Mobile cloud-assisted paradigms for management of multimedia big data in healthcare systems: Research challenges and opportunities

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Editorial

Mobile Cloud-Assisted Paradigms for Management of Multimedia Big Data in Healthcare Systems: Research Challenges and Opportunities

Medical field is rapidly changing due to the advancements in high quality healthcare services at low-cost. Government along with public and private sector is looking for innovative solutions to enhance the life-style of common person by providing better medical facilities with equal quality to both rural and urban population. The integration of smart devices and cloud services can be a major player in revolutionizing the healthcare sector. Cloud with big storage and computational capabilities, offers improve services for patients, with enhanced access to relevant information, improved operational efficiency, and reduced treatment costs. Currently, access to cloud computing using resource-constrained devices such as smart phones and tablets is increasing. However, due to limited capabilities of smart devices, it is inherently difficult to cope with all the issues of multimedia big data in healthcare (Lv, Chirivella et al. 2016). Therefore, it is important to explore mobile-cloud computational paradigms for analysis of medical data, which may result in cutting-edge multimedia and information healthcare services. Mobile-cloud computing (MCC) offers following major advantages in healthcare applications, which requires further exploration from researchers:

- **Collaborative Healthcare Services:** It is observed that in various scenarios some specific information is required at different localities by health services providers, simultaneously. Cooperation of smart devices and cloud provides a collaborative information processing and sharing framework. This information can be synchronized and shared in real time, making its access ubiquitous.
- **Cloud Mobility:** Cloud facilitates the fast upgradation of its features less expensively without any service interruption. It also helps to coordinate patient's electronic health record with his physician, specialist and other concerned medical personals. Thus with mobility feature, cloud computing and information coordination, doctors can easily access, and analyze patients information and make informed decision about a healthy lifestyle.
- **Security and Privacy:** Almost all cloud service providers comply with the privacy standards for example Health Insurance Portability and Accountability Act etc. Moreover, there are many other emerging standards which are stricter and consider all the security and privacy concerns of users. Thus, mobile-cloud based services are getting users' trust, which resulted in an increased adaptability and social acceptance from customers.

- **Adaptive Offloading.** Adaptive offloading of data and computational tasks from mobile to cloud, helps reduce burden on smartphone, reducing resources utilization of mobile devices and increasing the access to more sophisticated tools for efficient analysis of medical multimedia data (e.g. tumor segmentation and detection from MRI, endoscopy video analysis, and content based retrieval of relevant information)(Wang, Li et al. 2016, Sajjad, Khan et al. 2017).

Healthcare services can be categorized into four groups as per the guidelines of European Union study on dynamic health systems and new technologies, as listed in table I. In this editorial, we present summary of each of the seven accepted papers. Different paradigms of mobile-cloud computing are discussed by considering the four basic categories of dynamic health systems as defined by the European Union. We then conclude the special issue with a brief discussion on future challenges and opportunities in the perspective of mobile-cloud computing, highlighting the deprived areas in medical field such as mobile-cloud based medical imaging analytics and real-time remote patient monitoring etc. Accepted papers related to the education and training research topic are discussed in Section I. In Section II, the work related to disease management is discussed. Accepted and few state-of the art papers related to mobile-cloud data security with information hiding are described in Section III. Research work related to management, administration and policy making for ICT-based healthcare services is discussed in Section IV. In Section V, the summary is given along with a brief discussion on opportunities and challenges faced by the MCC in medical field.

Table I: Categorization of ICT applications in healthcare

	Applications Categories	**Details**
1	Education, research and training	Services which provide knowledge infrastructure, medical training, and education, as well as practical clinical trials.
2	Disease management	Disease detection, classification, prevention, diagnosis, rehabilitation, therapy and telemedicine.
3	Security and confidentiality	Development of security and privacy protocols to make healthcare services acceptable for users.
4	Management, administration and logistics	Policy making, standardizing patient record management, and supply of health related goods and services.

I. EDUCATION AND TRAINING

Mobile-cloud based applications can play a vital role in medical education as the adaptability of technology has increased for students training (Khoumbati 2009). It is noted that medical students have been using smart devices for various educational purposes such as recording their experiences/laboratory trials, accessing information for medical conditions and drug treatment, performing different statistical and their calculations. Mobile-cloud assisted medical services facilitate healthcare institution to practice and train laboratory workers, assuring a high education and work quality.

In this section two papers are accepted. Karambakhsh et al. developed a augmented reality assisted tool for learning the anatomy of human body (Karambakhsh, Kamel et al. 2018). This tool is using the deep convolutional neural networks and can be operated with gesture interaction, which makes it easy to use and helps learning the anatomy. It offers various interesting features which can replicate and improve conventional teaching method adopted for anatomy learning. Moreover, students can use it with audio lecture to better understand the medical concept. It provides features like Pan, Pinch, Fist, and Tap gestures for interaction and visualizing the different anatomy parts from different angles. Apart from gesture recognition, this system has the feature of 3D reconstruction of specimens. It is using death map along with RGB camera streams. Similarly, Nabi Sultan explored conventional and emerging wearable sensors to explore their current and potential applications in medical education (Sultan 2015). The challenges that are likely to face this technology are also discussed in this paper. Thus, there is lot of scope and much work needs to be done to facilitate quality learning and training across the globe, providing equal health services. Second accepted paper is presented by Sodhro et al. which proposes a framework for real-time enhanced video streaming over 5G network. This framework aims to optimize medical quality of service (m-QoS) in mobile-edge computing driven heal care services. It takes into account different network parameters: standard deviation, delay, peak-to-mean ratio, and jitter (Sodhro, Luo et al. 2018). Authors have compared the performance of the presented model with various state-of-the-art methods. This kind of contribution in increasing the quality of video streams can play a significant role in optimizing QoS in various mobile-cloud based healthcare application such as tele-surgery, remote patient monitoring etc.

II. DISEASE MANAGEMENT

The integration of smart devices and cloud services has resulted in an increased patient care either locally or remotely e.g. remote consultations with medical specialists, tele-surgeries, patient portal messaging, and remote patient monitoring etc. In this section, two papers were accepted as explained in subsequent sections.

1. Telehealth And Mobile Healthcare (mHealthcare)

The purpose of mhealthcare is to provide enhanced access to the required information in a timely manner. It offers a variety of distributed services to mobile healthcare users such as secure access to patient health record, remote medical data analysis and diagnosis services. MCC in healthcare applications plays a significant in reducing the limits of traditional medical applications (e.g., security, small storage, and medical errors). The first paper accepted in this section is “An m-health application for cerebral stroke detection and monitoring using cloud services” by García et al. (García, Tomás et al. 2018). This is a mobile-assisted app to detect cerebral stroke by employing the cloud services to store and analyze data. This framework makes decision on the basis of three symptoms: user smile detection, voice analysis to check whether a given sentence is repeated correctly and, determine if the user arms can be raised. In-case of cerebral stroke detection, concerned person is notified via SMS immediately. Medical emergencies are also contacted to give treatment at earliest. All this information is also stored on cloud for an overall analysis of this diseases across the region. Karaca et al. developed a stroke detection system (Karaca, Moonis et al. 2018). This MCC driven method uses Virtual Dedicated Server (VDS) as 4 VCPU and 8 GB RAM. This method is based on Android for stroke patients with cardioembolic (689) and cryptogenic (528) subtypes. Artificial Neural Network (ANN) is employed for efficient classification of two stroke subtypes while server application is used for saving the data from the patients. According to authors, presented model ensures service availability, security, and scalability for stroke patients.

2. Anomaly Detection

Habib et al. conducted a detailed survey to explore and analyze existing methods to detect anomaly from big data at real-time (Habeeb, Nasaruddin et al. 2018). This survey provides comprehensive insight about the state-of-the-art real-time big data technologies, applications and existing anomaly detection techniques. Furthermore, this also presents the details of the comparative analysis and the relationship of three different domains, which are anomaly detection, machine learning algorithms, and real-time big data processing. It highlights the major challenges and opportunities in the management of big data for anomalies detection at real-time.

III. SECURITY AND CONFIDENTIALITY

In this category, two papers are accepted. Rahman et al. (Rahman, Khalil et al. 2018) presented a framework for DNA data hiding is presented for data authentication in mobile-based medical systems. Its main objective is ownership management of DNA sequence which is based on blind and lossless DNA steganography algorithm. It embeds the device identification information in DNA sequence which works as a key for user to authenticate the device. Secret message is extracted from DNA sequence for verification. Secret message extraction process is the opposite of embedding procedure. Once secret message is embedded in DNA sequences, it alters the pattern, therefore, a filtering is performed before using the DNA sequence. This filtration is the reconstruction of original DNA sequence data. Both secret message generation and DNA reconstructions are performed in parallel to make system fast and easy to use.

Second accepted paper presented by Kaw et al. (Kaw, Loan et al. 2018). This is a reversible security framework, capable of securely embedding electronic patient record (EPR) in medical images for a mobile cloud based e-healthcare setup to ensure that cloud administrators have no unauthorized access to client data. This scheme applies technique similar to optimal pixel repetition (OPR) and embedding by pixel permutation to embed information reversibly. For the extraction of EPR from the stego image, the original image is not required. This method is histogram invariance between cover and stego images, which makes it resilient to statistical attacks.

IV. MANAGEMENT, ADMINISTRATION AND LOGISTICS

With the adoption of information and communication technologies in healthcare services, there is an increased interest to apply logistics and other practices and strategies such as supply chain management in healthcare sector (Dwivedi and Mustafee 2010, Brooks, El-Gayar et al. 2015). Healthcare logistics management and administration is multidisciplinary profession, combining process, technology, and people as well as industry knowledge, strong relationships, and specialized training to help medical experts and business owners achieve their patient care goals (Shaw 2014). Dwivedi et al. presented a generalized model for the adoption of healthcare services (Dwivedi, Shareef et al. 2016). In this study, market aspect of users' preferences and a cross-cultural impact and differences on this intrinsic and extrinsic adoption behavior of emerging healthcare services is analyzed. It aims to come up with a generic framework for the adoption of ICT-based healthcare series considering the constraint imposed by the cultural and other norms. According to this model, any medical service needs to consider its local as well as national cultural traits, making it more adaptable for the entire community, which is basically extends the theoretical concept of e Unified Theory of Acceptance and Use of Technology (UTAUT) model. In this special issue, no paper is accepted in this category due few and low-quality submissions in this category. It is recommended to concerned researchers, to develop some realistic and state-f-the-art frameworks focusing the management, administration and logistics policies in electronic healthcare services considering the perspectives of both government and customers, which may help to increase the quality and usability of these services.

All the accepted paper in this special section aims to explore the different paradigms of mobile-cloud assisted applications in medical field. Majority of accepted papers provide both conceptual model and research models which have been empirically tested for the theoretical contributions.

V. OPPORTUNITIES AND CHALLENGES

Summing up the findings of this special issue, it is noted that the papers (both accepted and rejected) cover few paradigms of mobile-cloud inspired frameworks and their applications in the healthcare. Nevertheless, it represents part of the current state-of-the-art in the discussed topics. It is expected that this special issue will stimulate further research and development activities to explore the current challenges and find their solutions. Following are some of the neglected but important areas in multimedia data analysis in the perspective of medical domain, never the less challenges are high but if resolved, could be a significant contribution in the healthcare.

1. Medical Imaging Analytics

These days, massive amount of data is created every day in medical field. The purpose of this data is efficient diagnosis and treatment of patients. However, distribution, analysis and management of such heterogeneous data is a challenging task. Integration of smart devices and cloud services, sharing and analysis of medical data is becoming easy and healthcare service providers are now able to find patient trends, referral generation, and personalized care. This cooperation of mobile and cloud technologies can be further enhanced to create more comprehensive pools of data for improved patient care. Advancements in machine learning, artificial intelligence and deep learning has opened new opportunities for more robust and efficient quantification of radiographic characteristics of tissues. However, there are critical challenges associated with the analysis of medical imaging data such as security, real-time analysis, and accurate diagnosis. While some of these challenges are specific to the imaging field, many others like reproducibility and batch effects are generic and have already been addressed in various other medical fields such as genomics. Mobile-cloud-based image management solutions make sense due to increased security, comprehensive functionality, and a more affordable cost than on-site data centers. It also equips desktop and mobile users with rapid, easy access to patients' medical images and radiology reports ubiquitously.

There is trade-off between multimedia data communication cost to the computation cost. An efficient model is required to deal with computational and communication energy trade-off. Thus, there is need for efficient and adaptive-offloading methods to reduce the usage of mobile resources and optimize the computational services of cloud. This offloading architectures must allow healthcare workers to select functions that need to be offloaded (Mehmood, Sajjad et al. 2014). These selected functions are known as kernel functions. The appropriate selection of kernel functions reduces the network traffic and computational load on smartphone devices.

2. Real-Time System For Remote Patient Monitoring

The end-to-end delay of today's communications networks are bottleneck in meeting the requirements of many data streaming applications. For example in remote patient monitoring, distance between mobile devices and remote data centers hinders the provision of real-time services due to delay in data communication. For instance, augmented reality and remote patient monitoring applications typically require a response time of around 10 milliseconds, which is hard to achieve by mobile-cloud solutions with a typical end-to-end latency of hundreds of milliseconds. In such scenarios, it is vital to think out of the box solutions and come up with new computational frameworks such as fog and mist computing. This requires dedicated efforts due to following listed requirements:

- Real-time multi-modal (visual and scalar sensors) data collection at remote cloud.
- Real-time data analysis with sophisticated AI techniques to detect abnormal events.
- Management (data summarization, indexing and retrieval) of multimedia data for later use.

3. Mobile-Cloud To Fog And Mist Computing

MCC has proved successful for a wide range of user needs. It is an internet-based computing model which facilitate global and ad-hoc access to cloud resources such as storage, computational power, security and other authenticity services. The massive data streams (especially multimedia data) produced by a vast and rapidly growing number of medical sensors is the major source of big data and transfer of enormous amounts of data to and from the cloud, results in a significant growth of network traffic which can upshot in a huge latency, becoming a bottleneck for real-time healthcare services.

Fog computing is a new concept compared to cloud computing. Major concept of fog computing is providing storage, communication, and configuration controls more close to the end users, which is a fascinating concept for users. However, its major fallback is the enormous increase data traffic in local networks and consumption huge computational resources of the fog nodes. Thus, fog nodes have to face bottleneck and latency issue. In order to complement the drawbacks of fog computing, the concept of mist computing is introduced recently. Mist computing is mainly concerned with IoT object such as sensors, cell phones, home appliance and any kind of smart devices. Mist computing is an emerging paradigm which utilizes those devices that have predictable accessibility to computational and communication resources as services to their neighborhood using IoT object-to-object communications. Thus, mist computing can be a potential game changer in healthcare domain for the analysis of big and complex healthcare data.

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