AIoT FOR DIGITAL TRANSFORMATION OF HEALTHCARE

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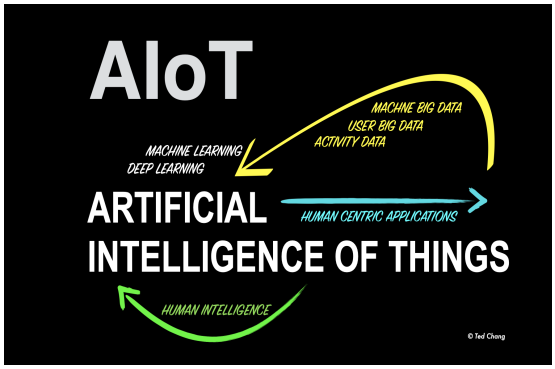

Fig. 1. Future smart medicine on prediction, prevention, precision and personalization

Introduction

The world is facing critical challenges from COVID-19 pandemics. Social distancing is changing our lifestyle. Working from home, on-line education is becoming the new normal of our society. Both medical and healthcare need to be transformed in order to provision precision and personalized medicine over the cloud under drastic medical resource shortage due to pandemics. In this paper, a novel end-to-end AIoT cloud platform of both Artificial Intelligence (AI) and Internet of Things (IoT) is proposed to address the critical healthcare transformation problem under pandemics. The value of traditional IoT is actually on

the “Internet” of big data generated by the “things”, while the value of the data is the intelligence created through machine learning or deep learning. Such AI is the core value of AIoT for the healthcare of the future.

Smart Medicine for the Future

To achieve the goal of future smart medicine on prediction, prevention, precision and personalization as in Fig. 1, the big data of the electrical medical record (EMR) in the hospitals, the vital sign data from new wearable medical devices or Internet of Medical Things (IoMT) [1] and even genetics of the patients need to be well managed and analyzed to optimize the patient care. Thanks to the recent development of cloud computing, secure storage and scalable computing for such big data analytics is no longer insurmountable. Moreover, the progress of machine learning and deep learning makes medicine and healthcare even smarter through AI [2]. The ultra-high bandwidth and low latency of 5G connectivity make the edge AI for time critical medical applications become possible. To sum up, an end-to-end AIoT platform which comprises AI, Big Data, Cloud Computing, Devices and Edge Computing would be essential for future smart medicine (see Fig. 2).

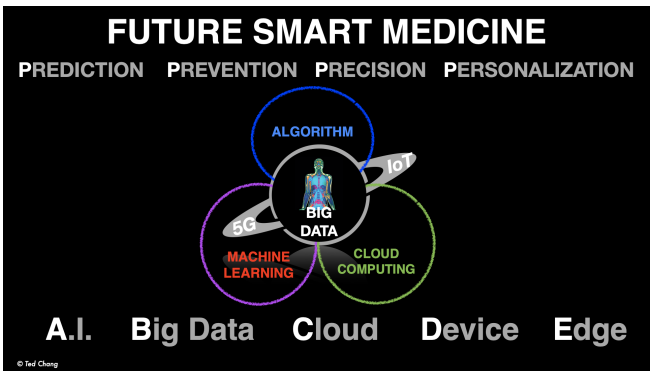

Fig. 2. ABCDE: AI, Big Data, Cloud, Device and Edge

Quanta AIoT Platform

Quanta AIoT platform illustrated in Fig. 3 is developed by the collaboration among MIT Computer Science and Artificial Intelligence Laboratory (CSAIL), Quanta-NYCU Joint AI Center and Quanta Computer. Quanta AIOT Platform is architected for smart applications and services in different domains like Healthcare, Education, Smart City, Agriculture and transportation, depending on the users, use cases and data used [3].

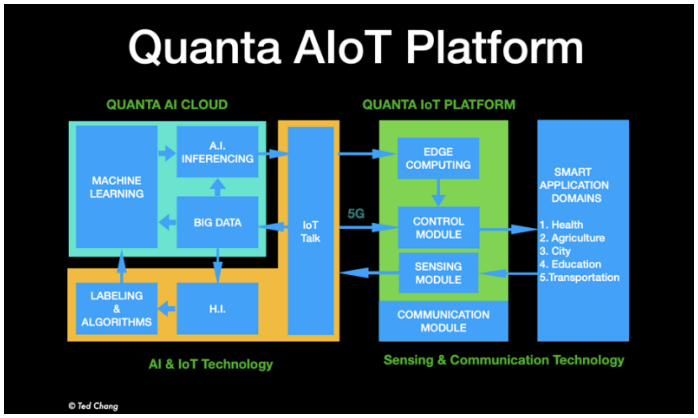

Fig. 3. Quanta AIoT platform

Quanta AIoT Platform includes the Quanta IoT Platform, IoTtalk and Quanta AI Cloud. The Quanta IoT Platform consists of three modules. The Sensing Module connects to different sensors, like ECG, SPO2, blood pressure and thermometer for healthcare. The Control Module connects to actuators to provide feedback control based on the data sensed and the algorithm installed. The Communication Module provides different connectivity and act as a gateway for wireless connected sensors. These modules can connect to AI Medical Cloud either directly or indirectly through IoTtalk. IoTtalk is a system that interfaces both Quanta AI Cloud and IoT Platform for remote IoT monitoring, management, control, calibration and data handling [4][5]. Quanta AI Cloud privates cloud that integrates both advanced server, storage and network switches from

Quanta Computer for Infrastructure as a Service(IaaS) and an optimized platform as a service(PaaS) for the whole pipeline of AI processing, which includes tools for big data analytics, governance, administration, data preparation, labeling, neural network model selection, training, Machine Learning, validation and inferencing.

Quanta AI cloud also supports AI deployment through OTA to IoT for Edge AI computing as illustrated in Fig. 4 for continuous optimization and self-learning.

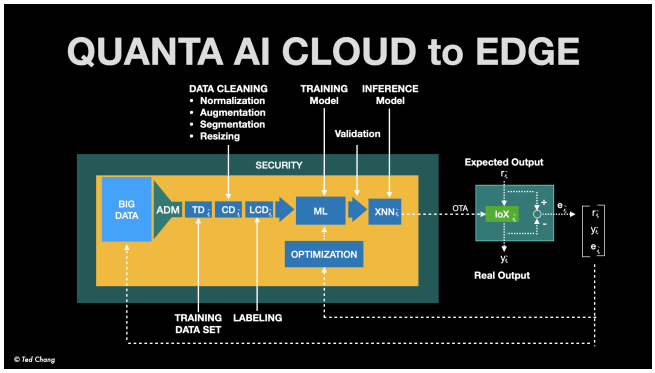

Fig. 4. Quanta AI: from cloud to edge

Quanta AI Medicine Cloud

"QOCA®aim" illustrated in Fig. 5 is a Quanta AI Cloud further tailored for physicians and smart medicine applications. QOCA® aim is designed not only for data engineers but also for data scientists like those physicians with strong domain know-how and with less coding skills. The IaaS is optimized for medical data with PaaS optimized for both machine learning and Digital Twin simulation. The resulting algorithms and neural network models shall be packaged as software applications in the SaaS layer.

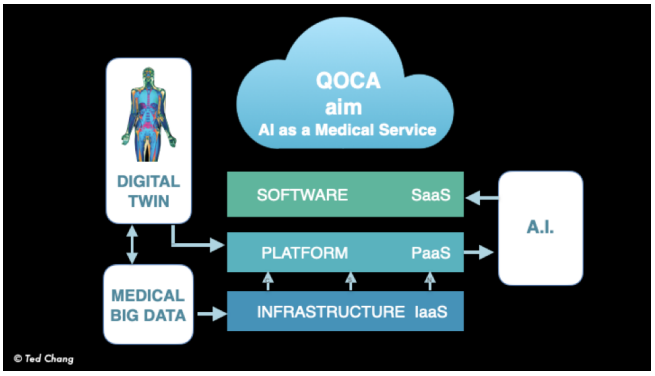

Fig. 5. QOCA® aim: the abstract view

Fig. 6 illustrates a more comprehensive structure of QOCA® aim. The raw medical data contains diversified data of signal, text, images, audio, video, to genetics sequences from Hospital Information System (HIS), EMR, Radiological Information System (RIS), Picture Archiving and Communication System (PACS), Laboratory Information System (LIS) and Pharmacy Information System (PIS) for precision medicine research. Additional work in processing data generated from the machine learning includes labeling data and neural network models shall also be archived as meta data of the projects. These meta data are extremely important to increase the speed and depth of collaborations among researchers using the same data set for AI.

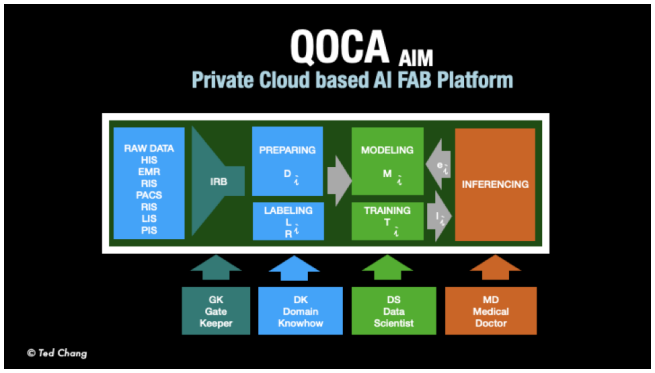

Fig. 6. QOCA® aim: the architecture

CASE I: Quanta Smart Telemedicine

Modern healthcare has paid more attention and resources to telemedicine development. Due to COVID-19, zero-touch healthcare between doctors and patients significantly promoted telemedicine solution [6].

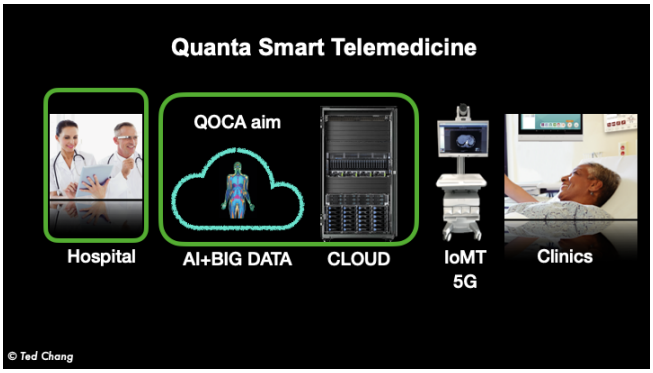

Fig. 7. Smart Telemedicine

Quanta Smart Telemedicine solution, QOCA® atm, is a cloud-based collaboration platform designed for hospitals with different professions to collaborate over the "Virtual Clinic" created on demand over the cloud as depicted in Fig. 7. The virtual clinic room offers real-time visual communications, shared whiteboard and electronic medical record and DICOM images sharing for joint diagnosis and AI inferencing from QOCA® aim. In addition, with the medical inspection systems, like portable X-Ray, mobile ultrasonic and endoscopes, connected as IoMT to the smart telemedicine platform, the system offers remote guided inspection for more precision medicine service. QOCA® atm has been successfully adopted in the major hospitals like Taiwan University Hospital (NTUH) Yunlin branch and Hsin-chu branch to support better quality of medical service in rural areas. The Hsin-Chu case has been published as a successful digital health story in the website of Supporting Emerging Technology Taskforce for APEC Business Advisory Council (ABAC). For more information to see the system at work, please refer to the following website, https://emerging-tech.site/smarter-telemedicine-in-rural-areas-ntuh-hsin-chu-branch/

CASE II : Quanta Smart Telehealth

Quanta Smart Telehealth, QOCA® acc, as illustrated in Fig. 8, aims at leveraging AIoT to tackle the problem of discharged patients, elderly care and chronic disease patients at home or care center. Due to the outbreak of COVID-19 pandemics, the system is further enhanced as a special version QOCA® aqc (Fig. 9) to cover the needs of quarantined patients in the isolated wards or quarantine hospitals. The major difference between CASE I and II are the scale of the patients to be monitored over the cloud and the medical devices used. For QOCA® acc there will be a web-based Case Management Portal(CMP) to support the call center so that one case manager could manage to watch over hundreds of patients at the same time. Moreover, AI and algorithms will be applied to monitor the changes of vital signs measured over time for early warning. The system supports multipoint video conferencing for social care. The connected medical devices designed will be of lower power, light weight with smaller form factor for home users. for more detail of these wearable medical devices, please refer to http://www.qoca.net/. Different versions of QOCA® acc have been widely applied and pilot-run for elderly care in Baycrest Canada, Post-Discharge Cardiac Care and High-Risk Patient Care in NTUH Yunlin

branch, and quarantine patient care in Taipei Veterans General Hospital (TVGH) among many others. Some of the successful cases could be found in the ABAC supporting emergent technology website: https://emerging-tech.site/cases/ .

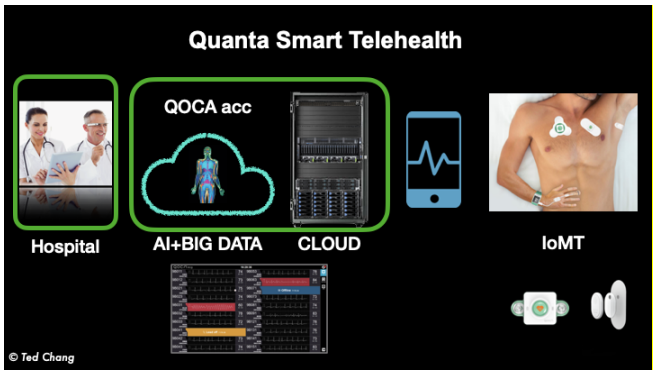

Fig. 8. Quanta Smart Telehealth

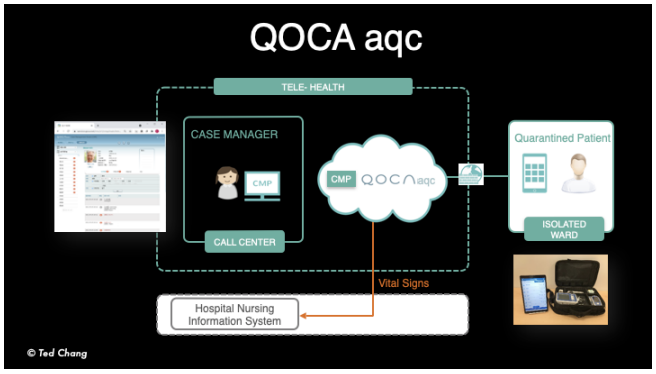

Fig. 9. QOCA® aqc

CASE III : AMBtalk: Quanta Smart Ambulance

An important function of smart ambulance is quick and primary diagnosis at point-of-care. For example, Acute Coronary Syndrome (ACS) emergency events require immediate chest pain identification in the ambulance. Fig. 10 illustrates Quanta Smart Ambulance for accurate and early ACS identification in an ambulance that provides real-time connection to hospital resources. The key to success is the development of the Quanta ecg1201 and AllCheck® [7] IoT devices, which quickly and accurately provide cardiovascular parameter values for early ACS identification. Quanta ecg1201 is a 12-leads portable ECG device with special electrodes patch design to assist non-professionals can place the electrodes at the right positions for signal data taking. The interactions between the diagnosis IoT devices, the emergency medical service center (EMS), the ambulance personnel and the hospital are achieved through the AMBTalk server in the cloud network. The server includes a video server that provides video streaming to be analyzed by QOCA® aim. The signals of the IoT devices in the ambulance are sent to the IoTtalk server. The IoTtalk server then forwards these signals to QOCA® aim for analysis. The resulting decisions are sent to the EMS for action. Right now, AMBtalk is being exercised in Department of Emergency and Critical Care Medicine of Changhua Christian Hospital Taiwan.

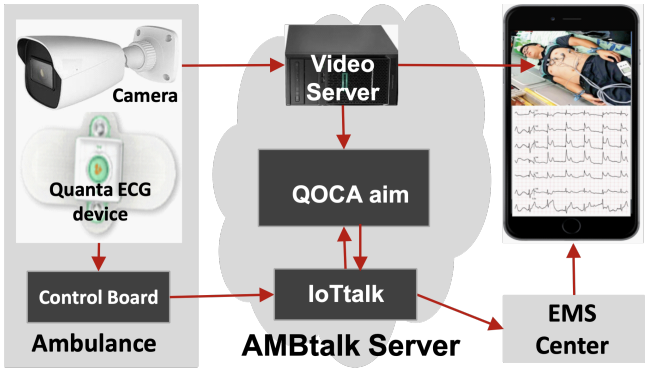

Fig. 10. Smart Ambulance

Conclusions

Quanta QOCA® is a novel end-to-end AIoT cloud platform for both AI and IoT, which addresses the critical healthcare

transformation problems under pandemics. QOCA® fully utilizes the data measured by IoT, conducts data preprocessing in Quanta cloud, and then provides valuable healthcare analytics through machine learning or deep learning. We demonstrated three sustainable cases of Quanta healthcare solutions: smart telemedicine, smart telehealth and smart ambulance. These Quanta show cases indicate the AI core value of AIoT for the digital transformation of healthcare and precision medicine for the future.

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