Hidden Pitfalls in Medical Application of Multispectral Color Imaging

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Introduction

Morphological diagnosis, which depends heavily on color, plays one of essential roles in medicine. However, a large potential risk of erroneous diagnoses caused by inaccurately reproduced colors has been left behind in rapidly spreading digital imaging in medicine\(^1\) (Table 1). Multispectral color imaging will provide a perfect solution to this medical color complication\(^2\).

Important questions are why medical practitioners who must be most nervous about erroneous diagnosis do not seem to mind inaccurate color reproduction, and why specialists of medical imaging seem to have little interest in multispectral imaging technology.

Our recent experience of collaborative studies\(^3\) with researchers from various medical sub fields and from the color-engineering field has revealed the very reason of them. That is, most of them have rational but so simplified color conceptions based on their medical knowledge, which may trap most of them in thinking pitfalls.

Consequently, if some people look this situation from other standpoints than medicine, they may consider there are only little color problems in medicine. If some specialists of color science are trapped in such a pitfall, they may extremely underestimate infinite potential of the multispectral imaging in medicine.

Although I hope these speculations of mine are needless anxieties, they are so serious to be overlooked that I would like to present them here.

Pitfalls in the Medical Territory

‘The three primary colors can reproduce every color because we have only three kinds of cone cells.’

In reality, because spectral sensitivity characteristic curves of three kinds of cone cells overlap with each other, RGB values calculated by color matching functions for some light wavelengths become negative numbers and they actually cannot be displayed.

‘Because spectral sensitivity characteristic curves of cone cells spread over a wide range of light wavelengths, improvement of color accuracy will have only small effect.’

Human visual recognition of vital information must be highly developed by means of real-time combined analysis of various kinds of signals. Therefore,

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\text{Table 1 Evaluation of quality of medical images displayed with various devices}^1.
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<table>
<thead>
<tr>
<th>Image No.</th>
<th>Image</th>
<th>Display equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-01</td>
<td>6.0</td>
<td>CRT1 CRT2 CRT3 CRT4 LCD1 LCD2 LCD3</td>
</tr>
<tr>
<td>M-02</td>
<td>6.0</td>
<td>CRT1 CRT2 CRT3 CRT4 LCD1 LCD2 LCD3</td>
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<td>M-03</td>
<td>6.0</td>
<td>CRT1 CRT2 CRT3 CRT4 LCD1 LCD2 LCD3</td>
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</tr>
<tr>
<td>M-08</td>
<td>6.0</td>
<td>CRT1 CRT2 CRT3 CRT4 LCD1 LCD2 LCD3</td>
</tr>
</tbody>
</table>

Tested displays have almost the same resolution, and the major difference among them is the performance of color reproduction. The highest grade was determined as ‘6’, and grade lower than ‘3’ means unusable. Beyond prior expectation, a grade of equipment No. 7 was varied from the highest to unusable. Specimen M-01 etc. got the highest grade with all devices, but specimen M-06 varied from the highest to unusable depending on used devices. Usually a user watches only one display, so may not notice this fact, which may incidentally cause erroneous diagnoses depending on the combination of medical images and display devices.
reproduction of accurate color reflectance may have a serious effect.

‘Complete color reproduction is impossible because no display equipment is free from physical limitations.’
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.

‘It is not realistic to replace present infrastructures based on the RGB color system.’
If estimation of spectral reflectance based on three principal components will succeed in making sufficient approximation, color data acquired by present imaging devices that have three channels may be also used for estimation of spectral reflectance. And also, present display devices that have three channels may well reproduce tristimulus values of the original spectral reflectance, if they are properly calibrated.

Pitfalls in the Engineering Territory

‘There does not seem to be serious requests for color accuracy from most of medical professionals, therefore need for accurate color representation is considered to be little.’
For example, there is a huge demand for recording precise images of skin lesions, but most dermatologists fall into the aforementioned pitfalls and give up to pursue any technological solution. Furthermore, most anesthetists do not recognize spectral color imaging may detect oxygen saturation of regional skin tissue. Only those who understand both needs and technologies would see effective applications of the technologies to satisfy the needs.

‘Quality required for medical imaging is so high that any technology would not satisfy medical professionals.’
Very high quality is not required in all cases. Required quality depends greatly on medical findings that should be detected in each case and that quality has large variety among key findings of each case. In general, small numbers of diseases have high frequencies and there are a large number of rare diseases. Therefore, an imaging technology should be selectively applied to cases that have high frequencies and the quality of diagnostic imaging required for them may be achieved by the technology.

Conclusions

To promote substantial studies in this area and to return eventually true benefits to many people who are suffering from painful diseases, we should have plain and clear evidence that plugs abovementioned pitfalls. One of key products to show the evidence to medical practitioners is a computer program that simulates a hypothesis mentioned in explanations of the forth pitfall in the medical territory. Anyone interested in this software are invited to join its development project.

References