Monitor: This article presents a health advisor for long time improper sitting posture based on Inertial Measurement Units (IMUs).

Segmentation Masks for the mini- Mammographic Image Analysis Society (MIAS) Database: This article presents accurate lightweight methods for automatic alignment of scanned mammograms that can be used in H-CPS.

A Review of Machine Learning Based Solutions for Real Time Stress Monitoring: This article provides an overview of stress monitoring approaches which use machine learning models and IoMT-edge computing paradigm.

An Overview of Blood Pressure Measurement in Telemonitoring Context: This article presents a comprehensive study of blood pressure measurement devices from the IoMT perspective.

COLUMNS

Bits Vs. Electrons -- Beyond the Interweb: This article presents thoughts on man-machine symposium based on videoconferencing experiences during stay-at-home due to COVID-19 pandemic.

The Art of Storage -- Gaming Consoles Go Solid State: This article analyzes the use of solid-state nonvolatile storage in gaming consoles.

Future Directions -- EasyBand: A Wearable for Safety-Aware Mobility during Pandemic Outbreak: This article presents a low-cost wearable which can be supplied to citizen for effective multilayer contact tracing during pandemic outbreak.

Standards -- IEEE SA Industry Connections 3D Body Processing Working Group and IEEE P3141 Standard for 3D Body Processing - Part 1: This article presents activities of 3D body processing standard group of the IEEE.

SOCIOECONOMIC IMPACTS

COVID-19 Contact Trace App Deployments: Learnings from Australia and Singapore: This article analyzes the effectiveness of COVID-19 contact tracing apps from real-life deployments in Australia and Singapore.

Getting Behind COVID-19 Contact Trace Apps: The Google-Apple Partnership: This article discusses disadvantages of various COVID-19 apps and possibilities of private-government partnership to solve the underneath problem.

SPECIAL SECTION

This Special Section on *Machine Learning for End Consumers* presents a selected set of articles to cover the scope. I would like to thank the guest editors Alvis Fong and Muhammad Usman 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.

LOOKING FORWARD

I hope that the current issue dedicated to Healthcare Cyber-Physical Systems (H-CPS) 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 strong active support of the editorial board, reviewers, and authors, around the globe.

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