[Document Identification Number : DIN01022801]
Digital Color Imaging in Biomedicine, 1-5, 2001.02.28
<http://biocolor.umin.ac.jp/book200102/din01022801.pdf>

Rapid Progress of Multimedia in Medicine and the Increasing Importance of Color

Hiroshi TANAKA[*1] (tanaka@cim.tmd.ac.jp)
[*1]Center for Information Medicine, Tokyo Medical and Dental University

Abstract:

The rapid spread of information technologies in medicine is notable as follows: (1) these are multimedia-based with intensive use of open networks, (2) the performance of these technologies is catching up with the level of medical requirements, (3) the legal bases for their use are going to be well prepared owing to the existence of the adequate social consensus, (4) the standardization of medical records and medical procedures is ready to be established.

Given this situation, some rules for transferring color data are urgently required in medical fields because inaccurate reproduction of colors of medical images may lead to erroneous diagnoses. For this purpose, (1) a focused discussion group should be established by various medical professions and specialists of related technologies, (2) we should know the concept of 'diagnostic equivalence', which means that two displays which reproduce colors differently are considered equivalent if the same diagnosis can be made observing a medical image reproduced on each of them, (3) the illuminant conditions at which the image was acquired and the specifications required for accurate image reproduction should be transmitted together with the digitized images.

1. Present status of the computerization of medicine -rapid progress-

1.1 Medical information systems are now going to develop with key concepts of multimedia technology

Recent advances in the application of multimedia technology in the fields of medical care have made it possible to digitize a very broad range of medical information and treat it in a uniform way. With these technical advances in the background, the concept of an "electronic patient chart", which has so far contained only a very restricted range of patient medical (digital) information, such as clinical laboratory test results and disease names, is going to have a substantial meaning in medicine. The impact of multimedia technology on medicine can be seen in various subfields of medical informatics. Let's take the example of the communication of medical information. Stimulated by the rapid

spread of the Internet, the infrastructure for a future-oriented communication technology, the so called "information super highway" (high-speed multimedia network or Gigabit network), which is expected to support tele-medicine and at-home health care in the near future, is now becoming rapidly equipped on a nationwide level. Alternatively, we could take the other example of medical images. Progress in image processing technologies used in medicine has made realistic a fine reconstruction of 3D patient images nearly a routine procedure at some advanced hospitals, and the spread of virtual reality technology in medicine is generating a new field of medicine which may be called, "virtualized medicine".

Not only in the fields of medicine but also in information technology (IT) itself, a dramatic change featuring the key policies of openness, multimedia and networking is now occurring. The aforementioned trends in medicine are just the reflection of these essential innovations in medicine, which are now going on in the field of the information technology.

1.2 The performance of information technologies is now catching up with medical requirements

Medical care, especially medical diagnosis has made the best use of patient "multimedia" information since its origin. We can enumerate various media which convey medical information: coding systems for diseases or medicines, numerical figures representing the serum laboratory test results, waveforms of ECG, still pictures of X-rays or CTs and motion pictures of ultrasonography or cineangiography. Hence, we could say that medical care is originally of a multimedia nature.

But until recent years the computerization of medical information has taken place only for character or numerical data because of the insufficiency of both digitization technologies and computer performance, so that patient information can hardly be said to be totally digitized. But recent advances in multimedia technology have made it possible to digitize the rest of the patient information and we can now store and display almost the full range of patient information on the same physician's workstation.

It can be said that the communication field is in the same situation. Already in the 1970s, several trials of tele-medicine had taken place; for example, the ECG data of a patient on an isolated island was transmitted to a central hospital to have the severity of the heart disease assessed. But since most patient medical information is of a multimedia nature, the information, which can be transmitted over common telephone lines, is restricted very much. To conduct tele-medicine in a genuine sense, a broadband optical fiber network enabling ATM multimedia communication should be equipped to transmit all kinds of patient medical information including digitized motion pictures, sometime those in 3D.

1.3 Legal and social bases supporting computerization of medicine

As for the legal and social bases supporting the computerization of medicine, governmental organizations in Japan such as the Ministry of Health and Welfare (MHW) have become rather positive towards the computerization of medical care and are promoting both the electronic patient record project and the standardization of medical terminology such as classification of diseases. Also, the MHW has moved to start a feasibility study on tele-medicine. To promote this computerization, a revision of the physicians' law was set forth along with computerization of medicine. Physicians were allowed to describe the patient charts with word processors according to a directive of the MHW issued in 1988. A common standard for medical imaging such as how to store

medical images onto an optical disk was formulated in a MHW notification issued in 1994.

Under a MHW directive issued in 1997, the legality of tele-medicine was acknowledged as a complement of conventional medical consultation in which patients meet physicians directly. Recently, the electronic patient record was officially acknowledged on the condition that it satisfied the principles of genuineness, readability and permanent conservation. Thus, all the conditions necessary for realization of multimedia-based computerization of medical information have been satisfied. Within five years the full-scale computerization of medical information will be accomplished if these trends maintain their present pace.

1.4 Standardization of the description of pathological status and medical treatments as a basis for the computerization of medicine

Besides satisfying the aforementioned technological and social requirements, there are other important conditions necessary for the spread of computerization in medicine; that is, those which are related to "standardization" of medical information.

As for standardization, there are various levels of it: the uppermost level is the standardization of the description of the pathological status and medical treatments. When we standardize terminology and formats for medical descriptions we can share the information on pathological status and treatment histories among different medical facilities and provide a smooth integration of medical treatments to the patients. To standardize the description of patient information, not only the standardization of related terminology but also a standardized record format like DICOM, which should be compatible with the context of the clinical information, are required. Furthermore, as seen in patient care maps, such standardization must give a common description framework for describing the various processes of medical care.

Of course, other more technology-oriented levels such as the documentation language, XML and communication protocol like HL7 for medical content, or more basic protocols such as TCP-IP should be also standardized.

These various levels of standardization provide the basis for computerization of medicine, and the fact that there is a hierarchy in them has been acknowledged in the medical world. Even if standardization is lacking for only one of these levels, we will lose its overall effects.

2. What should be done for the standardization of the medical color information?

2.1 The importance of color information and necessity of a medical color consortium

Despite the above-mentioned dramatic progress of multimedia information technology and its rapid spread into the medical profession, discussions on medical images so far have concentrated on sufficient spatial sampling rate and sufficient grayscale gradations for black and white pictures such as X-ray, CT and MRI. But the problems concerning the transmission of medical color images such as endoscopic and dermatological images have not been discussed intensively. In this network age, the need for real-time communication of diagnostic/therapeutic images is large in tele-medicine or tele-home-care. "Tele-existence" is the central concept of medical care in this network age. With these factors in

the background, advanced studies on real-time transmission of pathological, endoscopic and dermatological images through information networks are already being conducted. Concerning the transmission of color images, the reproducibility of the color information is a key problem in various developing stages of color reproduction technologies, from color synchronization to the multispectral reproduction of color information. But there is no appropriate venue to discuss the problems of color reproducibility in medical telecommunication, for example, the extent to which the color information should be exactly reproduced. Hence, there is an urgent necessity to establish an organization or consortium where we can discuss medical color problems occurring in all fields of medicine and exchange the knowledge studied in each field of medicine.

2.2 The principle of standardization of medical color: "diagnostic equivalence" [1,2]

The requirements regarding the precision of reproduced colors after transmission in telemedicine might vary according to various kinds of diagnostic situations; that is, the required reproducibility might be different among pathological, endoscopic and dermatological diagnoses. Hence, oversimplified or excessively restricted standardization should not be applied to medical color reproduction or compensation. As announced in the recent MHW notification about the electronic patient chart, the government would not impose detailed concrete requirements on standardization, rather, it should only define the principles essential for medical computerization, which are genuineness, readability and permanent conservation, as for the electronic patient chart. These kinds of principles will provide the guidelines for the communication of medical color information.

The principle of the communication of medical color images is, we think, that the diagnosis based on direct observation of an original color image and one made by observation of a digitized image that was transmitted through the network and reproduced on a display must be identical. This principle might be called "diagnostic equivalence". How can we prove this diagnostic equivalence? Classically, it will be verified through sensitivity-specificity analysis between the direct diagnosis and the diagnosis made through the network. Comprehensive studies for determining the range of statistical variation within which diagnostic equivalence could be defined are needed. For this purpose, collaboration between specialists of the color technology and professionals specialized in diagnosis of colored medical images must be established. The application of the diagnostic equivalence will clarify the required accuracy in color reproduction or the diagnostic tolerance to the inaccuracy when colored images are used for medical diagnosis. From this point of view, we should prepare guidelines for medical color image communication.

2.3 What should be standardized in medical color images?

In the DICOM standard, the medical context in which medical images are obtained is to be described. To complete the standardization concerning the communication of medical color information, not only the medical color information itself but also the exogenous information such as the situation in which the information is collected and instructions for reproducing exact colors using various equipment should be clearly defined. Hence color reproducibility will be guaranteed only when the color information of images is never altered during transmission and the aforementioned exogenous information is attached to each corresponding image and transmitted with it.

The strictness of standards for color reproducibility should be determined separately according to the medical classification of each image, from the standpoint of diagnostic equivalence. In the future, this information would be commonly transmitted together with

the image information. In any event, flexible discussions on the basis of these principles are necessary for medical color image standardization.

This monograph is the first trial of collaboration between color image specialists and medical professionals in order to study the various aspects of standardization for telecommunication of medical color images.

References

1. Masahiro NISHIBORI : Color Representation of Digital Imaging in Medicine. XX World Congress of Pathology and Laboratory Medicine, 167-172, 1999 (http://mn.umin.ac.jp/work19990921.html)

2. Masahiro NISHIBORI : Standardization of Color in Medical Imaging. Japanese Journal of Medical Informatics 20(2) : 165-167, 2000 (http://mn.umin.ac.jp/work20000603.html)