

TELEVISION AS MEANS OF TELEMEDICINE

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ABSTRACT

The authors describe peculiarities of fast developing in last decades field on the junction of medicine and telecommunications known as telemedicine, telehealth or e-heals. The most information is borrowed from medical sources because authors suppose that technicians do not often view these sources. The review of telemedicine means contains list of main technical, and first of all telecommunications, equipment which usually is used in telemedicine. Generalized classification of television means of telemedicine systems is proposed. Possible structure of telemedicine system with scanning optical stereomicroscope for microsurgical operations is considered.

INTRODUCTION

A search with Internet performed at the beginning of March 2002 gave 220,000 references concerning literary sources with key word “telemedicine” in title. Most of them relate to last two decades. So considerable number of publications is good proof of interest to this sphere. Telemedicine now is not only an attractive idea. It is practiced in all 50 states of the USA and in a lot of other countries, being a particular advantage for developing countries; more than 350 telemedicine programs exist nationwide; already more than 10,000 telemedicine consultations exist [1]. We would like to note that the telemedicine is the object of attention in Ukraine [2]. Our aim is to propose with this article brief review, knowledgeable on those representatives of telecommunication community who for some reason or other had no a possibility to be familiar with this field.

TELEMEDICINE

There are several determinations of the term “telemedicine”. For example, in accordance with [3] telemedicine is “the use of medical information exchanged from one site to another via electronic communication for health and education of the patient or health care provider and for the purpose of improving health care”. Some more determinations borrowed from [1,4,5,6] are: distance consultation, examination, diagnosis and treatment; provision of the health care services in an interactive fashion with the caregiver remote from patient; use of telecommunication technologies to provide medical information and services; providing access to medical care for consumers and health professionals via telecommunications; a term that encompasses any medical activity involving an element of distance. Some more terms with the same meaning as telemedicine are telehealth, online health, e-health. It is easy to see that not in all mentioned above determinations of term “telemedicine” the words “distance” and “remote” are used. At the same time typical cases of telemedicine usage are such as ship to shore, ship to ship [7], remote offshore island [8], battlefield telemedicine and so on. Subfields of telemedicine that are usually mentioned are as follows: telepathology, teleradiology, teletraumatology and battlefield medicine, telepsychiatry, teledermatology, telecardiology (teleechocardiography, teelelectrocardiography), telesurgery (teleneurosurgery), teleoncology, telerheumatology, teleultrasonology, teleophthalmology. In one’s turn telesurgery can be categorized as follows [9]: telepresence surgery (uses a technical facilities to transmit the surgeon actions at a surgical workstation to the operative site at the remote surgical unit with force feedback input to transmit to the surgeon the tactile environment of the operative field), telementoring (an experienced surgeon acts as a preceptor for a remote inexperienced surgeon by observing the surgeon via interactive video), telerobotics (remote control with a robotic arm without force feedback).

The telemedicine can be divided on two types: “store and forward” or asynchronous telemedicine, and “real-time” or synchronous telemedicine. The first one envisages that a technician or physician of one site acquires and stores data, e.g., on a telemedicine computer. This file can be then send to the computer at a remote site for later review. Alternatively, both sender and receiver can view the necessary data or procedures simultaneously if real-time mode is used. Both store and forward and real-time modes have advantages and shortcomings [10]. It is evident that, e.g.,

telesurgery demands real-time mode exceptionally. Telemedicine is a tight interlacing of several aspects, namely medical, technical, social, legal (see, e.g., [11]). Of course, there are many problems in these fields

EQUIPMENT

Telemedicine system requires a lot of different technical means. These means can be divided on three main parts: 1) means established at the patient side; 2) means established at the physician side; 3) connecting telecommunication channel between these two sides. In any case these three parts must ensure interactive mode of system operation. Equipment for telemedicine needs have been developed in accordance with general development of telecommunication, computer and medical apparatus technologies. This equipment can be presented as a pyramid of some main telemedicine means from simplest ones, disposed at the bottom of pyramid, to most complicated however used rarely, disposed at the top of the pyramid. The direction from bottom to top approximately corresponds also to temporal development of means. Usage of mentioned means permits to exchange visual (data, diagrams, texts, still images, live images, black-and-white or color) and audio information between physicist on the one hand and patient and his (her) family on the other hand. Both analog and digital (computer based, Internet) technologies are used. The simplest means are telephone, fax and e-mail. It is evident they permit to realize consultation only. The next position in pyramid is occupied with videophone, that is TV means appear, and the several kinds of diagnosis become possible. Some higher we can find more complicated TV equipment, such as TV cameras, video recorders, microphones and loudspeakers. More dip diagnosis can be proposed if majority of sensors and analyzing and registration devices are used: sensors of heart rate, blood pressure, central venous pressure, arterial saturation, rhythm analysis, stethoscope, ophthalmoscope, otoscope etc. Special kinds of sensors are used as the elements of smart alarms systems for critical patients. At the tope of our pyramid the most complicated kind of telemedicine appears – telesurgery with executive system, auditory environment visual (stereo) environment, tactile environment and medical instrumentation. There is the reason to notice that the use of computer technologies is the best way to security of individual health information ensuring.

Connecting communication channel can be of any kind used in telecommunication in general. The simplest and most spread is, of course, telephone line. Another variant of wire communication is using of electric power grid. Some types of modem must be used for these links, however speed of transmission with this kinds of communication is very low (usually 14.4 Kbps up to 56 Kbps). It means that only audio link can be realized in real-time mode. Transmission of images is possible only in asynchronous mode and may request long time up to hours for such images as echocardiogram. Better results can be obtained with Integrated Service Digital Networks (ISDN) that operate at 128 Kbps. Terrestrial lines (T1) operate at the speed 1.54 Mbps. Synchronous Digital Subscriber Lines (SDSL) as well as asynchronous (ADSL) that are used for high-speed Internet connections are very convenient because of their high speed (128 Kbps to several Mbps) and low cost. At last wireless communication lines, including satellite links (speed is equal to 24 T1 lines), have high speed, and they are indispensable in the cases of large distances and moving objects.

TELEVISION AND TELEMEDICINE

It is evident that almost all kinds of telemedicine services presuppose using of images – black-and-white or color, binary or halftone, still or live, 2D or, as in telesurgery, 3D, real-time or in asynchronous mode. It seems that telemedicine (excepting such primitive stage as telephone) started in the late 1950s from television that in interactive form was used for medical consult between a state mental hospital and Nebraska Psychiatric Institute with a microwave link usage [4]. Now, more than 50 years later, we continue to use television, leaning on all its achievements. We would like to underline that computerized systems in their part connected with image acquisition and image display are also based on TV principles and means.

In Fig. 1 a generalized classification of television means used with telemedicine is showed. Communication channel is not represented in the figure. A character of links among boxes shows that large variety of system structure is possible. It is necessary to point out that in all digital cases the system is rather analog-digital because as minimum the input unit(s) and output unit(s) are necessarily analogous. Three main groups of means are then picked out: RSC – radiation-to-signal converter; SLC – signal-to-light converter; R – recorder. The lower boxes show how these means can be performed. In these boxes CCD is Charge Coupled Device array, CMOS is image sensor based on metal-oxide-semiconductor technology, CRT is a Cathode Ray Tube. Two and more TV cameras are sometimes used at the patient side; one of them serves for overall observation and the other(s) – for observation of local objects including patient and instrumentation. All cameras are usually color. If high spatial resolution is necessary, TV scanners can be used what concerns, e.g., echocardiograms or radiographs. Of course, they act in asynchronous mode. Mentioned in the box “Optics” zoom is

controlled distantly. Box "Screen" contains three groups of screens, picked out in accordance with their size. Small size screens (2-5 cm in diagonal) can be used in head-mounted display units, mid size screens (40-50 cm) are most used for different purposes, large size screens (more than 1m) are convenient in training. Other items of boxes in Fig. 1 are rather understandable without explanation.

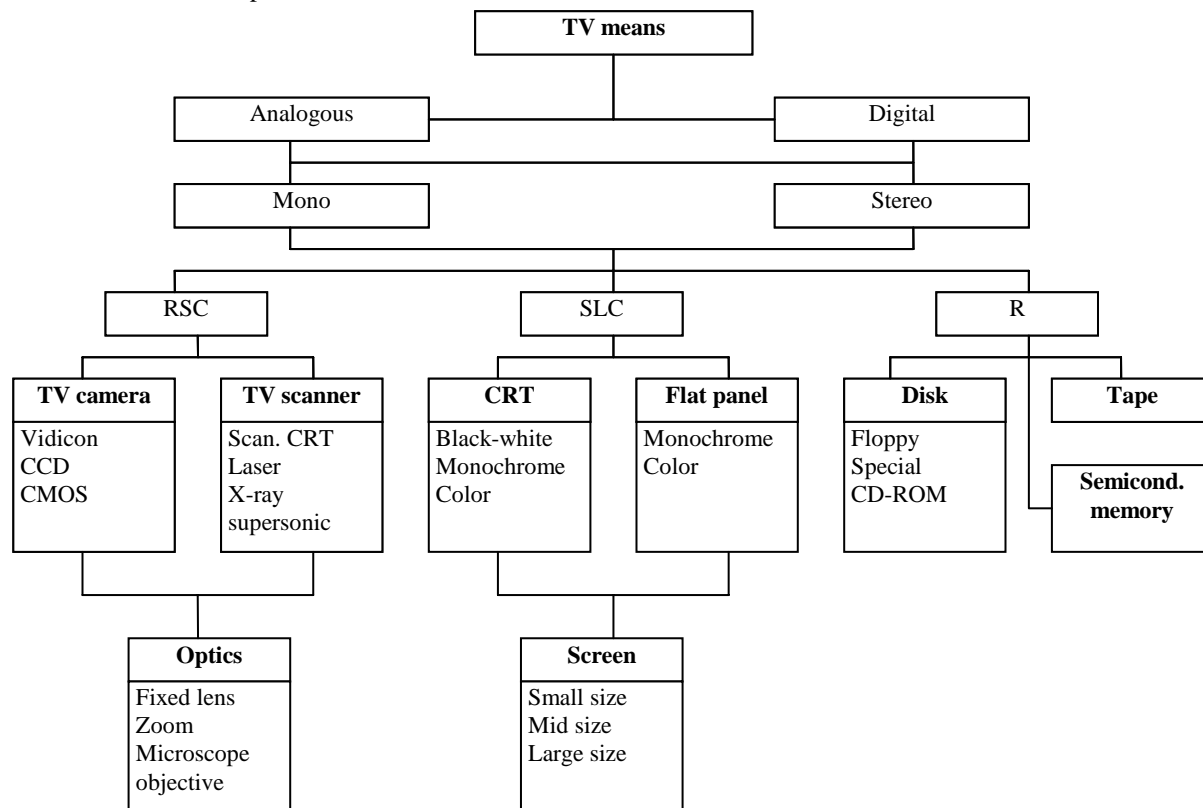


Fig. 1. A generalized classification of television means used with telemedicine

TELEVISION MICROSCOPY AND TELEMEDICINE

Television microscopy is a temperamental division of both applied television and telemedicine. Some aspects of scanning optical microscopy usage in telemedicine were discussed by us in [12]. Two approaches are used in television aspect of television microscope design - cameral and scanning. With the first type an ordinary optical microscope is supplemented by the television camera that, in essence, carries out functions of an eye. In the second one a principle of scanning of the microobject by light probe is used with further transformation of the reflected (or passed through) from object light onto electrical video signal that after processing creates the image of microobject on the screen of monitor. Both ways have some advantages and shortcomings nonetheless both can be successfully used for remote diagnostics and medical consultation, medical training, microsurgery. Large scale of magnification is usually typical for these applications. On the contrary, comparatively small magnification is used in the cases of microsurgical operations. The quality of operations fulfilment can be improved with stereomicroscope usage. Two special CRTs with high spatial resolution and low level of screen noise are used as sources of scanning light beams (probes). A generalized structure of possible variant of telemedicine system with stereomicroscope usage is showed in Fig. 2. Scanning Stereo Microscope (SSM) is included in the structure. It is presupposed that a surgeon performs an operation with eye under consultation of most experienced surgeon, and trainees may view the process of operation. Thus four main part of the system can be picked out: surgical room SR, remote consultant's site CS, remote training room TR, direct telecommunication channel DTC and feed-back telecommunication channel FTC. Other abbreviations used in Fig. 2 are as follows: VA - video amplifier, ADC- analog to digital converter, DAC - digital to analog converter, E - eye, Sp - loudspeaker, S - surgeon, M - microphone, LPC - local personal computer, MP - DMP - multiplexer - demultiplexer, TVC - television video camera, TVM - television monitor, VC - video compressing, DC - decompressing of video, LS - large screen, P - projector, DMP - demultiplexer, RPC - remote personal computer, C- consultant. Monitors of LPC and RPC work in stereo mode based on eclipse method. Accordingly surgeon and consultant should to apply eclipse glasses.

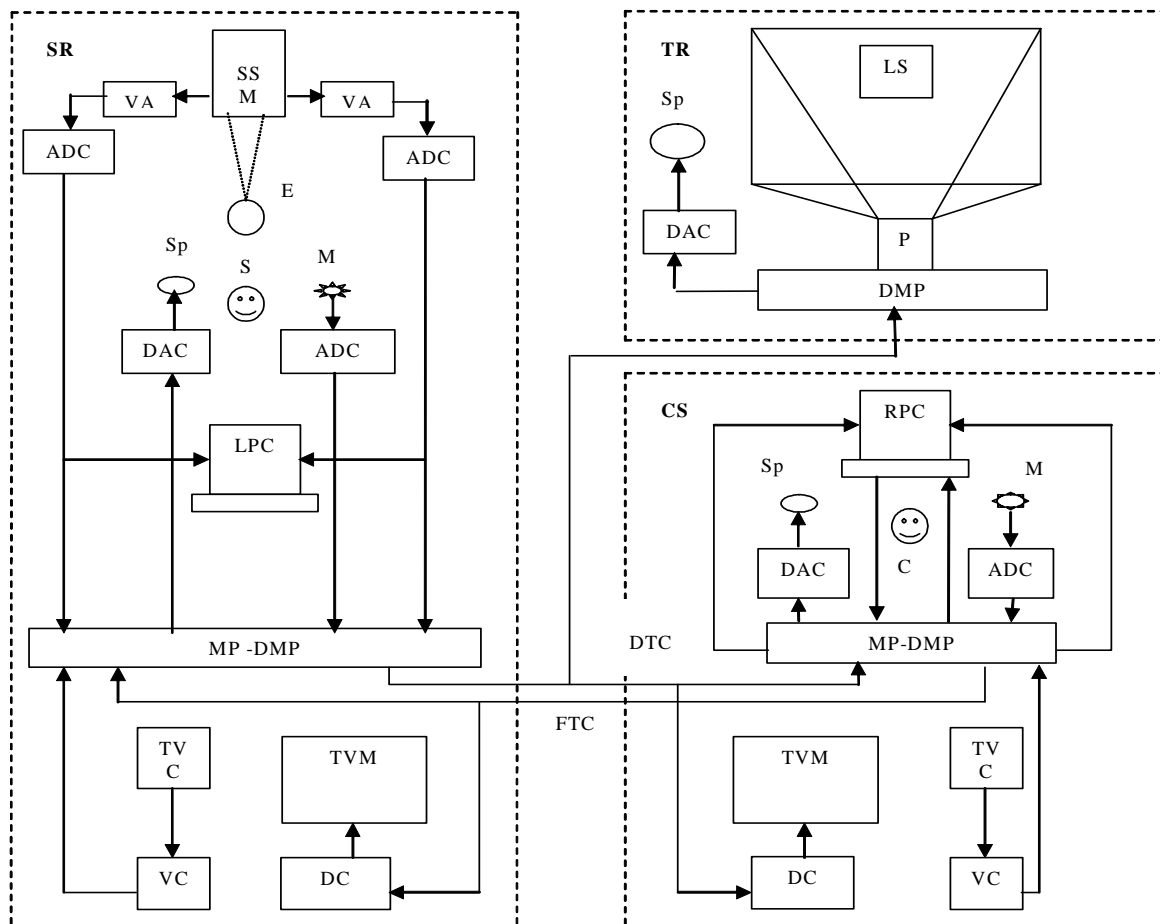


Fig. 2. A generalized structure of possible variant of telemedicine system with scanning stereomicroscope

CONCLUSIONS

Telemedicine today is fast developed field of medicine and telecommunications. Despite the fact that telemedicine is not enough cost-effective, it has success in many branches of medicine. Television in its different sorts plays very important role in telemedicine because of possibility to ensure the telemedicine procedures with several types of images, including microscopic, that gives exclusively useful information for all participants of telemedical action.

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