Quantifying beauty: an information system for evaluating universal aesthetics

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Quantifying Beauty: An Information System for Evaluating Universal Aesthetics

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Abstract

In this paper we propose that a metaphor can be used to represent domains that are not easily quantifiable and thus can be used to communicate information about those domains between the human and the computer at a cognitive and visual level. We propose a model which uses the metaphor of a human face as an interface for the perception and evaluation of universal aesthetics.

1. The problem

It is well known that the aesthetic quality of a particular art or artifact such as designs, paintings, music, trigger varying responses in human observers. It is not trivial, however, to relate these responses to particular characteristics of the art or artifact. The notion 'aesthetics of design', for example, describes those characteristics of the design that are responsible for the appearance and perception of a design artifact, and for that part of the artifact that impacts on our emotional and mental world. In particular, it refers to the responses that indicate the degree of discrimination in perception when confronted with a design. This perception depends on the individual's interpretation, which may arise from emotional responses and/or comparison with previous experiences.

The concern for most scholars contemplating aesthetic research is (at least) twofold: how can aesthetic preference be empirically assessed; and how can aesthetic preference be compared pan-humans and cross-culturally. In most instances, what counts as empirical data for aesthetic preference relies on overtly expressed or articulated views at the level of verbal discourse (van Damme, 1996). And even if these concerns were resolved, there still remains the problem of communicating such empirical data on aesthetic preference to the computer.

This paper addresses the issues concerned with cross-cultural aesthetic preferences. First we discuss aesthetics and the phenomenon of universal aesthetics, then we explore the feasibility of using the metaphor of a human face as a means of evaluating aesthetic and other non-quantifiable information. We propose a model which uses the metaphor of a human face as an interface for communicating the perception and evaluation of aesthetic preference to the computer. Finally we suggest future directions for research in the area of quantifying aesthetic preference.

2. Aesthetics

Aesthetics has been described as dealing with "the philosophy of the beautiful as well as with the standards of value in judging art and other aspects of human life and culture" (Lawal, 1974). The term *aesthetics* was first used by Baumgarten, a German philosopher, in the mid-1700s (van Damme, 1996).

The criteria for aesthetics are often expressed in the form of ratios between some numeric parameters of the structure of an artifact, whether it is a musical fragment or a building skyline. The perception of aesthetics is verbally described by closely interrelated terms like *style*, *taste*, *originality* and *beauty*. Taking the example of an aesthetic design again, a style refers to designs that have identifiable common characteristics. For example, ‘federation style’ in Australian building design would usually refer to characteristics such as red brick walls with white mortar, tiled roof, bay and leadlight windows, and timber verandah columns. Personal preferences in style are connected with individual taste. Style and taste are connected with the originality and individuality of a design, although not everything original is aesthetic. Beauty is an even more abstract term and is often used to characterise aesthetics. Beauty is sometimes understood as a part of aesthetics, sometimes as a synonym of aesthetics, which introduces additional confusion.

Visual aesthetic appeal, according to Berlyne (1971), depends partly on the level of arousal triggered by a stimulus. Arousal is characterised in terms of the related variables of novelty, complexity and surprisingness, and is measured by the degree of exploratory behavioural response in humans when confronted with appropriate proportions of these collative variables.

3. Universal aesthetics

The possible existence of universal aesthetics has piqued the interest of scholars from many disciplines, including philosophers, psychologists, anthropologists, cultural scientists and sociologists. According to Forge (1973), the existence of a universal human aesthetic is a matter of faith with neither those supporting nor those opposing the notion of a basic or genetic response to certain forms or proportions being able to prove their beliefs.

Among Westerners, there is widespread acceptance of the special aesthetic value of the famous ‘golden section’. The golden section, which has an approximate value of 0.618, guides many Western designs (Boselie, 1984) (see Fig. 1). Experimental work, however, has not supported the privileged position of the golden section in either Western communities (Eysenck, 1988) or non-Western communities (Berlyne, 1971).

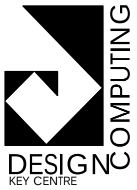


Fig. 1. The logo of the Key Centre of Design Computing, University of Sydney, is based on the principle of the ‘golden section’ (design by Richard D. Coyne).

While there is experimental support for cross-cultural agreement in the evaluation of aesthetic stimuli (notably Child and Siroto, 1971), there are also critics who point out that it is still not known which visual characteristics elicit a positive response across cultures. As Alland (1989) claims, “While they [the Child and Siroto experiments] suggest that some kind of universal principle (perhaps one concerning form) is operating, we have no way of telling what this principle is.” However, there are numerous characteristics of aesthetics that can be regarded as candidates for universal aesthetic principles, such as skill, symmetry, balance, clarity, colour, smoothness, brightness, youthfulness, novelty and fineness (van Damme, 1996).

The experimental evidence of cross-cultural agreement on aesthetic preferences is substantial but not unequivocal. We therefore make the following assumption:

> *Assumption 1: Beauty is perceived and evaluated similarly across humans, regardless of the object that exhibits the beauty.* In other words, the beauty of a building can generate a similar high-level perception and response as the beauty of a face. There is, for example, a high level of agreement pan-humans that the *Taj Mahal* is a beautiful building and that *Mona Lisa* has a

beautiful face (Fig. 2). Further, the emotional positive response to both objects is similar. Regardless of whether the object is a building or a face, the response caused in humans is of the same polarity.

a. Taj Mahal, Agra, India

b. Da Vinci's *Mona Lisa.*

Fig. 2. Perception of beauty.

Assuming the existence of universal aesthetics, there is a need to understand more fully the cognitive processes of perceiving and evaluating beauty. In the next section, we propose that a metaphor can be used to represent domains that are not easily quantifiable. In particular, we propose a model which uses the metaphor of a face as an interface to communicate information about aesthetic preferences between the human and the computer at a cognitive and visual level.

4. The metaphor

For more than two millennia, the metaphor has appealed to scholars interested in language, rhetoric and poetry. In the past few decades, the interest in formal theories of metaphor, which established relationships between its structure, functionality and cognitive nature, has increased and given birth to the contemporary theory of metaphor (Yu, 1998). In the seminal work of Lakoff and Johnson (1980), metaphors are described as depicting incomplete parallels between dissimilar ideas or things, emphasising some qualities and suppressing others. For example, if chess is used as a metaphor for a battle, features such as casualties, relative power and mobility of fighters are highlighted while features such as supplies of weapons and provisions, topography and weather are ignored (Goatly, 1997).

The power of the metaphor has also been employed in the area of human-computer interaction (HCI) and interface design. An example of a metaphor in interface design is the "virtual instrument", which was developed to represent a measure of a particular type of physical value. A visual representation of a sound mixer, for example, is used as a metaphor for adjusting the volume of different media channels. The virtual instrument not only provides conceptual and associative information, it also provides a representation of quantifiable information.

The model developed in this paper is based on the idea of visualising instances of metaphors that share configurations (that is, the metaphors have identical basic parts in the same basic arrangement), and the instances form an interface between human and computer with which the human is able to visually communicate ill-defined categories to the computer for processing. The human face is an example of such metaphor.

5. Why faces?

The power of the face as an object of perception and association has been used in various forms of visual art. Salvador Dali's picture *Abraham Lincoln*, completed in 1976, is an example of the sensitivity of the human visual data formatting and interpretation system.

Humans are able to recognise and derive a tremendous amount of knowledge from a human face. Part of this knowledge is concerned with the individual identity of the person and part of the knowledge conveys categorical information about sex, age, race and other personal characteristics. The face also is a window to the inner feelings and moods of the individual through the rich facial musculature that constitutes an elaborate means of expressing emotions.

From a cognitive point of view, the human face has an innate appeal (Fantz, 1970). From a very early age - even as young as four days - infants show a preference for gazing at representations of faces rather than arbitrary designs or colours (Fig. 3).

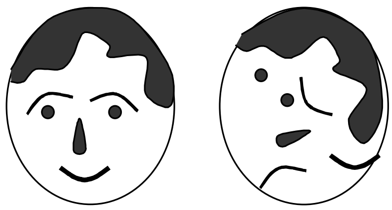


Fig. 3. Infants show more preference for gazing at the face sketch (left) than the sketch with scrambled facial features (right).

5.1. THE HUMAN FACE AS A VISUAL DATA FORMATTING TOOL

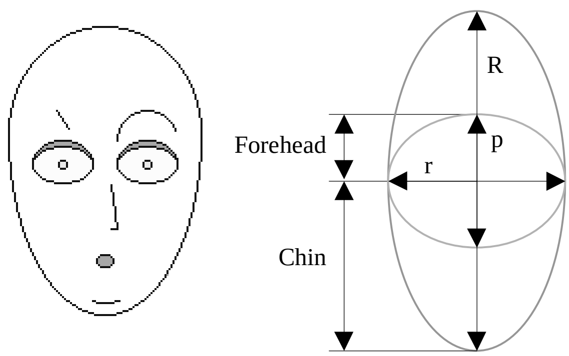
There are two ways of using the face metaphor for data visualisation:

- establish a mapping between model variables and particular facial features;
- establish a mapping between particular states of the face as a whole and particular states of the model representation; that is, of the mathematical description of the model.

In the first case we have an example of a classical data analysis/visualisation scheme in which we identify the elements of the model and then assign to each element a particular feature of the visualisation metaphor. Chernoff faces are well-known example of this approach.

5.2. CHERNOFF FACES

Chernoff (1973) introduced a technique of representing *n*-dimensional (originally $n \leq 18$) data points by means of faces. Widely divergent facial features are associated with different variables. Any change in the face (i.e. in one or more of these features when representing a different data point), can be perceived accurately by the observer. The method is based on the assumption that *the total facial expression from the face space can be related to the meaning of the data point variable space.* The idea is illustrated in Fig. 4. Each variable is associated with the shape of a particular facial feature.



a. Iconic face *b.* Composite parameters

Fig. 4. The idea of “feature-variable” representation in the Chernoff face.

The major drawback of Chernoff faces as a visualisation technique is the necessity to have preliminary knowledge about which features are dominant and which are not. In addition, psychologists (Rhodes et al., 1993; Barlett and Searcy, 1993; Tanaka and Farah, 1993) have demonstrated that the perceptual processing of face patterns involves an holistic analysis rather than decomposing into discrete local features.

6. The model

To the computer, qualitative categories such as beauty and ugliness expressed in symbolic form mean no more than a string of characters. As it is unable to communicate aesthetic preferences efficiently to the human, it does not support this type of visual reasoning. However, we propose that the face can offer a mapping between human perception (based on a visualisation of the face) and numerical computing (based on a digital representation and mathematical model behind this representation). We can communicate to the computer the degree of pleasure aroused by a particular aesthetic stimulus by manipulating a face that most accurately represents the experience. We therefore introduce another assumption:

> *Assumption 2: An interactive visual representation of a face can be adjusted by humans to portray categories of beauty which will be evaluated similarly across humans.* An underlying mathematical model behind the computer-aided visual representation of a face will generate a corresponding set of numbers (comprising both integers and intervals) and there will be a high level of agreement across categories of beauty.

As a simple example of a face metaphor and how the model works, we use instances of manipulated cartoon faces to represent different aesthetic preference (Fig. 5). A parameterised graphic model of the metaphor image is used for the input/output display. Each state of the image corresponds to a particular parameter vector of the underlying representation. These vectors are then compared using different similarity and distance measures. The completion of the framework requires the introduction of metrics in the face vector space.

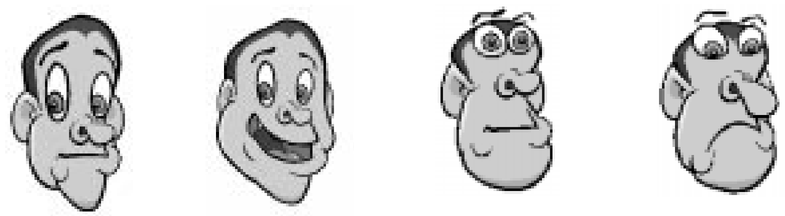


Fig. 5. The face metaphor representing different aesthetic preference (faces created in Catoon-O-Matic 2.0, software by Librande, Schoech, Belfer and Strawn, 1999).

7. Future directions

This paper described the ideas and initial assumptions behind our research in aesthetics. The application of our model will require the use of high-fidelity 3D interactive facial representations. These representations are based on volume lattices controllable through muscle and skin vectors (see Waters, 1992, for examples of such representations). The research project includes experimentation with individuals who will rank design stimuli according to their perceived aesthetic value and manipulate the interactive 3D face representation to match their aesthetic experience. The results will then be compared with the computed face vectors.

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