Fabric printing of colours measured in nature and the field evaluation there-of

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INTRODUCTION

Camouflage technology exists since 1979 at the CSIR. Spectral measurements of natural phenomena (leaves, bark, soil, rocks) were very difficult during the early days, and spectral measurements were performed on samples brought back from the field. Special care had to be taken to ensure integrity of measurements, especially on plant material. From these measurements the current camouflage colours used on vehicles were defined.

Figure 1: Measurements in the field, using the PR715

In the 1990's field measurements became a bit easier, when portable instrumentation became more readily available. Since 2001 CSIR used a Spectrascan PR715 radiometer for field measurements (Figure 1). The advantage of this instrument was that it is able to operate completely autonomously, and the data is stored on 3½" floppy disc, which enables easy data transfer to computer. The spectral data, once on computer, was manipulated to reflect CIELAB values, which are the most useful to work with.

COLOUR DATA

For three years colour data was collected along the South-African border areas. The majority of the data was collected along the Botswana-, Zimbabwe- and Mozambique borders. The vegetation types on the northernmost borders are grassland, savannah and mixed thorn bush. The border with Mozambique has Mopanie-field and savannah, while the coastal region with Mozambique has more dense tropical vegetation. Therefore, the dominant colours were browns and beiges.

Abovementioned colour data was compared to the colours currently used on the South African National Defence Force's (SANDF) equipment. It was concluded that these camouflage colours were a very good representation of the colours found amongst the border areas [1].

The measured data is stored in a database, together with location, photographs and a general description of the area around each data point. During 2004 all the CIELAB values was combined in one dataset. A colour prediction algorithm was developed, using custom Matlab code. This algorithm calculated eight "average colours", based on the available colour data. These colours were two light browns, two dark browns, two light greens and two dark greens (Figure 2).

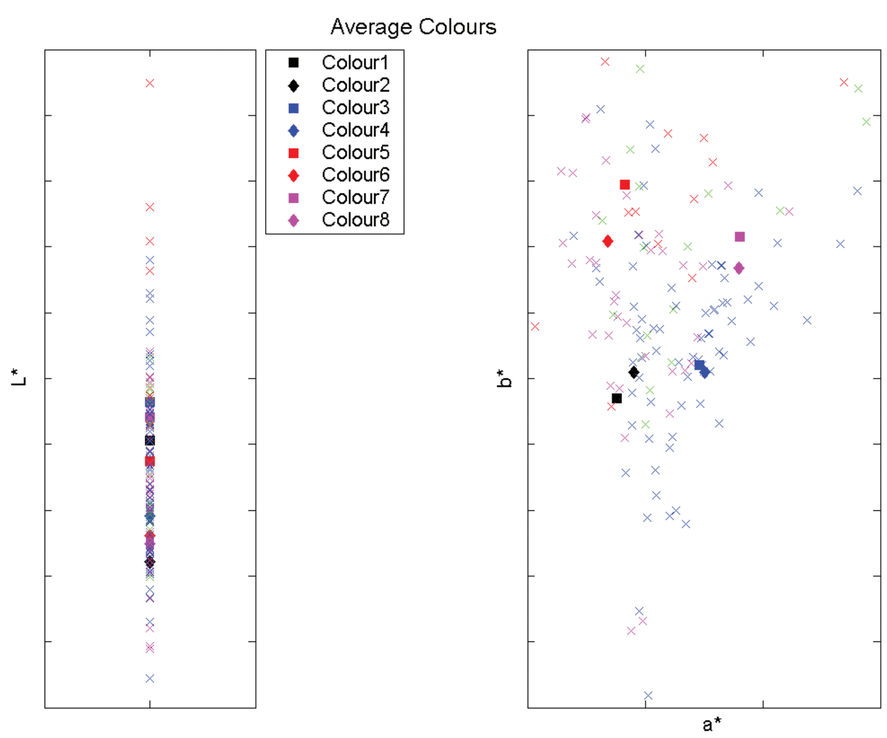

Figure 2: Eight Predicted Colours

COLOURS ONTO FABRIC

The colour coordinates of the eight "average colours" were supplied to a company that manufactures the SANDF's camouflage clothing. Using the current SANDF camouflage pattern, but different combinations of the calculated colours, sixteen different colour schemes were achieved, using standard screen-printing technique. These combinations were, amongst others, different dark- and light green, as well as dark- and light brown patterns. Camouflage shirts were then manufactured (Figure 3).

EVALUATION OF COLOURS

Thirteen of the camouflage shirts were then evaluated in the field. The procedure was as follows: each uniform was propped (separately) at the same location in the field, and digital photographs were taken of each uniform. Care was taken to ensure that each photograph covered the same area, and have the same camera settings (aperture and shutter speed). The RAW-format images were also used, in order to minimise the image processing that take place in the camera software. No compression was also done on the imagery, to ensure minimum loss of information.

Figure 3: Two of the Uniforms Manufactured and Evaluated

These digital photographs were then evaluated, using MATLAB's image processing toolbox and custom code. The raw digital data was imported into MATLAB. The RGB-values (red, green, blue) of the uniform were selected, and matched to the rest of the image. A tolerance of ±2 on each of the RGB-channels was allowed, to compensate for pixel-noise. The number of matching pixels was recorded, and the percentage matching pixels were calculated as follows:

$$\%MatchingPixels(MP) = \frac{NP}{TP} * 100$$

where NP = Number of Matching Pixels in Image
TP = Total Number of Pixels of the Image

Above relationship gave an indication of the colour match of the uniform to the environment. An example of the matching pixels is shown in Figure 4. The results for all the uniforms are shown in Table 1. The highest values are marked in green, and the lowest values in orange.

Table 1: MP values for the different designs

Design no	% Matching Pixels (MP)
NO1	28.9
NO2	46.0
NO3	31.1
NO4	21.9
NO5	18.7
NO6	16.0
NO7	31.5
NO8	45.7
NO12	29.3
NO13	32.0
NO14	48.1
NO15	46.8
NO16	38.1

Figure 4: Calculation of MP

CONCLUSION

Thirteen different colour designs have been evaluated in one scene, with the uniforms deployed both in full sunshine and broken shade. After image analyses the findings are as follows:

- The patterns containing only greens did not perform very well. The reason for this is that the greens on the uniforms did not match the greens in the scene very well.
- The patterns that have a mixture of brown and green (predominantly brown appearance) matched the scene's colours very well. The browns matched the soil and rocks much better than is the case for the match between the greens and the foliage.

It can therefore be concluded that design NO14 matched the scene's colours the best.

FUTURE WORK

The first question that arises when colours comparisons, using digital cameras, is undertaken, is how accurate these colour are represented by these cameras. The author is currently busy with an uncertainty model, in order to quantify and qualify the colour reproduction of these sensors.

The second question is: how do these digital comparisons, using only the RGB camera values, compare with the human eye's perception of the same scene? More specifically, the author is interested in the question: "Which of the abovementioned uniforms will fit a certain environment the best?" A comparison between the uniforms, using human subjects, will be undertaken in the near future.

REFERENCES

[1] Baumbach J, "The SANDF's Camouflage Colours: Comparison with the Colours found in Nature", International Colour and Lighting Conference, Cape Town, November 2003.