Computational Intelligence Approaches to Computational Aesthetics

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INTRODUCTION

Computational aesthetics is an area of research which attempts to develop computational methods that can perform aesthetic judgements in the same way as humans (Hoenig, 2005). It is an area of research which has not developed as a separate discipline till relatively recently. The notion of aesthetics is highly intuitive and often subjective. An aesthetic experience can be negative, positive or more subtly nuanced. Human beings have a strong and deep sense of aesthetics, however rationalising aesthetic decisions is challenging. As such developing computational models to make aesthetic decisions is particularly challenging.

While computational intelligence techniques such as evolutionary algorithms have been able to solve many real world challenges, still such techniques are not widely used to solve problems that involve aesthetic decisions. Making an aesthetic decision often requires a human in the loop which in turn creates a barrier between computational intelligence and aesthetics. However recent advancements in computational aesthetics have made computer generated art and aesthetics realisable in several domains (den Heijer & Eiben, 2012; DiPaola & Gabora, 2009).

The purpose of this article is to summarise the advancements in the area of computational aesthetics, challenges involved, computational intelligence approaches to art and aesthetics and possible future directions. The article first summarises early attempts to define aesthetics, through to more contemporary definitions and attempts in developing computational models of aesthetics in various domains. Then, it highlights the challenges associated with bridging the gap between aesthetics and computational intelligence. Thereafter it discusses how computational intelligence techniques are used in art and aesthetics ranging from simple classification problems to more advanced problems such as automatic generation of art artefacts, stories and simulations. The article concludes highlighting the future research directions that need to be undertaken in order to make significant advancements in computational aesthetics and its applications.

BACKGROUND

Aesthetics

The study of aesthetics is chiefly a branch of philosophy with links to other disciplines such as psychology. The term aesthetics was derived from the Greek word aisthanesthai (to perceive (by the senses or by the mind)) and introduced into the philosophical terminology in the eighteenth century (Saw & Osborne, 1960). The definition of aesthetics is a long standing debate. Early definitions of aesthetics are related to art or beauty (Santayana, 1904). Later attempts to define aesthetics discuss that aesthetics mean more than just art and natural beauty (Walton, 2007), (Palmer, Schloss, & Sammartino, 2013). Therefore more

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contemporary definitions are woven around human mental processes involved in making aesthetic judgements; for example:

- *The study of human minds and emotions in relation to the sense of beauty (Palmer et al., 2013).*
- *Psychological mechanisms that allow humans to experience and appreciate a broad variety of objects and phenomena, including utensils, commodities, designs, other people, or nature, in aesthetic terms (beautiful, attractive, ugly, sublime, picturesque, and so on) (Leder & Nadal, 2014).*

Computational Aesthetics

Computational aesthetics is an area of research which attempts to develop computational methods that can perform aesthetic judgements in the same way as humans (Hoenig, 2005). Classifying something as aesthetically appealing or not appealing might be relatively easy for a human even though it is subjective; however for a computer it is not straight forward to make such determinations. As such, a considerably large amount of literature attempts to define explicit measures of aesthetics that make it possible to distinguish aesthetically appealing objects from objects that are not.

In 1933, Birkhoff defined an aesthetic measure M, which can be explained as the regularity (order) perceived in an aesthetic object for a unit of effort (complexity) (Birkhoff, 1933). This can be defined as $M = \frac{order}{coplexity}$. The introduction of this measure is considered as the beginning of computational aesthetics. This measure was investigated by later researchers in relation to information theory. In 2007, Rigau, Feixas, and Sbert (2007) analysed the concepts of order and complexity for pixel values of paintings based on Shannon entropy (Shannon, 1948) and Kolmogorov complexity (Kolmogorov, 1965) and presented a new conceptualisation of Birkhoffs' aesthetic measure based on Zurek's physical entropy (Zurek, 1989). However, vision researchers argue that true entropy of an image, being a perceptual quantity, cannot be characterised with image statistics such as Shannon entropy (Graham & Redies, 2010).

Vision scientists have analysed whether humans have a preference for images that have similar spatial statistical structures to those that the human visual system has adapted for (Palmer et al., 2013). For example, Graham and Field (2007) have identified that paintings (a sample taken from a Museum of Art) and natural scenes have similar Fourier amplitude spectra. Similarly, Spehar, Clifford, Newell, and Taylor (2003) show that humans have a preference for fractal structures irrespective of whether they are natural or man-made.

There is a considerable amount of literature that discuss the shape of an object as an aesthetic measure. Several researchers have reviewed Golden Ratio/Golden Section as an aesthetic measure in various fields (Benjafield, 1976; Gilmartin, 1983; Green, 1995; McManus, 1980; Russell, 2000). If a line is divided into x: (1−x) ratio, the Golden Ratio arises when 1/x = x/(1−x) (Markowsky, 1992). This value is denoted by F and F ≈ 1.618. However, the results in the field are controversial and some studies have shown that the Golden Ratio have no special aesthetic appeal (Boselie, 1984; Davis & Jahnke, 1991; Markowsky, 1992).

Some studies have discussed the symmetry of an object as an aesthetic factor (Locher & Nodine, 1989; Osborne, 1986). Several recent such studies have shown that people have greater preference towards curved objects than objects with sharp contours (Bar & Neta, 2006; Silvia & Barona, 2009). However these measures are fragile and susceptible to many other factors depending on the domain of interest so that their applicability as an aesthetic measure is limited.

Although there is a huge amount of literature on attempts to measure aesthetics in various disciplines, currently there is no universal measure

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