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SBArt4 – Breeding and Evolving Abstract Images and Animations

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Abstract

Some extensions of computational aesthetic measures are proposed for a domain of evolutionary art in order to be embedded in a simulated breeding system, SBArt. In our experiences of the combination of breeding and evolution, it is effective to reduce the time for producing interesting abstract images and animations.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—

1. Introduction

Interactive Evolutionary Computation (IEC) [Tak01] is a powerful framework to explore in a huge search space efficiently to find better solutions based on subjective criteria. K. Sims [Sim91] is a pioneer of this field who developed a system that allows the user to breed interesting abstract images utilizing a functional expression as genotype. However, the user is often requested to repeat inefficient operations for selection among a number of candidates.

Computational aesthetic measure is useful to calculate fitness values in evolutionary computation to automatically obtain beautiful images. As one of the methods to reduce a user's fatigue of IEC, a combination of automated evolution based on a type of computational aesthetic measures was examined by P. Machado *et al* [MC02]. Several different types of measures were also examined for automated evolution by E. den Heijer *et al* [dHE10].

In the research presented here, we have examined to embed an automated evolution into a breeding system for abstract images, SBART, developed by the author [Une09], of which first release was in 1994. The system is using a functional expression for a genotype similarly to many other related works that calculates a color value for each pixel to paint a rectangular area. Some types of measures newly developed are introduced for fitness evaluation combined with measures borrowed and modified from previous works. In addition to measures for a still image, a criterion for animation is also examined for a new functionality to produce a short animation [Une10].

2. Aesthetic measures

We mention criteria for the layer of perception here but not recognition to avoid a large scale of knowledge base in a cultural context. It will be helpful enough for efficient breeding since it eliminates uninteresting individuals. We introduce three types of measures for spacial arrangement and two types for color variation as follows.

Information theoretic complexity [RFS08] is the ideal concept to measure how meaningful information the data contain, but the computation of this measure is not always able to be completed correctly within a feasible time and space. We use JPEG compression for an approximation, as same as previous works. Because the ideal value of compression ratio should be a subject to change depending on the user's preference, we developed a graphical user interface (GUI) that allows the user to adjust it.

Global contrast factor [MNN*05] is an alternative measure for interesting pattern, of which algorithm was originally designed to evaluate *contrast* as similarly to human's intuitive measure as possible. To expand it to a color space, the difference between brightness is changed into the Euclidean distance between color values in RGB space. Three components are weighted in 2 : 3 : 1 for red, green and blue to adapt to the characteristics of human eyes.

One dimensional distribution of brightness is newly introduced to consider two dimensional pattern by comparing the variances of brightness distribution between rows and columns. If the pattern is of horizontal stripes, the variance among rows is large, but the variance among columns is

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zero. The algorithm calculates the distances to the ideal distributions for each angle from 0° to 90° stepping by 15°, transforms each result from $[0,\infty]$ to $[1,0]$, then takes a geometric mean among them. The ideal distribution was extracted based on a statistical analysis over 500 snapshot photos similarly to the case of color histogram.

Color histogram is an extended version of the frequency distribution of brightness introduced by E. den Heijer *et al.* To extend the method applicable to colors, we divide the color space into $6 \times 9 \times 3$ for each component of red, green and blue, 162 clusters in total. Instead of well-known distributions, such as Benford's law and Zipf's law, we investigated the average distribution among 500 snapshot photos of natural and urban sceneries and portraits. We embedded a sequence of frequencies in top 45 colors that almost follows a mixture of Zipf's law and exponential distribution.

Favorable distribution of saturation is introduced to reflect the user's preference of color tones. A GUI of the system allows the user to indicate the ideal values of average and standard deviation on saturation values over all pixels. A gray image becomes preferable if both of the values are low, and a colorful image becomes preferable if the average is high. The measure is the two dimensional Euclidean distance between the ideal values and the actual values.

It is necessary to normalize the five measures described above because they are in different dimensions for each. We transform each of them into the range of $[0,1]$ from the worst to the best, so that the distributions are as same as possible. The transforming equation we designed is $f(x) = \max(0, \min(1, \frac{0.2}{\sigma}(x^{\log_m \bar{x}} - \mu) + 0.5))$, where m is the median, and μ and σ are the average and the standard deviation after exponential transformation. To determine these coefficients, we examined 1,000 images drawn with randomly generated genotypes.

Aesthetic measure for animation is to measure the distance to the favorable amount of motion in the animation. It is ideal to evaluate the whole duration, but it needs much of computational cost. We implemented an algorithm to calculate the average difference in two consecutive frames among ten samples evenly picked up from the whole sequence. The measure for a still image is also applied to each sample. The total evaluation is calculated as the weighted geometric mean between the average measure of still images and the average amount of motion in sampled frames. The weight is also adjustable by the user using a slider in GUI.

3. Evolutionary process

We chose Minimal Generation Gap (MGG) model [SOK97] for generation alternation because of the quick response and efficiency. The evolutionary process is dynamically illustrated in GUI with a trend graph of the best and average fitness and a collection of small views for the best 20 phenotypes. It is easy for the user to exchange the individual genotypes between the population in automated evolution and the field for simulated breeding by copy & paste and drag & drop operations.

Automated evolution is useful to produce a set of interesting individuals for the start point of breeding. The best one may not be user's favorite but it is easier to find candidates of ancestors than the case of random individuals. Iteration of breeding and evolution is useful to produce interesting, and sometimes beautiful, pieces efficiently.

4. Future works

There are remaining points to be considered in our future research. (1) Statistic analysis of measures concerning correlation and sensitivity should be conducted to clearify how each of the measures is important. (2) Here we employed a geometric mean because the measures should contribute as necessary conditions. The methods of fuzzy logic to calculate a membership value between logical conjunction is one of the alternatives. Some of the users might prefer to use more than two measures as sufficient conditions. (3) Two dimensional Fourier transformation and analysis of the resulted spectra may one of the useful measures for a still image. (4) Optical flow for animation and the distribution of flow vectors is alternative measure for animation. These ideas look useful but it should be checked if they are feasible in computation time for our purpose.

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