

Challenges, Systems, and Applications of Wireless and Mobile Telemedicine

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INTRODUCTION

Telemedicine can be defined as the delivery of healthcare, and the sharing of medical knowledge over a distance, using information and communication technologies (Pattichis, Kyriacou, Voskarides, Pattichis, Istepanian, & Schizas, 2002). Telemedicine aims at providing expert-based medical care to any place where healthcare is needed. It was introduced about three decades ago, where the only available communication technologies were telephone and fax machines. However, in recent years, many telemedicine applications have been developed over wired telecommunication technologies, wireless telecommunication technologies, as well as integrated wired and wireless networks.

Wireless communication and networking technologies such as 2.5G, 3G, 4G, and 802.11 Wireless LANs and Bluetooth have allowed the provision of wireless telemedicine systems, thus freeing the medical personnel and the patient from being bound to a fixed location. The wireless communication technology provides more flexible access to doctors and patients with the use of mobile stations. Mobile computers are gradually gaining more interest as the point of care tools used by many physicians and healthcare professionals. Since their introduction in the early 1990s, Personal Digital Assistants (PDAs) are increasingly becoming more and more popular for a large variety of medical applications. PDAs can be used in many areas of medicine as off-line reference tools, risk estimation for specific diseases, off-line diagnosis code databases, drug reference databases, and many more useful emerging applications. Some of these applications are stand-alone mobile applications, while many others are networked.

There are many benefits which wireless and mobile telemedicine can provide to healthcare and medical applications. Some of the specific benefits are outlined as

follows. First, it can provide rapid responses to critical medical care, regardless of geographical barriers. It can be quickly deployed in disaster recovery areas, where existing communication links may have been disrupted. Second, it can provide flexible and reliable access to expert opinion and advice at the point of care with insignificant delay, and with improved management of medical resources. Third, it can allow patients to remain in their communities and receive medical services. This significantly reduces the costs of healthcare through improved healthcare management systems and reduced travel expenses. Fourth, it can provide interactive medical consultation and communication of medical records, image and video data in mobility scenarios, and with global coverage and connectivity, and fifth, it can support the empowerment and management of medical expertise in rural and underserved areas through the use of wireless infrastructureless networking technologies.

CHALLENGES IN MOBILE AND WIRELESS TELEMEDICINE

Mobile and wireless telemedicine faces a number of technical challenges emanating from various sources, including design and application scenarios. In this article, we will discuss the challenges related to image and video transmission, wireless signal quality, design, and standards. These challenges are briefly described in the following section.

Image and Video Transmissions

A telemedicine system would require the transmission of digital images as well as digital video. There are no set bandwidth requirements for the transmission of medical images. Some medical images, like a chest cardiogram,

can take up to 50 MB of space, and would require longer transmission times. The transmission of medical images would require the use of compression algorithms. There are two types of medical image compression techniques: lossless, and lossy compressions (Kivijarvi, Ojala, Kaukoranta, Kuba, Nyul, & Nevalainen, 1998). Lossless techniques restructure the image exactly from its compressed format, preserving original quality, but providing limited compression ratios. On the other hand, lossy compression ratios provide an approximate reconstruction of the original image. The use of lossy compression in wireless telemedicine would require a careful evaluation of the effect of the compression on different medical diagnostic scenarios. When appropriate, the background of an image could be ignored, since it may be of no diagnostic value. Adapting such techniques can avoid compression of the background and other insignificant regions, providing substantial improvements of compression ratios (Young, Whiting, & Foos, 1999).

A reliable wireless telemedicine system also requires optimal transmission of digital video. In telemedicine, video transmission can be segregated into several categories, namely: real-time video transmission, off-line video transmission, medical video and audio for diagnostic applications, and nondiagnostic video and audio. Real-time diagnostic audio transmission includes transmission of stethoscope audio, as well as audio that accompanies diagnostic video (Pattichis et al., 2002).

There are a number of research projects investigating various techniques of video compressions. One possible technique for achieving acceptable video compression for diagnostic proposes the use of object-based encoding and decoding. Here, the video is segregated into different segments of diagnostic, and then assigned a corresponding bit rate, according to the predetermined significance. This technique significantly reduces the bandwidth, while retaining high-quality video images of regions with diagnostic interest (Pattichis et al., 2002). The difficulty of using object-based encoding is the uncertainty over which part of the video is diagnostically significant. Using interactive video may be enough in overcoming this uncertainty.

Many applications often transmit different types of streams simultaneously, such as medical images, vital signs, real time video, and other readings from various medical sensors. Depending on the application, the wireless transmission requirements for each

stream can be quite different. Thus, a challenge when implementing a wireless telemedicine application would be to establish policies to coordinate, prioritize, and compress the various media streams to eliminate signal impedance and congestion problems.

Wireless Communication

The actual throughput of current commercially available cellular wireless links is fluctuant (Chu & Ganz, 2004). For example, CDMA provides data rates of about 153.6 kbps. However, the actual throughput of such cellular wireless links is fluctuant with an average throughput of about 70 kbps. Hence, the implementation of a mobile telemedicine system over such a link will have to take this limitation into account. Other forms of wireless communication technology also have their share of concerns. The use of satellite communications demands the procurement of expensive equipment, dedicated links, as well as skilled operators. Short range wireless technologies, like wireless local area network (WLAN) and Bluetooth, offer data rates that can support multimedia information—unfortunately, over short distances and with degrading results with increasing distance. The 802.11 WLANs offer data rate of 54 MBPS, while Bluetooth offers rates of up to 723 kbps. The 2G and 3G Cellular technologies offer the advantage of distance, but with lower maximum data rates. The maximum theoretical data rates for global system for mobile communications (GSM), general packet radio service (GPRS), EDGE, and universal mobile telecommunications system (UMTS) are 9.6 kbps, 171.2 kbps, 384 kbps, 2 mbps, respectively. The choice of the type of wireless communication technology to be employed depends on several factors, including deployment location, desired quality of transmission, and security level.

Design Challenges and Standards

One of the major challenges for the adoption of mobile data applications is getting the right form factor. This is also true in telemedicine, where it is significant to build the right device to handle the need of the healthcare service it provides. The challenge here is in getting the devices to a manageable size, thus minimizing inconvenience to the user (patient or the practitioner) (Tachkara, Wang, Istepanian, & Song, 2003). Patient confidentiality during use of a handheld device is an

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