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University of the Visual and Performing Arts

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Enhancing Aesthetic Quality of Digital Images: A Computational Aesthetics Approach

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Abstract

Producing a creative artwork is a significant task that the artists are involving throughout their artistic lives in the field of visual & performing arts. Even though, there are several traditional mechanisms available to generate new products, some of the artists would like to apply new technologies for producing innovative artworks in such way that ensuring its visual aesthetic value while keeping its informative idea as it is. Today, artists are enthusiastic on emerging information technology techniques for applying aesthetic operations like assessment, color analysis and other low level factor adjustments for the enhancement of their designed product efficiently while applying traditional concepts to produce the initial form of the artwork. Computational aesthetics is the research of computational methods that do make applicable aesthetic decisions in a similar fashion as human can. This paper introduces an approach that can be used to judge most critical parameter set which is supposed to be adjusted for generating a creative artwork of a particular product and to adjust those parameters using image processing techniques in the area of computational aesthetics. Further, some of the new tools have been introduced with a view to justify the suitability of the proposed approach.

Keywords: computational aesthetics, Analytic Hierarchy Process (AHP), aesthetics quality, aesthetics design, artwork evaluation.

1.0 Introduction

Creativity is inbuilt to the aesthetic subject area and it is the most challenging task how to incorporate creativity to the art work as it

is a subjective matter and there are not clear standard procedures which can be applied directly to measure it. The theory of aesthetics introduced by George David Birkhoff (1933) in his book *Aesthetic Measure* involves a lot of computational methods. It has built a foundation for several other researchers to come up with different frameworks and models for computational aesthetics. Computational aesthetics is the research of computational methods that can make applicable aesthetic decisions in a similar fashion as human can [2]. Therefore, particular area is needed to study well in terms of assessment and enhancement of a given artwork in the area of visual arts. Practically, it depends on the adjustment of local parameters which lead to the form of the artwork using the ability or the skill of the artwork creator. Currently there is no standard or clear procedure to come up with a decision to select the most critical parameters that should be adjusted in this entire process of creation. It is a qualitative measurement and ultimately, their own experience is used for all the decision making and enhancement of the product without using any methodical approach. Therefore, a requirement arises to propose a model which is applicable to select most significant low level parameters out of the available parameter set.

In this paper, it will propose an approach using a mathematical approach, called Analytic Hierarchy Process (AHP) [10] for selecting the most critical low level parameter set and Image processing techniques have been identified for the adjustment of suggested parameter set in the process of generating a creative artwork. Further, this paper discusses pros and cons of the

experimental results of this approach to justify the suitability of the proposed tools for the enhancements. The paper is organized as follows. First section contains an introduction and the next section includes a discussion on what creative artwork is and the importance of computing aesthetics using a model. Third section discusses about the proposed architecture for selecting most critical parameter set of a digital image. Next section discusses about the image processing techniques required for the adjustment of local parameters of a digital image and the tools developed for color segmentation and the enhancement of digital images. Then, experimental results have also been presented there followed by evaluation and discussion. After that conclusion and future work have been added.

2.0 Creative Artwork and the Importance of Computing Aesthetics Using a Model

When producing a creative artwork, the quality of the product totally depends on the visual aesthetics value. As visual aesthetic value depends on several parameters of an artwork, it is required a multi-criteria decision making method for computing it. Thus, a new approach called AHP was applied as the core theory of this approach. According to Thomas L. Saaty (1980), AHP is a multi-criteria decision-making method. It can be used to select the best quality image with relative weights of its parameters that contributes to the final goal: highest visual aesthetic value. Therefore, this technique can be used to select the most critical set of parameters with their weights for particular image theme. When dealing with aesthetic decisions in artworks, normally, evaluator or group of evaluators will have to express satisfaction

feelings based on the aesthetic quality of the artwork. As the visual aesthetic quality mainly depends on several parameters (design variables) of an artwork, it was able to compute the parameter contribution to the main goal using AHP. In the current architecture, a set of different image groups that can be analyzed based on their form (physical attributes, shape, composition, etc.) were the input images selected by referring some reputed painting archives publicly available [4],[7].

3.0 Proposed Architecture for Assessing Aesthetic Visual Quality of Digital Image and Selecting Most Critical Low Level Parameters

According to the AHP theory, data has to be collected from the participants in subject area based on the hierarchy of parameters built for the main goal and AHP calculations have to be done using the mathematical procedure (Figure 1). As the end result, user can make a comparison for three images according to the set up hierarchy and most significant parameters that will contribute to the visual aesthetic value can be obtained with their weights. Therefore, this comparison will limit for a given set of images, despite the variety inbuilt with the diverse category of available digital image of images to be compared. So, this will be an issue for generalizing the concept for any given set of images. But this can be rectified by developing a tool (system) to get online response from the user/users and do the comparisons for the given set of images. Then, tool will use the AHP theory and do all the required calculations to rank the given set of images. Further, some low level parameters will be selected by the tool opening the way on how to adjust those variables in the product

for the purpose of enhancing up to a creative artwork. Accordingly, assessing tool was developed using the following architecture (Figure 2).

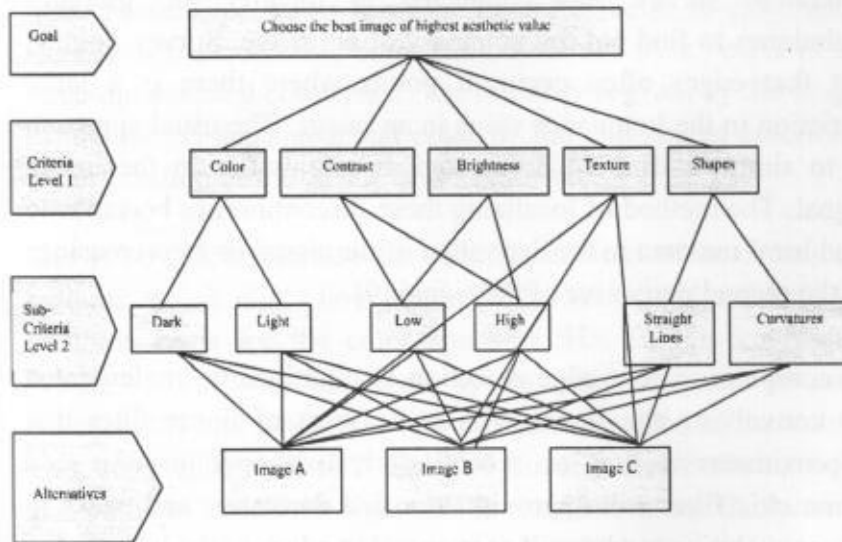


Figure 1: The AHP architecture (customized for three images)

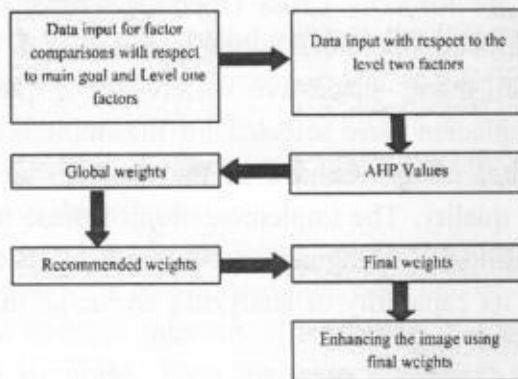


Figure 2: The proposed architecture

4.0 Image Processing Techniques

4.1 Introduction

Literature survey was conducted to identify the graphics techniques to find out the boundary of an image. Survey pointed out that edges often occur at points where there is a large variation in the luminance value in an image. The usual approach is to simply define edges as step discontinuities in the image signal. The method of localizing these discontinuities becomes to find local maxima in the derivative of the signal or zero-crossings in the second derivative of the signal [9].

In computer vision, edge detection is traditionally implemented by convolving the signal with some form of linear filter that approximates a first or second derivative operator. An odd symmetric filter will approximate a first derivative and peaks in the convolution output will correspond to edges in the image.

There are several techniques that are used to identify edges. Some of them are Robert's Cross Operator, Prewitt Operator, successive difference operator, Sobel operator and Laplacian operator. Out of them, successive difference operator, Sobel operator and Laplacian were selected for the implementation to check how digital images behave in the analyzes in terms of visual aesthetic quality. The implementation of these techniques was done by using java language as its application area is so much high and its capability of analyzing an image through the object oriented concepts.

4.2 RGB and Color Spaces

A color recognized by the human eye can be defined by a linear combination of the three primary colors namely red, green and blue. These three colors form the basis for the RGB-colorspace. Hence, each perceivable color can be defined by a vector in the three-dimensional colorspace. The intensity is given by the length of the vector, and the actual color by the two angles describing the orientation of the vector in the colorspace.

The RGB-space can also be transformed into other coordinate systems, which might be more useful for some applications. One common basis for the color space is IHS. In this coordinate system, a color is described by its intensity, hue (average wavelength) and saturation (the amount of white in the color). This color space makes it easier to directly derive the intensity and color of perceived light and is therefore more likely to be used by human beings. In this research RGB color space is used for the implementation of different type of image operations.

4.3 Edge Detection

Edge detection, is based upon the detection of local discontinuities which mainly correspond to the boundaries of objects in the image. An edge, also known as a discontinuity, in a signal is usually defined as a transition in the intensity or amplitude of that signal.

Typically, an ideal one-dimensional edge can be defined as a step from low to high intensity. In practice, the signal is usually corrupted by noise. Then the edge is defined as the transition

from an average low to an average high intensity. Such edges are characterized by their contrast (difference between high and low intensity), and their width or rate-of-change. These measures differentiate between sharp and smooth edges.

4.4 Color Segmentation

In case of a digital image analysis, it is required to include both color and shape information. Images of natural scenes and other themes usually have many color combinations and complicated shapes. So the first logical step would be to simplify both colors and shapes for further analysis. Once that is done, you still have the difficult problem of finding a good way to use your simplified colors and shapes to generate a meaningful algorithm for the particular problem to be solved. Color segmentation can be used to find out the regions of significant size and nearly uniform color. There are different algorithms for color segmentation. Out of the available algorithms, k-means gives better results for digital images [6].

The K-Means is a nonhierarchical clustering technique that follows a simple procedure to classify a given data set through a certain number of K clusters. That algorithm updates the space partition of the input data iteratively. Elements of the data are exchanged between clusters based on Euclidian distance (the distance between the cluster centers and the vector under analysis) in order to satisfy the criteria of minimizing the variation within each cluster and maximizing the variation between the resulting K clusters. The algorithm is iterated until no elements are exchanged between clusters. This clustering

algorithm consists of mainly four steps that are briefly described below.

1. Initialization which generates the starting condition by defining the number of clusters and randomly selects the initial cluster centers. Generate a new partition by assigning each data point to the nearest cluster center.
2. Recalculate the centers for clusters receiving new data points and for clusters losing data points.
3. Repeat the steps 2 and 3 until a distance convergence criterion is met.

4.5 Tool Developed for Color Segmentation

Based on the above theory, a tool was developed to analyze the digital image by changing the parameters like the number of clusters, maximum number of iterations, epsilon and the initialization method (evenly spaced values, random data samples or random values). So, user will have a chance to produce a segmented image based on the parameter values given.

5.0 Experimental Results

According to the above architecture, tool was developed to proof the concept. Netbeans software [5] was used as the main IDE and user will have to follow the scale of measurement from -9 to +9 for data entering.

In this tool, second window will appear by clicking start button on starting window. Then, user has to enter responses within the given scale by comparing high level parameters with respect to

main goal. In third window, responses should be entered by comparing three digital images (image1, image2 & image3) two by two with respect to level 2 parameters.

5.1 Example Test Case: Three Flower Images

Table 1 shows the recommended parameter weights suggested by the tool for a particular user input.

Quality image	Global weights	Dark Color	Light Color	Low Contrast	High Contrast	Low Brightness	High Brightness
image 2	35.3	24.3	7.6	34.4	5	22.9	5.7

Table 1: Recommended parameter weights

According to the table, image 2 was selected as the best aesthetic quality image comparing to the other two images.

Either dark color or light color can be selected by using the theory of dark color or light color will dominate the other. And also, same will apply to the contrast and brightness. Ultimately, the three parameters in Table 2 are the most critical parameters that should be used for generating a creative artwork. In this creation, user would have a chance to use either ImageJ tool[3] for adjustment contrast and brightness or color segmentation tool for the creation of a color segmented image as color is one of the critical parameter.

Dark Color	Low Contrast	Low Brightness
24.3	34.4	22.9

Table 2: Final parameter weights

Final output of the color segmented image of image2 (after adjusting) & the input image of mage 2 (before adjusting) display in Figure 3.



Figure 3: Input digital image and segmented image

6.0 Evaluation and Discussion

In the evaluation of the results set, feedback was taken from 100 users in the subject area. Most of them agreed to the approach used. And also, they can compare the dynamic view of more than one user that is facilitated by this technique even though, it limits only for three image comparisons. They agreed to the flexibility to get the dynamic view of several participants. Specially, they commented on the behavior of the assessing tool of which considering any type of image for the comparisons. One of them commented on the limitation of the system only for three image comparisons. And also, they were happy the behavior of the other tools for adjusting contrast and brightness of the image and creating the color segmented image. Some of them suggested finding a way to add more attributes (parameters) to the same system that will add more flexibility at the time of comparison depending on the users' concern for the visual aesthetic quality.

7.0 Conclusion and Future Work

7.1 Conclusion

Based on the above result, it can conclude that it has been achieved a good result for the research problem. Research work is mainly meant to provide a new framework to characterize an image in terms of visual aesthetic quality. Further, it aims to inspire more interests in this new and fundamentally important and challenging research direction. This research work includes simple image themes for the purpose of simplifying the complexity of the area of study. Therefore, it is required to integrate another soft classification of the image's visual category to classify different category images as a future work of this research.

7.2 Future Work

In this research, author was able to propose a frame work for computational aesthetics in the area of visual arts. Therefore, this can be the foundation for another researcher to study some other area like dancing or music which is in a same state to express another set of attributes for the aesthetics value of particular area. Further, assessing tool was developed by using only three images. Number of input images can also be extended as a future enhancement to expand the usability of the tool in different situations. The selection of parameters related to the aesthetic quality was done by consulting expert views and observing research papers published on the same area of study. Therefore, tool can be enhanced by incorporating different set of parameters proposed. Common aesthetic preferences are mainly focused in

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this study due to the practical limitation. Distinctive aesthetic preferences which vary upon an individual consumer's profile (race, culture, religion, age and gender) can be considered as a future enhancement of this research.

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