Modeling the Perception of Visual Complexity in Texture Images and Painting Images

(テクスチャー画像および絵画に対する複雑さ

の知覚モデルの構築)

by

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Abstract

This thesis devotes to building a relationship between human visual complexity perception and objective image features.

Visual complexity of images is a worth-well investigation. It has a wide range of applications from computer science (emotion semantic image retrieval, digital watermarking and image analysis, etc.) to arts (the design of product surface, wallpapers, painting appreciation and selection, etc.). Various methods for computing image complexity have been developed depending on different applications, such as information theory, fractal dimension, quad tree method, etc. However, these measures are not sufficiently related to human visual perception of complexity. Intuitively, visual complexity is influenced by various factors perceived by humans from the image, not directly related to simple objective measures like distribution of spatial frequencies.

In this thesis, we have investigated the perception of visual complexity in texture images and painting images from the point of human visual perception. The motivation of this research was to build a relationship between human "Kansei" (visual complexity) and computable image features. "Kansei" is a Japanese word with meaning of emotion and sensibility. Kansei Engineering is an approach to connect human sensibility to computing application. The main achievements proposed in this thesis are listed as below.

1) A new method of estimating visual complexity of texture images has been proposed.

A texture has certain features that can affect viewers' complexity perception. We firstly conducted a set of psychophysical experiments to identify these features. By the experiments, we have identified that five important features affect human visual complexity of textures, namely, regularity, roughness, directionality, density, and understandability. Visual complexity is a function of not only each individual characteristic but also of interactions between them. Then a set of methods was designed for objectively measuring the features of regularity, roughness, directionality, and density.

We proposed in particular a new method for estimating understandability of a texture by naming the textures. We discovered that understandability is affected by two factors of a texture: the maximum number of similar names assigned to a specific type and the total number of types.

Multiple linear regression was performed as a mapping function to bridge the relationship between visual complexity perception and five texture features. A series of statistical analyses was performed to test the fitness and correlation between prediction from the proposed model and subjective complexity evaluation given by humans. Compared with the conventional measures based on information theory and fuzzy pattern, the proposed method considers human visual perception, and it predicts the visual complexity of a texture corresponding with the subjective visual impression.

2) A novel framework to assess visual complexity of painting images has been developed.

We proposed a framework to assess visual complexity of paintings. This framework provides a machine learning scheme for investigating the relationship between human visual complexity perception and low-level image features. Since the global and local characteristics of paintings affect human's holistic

impression and detail perception, we studied theoretical and empirical concepts from psychology and art theory to extract the features that represent the global and local characteristics of paintings. Inspiration for these features was from a questionnaire survey we conducted to identify the factors that affect human's complexity assessments of paintings. Then we conducted feature selection, by which we looked into the role that each image feature plays in assessing visual complexity, and then obtained the feature combination that yields the best performance. From a computational perspective, we need to obtain a prediction of visual complexity from all input image features (some responses on complexity that corresponding with human assessment). But it is difficult to predict a specific value for visual complexity. Instead we introduced a machine learning method to classify the visual complexity into three classes: low complexity, middle complexity, and high complexity. All features were combined by a support vector machine for classification.

Experimental results indicated that the proposed work can predict the visual complexity perception of paintings with the accuracy of 88.13%, which is highly close to the assessments of visual complexity given by humans. Compared with the conventional measure of complexity, our approach considers human visual perception and performs more efficiently in assessing visual complexity of painting images. Furthermore, we applied the proposed method to architecture images. The experimental results showed the validity of our method in architecture images.

Keywords: visual complexity, texture images, painting images, kansei engineering, affective engineering, image features, support vector machine, color complexity, understandability.