Every year, millions of poor grey scale reproductions of colour images are made. Through our research we aim to make millions more good grey scale prints. It is now increasingly common to capture images using colour digital cameras and display them on colour monitors or using colour inkjet printers. However, there are still many occasions when colour images are reproduced in greyscale: the use of black and white printers, photocopiers and fax machines is still an everyday occurrence. Unfortunately, the conversion of colour images to their greyscale equivalent, either by these devices, or through other means, often results in a poor reproduction of the images. The aim of our research is to develop a method to derive the best possible greyscale reproduction of a colour image, by a careful consideration of the limitations of our own visual system, and by exploiting the underlying physics of colour image formation.

The most common colour-to-greyscale strategy is to approximate the luminance of the stimulus, and then to use this luminance value as the grey value. A significant drawback of this approach is the loss of image contrast in areas where colour contrast dominates over luminance contrast. This problem reaches an extreme for isoluminant images, where all colours are assigned the same greyscale value. The top row of Figure 1 shows two example images: in Figure 1 (a) there is an image of a field of poppies, and in Figure 1 (b) a synthetically generated isoluminant version of the same image. The second row of this Figure (subfigures (c) and (d)) shows what happens when luminance is used to convert to greyscale: significant details are attenuated (e.g. the poppies disappear in the luminance rendering of the original) or disappear altogether (as in the isoluminant image).

The solution to this problem, adopted by a growing number of computational approaches [1, 2, 3, 4, 5, 6], is to encode the colour contrast from the original image as greyscale contrast. One of the earliest examples of such a technique, and also mathematically most elegant, was proposed by Socolinsky and Wolff [1]. In their work they define

---

*Work supported by EPSRC grants EP/E012248/1 and EP/E12159/1.
the contrast of the image as the gradient of thecolour image, which is encapsulated by a contrast vector-field. By reintegrating this vector field they find the greyscale image whose gradient is as close as possible to that of the colour image. The final row of Figure 1 shows an output of this algorithm for the poppies image: the colour contrast is clearly better maintained.

Figure 1: Colour-to-greyscale conversion comparison between luminance and the Socolinsky and Wolff algorithm
Despite the improvements over luminance that existing colour-to-greyscale algorithms provide, there are still many unresolved problems. For many images the different techniques produce artefacts that are unacceptable for greyscale printing applications. For example, although the magnitude of the gradient of the colour image is well described by Socolinsky and Wolff’s contrast-vector-field, the sign of the gradient is completely undefined. In our work we have investigated different approaches for sign-assignment, and discovered methods that reliably improve the visual appearance of the final image [7]. In our work we also use psychophysical methods to determine which properties of greyscale images are preferred by human observers [8], with the ultimate goal of feeding back these properties into a successful colour-to-greyscale algorithm [9].

In addition to tackling the colour to greyscale problem, our goal is to expand the proposed techniques into different imaging areas. For example, the colour at a given image point is usually coded by three numbers \((R, G, \text{ and } B)\) and in the greyscale transformation these three numbers are reduced to just one grey value. However, more generally, colour information might be coded using \(N\) (where \(N > 3\)) numbers, and in this case it is useful to be able to derive methods to reduce these \(N\) numbers to 3, or fewer, so that the \(N\)-dimensional information recorded can be displayed on conventional imaging technology. By generalising our colour-to-greyscale algorithms, we provide the potential to better visualise the information contained in, for example, satellite images. We also expect that it will be possible to exploit the technology we develop to make colour images that can be viewed without error or confusion, by colour-blind observers. In addition, the work will lead to improvements in existing image processing algorithms, and to a better understanding of how our own visual system perceives colour and brightness information.

References


