A Strategic Road Map of Medical Application of Multispectral Imaging

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Abstract

Multispectral imaging will become a great impact on medicine in so many aspects that the way to reach that status does not seem a simple straight road, but seems a complicated network that has many dead ends. A strict prospect that what a concrete medical problem will be solved by a specific multispectral technology is indispensable for wining a goal. And it is also important to understand that medical usefulness is not necessarily in proportional to the degree of advancement of technologies applied for medical equipment.

Two major products of multispectral imaging will be (1) a digital image each pixel of which has spectral reflectance and (2) a digital image that has very precise color reproduction. The product (1) will lead to a new morphological diagnostic method beyond human visual perception and a discovery of the mechanism of human color recognition. The product (2) will lead to a large improvement of diagnostic reliability of digital images and the much wider spread of medical use of it. The former will require large investment and bring very advanced effects in a few specific medical sub-fields, and the latter will bring very practical and general effects in medicine and will cost smaller.

Introduction

Research and development of a new medical equipment is a risky enterprise. Usually a new technology devised in the engineering field is applied for other fields than medicine at first, then the product is introduced to medical use. In our opinion, many technologies has lost their true medical virtue through such detours and users in the medical field have been able to enjoy only a few part of their benefit. Multispectral imaging is surely one of the most hopeful technologies and it should not follow the same unhappy course as precedent ones. Through intensive inter-disciplinary research collaboration between engineering and medicine, the author and co-researchers learn actual situations of each other to draw a road map of medical application of multispectral imaging. In this paper, the road map is proposed to reduce the risk of challengers to this labyrinth and to inspire interested people to challenge to it.

Dead Ends in the Road Map

Very high quality is not required in all cases. Required quality for an image depends greatly on a medical finding that should be detected by a physician who observes it and has a wide range of degree that depends on a variety of medical findings. In medical application, even if there is a recognizable difference between a digitized image and original one, it can be allowed as far as it does not affect medical diagnosis. In other words, two imaging systems that reproduce colors differently with each other are considered as medically equivalent if the same diagnosis is gotten. If there is another more expensive system that reproduces colors more precisely, it will not sell in the medical market.

In general, only a few diseases have high frequencies and there are a large number of rare diseases. Therefore, an imaging technology should be selectively applied to such a case that has high frequency and requires quality of less degree than achieved by the technology.

Individual physicians will have exact and proper needs that will be satisfied by multispectral imaging, but usually they are not concerned with a frequency's matter. If medical equipment will be designed following such physicians' opinion without considering marketing aspects, the investment thrown for it will not be returned.

Resource-Consuming but Steady Pathways

In medical field, a theory gotten by deduction will be rarely true. Now whole human genome has been analyzed, but functions of most genes are unclear. A functional model of color sensation has been established already, but no one can tell how we recognize someone's face using visual information, distinguish it from others and remember whose it is. Furthermore, the mechanism of medical diagnosis and decision-making is still wrapped in mystery.

Therefore, effects and adverse effects of medical equipment should be proved through an appropriate experiment not only before putting into clinical use, but also in process of research and development. When medical application of a new technology is considered, one should not believe it possible without any experiment. And

it is more important that one should not believe it impossible without any experiment.

A medical experiment is a resource-consuming and risky project. An experiment on a human body will give rise to any ethical problem. However, there is no other sound way to win a goal. Because medical needs are infinite, there will be infinite goals and continuous endeavor must reveal one of them. Especially for precise color reproduction, medical practice has the strongest demand among major fields of serious business. Unlike other technologies, multispectral imaging will be utilized in the medical domain at first, then the product will spread into other industries.

Example of Hopeful Goals

Although the road map has not been completed yet, possible goals of biomedical application of multispectral imaging that have emerged so far through research collaboration between engineering and medicine follows.

A Digital Image Each Pixel of Which Has Spectral Reflectance

If spectral reflectance of skin or mucus is recorded, a specific range of a wavelength can be flexibly enhanced to make some latent medical findings visible when displayed. Spectral reflectance of an infrared area and an ultraviolet area will be also recorded. Therefore, variety of new morphological diagnostic methods beyond human sensation will become possible.

Because the number of major pigment of human skin, which is melanin, hemoglobin and oxyhemoglobin, is three, spectral reflectance of skin and also amount of each pigment will be estimated even from a picture taken by a digital camera that has three color channels.

Comparing color spectra and color appearance, characteristics of human color perception will be investigated in more detail. If a large difference in sensitivity of color difference by wavelengths will be unveiled, optimum compression for recording precise colors will be devised. Moreover, these knowledge will make a breakthrough for elucidating the mechanism of human color perception.

Impacts of these applications on medicine will be very large, but each of them will have its effect on a small number of specific patients. When every one of these goals will be achieved, it will bring very advanced effects in a few specific medical sub-fields and investment required for its achievement will become relatively large

A Digital Image That Has Very Precise Color Reproduction

A multiband camera and a multiband display will realize precise color reproduction that is independent of both devices and illumination. Although even a multiband display will have differences in color appearance caused by differences in the color matching function among individuals, there will be a method of calibration. Furthermore, this theory will be applied for a display that gives color-blind people the same color appearance as others.

As mentioned before, spectral reflectance of skin will be estimated from a picture taken by a common digital camera. Because we have only three kinds of cone cells, colorimetric color reproduction using three primary colors may reproduce a considerable range of visible colors very precisely. Then, color of skin will be reproduced very precisely using common equipment and illumination.

Presently, digital color imaging has spread only in the medical sub-fields that require not so precise color reproduction. In the field of dermatology, nursing, etc., there will be a huge latent needs for that, but required degree of color precision is unclear.

Because most clinical cases will require not so high degree, products developed for device independent color reproduction will bring very practical and general effects in medicine and will cost relatively small.

Conclusion

Although every new technology devised in the engineering field will not easily introduced to medicine, there is a great chance of success provided that clinical needs and each frequency is exactly understood and a steady process is followed. Especially multispectral imaging will be put to practical use in relatively early stage, any active challenge will be welcome. The author is very happy if this paper will be helpful for such challengers.

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