Final report on the project

Developing a Technique for Obtaining Colour Accurate Photographs of Australian Native Flowers

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Michael Eckert

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Summary
The colour within a photographic print depends heavily on the illumination at the scene (sunny day, cloudy day, morning, evening, flash, etc.), the colour accuracy of the film, and the colour accuracy of the print. Because of the combination of these factors, it is usual for photographs to exhibit large colour shifts from the original flower, both in hue and saturation. At best, red flowers remain red, blue flowers vary between blue and purple, and yellow flowers vary between yellow and orange. The primary objective and achievement of this project was to develop and validate a technique to obtain colour accurate digital photographs of Australian native flowers and leaves in the field. Colour correct images from species in the genera *Acacia*, *Anigozanthos*, *Banksia*, *Boronia*, *Crowea*, *Darwinia*, *Dillwynia*, *Epacris*, *Gompholobium*, *Hakea*, *Hibbertia*, *Isopogon*, *Lambertia*, *Leptospermum*, *Leucopogon*, *Persoonia*, *Styphelia* and *Woollsia* can be viewed from the summary on the Australian Flora Foundation website.

Introduction:
The colour accuracy of photographs of Australian native plants is variable. The colour within a photographic print depends heavily on the illumination at the scene (sunny day, cloudy day, morning, evening, flash, etc.), the colour accuracy of the film, and the colour accuracy of the print. Because of the combination of these factors, it is usual for photographs to exhibit large colour shifts from the original flower, both in hue and saturation. At best, red flowers remain red, blue flowers vary between blue and purple, and yellow flowers vary between yellow and orange. This project had three aims: (a). The primary goal was to develop and validate a technique to obtain colour accurate digital photographs of Australian native flowers and leaves in the field. (b) A secondary goal of the work was to develop a database of Australian flower photographs taken over several seasons at Royal National Park to use as an example of the technique. (c) A final goal was to evaluate the colour distribution of flowers taken in individual seasons.

Materials and Methods
The focus was on developing a technique that could be implemented by any reasonable photographer, not simply one who had access to specialised scientific equipment. The objective has been achieved and validated.

The technique is as follows:

1. Obtain photographs of flowers and foliage in diffuse illumination rather than direct sunlight. This can be done by taking photographs either on a cloudy day or by taking a photograph of the flower under a diffusion tent [1]. Direct sunlight increases the contrast of the image of the flower (the difference between the darkest and brightest points), creating a difficult photographic environment for film that has a limited dynamic range. In addition, direct sunlight creates shifts in the colour of the flower (essentially it de-saturates the colours) by introducing a large component of illuminant into the image. A diffuser or diffusion tent is simply a translucent shield placed between the direct sun and the object being photographed. Examples of a translucent shield might be a translucent thin plastic sheet or a large piece of white satin. Commercial diffusers are available, but they are also simple to make (see reference [1]).
2. Use film with minimal or no sensitivity to infra-red and ultra-violet light, eg, with wavelengths greater than 700 nm (infra-red) or shorter than 400 nm (ultra-violet). There are only a few slide films that meet this criterion, such as Fuji Astia and Kodak Ektachrome 100 EPN. Alternatively, an Ultra-violet and Infra-red blocking filter can be used on the camera. Why is this important? Colour accuracy for film is only required for particular applications such as industrial applications and fashion photography. Typically, the spectral sensitivity of print and slide film is designed to create "punchy" and highly saturated images as demanded by the market place. Examples include both consumer negative film such as Kodak Gold 100 and professional slide film such as Fuji Velvia and Fuji Provia. One of the ways to create greater saturation is to allow higher sensitivity in the ultra-violet (to create strong blues in the sky) and higher sensitivity in infra-red (to create stronger reds). Unfortunately, flowers are often strongly reflective in infra-red and ultra violet, leading to the phenomenon known as "anomalous colour" [2]. Kodak identified flowers such as blue morning glories, gentians, and ageratum flowers as known to be difficult to photograph for exactly this reason. The use of digital cameras does not alleviate this problem: The spectral sensitivities in spectral elements are often designed with cost in mind, as well as the need to create "punchy" photographs. Digital cameras are often highly sensitive to infra-red and photographs may exhibit anomalous colour shifts, in the same way of amateur film. This was one of the reasons that film has been primarily used in this project- spectral sensitivity curves for film are published by manufacturers and, when the correct film is used, one can be confident that anomalous colour is not an issue.
3. Set film exposure by using a grey card (18% grey) to set the shutter and aperture with "through the lens" metering. Through the Lens (TTL) metering will be quite accurate for this situation because the illumination is diffuse and the scene contrast for flowers are usually quite accurately captured with a standard grey card. Over or underexposure of film will create colour shifts in the final photograph. While these colour shifts will, for the most part, be removed at the next stages, extremes of colour compensation can introduce colour noise artefacts.
4. Take two photographs of the flower: The first photograph will be the photograph that will be processed and used, the second photograph will contain both the flower and a mini Macbeth Colour Checker Chart to be used as a grey scale and colour compensation. The photograph with the Macbeth Colour Checker Chart will be used to perform a warping of the grey scale and colour space of the

captured digital photograph. The technique uses a commercially available software package.
5. Process the film at a reputable film processing laboratory.
6. Calibrate the slide scanner using a colour profiling package [3]. This is necessary to ensure that the scanner creates as accurate a possible rendition of the photograph as possible. Profiling corrects for colour shifts and grey scale non-linearities introduced by the scanner. Profiling also has the advantage that it creates a constant colour and grey scale mapping to apply to multiple scans, rather than having the scanning software remap the photograph depending on some internal software.
7. Scan the two photographs with the profiled scanner.
8. Create grey scale and colour correction maps from the photograph with the Macbeth Colour chart. The technique uses a commercially available software package "Picture Window Pro" [4] - however the same procedure could be implemented with a colour profiling package [3]. The effect of the colour corrections is shown in Figures 1-4.
9. Apply the grey scale and colour correction maps to the original flower photograph (Figure 5).

The resulting colour photograph will have reasonably accurate hues and colour saturation as long as the saturation is within the saturation range of the colour panels on the Macbeth Colour Checker chart.

Validation

The above technique was validated by taking photographs containing both a Macbeth Colour checker Chart and an IT8 chart. The scanned photograph was calibrated using the Macbeth Colour Checker Chart. The patches on the IT8 chart have known colours. The colours within the photograph could then be read off and compared to the known colours. If the measured colour was close to the known colour, then the technique can be considered to have succeeded.

Such a validation was performed, and the accuracy of colour was evaluated using a colour difference metric defined by the CIE (dE*94 and dE*2000) and the results compared to published results for a similar validation process described in [8]. The results showed that the accuracy of the technique either matched or exceeded the published examples, indicating that the approach produces colour accurate photographs that are, essentially, as accurate as can be obtained using standard photographic techniques.

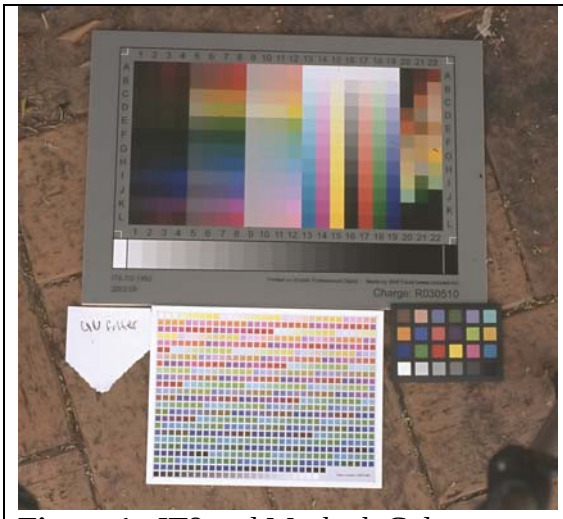

Figure 1: IT8 and Macbeth Colour checker targets. Pictures containing multiple targets were used to validate the technique. This particular slide demonstrates a picture that has been rendered colour neutral (eg, all of the grey patches are grey), but the hue and saturation are still not accurate.

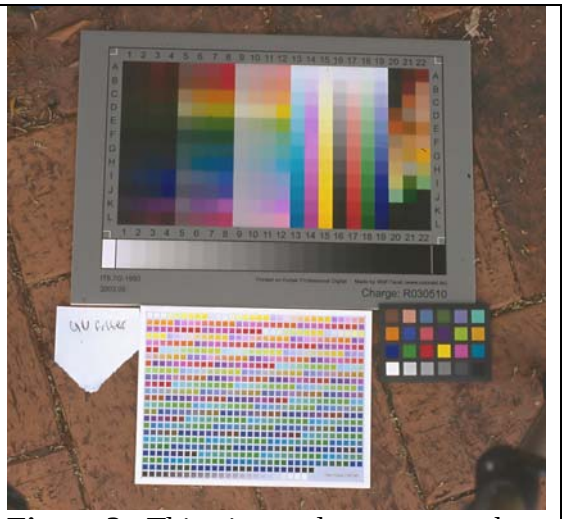

Figure 2: This picture demonstrates the change after hue and saturation colour corrections have been applied. The colour panels on the Colour checker are now accurately represented. The colour panels on the IT8 target have been validated as being close to the true colour.

Figure 3: The technique applied to a photograph of *Banksia ericifolia*. The picture contains a Macbeth colour checker target. This picture has been rendered colour neutral, but without compensation for hue and saturation.

Figure 4: The photograph after grey scale compensation, hue, and saturation compensation for colour accuracy.

Figure 5: Resulting picture of *Banksia ericifolia.*

Examples of the photographs can be found by going to the AFF website (http://www.aff.org.au) then to 'Results and reports', then to 'Summaries', then to '02/03', and clicking on the Eckert summary. The summary provides a link to 82 colour accurate photographs from 17 genera. The images are scaled down versions of the originals. The latter, subject to copyright restrictions, are available from the author.

Record of flower pictures obtained in Royal National Park as part of the project:
Lambertia formosa
Banksia ericifolia
Epacris longiflora
Leptospermum squarrosum
Banksia integrifolia
Leucopogon microphyllus
Crowea saligna
Dillwynia
Darwinia fascicularis ssp fascicularis
Acacia linifolia
Kunzea ambigua
Isopogon anemonifolius
Carpobrotus glaucescens
Hibbertia scandens

Dissemination of the project
The intent is to disseminate this work in two ways:
(a). Publish a description and examples of the technique in either the print or online version of "Australian Plants".
(b). Publish the database of the Australian flowers - preferably on the website of the "Society for Growing Australian Plants"

5. References

[1]. Blacklock, C, and Blacklock, N., "Photographing Wildflowers: Techniques for the Advanced Amateur and Professional", 1987. Text describes the construction and use of a diffusion tent.
[2]. "Why a Color May Not Reproduce Accurately", Kodak Data Technical Bulletin, September 1999.
[3]. Profile Prism, "ICC Profiling Software for Digital Cameras, Scanners, and Printers", http://www.ddisoftware.com/prism/
[4]. Picture Window Pro. http://www.dl-c.com/
[5]. Berns, R.S., "Billmeyer and Saltzman's Principles of Color Technology", 2000, John Wiley and Sons.
[6]. Wyszecki & Stiles, Color Science: Concepts and Methods, Quantitative Data and Formulae, 1982, John Wiley and Sons.
[7]. Hunt, R.W.G., Measuring Colour, 3rd Edition, 1998, Fountain Press, England.
[8]. Berns, R.S., "The Science of Digitizing Paintings for Color-Accurate Image Archives: A Review", Journal of Imaging Science and Technology, Volume, 45, Number 4, 2001.

Budget

Item purchased (and reason)	Cost ($AUD)	Reimbursed yet?
Macbeth Colour chart	191.56	Yes
IT8 colour and grey scale targets	168.41	Yes
Canon Lide scanner	209.00	Yes
Profile Prism (Scanner Profiling software)	119.10	Yes
Ektachrome EPN processing (1 roll - mounted)	17.60	Yes
Fuji Astia processing (1 roll)	7.95	Yes
Fuji Astia processing (2 rolls)	21.90	Yes
Fuji astia processing (2 rolls)	21.90	Yes
Fuji Astia processing (1 roll)	10.95	Yes
Total purchased	**768.37**	
Total remaining in budget	**886.38**	

I will continue to work on the project and use the rest of the money in the budget as specified within the grant: to complete the database of flowers. A subsequent report can be issued once the budget is used up - estimated to occur sometime over the next six months.