An Advance Wireless Multimedia Communication Application: Mobile Telemedicine

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Abstract: - In this paper, we describe mobile telemedicine, which is an application in advanced wireless multimedia communication. Mobile telemedicine is one of the advanced technologies of the 21st century. It can be used to provide auxiliary medical service and has accordingly been used in emergency situations, mobile hospitals, personal healthcare, and in rapidly alerting doctors to patients' disease, rehabilitation, etc. By exploiting the advantages of wireless multimedia communication, such as current high utility, convenience, high data transmission rates, high reliability, and wide coverage, we have developed a range mobile telemedicine systems. Mobile telemedicine technology is a wireless remote medical technology that incorporates a combination of biomedical engineering, electrical engineering, and computer science; the technology also includes various advanced medical services. It is a technology unconstrained by the limitations of time and space. Using this technology, family doctors can be more actively involved in the daily lives of their patients. There is no doubt that in the future, we will witness an era of 'ubiquitous mobile telemedicine'. This technology is expected to bring about revolutionary changes in the fields of medicine and engineering. Such changes will be accompanied by ample opportunities for business, scope for the early diagnosis of diseases, and improvements in medical services. Moreover, manufacturers of clinical equipment are expected to respond favourably to these developments. Advanced technologies of the 20th century, such as the internet and mobile communication, have made human lives considerably easier. The combination of these two technologies has given rise to wireless multimedia networks, an extension of which is the mobile telemedicine systems. We would like to emphasize that the R&D process of these mobile telemedicine systems is similar to that of pharmaceuticals.

Key-Words: - ubiquitous mobile telemedicine, advanced wireless multimedia communication, emergency situations, mobile hospitals, personal healthcare, patients' disease, rehabilitation.

1 Introduction

Mobile telemedicine is one of the advanced technologies of the 21st century. It can be used to provide auxiliary medical services and has accordingly been used in emergency situations, mobile hospitals, personal healthcare, and in rapidly alerting doctors to a patients' disease, rehabilitation, etc [1-31]. By exploiting the advantages of wireless multimedia communication, such as current high utility, convenience, high data transmission rates, high reliability, and wide coverage, we have developed the mobile telemedicine system. Typically, when an ambulance leaves a hospital, to attend to an accident victim the crew includes only one physician. In an emergency telemedicine system, the ambulance is equipped with GSM (global system for mobile communication), GPRS (general packet radio service), 3G, WiMAX, or a satellite mobile communication system- technologies that facilitate the wireless transmission of videos, images, cardiographs, and pulse information of the accident victim to the emergency clinic. This enables the physician in the clinic to assess the patient's physiological condition in advance and arrange for emergency medical resources well in time, which could decrease the actual time required for treating the patient. The concept of the E-hospital has been readily accepted by medical personnel, and internet technology has been used to enhance the efficiency and quality of hospitals. In the further, mobile hospitals (M-hospitals) are expected to be deployed more commonly by hospitals. In the next phase of development, the wireless internet, as well as wireless multimedia communication technologies, will be used in and modified for M-hospitals in next steps. Mobile hospitals frequently encounter problems such as their highly sensitive quality of service parameters in wireless clinical application. It would be interesting to investigate how this wireless multimedia communication could be used in or modified for the healthcare market. For this purpose, it will be necessary to discuss the electrical magnetic interference in medicine detection instruments such as cardiograph meters, and blood pressure gauges; it will also be necessary to evaluate the acceptance of mobile hospitals by medical personnel. Furthermore, it will be essential to enhance the efficiency and quality of E-hospitals. Personal health management is an interesting and popular research topic at present. Such management can be achieved by using medical detection instruments, that can assess the patient's physiological condition on a daily basis. This information can then be transmitted via a wired or wireless multimedia communication network to hospitals and is stored in their databases. Armed with this information, the family doctor can provide appropriate advice to the patient and is able to detect symptoms of various diseases. In this manner, the doctor can alert the patient to his/her disease at an early stage. When the patient recovers to a certain extent, the doctor may permit the patient to leave the hospital and take rest at home. Follow-up rehabilitation can be achieved by installing the medical detection instruments in the patient's home, thereby enabling the doctor to continually monitor the patient's physiological condition. Furthermore, the patient can interact with the doctor via remote teleconference. Such teleconferences reduce the need for the patient to be hospitalized, and also the necessity of traveling between the hospital and home for rehabilitation purposes. In the paper, we describe the progress in wireless multimedia towards mobile telemedicine.

2 Method

Generally Mobile telemedicine technology is a wireless remote medical technology that incorporates a combination of biomedical engineering, electrical engineering, and computer science; the technology also includes various advanced medical services. This technology is unrestrained by the limitations of time and space, and allows family doctors to become more actively involved in the daily lives of their patients, as shown in figure 1. In a mobile telemedicine system, medical signals are processed, and tasks based on biomedical engineering, electrical engineering, and computer science are performed. Examples of such tasks include data compression to reduce the volume of transmitted data; data encryption to protect the privacy of the patients [25-27]; and obtaining instantaneous frequency data, using approaches such as the Hilbert-Huang Transform (HHT), in order to carry out time or frequency domain analysis of the electroencephalograms (EEG) of alcoholic patients. As shown in figure 1, clinical media contain information in various forms such as text, graphics, audio signals, images, and video signals. They can also contain information in the form of static data, for example, X-ray images, clinical EEG signals, or the results of ultrasonic scans. Therefore, it is necessary to identify and classify these clinical media. We should acquire clinical signals using various low-cost and high-accuracy medicine clinical detection instruments, and then transmit these clinical signals via wired or wireless multimedia communication networks. Telemedicine using wired multimedia networks has been commonly used and well studied in the past. Here, we discuss the progress in wireless multimedia communication towards mobile telemedicine. Mobile telemedicine is an extension of wired telemedicine. There have been increasing advancements in wireless multimedia network technologies, if such advanced technologies can be used in combination with clinical technologies, the resultant technology, so called mobile telemedicine, can be used unconstrained by the limitations of time and space. The primary objectives of mobile telemedicine are as follows digitalization of the media, wireless transmission, personal health monitoring, and facilitation of remote disease diagnosis. Examples of wireless transmission platforms include Bluetooth, ultra-wideband systems, wireless local area networks, mobile satellite communication systems, and ground cellular mobile communication technologies such as GSM, GPRS, 3G cellular telephony, and WiMAX. When designing a mobile telemedicine system, it is important to consider the quality-of-service parameters of wireless multimedia transmission platforms, such as transmission distance, data transmission rate, and bit error rate (BER). Moreover, it is important to ensure that the selected wireless

transmission platform does not induce electrical magnetic interference in the detection instrument, as this could adversely affect the accuracy of detection. Usually, measured values of clinical data, such as cardiographs, clinical EEG signals, pulse, blood pressure, history, and body temperature are expected to have a maximum transmission BER of 10^{-7} ; image signals such as digital X-ray films are expected to have a maximum BER of 10^{-4} ; and audio signals, a maximum BER of 10^{-3} . Next, we discuss the coverage range and data transmission rates of the abovementioned transmission platforms. The coverage range and data transmission rate of Blue-tooth are within 10m, and 1-2 megabits per second (Mbps), respectively.; whereas those of ultra-wideband systems are 10m, and up to a few hundred Mbps;

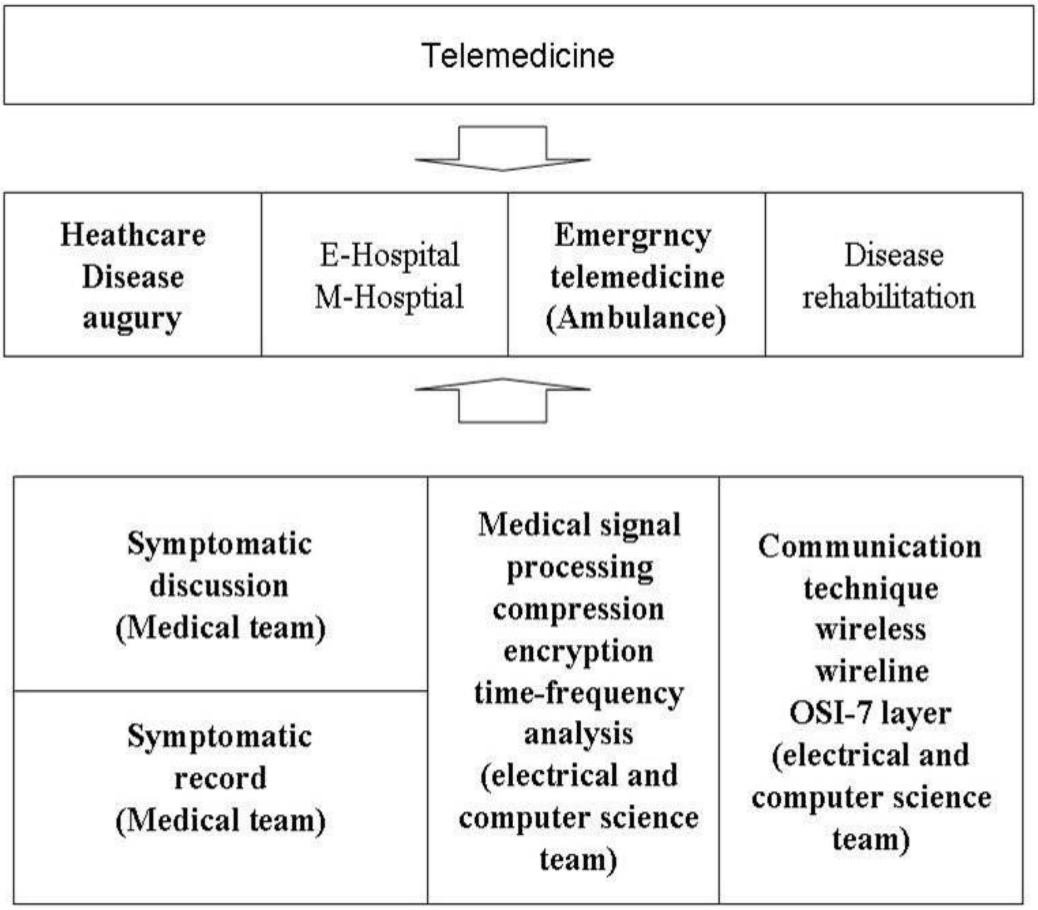

Figure 1 The concept in mobile telemedicine

and those of wireless local area networks are 100m, and up to a few hundred Mbps. Blue-tooth, ultra-wideband systems, and wireless local area networks are all suitable for

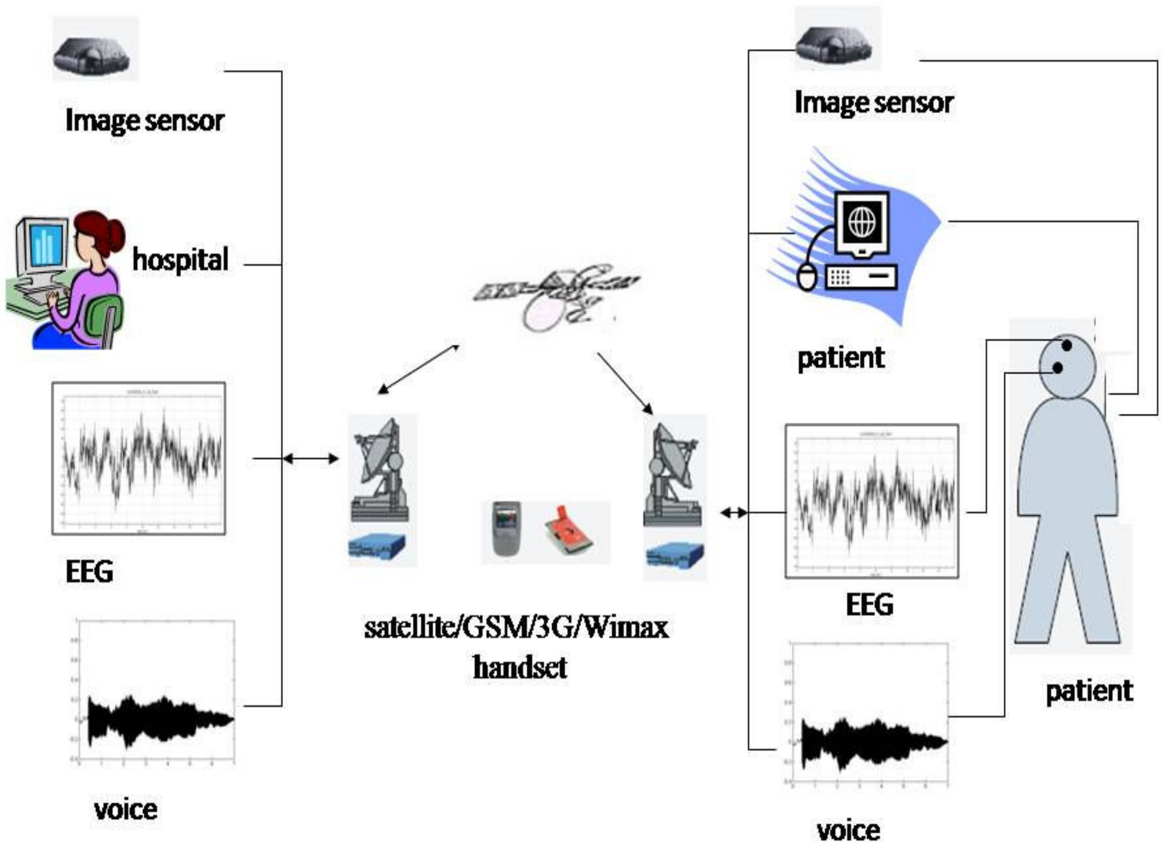

Figure 2 The transport architecture in mobile telemedicine

indoor applications. The coverage range and data transmission rate of GSM are 50km, and 9.6 kilo bits per second (kbps); whereas those of GPRS are 50km, and 100 kbps; those of wideband code-division multiple-access (WCDMA) are 50km, and 384 kbps; and those of WiMAX are 50km, and up to10 Mbps, respectively. Finally, the coverage range and data transmission rate of a mobile satellite communication system are 500km, and a few kbps to a few tens of Mbps. GSM, GPRS, WCDMA, WiMAX, and mobile satellite communication are accordingly suitable for high-speed outdoor applications. Figure 2 shows an example of the transport architecture of a mobile telemedicine system, i.e., a medical detection instrument. The system includes an EEG instrument, a microphone, and an image sensor, and it transmits data to a hospital via a satellite or cellular mobile communication system. Doctors and patients can participate in

interactive teleconferences and conduct discussions on the basis of information transmitted in the form of clinical EEG signals, the characteristics of clinical signals of time-frequency analysis, etc. Clinical signals that are currently commonly employed in recent times include X-ray images, cardiographs, EEG signals, patients' histories, body temperatures, pulse, CO_2 concentration, ultrasonic images, and blood oxygen concentration. Figure 3 shows an example of the mobile telemedicine concept. In section III, we describe a Ka band multi-code CDMA-based transport used in mobile telemedicine [30].

3. A Ka Band Multi-code CDMA-based

Transport Architecture Used in Mobile Telemedicine

Figure 3 An example in mobile telemedicine

A multi-code CDMA system is one of the various multiple access techniques for future mobile communication. It provides multi-rate multimedia services by varying the number of spreading codes assigned to each user in order to meet the throughput requirement. Figure 4 illustrates our previous work on a downlink Ka band LEO multi-code CDMA mobile medicine system [30]. The mobile telemedicine system can provide (i) measured blood pressure and body temperature; (ii) medical signals measured by an electrocardiogram (ECG) device; (iii) mobile patient's histories; and (iv) G.729 audio signals, MPEG-4 CCD sensor video signals, and JPEG2000 medical images. Presentation of pre-orchestrated medical information requires synchronous playback of time-dependent medical data according to some pre-specified temporal relationship. At the time of the creation of medical information, a patient needs a model to specify temporal constraints among various data objects which must be observed at the time of playback. The model, which is called the Object-Composition Petri-Net (OCPN) [32], is able to describe the temporal relationships for the various components of a telemedicine document, including its type, size, throughput requirements, and the duration of its presentation. Blood pressure, body temperature, and ECG signals are integrated in data bit streams. These data bit streams give high error protection. The 64-kbps microphone audio signal is compressed by G.729 to 8-kbps audio bit streams. These audio bit streams give low error protection. The 600-kbps CCD sensor video signal is compressed by MPEG-4 to become a 64-kbps

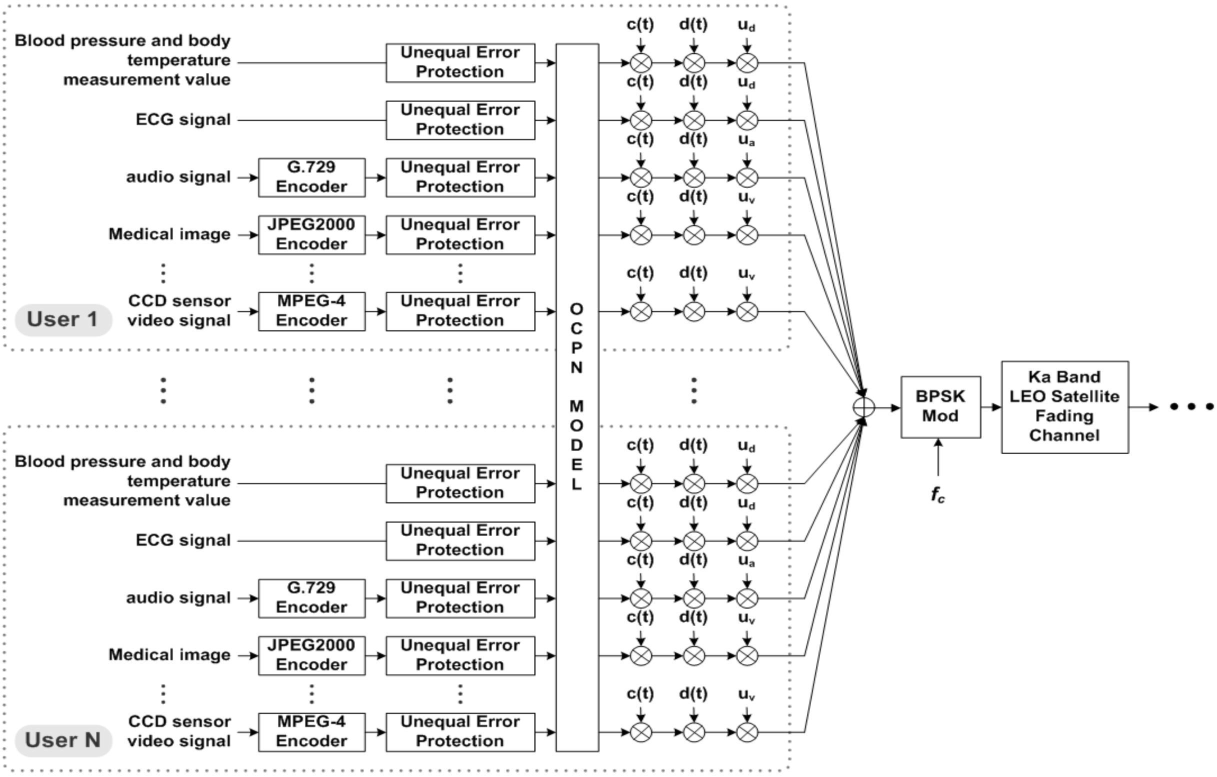

Figure 4 A downlink Ka band LEO multi-code CDMA mobile telemedicine system.

video bit stream. The 3340-kbits X-ray medical image signal is compressed by JPEG2000 to form a 128kbits image bit stream. These image and video bit streams give medium error protection. The image, video, audio, and data bit streams are inserted into the OCPN models. There are three types of channel in our transport architecture for the transmission of audio, video, and data bit streams; the audio, video, and data channels, respectively. The total number of audio, video, and data sub-channels is calculated from the OCPN models. This is because the OCPN models indicate transmission throughput of concurrent medical objects. In our system, the length of the Walsh code c(t) is 1024 and is concatenated with $2^{42}-1$'s PN Code d(t) to form the spreading codes. The transmitted medical signals contain outputs of an ECG detector, blood pressure values, body temperature values, G.729 audio signals, JPEG2000 medical image signals, and MPEG-4 CCD sensor video signals. Patients can consult doctors interactively through a platform. In order to meet the demands of the requisite transmission BER of a mobile telemedicine network in different weather conditions, we use a down-link power assignment mechanism for different media sub-channels with different transmission power weightings of audio, image, and data signals. The system is described in detailed in our previous studies [30]. In this design, a multi-code voice virtual channel is used to deliver G.729 voice signals. Eight multi-code video virtual channels are used to deliver MPEG-4 CCD sensor video signals, and another video channel is used to transmit JPEG2000 X-ray medical images. The image channel is different to the video channel in that the former is repeated every 16 seconds to deliver the 128kbits of compressed data. We assume that there are many other patients, such that the total number of channels is 700(300 video channels, 300 audio channels, and 100 data channels). The reference signal to white Gaussian noise is 10 dB. A Gaussian distribution with mean 0.7439, variance 0.0097 and a Rayleigh distribution with variance 0.0192 are used in the simulation to represent rain fading and multipath fading effects. Simulation results show that when transmission power weighting for audio, video, and data signals are 0.1033, 0.2742, and 0.5927, respectively, in light rain fading, the corresponding BERs are 0.00091, 9.7×10^{-5}, and 9.96×10^{-8}, respectively. These are close to the required values $10^{-3}, 10^{-4}$, and 10^{-7}, respectively. The results of received telemedicine signals in the unequal error protection multi-code CDMA mobile telemedicine system with downlink power assignment mechanism are as follows. The mean square error between the received and the original electrocardiogram signals is 0.0061, and the mean square error of the original and the received audio signal is 3.39×10^{-4}. This is clearly within the range of human hearing. The peak signal-to-noise ratio (PSNR) value of this received and decoded JPEG-2000 medical image is 38.11dB. The average PSNR value of the received MPEG-4 CCD sensor video signal is 36.31dB. On the basis of these simulations, it is evident that by using power control the required QoS for a mobile telemedicine system can be achieved.

4. Discussion

There is no doubt that in the future, we will witness an era of 'ubiquitous mobile telemedicine'. Such a technology is expected to bring about revolutionary changes in the fields of medicine and engineering. These changes will be accompanied by ample opportunities for business, scope for early diagnosis of diseases, and enhanced medical services. Moreover, manufacturers of clinical equipment are expected to respond favourably to such changes. Choi et al. [2] discuss the importance of formulating new standards for remote healthcare and the status of currently available standards. We are interested in ways of combining advanced, high-speed, and reliable mobile multimedia networks with clinical application, and in enhancing medical services. In particular, we are interested in discussing standardization of telemedicine codes related to medical services, health care providers, telemedicine conference, and information security management. In mobile telemedicine, advanced, high-speed, and reliable wireless communication technologies are used to transmit information on the patient's health and medical history. The US Department of Health and Human Services (DHHS) has reported that there are approximately 400 telemedicine teams conducting experiments across the US. However, mobile telemedicine services have yet to be standardized worldwide. Many hardware devices and software programs developed by telemedicine teams are not popularized. This is because they are inefficiently link or because they are too expensive. The American National Standards Institute, (ANSI) is currently attempting to formulate standards for telemedicine, for example, 'health level 7, HL7'[3]. HL7 is a standard that mainly discusses the management and healthcare of patients in telemedicine, and also discusses ways to design a telemedicine system. There is a high demand for emergency medical rescue and healthcare monitoring in aircraft, ships, and in isolated terrains such as islands, mountainous areas, and tropical rain forests. Doctors can use a telemedicine system to hold interactive telemedicine conferences with patients in such locations, and can access the patients' clinical data via seamless satellite multimedia communication technology, without the limitations of time and space. The data transmission rate of second-generation mobile satellite communication systems is 10-100kbps; for example, that of the international maritime satellite communication system, INMARSAT, is 24 kbps. Further, the data transmission rate of third-generation mobile satellite communication systems is 100kbps-100Mbps. Maritime telemedicine systems include Engineering Test Satellite No. V (ETS-V)[4], MERMAID[5], Advanced Communication Technology Satellite (ACTS) [6], TelePACS[7], MEDI[8], satellite wideband code division multiple access, (SWCDMA)[21], and satellite orthogonal frequency multiplexing access, SOFDM [22], and etc. As mentioned earlier, ground cellular multimedia communication technologies such as GSM, PHS, WCDMA, and OFDM can be used in mobile telemedicine; examples of their application include AMBULANCE[9], wireless application protocol (WAP) [10], and Airmed-Cardio[11]. Further, the Teletrauma telemedicine system instantly transmits video images, clinical images, and cardiographs of patients for accelerating preliminary preparations in hospitals[12]. Universal mobile telecommunications system (UMTS) channels transmit information useful for mobile telemedicine[13], mobile telemedicine systems designed on the basis of the WiMAX [14], and multi-code CDMA [23]. Examples of mobile telemedicine systems that can be used over short distances are Bluetooth telemedicine technology [15], body area network [16], and 802.11 b/a/g WLAN, which can be used as wireless telemedicine systems [17], and ultra-wideband multimedia system, which is an advanced telemedicine technology [24].

5 Conclusion

Advanced technologies of the 20th century, such as the internet and mobile communication, have made human lives considerably easier. The combination of these two technologies has given rise to wireless multimedia networks, an extension of which is the mobile telemedicine systems. The important factors to be considered when designing mobile telemedicine systems include the transmission BER, data transmission rate, electrical magnetic interference, data encryption, and the portability and size of the transmission system. We can use mobile telemedicine systems for emergency clinical rescue, and alerting doctors to a patient's disease and rehabilitation. Currently, there exists a dense worldwide mobile telemedicine network; this network is a result of the combination of the following technologies: (1) mobile satellite multimedia communication separately used in conjunction with maritime medicine, and aviation medicines, and (2) a short distance wireless telemedicine system used in conjunction with ground cellular mobile telemedicine technologies such as Bluetooth, wireless local area network, and ultra-wideband communication technology. Finally, we would like to emphasize on the point that the R&D process of these mobile telemedicine systems is similar to that of pharmaceuticals. In the future, we will describe a mobile telemedicine system with application in the real-time diagnosis of the symptoms of epilepsy and in voice rehabilitation.

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