Kansei Imaging: first steps

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Abstract

Kansei engineering (also called affective engineering) studies and develops methods of translating and embedding perceptual and emotional qualities into the product design features. We adopt this principle and apply it to imaging: we propose a new concept, "Kansei Imaging", which refers to development of algorithms aimed at modifying an existing image so as to reach a set of pre-defined emotional qualities. We sketch the elements required for building a Kansei imaging system, review the available related literature and, as a demonstration of the concept, we present initial results of editing image colours in the colour emotion domain. Finally, we argue that generating emotionally satisfying images is the ultimate goal of consumer imaging, and that the Kansei imaging framework can provide a set of tools to help achieve that goal.

1 Introduction

In automatic image enhancement systems such as those embedded in digital cameras (i.e. "imaging pipelines"), consumer images are treated mostly as providers of visual "information". Thus the function of such systems is often limited to optimising this information for visual consumption by means of white balancing, improving contrast, sharpening and denoising. However, images possess emotional qualities as well as technical ones: we speak of images being sad or happy, upsetting or relaxing, warming or chilly. Colours of an image photographed in candle light can be adjusted to be perfectly colour-balanced from the technical point of view but, by doing so, the "warmness" of the image will be destroyed. Conversely, improving the emotional characteristics of such an image by enhancing its warmth can result in a better image even if this is done at the expense of degrading its "technical" qualities.

In order to avoid failures of this kind, our imaging system needs to be able to perform human-like judgement of the image: to identify the objects and their properties, to characterise the scene and to identify the importance of the image regions. Furthermore, the system needs to operate with terms that are currently reserved for "artistic" discourse such as image *character*, the *mood* and *emotion*. The operation of such system will in fact resemble the action of a photographer who edits the image in order to achieve certain artistic goals rather then just improving mere technical characteristics. In other words, we need our system to perform *affective* judgement and manipulation of the image, whereby the technical image parameters such as contrast and colour are analysed and manipulated to achieve a certain affective response. We call such a system a *Kansei imaging* system – analogous to *Kansei engineering.* In this paper we attempt to sketch the properties of Kansei imaging systems, review the available related publications, and identify the future research directions that would facilitate the system development. Furthermore, we present the first example of affective image editing based on colour emotion space.

2 Image and emotion

Although, as we note below, some elements of affective imaging have been around for a long time, we are not aware of a published research utilising a systematic approach to affective image manipulation as we present it here. However, Kansei imaging does rest on a rich body of empirical and applied research in several disciplines including experimental psychology, psychophysiology, artificial intelligence, computer science and colour science. Below we give a brief review of selected publications, and identify future research topics.

2.1 Psychophysiological measurements of image emotion

It is a widely accepted view that emotional and aesthetic responses to images are highly individual, and are guided by personal preferences or aesthetic habits. However, published research in experimental psychology has established that emotions can be measured and quantified, that common emotional response patterns exist among people with widely varying cultural and educational backgrounds, and that relationships can be established between the measurable properties of the image and emotion.

Although it is possible to measure the emotion psychophysically, the physiological measurements are considered to be far more precise. For instance, the startle response (measured by the eye blink response) to a burst of white acoustic noise introduced while the subject is viewing an image was reported to correlate well with the degree of image pleasantness, as well as with subject’s level of attention [Vrana et al. 1988; Cuthbert et al. 1998]. Affective independent dimensions of valence (pleasantness) and arousal (excitation) are widely used in the research, while each axis can be characterised by a particular physiological measurement; for instance Lang et al. associate involuntary facial expression with valence, and skin conductance with arousal [P. J. Lang et al. 1993] . Although some gender variations were found, generally subjects exhibited common response patterns. Building on Lang's et al. and other related work, recent developments in affective computing include a system for automated recognition of complex mental states from facial expressions [El Kaliouby & Robinson 2004].

There have been only a few attempts to establish relationship between the image properties and the affective response to it. Bernat et al. reported correlation of image thematic content and all physiological measures of affect [Bernat et al. 2006] for themes including erotic, adventure, victim and threat. The authors use the term of “affective intensity”, suggesting that a continuous scale can be established between the image content and emotion – although we are not aware of attempts to devise such a scale. Another studied aspect of image emotion is viewing geometry: skin conductance measurements were found to relate linearly to the image size, suggesting a link between the image size and arousal [Codispoti & De Cesarei 2007].

2.2 Colour emotion

Colour emotion is an area of colour science research, which has been developed in the context of affective design and engineering. It aims at developing psychophysical scales to be used in automated decision tools for the generation of colour palettes having pre-defined emotional or harmonic properties.

Feldman et al. developed a systematic approach to quantifying what they termed *colour experience* [Feldman et al. 1993]. They identified a number of *dimensions of colour experience*, grouped in two categories, chromatic and spatial, performed measurements relating each dimension to affective response, and suggested that relationships between colours in the stimulus can be adjusted to achieve a predictable emotional response. Development and demonstration of the application of the developed model were subsequently published [Jacobson & Bender 1996].

Ou et al. seem to be the first to publish a quantitative model relating the stimulus colorimetry and the emotional response to it [Ou et al. 2004b; Ou et al. 2004a; Ou et al. 2004c]. They have conducted a series of psychophysical experiments whereby observers viewed a simple colour stimulus — a colour patch, or a combination of patches. Observers then graded their emotional response to the stimulus on some scale with psychologically-defined ends: for example "fresh-stale", "hard-soft", "tense-relaxed". The fit to the psychophysical data provided a model relating the CIELAB colour space and colour emotion. Moreover, several of the paper's conclusions suggest the model's applicability in imaging applications, namely:

1. All colour emotion pairs can be represented in a three-dimensional domain with the independent opponent axes "active-passive", "heavy-light" and "warm-cool", which is directly related to the CIELAB space. Thus, image pixel can be characterised by three coordinates in this *Colour Emotion Space*.
2. Colour emotion of a two-colour combination is a simple mean of the pair's constituents. This suggests that image colour emotion can be characterised (at least in part) by the mean of colour emotion values of its pixels.
3. Colour emotion is independent of the cultural background. The conclusion was confirmed by a later study [Gao et al. 2007], suggesting the possibility of universal applicability of colour emotion space.

2.3 Imaging analysis, understanding and manipulation

Affective image manipulation is only possible when the imaging system is able to infer perceptually- and emotionally-meaningful information from image digital data, and modify the image while retaining its realism and integrity. This ability is provided by number of imaging technologies which have been rapidly developing in the recent years.

Image segmentation techniques [N. R. Pal & S. K. Pal 1993] divide the image area into perceptually meaningful regions such as sky, grass or human skin. Moreover, recent developments in image understanding techniques include recognition of individual objects within the picture [Cour & Jianbo Shi 2007] and of scene spatial configuration (perspective, occlusions, etc.) [D. Hoiem et al. 2007; Derek Hoiem et al. 2007]. Detection of human faces [Hsu et al. 2002; Viola & Jones 2004] is a rapidly developing topic boosted by its numerous applications in image enhancement, surveillance, and others. Finally, works are beginning to appear [Liu et al. 2007] on subjective analysis of perceptual importance of objects in the image.

On the side of image manipulation, global and local lightness and colour corrections in images have been available for a long time. Recent algorithms take advantage of advanced image analysis, and are incorporated in commercial imaging products. Relatively new are the topics of automated photorealistic image manipulation such as, for example, insertion of objects while fitting it into the image's three-dimensional structure [Keren et al. 2004], manipulations and animation of human faces [V. Blanz et al. 2003; Volker Blanz et al. 2004], and image matting [Levin et al. 2008].

3 Kansei Imaging

The term *affective imaging* was coined in the title of 2001 paper by Fedorovskaya et al. [Fedorovskaya et al. 2001]. Since the research was conducted in a commercial, rather then academic, context, the authors were interested in the practical use of image affective characteristics rather in an investigation of psychological mechanisms. They tested whether the affective response, measured by verbal as well as physiological means, can be predicted in advance by selecting an image with appropriate emotional content. They demonstrated that the affective response could indeed be influenced by the choice of picture, hence the term *affective imaging*. However, we have not been able to locate publications on *affective image manipulation*, i.e.: introducing changes ("enhancements") within the image such that the image's emotional properties reach a pre-defined state. We term this type of imaging operation *Kansei imaging*, adopting the accepted terminology of *Kansei design and engineering*, which refers to the process of product design – to emphasise the fact that the imaging system is, in fact, re-designing the image rather then just attempting to preserve it.

We reviewed a number of scientific and technological developments that will enable affective image manipulation. Research in psychology provides us with the basic understanding of mechanisms of image emotion. Novel image analysis and understanding algorithms provide us with a plethora of information about the picture – from colour and contrast statistics to the nature of the subject matter, lighting conditions, object identification, type of the scene, and even emotional state of the photographed people. Imaging manipulation allows high quality photorealistic operations – from advanced localised colour and contrast corrections to modification of image content, moving and inserting new objects, and changing facial expressions.

Having all the information about the image in one hand, and all the tools for image manipulation in the other – how is our imaging system to decide what to do with the particular image? In order to identify the missing blocks of knowledge, it is helpful to sketch a high-level description of a system. Our hypothetical Kansei imaging product must have the following blocks:

1. **Understanding of image affective content**, whereby the image is segmented into perceptually meaningful areas, the spatial, colour and perceptual properties of the image are analysed, and objects and scenes are identified. Using the extracted information, the image is classified into a perceptually-meaningful category such as indoor/outdoor, sunny/cloudy, beach/forest, and others. Finally, the available information is processed to learn the affective content of the image: the subject matter for which a person might have emotional attachment (i.e. a kid, a car, a pet), or from which a person might expect certain emotional qualities (sports, celebration, wedding, funeral).
2. **Evaluation of image affective state**: does the current affective state, as characterised by image measurable parameters, meets the requirements of the emotional content? Does the sports scene look active, the funeral look sad, and the wedding look warm and happy?
3. **Correction of image's affective state**: modifying the image characteristics – contrast, sharpness, colour, composition - so the new affective state fits the one required by the scene.

We seem to already have many elements of block 1, provided by recent advances in imaging science and technology. We have only small part of the knowledge required to build blocks 2 and 3. Although we can associate certain scenes with emotion, further research is needed to learn to combine the measurable image spatial, colour and perceptual characteristics and to infer from them the emotion the image currently transmits to the viewer, and how to modify these characteristics in order to change the image emotion in a controllable manner.

In other words, what is missing are the stages that will enable application of psychological knowledge to image processing operations, namely – psychometric scales that quantify image affective content, and relate measurable properties of images with affective states. Development of such psychometric scales is the next stage of this research.

4 Case study: Image Colour Emotion Manipulation

As discussed above, although Ou et al. [Ou et al. 2004b; Ou et al. 2004a; Ou et al. 2004c] have done their experiments with discrete colour patches and not with images, their conclusions imply that it might be possible to use the developed colour emotion space to modify image colour emotion. We present an attempt to do so below, at this initial stage referring to colour emotion manipulation only, while ignoring the analysis of the emotional effect of the image content.

Ou et al. [ibid] developed a forward mapping from CIELAB coordinates to three-dimensional colour emotion domain (Eqs. (6-8) in the original publication, see Figure 1). A straightforward application would involve converting image values to the colour emotion space, applying the edits, and converting the values back to image encoding (i.e. CIELAB). Unfortunately, the paper does not include an inverse model, and the published forward equations are not easily invertible. Therefore we adopt an alternative approach: we apply the edits in CIELAB space, while the direction and magnitude are guided by the Ou's colour emotion model, and by Sato's [Sato et al. 2000] principle: in the uniform colour space (i.e. CIELAB or CIECAM02), the colour emotion value is related to the distance from the colour having the minimum colour emotion grade on a relevant scale, i.e the *colour emotion anchor colour*.

4.1 Colour Activity

The anchor, i.e. the least active colour, is set to be the muddy yellowish grey at CIELAB coordinates L* = 50, a* = 3 and b*c = 17. Hence the pixel's activity is modified by

$$
\begin{aligned}
L_a^* &= \left(L^* - 50\right)\left(1+k\right)+50 \\
a_a^* &= \left(a^* - 3\right)\left(1+k\right)+3 \\
b_a^* &= \left(b^* - 17\right)\left(1+\frac{k}{1.4}\right)+17
\end{aligned}
\qquad (1)
$$

Here *k* is the correction coefficient controlling the magnitude of "activation" or "deactivation".

The perceptual equivalent of Equation (1) modifies lightness and colour contrast, but doing so relative to the anchor colour rather then to the CIELAB origin, while simultaneously rotating the hue slightly. As the result, the positive "activity" enhancement reduces the low-chroma yellowish tones while simultaneously increasing the chroma of the rest of the colours, giving the feeling of a "cleaner" and more vivid image. According to this model, more active images will have higher lightness contrast, more vivid colours and tones slightly shifted to blue; less active ones will be yellowier and have reduced contrast (Figure 2 (A)).

4.2 Colour Weight

In Ou's model, colour weight is determined by combination of Euclidian distance of L* coordinate from the white L* = 100, and of angular distance of colour's hue h* from the anchor hue h* = 100. Thus, the modified hue is computed as

$$h_w = \begin{cases} h_0 + h_0 \dfrac{(180 - h_0)}{180} w_C k + 100; & h_0 \le 180 \\ h_0 + (360 - h_0) \dfrac{(h_0 - 180)}{180} w_C k + 100; & h_0 > 180 \end{cases} \tag{2}$$

Here k is as in Eq. (1), h_0 is the pixel's hue shifted towards the anchor hue, i.e. $h_0 = h - 100$, and w_C *is* the weighting factor set according to the Chroma C^* of the original pixel:

$$w_C = \left(1 - \frac{C^*}{150}\right)^3 \tag{3}$$

The lightness of the pixel is modified by a gamma function $L_w = L^\gamma$, where γ<1 to increase colour weight, and γ>1 to reduce it.

The perceptual equivalent of colour weight can be described as the overall degree of lightness and "yellowness". Lighter (than the original) images will be yellowier and brighter, with no deep shadows and high-contrast areas. Heavier images, on the other hand, will be bluer, dominated by shadows, and high in contrast (Figure 2 (B)).

5 Colour warmth

Colour warmth is perhaps the most familiar of the emotional colour attributes: most viewers would agree that yellow-redder images are warmer and bluer ones are cooler. In Ou's model, the colour warmth depends on a colour's Chroma and the angular distance from the anchor hue angle h = 50. Consequently, we modify Chroma as

$$C_H^* = C^{*(1+0.03ks)} \tag{4}$$

where k and s are as in (Eqs. 1-2). Hue is modified as described in Eq. 2, just with the different

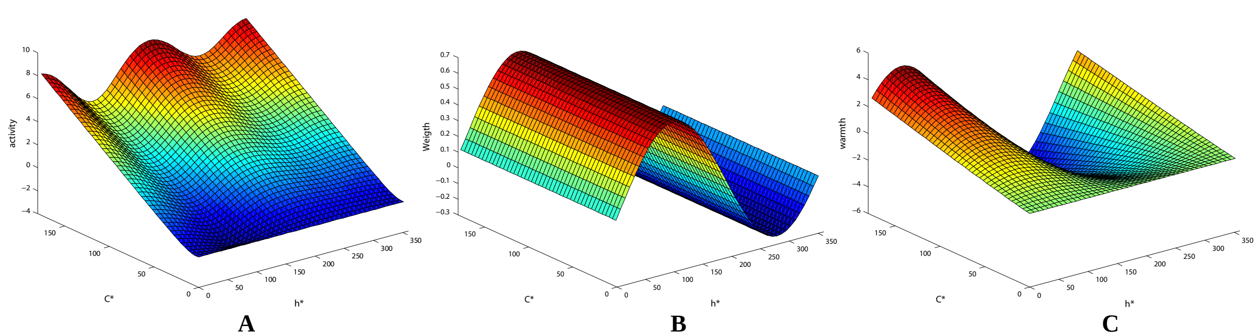

Figure 1 Colour emotion model by Ou et al. 2004a illustrated as surface plots. Colour Activity (A), Weigth (B) and Warmth (C) as functions of CIELAB hue and Chroma, computed for the constant value of Lightness L* = 50.

anchor hue angle value, i.e. $h_0 = h - 50$.

The perceptual effect of enhancing the colour warmth is mostly in making the image more “red” and slightly more vivid (having higher Chroma); we reduce red and Chroma to reduce the warmth (Figure 2 (C))

6 Conclusions

Elements of *Kansei imaging* have always been around in the photography industry. For example, the chemistry of silver halide process has been tuned so the “memory colours” (i.e. sky, skin, grass) are more pleasing, or to tune the general tone to be more “warm” or “vivid” or “cool”, camera lenses have been engineered to result in “soft” or “hard” images, and so forth. By building the composition the photographer designed the content of an image; by choosing the equipment and the film and paper the photographer could effectively design the “feel” of it. We would like to argue that future image processing pipelines will take over some of the professional photographer’s functionality, and make decisions such as “*what was the artistic intent of this image?*”, “*would this person look better with the head slightly turned?*”, “*how can we improve the composition of this image?”*.

The ultimate aim of the imaging industries is to devise products that “… make pictures and please people” [Hunt 2002]. As the digital image capture, reproduction and processing technologies mature, all imaging products will produce good “technical” quality images. When all the products provide similar functionality - how can a company differentiate its products from everyone else’s? Similar questions in industrial design and engineering led to the realisation that products must not only perform their function, but also address users’ emotional needs; this is how the fields of affective design and engineering have emerged. Indeed, many recent cult consumer products owe their success to this approach.

Consumers evaluate their imaging products by the extent to which they are satisfied with the images the product produces. In fact, we might consider the image itself as becoming a product that we sell to the consumers. When this is the case, the intelligent imaging system will have to make “product design” decisions. It will have to decide how, based on a “raw” consumer image, to design an *iPod of an image*; i.e. an image that will be emotionally attractive to the viewer? Consequently, the methodology for doing this can be adopted from product design; i.e. by adopting the *affective design* principles. This is the rationale behind the *Kansei imaging* concept proposed in this paper.

A) less active original more active

B) heavier original lighter

C) cooler original warmer

Figure 2 Examples of modifying image colour emotion properties (as labelled).
Images B) and C are used with permission under Creative Commons 2.0 Attribution license copyright.
B) http://www.flickr.com/photos/jurvetson C) http://www.flickr.com/photos/dracorubio

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