# Processing Colour Image Information

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This paper examines one of the core technologies in colour printing solutions - colour image information processing - and discusses our related development activities in the fields of colour science research, colour processing research and development, and colour printer product technology.

The first topic, colour science research [1) 2) 3) 4) 5)], forms a background for both colour processing research and colour printer product technology development. In the section on colour processing R&D, we will take a broad look at several relevant themes, whilst the section on colour printer product technology gives an overview of the colour processing firmware, colour processing LSIs, and colour processing utilities that we have designed and developed, and already introduced in our products as core processing units.

In our contribution towards the development of colour printer products and printing solutions which incorporate these printers into system packages, we have set our sights not only on colour image information processing, but also information processing in general, thus ensuring that we approach our solution from a broad perspective.

## Colour science research

"Colour science" is the academic field which examines the relationship between light and human perception, in particular when the subject relates to colour perception. "Colour engineering", on the other hand, is a branch of colour image information processing which refers to technical developments in relation to image input and output, storage and transmission, and the digital information processing and media information processing associated with these, based on the key fields involved in colour science, namely, optics, sight, illumination, and psychology. This subject is discussed in depth later on in this article.

Of the many themes in colour science, this paper looks at preferable colour reproduction and colour scheme harmonization. These are aspects which we ultimately aim to reflect in our products, or which are already reflected in them.

### (1) Preferable colour reproduction

What we consider to be "preferable colours" are influenced by environment and individual tastes. The latter are affected by factors such as age, gender, race, personality, etc., whilst environmental factors include local climate, customs, habits and history. However, there are some constant aspects, in terms of common elements of eyesight at a structural level and common tendencies towards colour preferences based on basic human feelings. The reasons for these common aspects have not yet been properly explained, but their existence is clearly suggested by several experimental studies.

Our approach to this problem is described below. The true answer can of course be found by using a very large number of sample observers, but the problem lies in predicting or estimating this truth when only limited experimental resources and man-hours are available. We developed a model-based prediction and estimation method, using findings from previous colour perception models to create several hypotheses and investigating these in models. Fig. 1 shows processing block of these models. The hypotheses were based on a colour perception model, as described above, and a psychological model, each hypothesis being examined by psychological experiments to determine whether it was true or false. The parameters corresponding to the proven hypothesis were used as basic colour perception data to achieve a preferable colour reproduction design.

Using this method, we were able to obtain basic data relating to a number of elements that are common between different races, and basic data on variables which depend on geographical parameters, such as latitude. Only the most reliable of these data were used

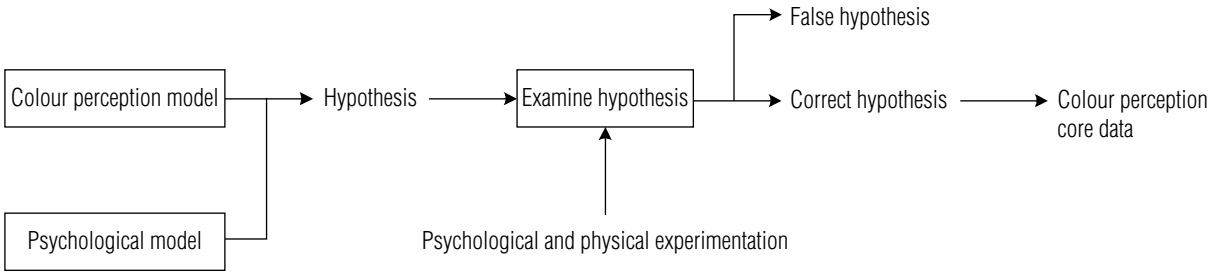



**Fig. 1 Obtaining colour perception data**

in practice.

The psychological experiment included parameters such as the number of experiments performed, and fundamental research [4) 5)] into methodologies for incorporating parameters such as this was also carried out.

A part of results from these researches is reflected on colour matching processing involved in colour printer firmware which is discussed later.

**(2) Colour harmonization**

The colour solution applications which provide added value in our colour printers require the use of harmonious colour schemes. Colour harmonization relates to the successful or unsuccessful combination and arrangement of a plurality of colours. Whereas preferable colour reproduction chiefly corresponds to images, colour harmonization relates to the quality of the spatial combination of colours in a graphics picture.

We have developed our own special theoretical framework for evaluating colour harmonization. One example of the application of this theory is discussed in the paragraph on colour agents, in the following section.

## Colour processing research and development

As stated previously, colour engineering involves technical developments for image input and output, storage and transmission, and the digital information processing and media information processing associated with these operations, working on the basis of the key fields of colour science, such as optics, sight, illumination and psychology. This section and the next describe various aspects of colour engineering, a subject which occupies the major part of our activities. In this, we are researching and developing elemental technologies with a view to realizing the required functions in practicable systems, and below we present some of the themes relating to these developments.

**(1) Multi-spectral colours**

Today, we are starting to see the use of so-called "multispectral images", which contain spectral information for each pixel of the picture. These multispectral images are able to reproduce colour information that cannot be represented satisfactorily in conventional RGB colour images, and they are valuable in the field of e-commerce, for example, where more accurate colour reproduction is demanded. We have developed our own particular representation method which is usable with multispectral image data [6)].

Fig. 2 shows a comparison between an RGB colour image (a), and a multispectral image (b). The colour range of the flower is hard to reproduce in a standard RGB colour picture, but the multispectral image in (b) reproduces the original colour to a high degree of accuracy (here, the illustration shows the difference between the images in terms of the colour reproduction when printed).

(a) RGB colour image

(b) Multispectral colour image

**Fig. 2 RGB colour image and multispectral colour image**

**(2) Object-oriented preferable colour reproduction**

On top of the general colour preferences described previously, there is a further aspect of colour reproduction relating to the colours that people regard as preferable in relation to different types of objects. By portraying individual objects in a picture within their respective preferable colour ranges, whilst maintaining an equilibrium with the other objects, it is possible to increase the attractiveness of the image as a whole. We started by using food items as our objects and attempting to create a database of preferable colour reproduction ranges for each item, based on preferable colour theory for foods. The regions of the image were then divided up and labelled according to object type, and the colours were then converted by using the colour reproduction range database. Fig. 3 shows the original image (a), and the object-oriented preferable colour reproduction image generated from this. Whilst maintaining the balance of the overall image, the individual vegetables are portrayed in a bright and appetizing way, thus creating a fresher, more appealing picture.

**(3) Colour agents**

One of the frameworks for processing concepts in printing solutions is to adopt an agent-based approach. More specifically, this application aims to provide a function which helps the user to create colour schemes for a PowerPoint [*1)] presentation, which can be treated as a single object for printing out from a colour printer, or outputting to an OHP.

In the field of information processing, the term "agent" has the connation of "a software system which provides helpful, expert assistance", and this is one of the forms that solution development should take, or the direction in which it should be heading.

*1) PowerPoint is a registered trademark of Microsoft Corporation US, in the United States and other countries.

**(a) Original image**

**(b) Object oriented preferable colour reproduction**

**Fig. 3 Original image and object oriented preferable colour reproduction**

Over and above the added value afforded by functions which help first-time colour design users to complete the highly demanding task of creating colour schemes, the feeling of satisfaction and achievement that this type of solution brings to the user relates to the direct, visual appeal of obtaining an excellent harmonized colour scheme. In this way, the solution conveys the expert, high-quality image conveyed by the word "agent".

Fig. 4 is a block diagram giving an overall illustration of these functions.

From the original colour scheme of the edited presentation opened in PowerPoint (Fig. 5(a)), a number of different suggested colour palettes are generated by deduction processing and offered to the user (Fig. 5(b)), who then chooses one of the palettes. There is also a function for extracting colour scheme information from another PowerPoint file, apart from the presentation being edited, or from a BMP, JPG or GIF picture file, or HTML file, and using this colour scheme in the current presentation.

## Colour printer product technology

As described above, elemental technology developed on the basis of a broad-ranging approach has been applied to products in four guises: colour processing firmware, colour processing LSIs, colour processing utilities, and colour application.

### (1) Colour processing firmware

We have developed our own independent firmware for printer colour management. In the field of gamut mapping for aligning differences in reproduction colour range between devices, we are mounting a proprietary gamut mapping system which comes within the category of shape correlation systems.[7] We have also developed and mounted a firmware-based automatic density correction system.

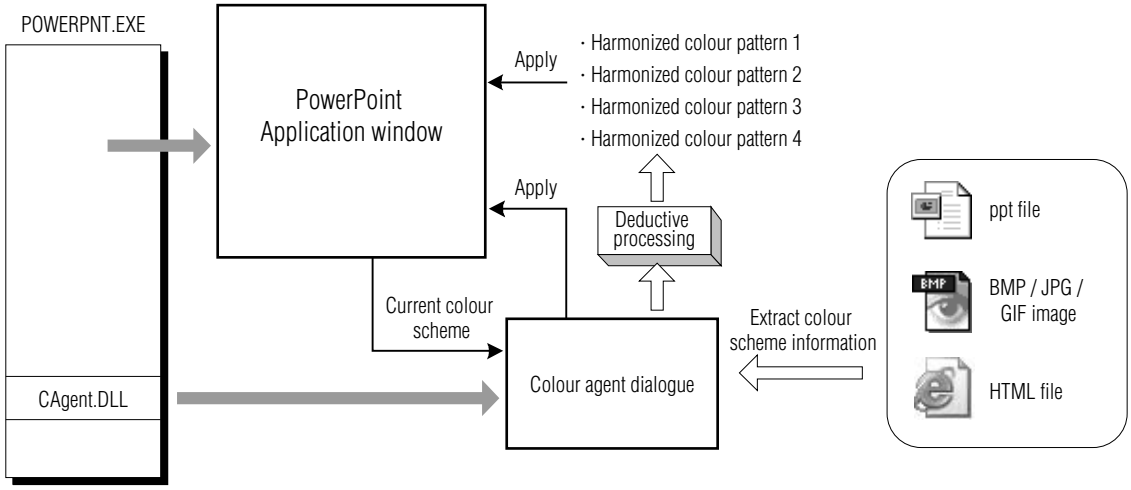
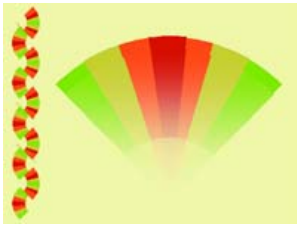
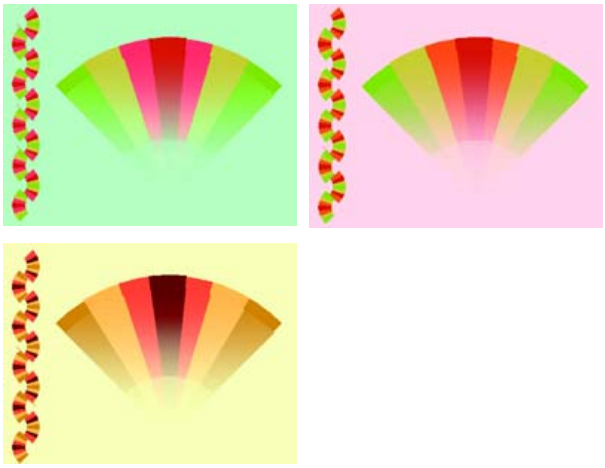



**Fig. 4 Block diagram of colour agent**



(a) Original colour scheme



(b) Suggested colour schemes

**Fig. 5 Example of colour agent processing**

### (2) Colour processing LSI

We have built colour matching processes into an LSI, in order to speed up colour management processing. We have also mounted multiple-value colour picture data compression processes and binary colour picture data compression processes [8] on special LSIs, in order to raise internal data processing speeds. The multiple-value compression process uses a proprietary analytical synthesis type data compression method, whilst the binary compression process is based on an arithmetical copy code data compression method, again a proprietary system of Oki.

### (3) Colour processing utilities

The operation of colour adjustment, which combines both sensory judgements and quantitative analysis, requires a first-rate human interface to be provided for interaction between the user and the PC GUI. Some human interfaces, for instance, allow the user to indicate directly which colour they want to replace with a particular colour from a set of samples, thereby meeting the user's demands efficiently, through a simple series of commands.

## Conclusion

Here, we have taken a broad look at the research and development carried out by Oki Data in relation to colour image information processing, which is one of the core technologies in colour printing solutions.

We believe it is vital that products are cultivated within a flexible development structure, which spans the borders between theory, application and practical implementation, and from here on, we hope to continue to develop product technologies which support our product cycle, in the right place at the right time.

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