A Survey on Multimedia Quality of Experience Assessment Approaches in Mobile Healthcare Scenarios

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Abstract. The digital revolution in healthcare presents day after day new solutions to us. As one of the major roles in healthcare is the prevention of being diseased by the popularization of healthier living and doing sports, a vast majority of digital applications aims at self-monitoring and activity tracking via new wearable gadgets and smartphone apps. Also there are solutions for making the work of physicians and medical specialists easier and change their attitude for digital resolutions. This article gives an overview of mobile healthcare status respect to general and multimedia-related solutions and highlights the importance of the respect of Quality of Experience in these applications.

Keywords: Quality of experience (QoE) · mobile healthcare (mHealth) · electronic healthcare (eHealth) · Mobile medical multimedia · Quality assessment

1 Introduction

The term eHealth[1] exists from 1999 [1]. It describes the use of electronic communication and information technology in healthcare. eHealth also includes the transmission and storage of digital data for clinical, educational scenarios and their administration [2]. A research from 2005 found out that under the term eHealth specialists mean a large spectrum of themes but there was not a solid definition about what is eHealth [3]. Therefore eHealth involves several topics such as telemedicine, homecare and clinical information systems [4,5].

A new idea in eHealth should be well mature and prepared towards to a solution that is suitable for the medical practice and accepted by physicians and patients as well. However, another important aspect when discussing about eHealth services is the patient - health professional relationship. In several cases patients are more involved in the case of eHealth services than in the case of regular healthcare services, in short eHealth brings closer the patient to the doctor [6].

[1] electronic healthcare.

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As the mobile world has started its exponential evolution from the early 2000s, a new term has appeared stem from eHealth: the mHealth[2]. Under this theme, there are increasingly popular solutions that use the possibilities of ever-changing telecommunication networks and mobile devices in medical practice and supporting for the everyday user's health-related intentions (self-"patient monitoring") as well [7]. An example for patient-monitoring application is Laborom, a free to use iOS and Android app which brings the medical data (e.g., diabetes records) about the patient to their pockets and they can send them in a report format to their doctors [8].

The wireless networks that deliver the mHealth services to users need well-defined QoS[3] parameters (e.g., bandwidth and delay) that grant the reliable transmission. These QoS parameters are often unknown so they need to be predicted, like it is presented in [9]. However, a mHealth application itself could set extra QoS requirements that should be taken into consideration in addition to network's demands. For example in a real-time scenario, an ECG[4] signal should be transmitted without noticeable delay [10].

The increase of available gadgets that communicate to the smartphones in wired or wireless way causes a raise in the world of mHealth applications. This is the case with a smartphone dongle which can make a laboratory-quality diagnosis of infectious diseases, such as HIV and syphilis within 15 min. It simplifies the diagnosis procedure with reducing the laboratory costs and waiting time for the results [11].

A large group of these applications deals with the transmission, visualization and storage of multimedia content in mobile equipments, created by medical devices [12]. In this scenario a product made by Philips, called Lumify implements a simple portable ultrasound solution. Lumify includes a handheld ultrasound device and its smartphone/tablet application which enables the user to watch and store lively the ultrasound recording [13].

The available bandwidth and other parameters should be considered when transmitting multimedia signals in various wireless telecommunication systems. Therefore the image and video content should be compressed to satisfy the bandwidth requirements [14]. The level of quality degradation caused by compression and transmission could be measured by evaluating the quality perceived by specialists and outsiders. The respect of QoE[5] when designing an eHealth or mHealth services is a cardinal issue since it is the most important factor of the implementation. The goal of this paper is to provide a survey on topics of Quality of Experience assessment in medical multimedia applications and mHealth services.

This article has the following structure: it begins with an explanation of the role of QoE in eHealth and mHealth services, after that a review of various QoE-based service improvement approaches in mHealth is presented. Finally, in Sect. 4 we conclude the paper.

[2] mobile healthcare.
[3] Quality of Service.
[4] Electrocardiography.
[5] Quality of Experience.

2 The Role of QoE in Electronic and Mobile Healthcare Services

To realize a mHealth (or an eHealth) application is a challenge. A wide range of aspects should be concerned, such as: the human demands (both non-specialists and medical specialists), technology limits, economical considerations and legal issues. A statistic from article [15] points out that the most important factor for an eHealth service implementation is the user acceptance.

The importance of adequate QoE in eHealth is obvious. For example: data loss could cause false judgments in diagnosis and latency or delay has effect e.g. to the remote surgeon's performance. It is essential to realize the characteristics of eHealth services and define the role of QoE in acceptance of these services. It is supposed that eHealth in general should follow the same standards of quality and safety as that in the traditional healthcare. Therefore eHealth services could have several quality requirements depending on the "application purpose", which could be for example: professional, clinical interest or non-clinical interest (i.e. educational). It is noticeable that clinical applications have the most strict requirements. Other subjective sights of a service could affect the quality requirements and the user perception as well, i.e., content type (video, audio, image) and user context (emergency, hospital or primary care). The quality requirements of an eHealth application also depend on the context of use: real-time and non real-time solutions have different quality demands [16]. Based on the above mentioned remarks it is obvious that the user acceptance should be in the centre of an eHealth system and every stakeholders of this system should operate to subserve the user acceptance of the system [15,17]. In the acceptance process of an electronic or mobile healthcare solution the users are both the patients and healthcare specialists [18].

When planning a mobile or electronic healthcare application that will be used in a medical establishment, QoE has an undealt conception: the diagnostic relevance. This means that medical specialists should be involved in the right segment of the implementation. Only they could validate an IT innovation in medical practice. Some researches (e.g., [19–22]) investigate in lossy compression methods in the case of medical videos in order to reduce the need to huge bandwidth and high compression ratios. However, impairing a medical video could cause quality degradation regarding to the diagnostical relevance too. To examine this lessened diagnostical quality in medical recordings a quality evaluation method could be used. The article [23] classifies and specifies the different medical image and viceo quality assessment approaches in eHealth services.

Nedia Nouri et al. in [19] used the DSCQS[6] measurement method recommended by the ITU[7] [24]. Seven expert surgeons were involved in the subjective test. Reference and impaired videos were shown to the attendants and they had to evaluate the sequences regarding to the diagnostical relevance based on their medical experience. The outcome of the analysis is that a compression ratio

[6] Double-stimulus continuous quality-scale.
[7] International Telecommunication Union.

of around 90:1 can be achieved with MPEG-2[8] compression in robotic-assisted surgery videos. A more complex task in telesurgery is the implementation of 3D video which is a complex multimedia signal regarding to the human perception. 3D video uses higher bandwidth and storage capacity compared to other 2D medical video thus it is necessary to use the compression method with a setup which results degradation under the surgeons' perception [20].

The research [21] used the DSCQS evaluation method for similar purpose. M. Razaak et al. reviewed the usage of HEVC[9] compression coding in the case of ultrasound videos. The huge result of this measurement is that diagnostic quality videos can be obtained at the compression ratio range of 140:1 to 420:1 by HEVC compression.

The H.264 coding standard for ultrasound and CT[10] recordings was examined in article [22]. In this case the DSCQS method was used to verify the efficiency of a new rate control scheme in H.264 standard proposed by Hongtao Yu et al. The result is that the proposed model can achieve better perceptual quality than the existing method implemented in H.264.

In this section the importance of QoE and diagnostical relevant quality assessment in electronic and mobile healthcare services was presented with some examples. The next section introduces several service improvement approaches based on having respect for QoE in mHealth services.

3 QoE-Based Service Improvement Approaches in mHealth

Mobile healthcare services as eHealth, bring together the IT sector's innovations and the demands of the healthcare services. mHealth takes advantage of mobile networks, mobile computing and medical sensors [25] and produces new wireless solutions in e.g. telemedicine and telemonitoring with using wearables in body area networks. With worn and/or implanted sensors several physiological parameters could be monitored, such as blood pressure, body temperature and ECG signals [26]. ECG signals are measured in project [28] which realizes telemonitoring system's mobile adaption for patients with cardiovascular diseases in Georgia with using 3-channel ECG Loop Recorder communicating with smartphones via Bluetooth. ECG and other patient vital signal types are one of the influence factors in QoE of remote monitoring services. Other QoE factors and their details are discussed in [29,30]. In [27] in order to satisfy the medical level QoE/QoS requirements in multi-sensor based mobile patient monitoring services a proper Wi-Fi network selection method is presented which is using a multi-criteria decision engine.

It is necessary to run the mHealth service on a robust wireless broadband network that can grant a connection for the desirable bandwidth. The bandwidth requirement is crucial in the case of mHealth applications that realize solutions

[8] Moving Picture Experts Group 2 standard.
[9] High Efficiency Video Coding (H.265).
[10] Computed tomography.

in e.g., wireless diagnostic system for patients living in a distance, hospital consultation with streaming medical video content and emergency scenarios where data transfer between the scene and the hospital [31]. To optimize the service that uses the wireless network, the QoS requirements of the mHealth application should be defined. A comprehensive overview of QoS demands (e.g., delay and loss) of different types of eHealth and 4G mHealth applications could be found in [32,33]. A possible optimization could obtain by using cross-layer designed network (e.g., 3G and 4G systems) concept that allows the medical video streaming [39]. The priorization of the traffic of eHealth services with different QoS requirements can be done based on QoE management [40].

In an ubiquitous health monitoring service with heterogeneous networks, the medical images should be perfect in regarding to pixel loss that might influence the diagnostic process. The article [34] summarizes the objective, subjective and quasi-subjective metrics in medical-image quality evaluation. Objective quality metrics are serving instant information about quality thus they are suitable in real-time scenarios [35]. Objective metrics mentioned in [34] are suitable to reflect to the quality percieved by medical experts [36,37]. The article [38] analyses the quality with subjective and objective metrics in the case of mobile robotic teleultrasound system that sends ultrasound images through 3G network.

More than 165,000 health-related apps exist in the online smartphone application stores for general purposes for everyday users, e.g.: fitness, workout assistant, bodyweight tracker, sleep monitoring applications. Only few of these applications have reasonable quality reviews. The problem is that there is no standardized quality evaluation method for smartphone apps [41,42]. In [43] several health-related app evaluation and selection methods are proposed to healthcare service providers to make the app recommendation to their patients easier. The tool [44] measures the QoE in the case of mHealth apps. The measurement is based on a survey which contains 21 questions about several quality factors of a health-related application, e.g., content quality, security, use, availability, performance and accuracy. The similar MARS mHealth app quality rating tool [45] relies on quality indicators, such as: subjective quality, engagement, functionality, aesthetics and information quality, that were extracted from previous mHealth literature and researches.

4 Conclusion

This paper reviews a few solutions from the area of eHealth and mHealth services and features the term of Quality of Experience. It discusses several mHealth service improvements based on increasing the QoE by the help of quality assessment methods. This article grounds for further works that takes account of Quality of Experience in the field of mobile healthcare.

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