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Chapter 19

Telemedicine: A Multimedia Communication Perspective

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19.1 Introduction

With the rapid advances in computer and information technologies, multimedia communication has brought a new era for health care through the implementation of state-of-the-art telemedicine systems. According to a formal definition recently adopted by the Institute of Medicine, telemedicine can be defined as “the use of electronic information and communication technologies to provide and support health care when distance separates the participants” [1].

The envisioning of health care service performed over a distance first appeared in 1924 in an imaginative cover for the magazine Radio News which described a “radio doctor” who could talk with the patient by a live picture through radio links [1]. However, the technology to support such a visionary description, namely television transmission, was not developed until 3 years later, in 1927. According to a recent review, the first reference to telemedicine in the medical literature appeared in 1950 [2], with a description of the transmission of radiological images by telephone over a distance of 24 miles. An interactive practice of telemedicine, as a signature mode currently perceived by many people, began in the 1960s when two-way, closed-circuit, microwave television systems were used for psychiatric consultation by the clinicians at the Nebraska Psychiatric Institute [3]. Although these pioneering efforts have demonstrated both technical and medical feasibilities and received enthusiastic appraisal from the health care recipients of telemedicine [4], the issue of cost-effectiveness was debated at a premature stage by the telemedicine authorities, especially the major funding agencies. The prevailing fear was that as the technologies for telemedicine became more sophisticated, the cost for telemedicine would only increase [3]. Such fear has been proven to the contrary, as many applications of telemedicine are now considered to have potential in reducing health care costs or reducing rates of cost escalation [1]. The rapid advances of modern communication and information technologies, especially multimedia communication technologies in the 1990s, have been a major driving force for the strong revival of telemedicine today.

In this chapter, we will examine recent advances in telemedicine from a multimedia communication perspective. We will first demonstrate the needs for multimedia communication to improve the quality of health care in various telemedicine applications. We will then present examples of telemedicine systems that have adopted multimedia communication over different communication links. These diverse applications illustrate that multimedia systems can be designed to suit a wide variety of health care needs, ranging from teleconsultation to emergency medicine.
19.2 Telemedicine: Need for Multimedia Communication

Notice that there are three essential components in the definition of telemedicine adopted by the Institute of Medicine: (1) information and communication technologies, (2) distance between the participants, and (3) health or medical uses. With a well-designed telemedicine system, improved access to care and cost savings can be achieved by enabling doctors to remotely examine patients. The distance separating the participants prevents doctors from engaging in traditional face-to-face medical practice. However, this also creates the opportunity for information and communication technologies to be integrated with health care services in terms of patient care, medical education, and research. In general, patient care focuses on quality care with minimum cost; education focuses on training future health care professionals and promoting patient and community health awareness; research focuses on new discoveries in diagnostic and therapeutic methods and procedures. In each of these service categories, multimedia communication can facilitate an enabling environment to take full advantage of what the state-of-the-art computing and information technologies are able to offer to overcome the barriers created by distance separating the participants.

In the case of patient care, a telemedicine system should be able to integrate multiple sources of patient data, diagnostic images, and other information to create a virtual environment similar to where the traditional patient care is undertaken. During the last decade, we have witnessed major advances in the development of hospital information systems (HIS) and picture archiving and communication systems (PACS). The integration of both HIS and PACS can provide a full array of information relevant to patient care, including demographics, billing, scheduling, patient history, laboratory reports, related statistics, as well as various diagnostic medical images. With a remote access mode for participants, the interaction between the participants as well as between the participants and the systems of HIS and PACS will undoubtedly need to operate with multiple media of information transmission. To seamlessly integrate multiple media into a coherent stream of operations for a telemedicine system, the development of multimedia communication technology suitable for health care application will become increasingly important. For example, Professor H.K. Huang and his group at the University of California at San Francisco have shown that a networked multimedia system can play an important role for managing medical imaging information suitable for remote access [5]. The information types considered in this system include still 2D or 3D images, video or cine images, image headers, diagnostic reports (text), physicians’ dictation (sounds), and graphics. The networked multimedia system capable of integrating multimedia information meets the need to organize and store large amounts of multimodel image data and to complement them with relevant clinical data. Such a system enhances the ability of the participating doctor to simultaneously extract rich information embedded in the multimedia data.

There are two major modes of telemedicine involving patient care: teleconsultation and telediagnosis [6]. Teleconsultation is the interactive sharing of medical images and patient information between the doctor at the location of the patient and one or more medical specialists at remote locations. Figure 19.1 illustrates a typical teleconsultation system. In this case, the primary diagnosis is made by the doctor at the location of the patient, while remote specialists are consulted for a second opinion to help the local doctor arrive at an accurate diagnosis. In addition to video conferencing transmitting synchronized two-way audio and video, networked multimedia communication is very much desired to access HIS and PACS, to share relevant medical images and patient information. The verbal and nonverbal cues are supported through the video conferencing system to mimic a face-to-face conversation. An integration of the networked multimedia system and the video conferencing system is needed to enable a clear and uninterrupted communication among the participants. However, some loss of the
image quality in the case of video conferencing may be acceptable. One successful example of such a telemedicine system is the WAMI (Washington, Alaska, Montana, and Idaho) Rural Telemedicine Network [6]. Telediagnosis, on the other hand, refers to the interactive sharing of medical images and patient information through a telemedicine system, while the primary diagnosis decision is made by the specialists at a remote location. Figure 19.2 illustrates a typical telediagnosis system. To ensure diagnosis accuracy, no significant loss of the image quality is allowed in the process of acquisition, processing, transmission, and display. For synchronous telediagnosis, high communication bandwidth is required to support interactive multimedia data transfer and diagnosis-quality video transmission. For asynchronous telediagnosis, lower communication bandwidth is acceptable because the relevant images, video, audio, text, and graphics are assembled to form an integrated multimedia file to be delivered to the referring physician for off-line diagnosis. In the case of emergency medicine involving a trauma patient, telediagnosis can be employed to reach a time-critical decision on whether or not to evacuate the patient to a central hospital. Such a mode of telediagnosis operation was successfully implemented during the Gulf War by transmitting X-ray computed tomography (CT) images over a satellite teleradiology system to determine whether a wounded soldier could be treated at the battlefield or should be evacuated [7]. In this case, high communication bandwidth was available for telediagnosis operation.
Examples of clinical applications of telemedicine in different medical specialties include teleradiology, telepathology, teledermatology, teleoncology, and telepsychiatry. Among them, teleradiology is a primary image-related application. Teleradiology has been considered a practical cost-effective method of providing professional radiology services to underserved areas for more than 30 years. It has now been widely adopted to provide radiology consultations from a distance. Teleradiology uses medical images acquired from various radiological modalities including X-ray, CT, magnetic resonance imaging (MRI), ultrasound (US), positron emission tomography (PET), single-photon emission-computed tomography (SPECT), and others. Associated with these medical images, relevant patient information in the form of text, graphics, and even voice should also be transmitted for a complete evaluation to reach an accurate clinical decision. Figure 19.3 illustrates a typical teleradiology system. The need for multimedia communication is evident when such a teleradiology system is implemented.

FIGURE 19.3
Illustration of a typical teleradiology system.

In the case of medical education, a telemedicine system generally includes video conferencing with document and image sharing capabilities. The modes of operation for the telemedicine system used for remote medical education include one-to-one mentoring, online lecturing, and off-line medical education. Depending on the mode of operation, such a telemedicine system may use either point-to-point or point-to-multipoint communication. In general, multimedia presentation is desired because the education may involve clinical case study using medical images, video, and patient history data. Similar telemedicine systems can also be designed for public access to community health care resources. With Internet and World Wide Web resources, health care information can be readily obtained for the formal and informal provision of medical advice, and continuing medical education can be implemented at multiple sites with effective multimedia presentations.

In the case of medical research, the telemedicine system can be used to collect patients’ data from distinct physical locations and distribute them to multiple sites in order to maximize the utilization of all available data. One prominent application of such a telemedicine system is the research on medical informatics in which distributed processing of multimedia medical information at separate physical sites can be simultaneously executed. Such a mode of operation is also very useful when research on public health is conducted. In general, public health research involves massive and timely information transfer, such as for disease monitoring. For public health research, we expect that a telemedicine system with advanced multimedia
communication capability will be able to provide the connectivity needed for mass education on disease prevention and the global network needed for disease monitoring.

In summary, the required multimedia communication infrastructure for telemedicine depends on the type of telemedicine applications. However, the need for advanced multimedia technology is clear. It is the enhanced multimedia communication capability that distinguishes the present state-of-the-art telemedicine systems from the early vision of “radio doctor” consisting of only live pictures of the doctor and the patient.

19.3 Telemedicine over Various Multimedia Communication Links

There have been numerous applications in telemedicine, both clinical and nonclinical, as we have discussed in the previous section. Although the capability of multimedia communication is desired in nearly all telemedicine applications, the required communication capacity in terms of bandwidth, power, mobility, and network management can be quite different from one application to another. Traditionally, plain old telephone service (POTS) has been the primary network for telecommunications applications. Early telemedicine applications started with the POTS in which the transmission of radiological images by telephone over a distance of 24 miles was reported in 1950 [2]. However, modern telemedicine applications have recently moved quickly toward making use of advanced high-performance communication links, such as integrated service digital network (ISDN), asynchronous transfer mode (ATM), the Internet, and wireless mobile systems. In this section, we discuss how different communication links can be used in various telemedicine applications to enhance their multimedia communication capabilities.

19.3.1 Telemedicine via ISDN

ISDN is essentially a high-speed digital telephony service that carries simultaneous transmission of voice, data, video, image, text, and graphics information over an existing telephone system. It originally emerged as a viable digital communication technology in the early 1980s. However, its limited coverage, high tariff structure, and lack of standards stunted its growth early on [8]. This situation changed in the 1990s with the Internet revolution, which increased demands for more bandwidth, decreasing hardware adapter costs, and multiple services. In North America, efforts were made in 1992 to establish nationwide ISDN systems to interconnect the major ISDN switches around the United States and Canada. In 1996, ISDN installations almost doubled from 450,000 to 800,000, and they were expected to reach 2,000,000 lines by the year 1999.

ISDN provides a wide range of services using a limited set of connection types and multipurpose user–network interface arrangements. It is intended to be a single worldwide public telecommunication network to replace the existing public telecommunication networks which are currently not totally compatible among various countries. There are two major types of ISDNs, categorized by capacity: narrowband ISDN and broadband ISDN (B-ISDN). Narrowband ISDN is based on the digital 64-Kbps telephone channel and is therefore primarily a circuit-switching network supported by frame relay protocols. A transmission rate ranging from 64 Kbps to 1.544 Mbps can be provided by the narrowband ISDN. Services offered by narrowband ISDN include (1) speech; (2) 3.1-KHz audio; (3) 3-KHz audio; (4) high-speed end-to-end digital channels at a rate between the basic rate of 64 Kbps and the super-rate of 384 Kbps; and (5) packet-mode transmission. B-ISDN provides very high data transmis-
sion rates on the order of 100s Mbps with primarily a packet-switching model [9]. In 1988, the International Telecommunication Union (ITU) defined the ATM as the technology for B-ISDN to support the packet-switching mode. The transmission rate of B-ISDN ranges from 44.736 Mbps, or DS3 in the digital signal hierarchy, to 2.48832 Gbps, or OC-48 in the optical carrier hierarchy in synchronous optical networks (SONETs). A variety of interactive and distribution services can be offered by B-ISDN. Such services include (1) broadband video telephony and video conferencing; (2) video surveillance; (3) high-speed file transfer; (4) video and document retrieval service; (5) television distribution; and potentially many other services.

The characteristics of ISDN to provide multimedia and interactive services naturally led to its application in telemedicine. Figure 19.4 illustrates an ISDN-based telemedicine system in which transmission of multiple media data is desired and interactivity of the communication is required. In addition, the current ISDN systems are fundamentally switch-based wide area networking services. Such switch-based operations are more suitable for telemedicine because many of its applications need network resources with guaranteed network bandwidth and quality of service (QoS). In general, switch-based ISDNs, especially the B-ISDN, are able to meet the requirements of bandwidth, latency, and jitter for multimedia communications in many telemedicine applications. From a practical point of view, the advantages of ISDN are immediately ready in many areas, the telecommunications equipment and line rates are inexpensive, and there are protocol supports among existing computing hardware and software [10]. Another characteristic of ISDN is its fast establishment of bandwidth for multimedia communication within a very short call setup time. This matches well with the nature of the telemedicine applications in which the need is immediate and the connection lasts for a relatively short period of time. In addition, the end-to-end digital dial-up circuit can transcend geographical or national boundaries. Therefore, an ISDN connection can offer automatic translation between European and U.S. standards [11].

**FIGURE 19.4** Illustration of a typical ISDN-based telemedicine system.

Because of its worldwide deployment, the ISDN has also been used to implement telemedicine applications outside Europe and North America. A telemedicine project via ISDN has been successfully implemented in Taiwan, China [12]. In this project, a telemedicine link was established between the Tri-Service General Hospital (TSGH) and the Lian-Jian County Hospital (LJCH), Taiwan. Lian-Jian County consists of several islands located 140 miles northwest of Taiwan island with a population of 4000. However, the LJCH has only five physicians, without residence training. Therefore, the telemedicine system was expected to provide better health care services to the residents in Lian-Jian County while reducing unnecessary patient transfer. On-the-job training of county hospital physicians has also been provided.
The telemedicine system consists of two teleconsultation stations located at TSGH and LJCH, respectively, and a multimedia electronic medical record system at TSGH for storing the multimedia medical records of patients. Each teleconsultation station is equipped with a video conferencing system, a high-resolution teleradiology workstation for displaying multimedia electronic medical records, a film digitizer for capturing medical images, and document cameras for online hard-copy documents capture. The two sites are linked by six basic rate interface (BRI) ISDNs with a total bandwidth of 768 Kbps to transfer images and real-time audio–video data.

The TSGH–LJCH telecommunication system was in operation in May 1997. Between May and October 1997, 124 cases were successfully teleconsulted. Assessments show that the telemedicine system achieved the previously set goals. Surveys were also conducted to investigate how people would accept this new health care technology. The results show that 81% of doctors at TSGH and 100% of doctors and 85% of patients at LJCH think the teleconsultation services are valuable and should be continued.

It is evident that current ISDN systems offering integrated multimedia communication are suitable for many telemedicine applications. However, current bandwidth limitations confine the applications to mainly teleconsultation over video conferencing format. With large-scale deployment of the B-ISDN systems worldwide in the future [13], we expect a much improved multimedia communication quality in telemedicine applications that are based on ISDN systems.

19.3.2 Medical Image Transmission via ATM

The bandwidth limitation of ISDNs prohibits the transmission of larger size medical images. Even at a primary rate of 1.92 Mbps, transfer of medical images of 250 Mb over ISDN would require 130 s without compression and 6.5 s with 20:1 compression. Such applications of medical image transfer would call for another switch-based networking technology, the ATM.

In general, ATM is a fast-packet switching mode that allows asynchronous operation between the sender clock and the receiver clock. It takes advantage of the ultra-high-speed fibers that provide low bit error rates (BERs) and high switching rates. ATM has been selected by the ITU as the switching technology, or the transfer mode, for the future B-ISDN, which is intended to become the universal network to transport multimedia information at a very high data rate. ATM is regarded as the technology of the 21st century because of its ability to handle future expanded multimedia services.

The advantages of ATM include higher bandwidth, statistical multiplexing, guaranteed QoS with minimal latency and jitter, flexible channel bandwidth allocation, and seamless integration of local area networks (LANs) and global wide area networks (WANs) [14]. The higher bandwidth of ATM is sufficient to support the entire range of telemedicine applications, including the transfer of large medical images. Figure 19.5 shows a typical ATM-based telemedicine system used to transfer massive medical images. For the transfer of the same size (250 Mb) medical image over ATM at the transmission rate of 155 Mbps, only 1.6 s without compression and 0.08 s with 20:1 compression are required. Statistical multiplexing can integrate various types of service data, such as video, audio, image, and patient data, so that the transport cost can be reduced and the bandwidth can be dynamically allocated according to the statistical measures of the network traffic. Such statistical multiplexing offers the capability to allow a connection to deliver a higher bandwidth only when it is needed and is very much suitable for the bursty nature of transferring medical images. The ATM’s guaranteed QoS and minimal latency and jitter are significant parameters when establishing a telemedicine system, especially when interactive services such as teleconsultation and remote monitoring are desired. However, the disadvantages of ATM-based telemedicine systems are the current high cost and
scarcity of ATM equipment and deployment, especially in rural areas. We expect these costs to decrease steadily as the ATM gains more user acceptance and the ATM market increases.

FIGURE 19.5
Illustration of a typical ATM-based telemedicine system.

One successful example of medical image transmission via ATM is the European High-Performance Information Infrastructure in Medicine no. B3014 (HIM3) project started in March 1996 and completed in July 1997 [15]. This work aimed at testing the medical usability of the European ATM network for DICOM image transmission and telediagnosis. This cooperative project was carried out by the Department of Radiology, University of Pisa, Italy, and St-Luc University Hospital, Brussels, Belgium. The Pisa site was connected to the Italian ATM pilot and the St-Luc University Hospital was connected to the Belgium ATM network. A link between the two sites was established via the international connections provided by the European JAMES project.

DICOM refers to the digital imaging and communication in medicine standard developed mainly by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) in the U.S., with contributions from standardization organizations of Europe and Asia. The standard allows the exchange of medical images and related information between systems from different manufacturers. In the project reported in [15], the use of DICOM was limited to remote file transfer from image servers accessed via an ATM backbone. Users could select and transfer medical images to their own DICOM-compatible viewing stations for study. The project also included interactive telediagnosis using a multi-platform telemedicine package with participation by radiologists in both hospitals. It was concluded that such an ATM-based telemedicine project was successful from both a technical and a medical point of view. This project also illustrated that simultaneous multimedia interaction with huge amounts of data transmission can be implemented with ATM technology.

19.3.3 Telemedicine via the Internet

The communication links through ISDN and ATM offer switch-based networking for telemedicine applications. For many telemedicine applications, the guaranteed network bandwidth and QoS are critical. However, switches are fundamentally exclusive, connecting opera-
tions that are efficient in terms of network resource sharing. For some telemedicine applications in which exclusive connection between the participants can be compromised, the communication links can be established via the routed networks. In fact, most wide-area data networks today are routed networks. One important characteristic of the routed network is its capability to work at a high level in the protocol hierarchy and efficiently exchange packets of information between networks of similar or different architecture. Such capability enables efficient sharing of the network resources.

One giant routed network today is the Internet, a worldwide system of computer networks, or a global network of networks. The Internet began as a project of the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense in 1969 and was therefore first known as ARPANet. The original aim was to link scientists working on defense research projects around the country. During the 1980s, the National Science Foundation (NSF) took over responsibility for the project and extended the network to include major universities and research sites. Today, the Internet is a public, cooperative, and self-sustaining facility accessible to hundreds of millions of people worldwide — the majority of countries in the world are linked in some way to the Internet.

The basic communication protocol of the Internet is the transmission control protocol/internet protocol (TCP/IP), a two-layered program. The higher layer of TCP/IP is the transmission control protocol. It manages the assembling of a message into small packets that are transmitted over the Internet and the reassembling of the received packets into the original message. The lower level is the Internet protocol, which handles the address part of each packet so that it can be transmitted to the right destination. Therefore, a message can be re-assembled correctly even if the packets are routed differently. Some higher protocols based on TCP/IP are (1) the World Wide Web (HTTP) for multimedia information; (2) Gopher (Gopher) for hierarchical menu display; (3) file transfer protocol (FTP) for downloading files; (4) remote login (TELNET) to access existing databases; (5) usenet newsgroups (NNTP) for public discussions; and (6) electronic mail (SMTP) for personal mail correspondence.

With its worldwide connection and shared network resources, the Internet is having a tremendous impact on the development of telemedicine systems. There are several advantages in implementing telemedicine applications via the Internet. First, the cost of implementing a telemedicine application via the Internet can be minimal because communication links can make use of existing public telecommunication networks. Second, the capability for universal user interface through any Internet service provider enables access from all over the world. Third, because WWW browsers are supported by nearly all types of computer systems, including PCs, Macintoshes, and workstations, information can be accessed independent of the platform of the users. Moreover, the WWW supports multimedia information exchange, including audio, video, images, and text, which can be easily integrated with HIS and PACS for various telemedicine applications. Figure 19.6 illustrates a typical telemedicine system based on the Internet.

A successful project using the Internet and the WWW to support telemedicine with interactive medical information exchange is reported in [16]. The system, based on Java, was developed by a group of Chinese researchers and is able to provide several basic Java tools to meet the requirements of desired medical applications. It consists of a file manager, an image tool, a bulletin board, and a point-to-point digital audio tool. The file manager manages all medical images stored on the WWW information server. The image tool displays the medical image downloaded from the WWW server and establishes multipoint network connections with other clients to provide interactive functionality. The drawing action of one physician on the image can be displayed on all connected clients’ screens immediately. The bulletin board is a multipoint board on which a physician can consult with other physicians and send back
the diagnosis in plain text format. The point-to-point digital audio tool enables two physicians to communicate directly by voice.

The designed telemedicine system was implemented on a LAN connected to the campus network of Tsinghua University, China. The backbone of the LAN is a 10-Mbps Ethernet thin cable. PCs using Windows NT and Windows 95, as well as a Sun workstation using a Unix operating system, were linked together as clients. Unlike many other systems designed for teleconsultation using specific protocols, this system provides a hardware-independent platform for physicians to interact with one another and access medical information over the WWW. With the explosive growth of the Internet, we expect to witness a entirely new array of telemedicine applications that make full use of the continuously improving capacity of the Internet in terms of backbone hardware, communication links, protocol, and new software.

19.3.4 Telemedicine via Mobile Wireless Communication

Access to communication and computer networks has largely been limited to wired links. As a result, most telemedicine applications discussed in the previous sections have been implemented through wired communication links. However, the wire link infrastructure may not be possible in some medical emergency situations or on the battlefield. A natural extension of the desired telemedicine services to these applications would be to make use of wireless communication links encompassing mobile or portable radio systems. Historically, mobile wireless systems were largely dominated by military and paramilitary users. Recently, with the rapid development in VLSI, computer and information technologies, mobile wireless communication systems have become increasingly popular in civil applications. Two ready examples are the cordless telephone and the cellular phone.

In contrast to wired communications that rely on the existing link infrastructure, wireless communication is able to provide universal and ubiquitous anywhere, anytime access to remote locations. Such telecommunication technology is especially favorable when users are in moving vehicles or in disaster situations. Various technologies are used to support this
wireless communication. One widely adopted technology is the code division multiple access (CDMA) technique, which uses frequency spreading [17]. After digitizing the data, CDMA spreads it out over the entire available bandwidth. Multiple calls are overlaid on the channel, with each assigned a unique sequence code. One prominent characteristic of CDMA is the privacy ensured by code assignment. It is also robust against impulse noise and other electromagnetic interference. CDMA has been successfully adopted in wireless LANs, cellular telephone systems, and mobile satellite communications. Cellular technology has been used in mobile telephone systems. It uses a microwave frequency with the concept of frequency reuse, which allows a radio frequency to be reused outside the current coverage area. By optimizing the transmit power and the frequency reuse assignment, the limited frequency can be used to cover broader areas and serve numerous customers. Mobile satellite communication has also been making rapid progress to serve remote areas where neither wired links nor cellular telephones can be deployed. It provides low- or medium-speed data transmission rates to a large area covered by the satellite. At the mobile receiver end, directional antennas are generally equipped for intended communication.

Although mobile wireless communication, compared with wireline networks, has some limitations, such as lower transmission speed due to the limited spectrum, the universal and ubiquitous access capability makes it extremely valuable for many telemedicine applications that need immediate connection to central hospitals and mobile access to medical databases. The most attractive characteristic of wireless communication is its inherent ability to establish communication links in moving vehicles, disaster situations, and battlefield environments.

An early success of a telemedicine system via mobile satellite communication (MSC) was reported in [18]. Figure 19.7 illustrates such a wireless telemedicine system. The system was established in Japan through cooperation among the Communication Research Laboratory of the Ministry of Post and Telecommunications, the Electronic Navigation Research Institute of the Ministry of Transport, and the National Space Development Agency of Japan. The telemedicine system includes the three-axis geostationary satellite, ETS-V, a fixed station providing basic health care services located in the Kashima ground station of the Communication Research Laboratory, and a moving station with patients either on a fishery training ship or on a Boeing 747 jet cargo plane.

**FIGURE 19.7**
Illustration of a satellite-based wireless telemedicine system.

The system was capable of multimedia communication, transmitting color video images, audio signals, ecocardiograms (ECGs), and blood pressures simultaneously from the mobile station through the satellite to the ground station. The system was also able to transmit audio signals and error control signals to the mobile station in full duplex mode. To ensure a reliable
transmission of vital medical information in the inherent error-prone wireless environment, the system adopted error control techniques to protect the ECG and blood pressure signals. In particular, an automatic repeat request (ARQ) has been applied to ECG signals and forward error correction (FEC) has been applied to blood pressure signals. Experimental results show that telemmedicine via mobile satellite communication is feasible and may have a significant implication on health care services through mobile and remote access.

Another fine example of mobile wireless communication in telemedicine is the mobile medical database approach for battlefield environments proposed in [19]. The proposed mobile system enables medical personnel to treat a soldier in the field with the capability of real-time, online access to medical information databases that support the care of the individual injured soldiers. With mobile wireless access, the amount of evacuation or patient movement can be reduced.

Many telemedicine applications based on mobile wireless communication can be envisioned. One example of such applications is emergency medicine in a moving vehicle, such as an aircraft, ship, or ambulance. The treatment of a stroke or other severe injury by the onboard medical personnel may be greatly enhanced with a live telemedicine system that connects the vehicle with a medical specialist. Another example is emergency medicine in a disaster area. In the case of an earthquake or flood, ground communication links may well be in disorder. In these cases, emergency medicine may have to rely on mobile wireless communication for the rescue members to receive pertinent instructions from medical specialists to effectively select the most serious cases for treatment. In summary, mobile wireless communication certainly is able to provide another importance dimension to expand telemedicine services to situations where wired links are beyond reach.

19.4 Conclusion

We have discussed various telemedicine applications from the multimedia communication perspective. Rapid advances in computer, information, and communication technologies have enabled the development of high-performance multimedia communication systems. With enhanced multimedia communication capability, telemedicine systems are able to offer many health care services that could only be dreamed about just a few years ago. With mobile wireless communication booming over the entire world, universal and ubiquitous access to a global telemedicine system will soon become a reality.

Although the great potential of telemedicine will undoubtedly be realized with continued advances in computer, information, and communication technologies, great challenges remain. Many of these challenges are dependent on factors other than the technologies supporting telemedicine. They include the lack of a comprehensive study on cost-effectiveness, the lack of standards for telemedicine practice, and the obstacles presented by the human factor and public policies. Only after these nontechnological issues are also duly resolved can telemedicine achieve its maximum potential.

References


