

Accelerating Evolution by Direct Manipulation for Interactive Fashion Design

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Abstract

In usual evolutionary computation (EC) is not effective for local search, but efficient for global search due to its probabilistic operators. This problem becomes worse in the interactive EC (IEC) applications, which have the generation length limitation caused by user evaluation. To solve that, this paper proposes direct manipulation (DM) method, well known in HCI field, of evolution for IEC. It allows the user to manipulate individuals directly, instead of using evolutionary operators as an interface to each individual. Through this approach, the DM overcomes the shortcoming of EC, letting alone the ability of global search to the original operators. We have applied the DM concept to the fashion design system based on IEC, and shown that the application is promising with two experiments.

1. Introduction

Evolutionary computation (EC) provides efficient method for machine learning, optimization and classification, based on evolution mechanisms such as biological genetics and natural selection [1]. Though the extensive use of EC, it has not been seldom applied to the artistic domains such as music or design because of difficulty in deriving formal fitness functions to evaluate individuals. Thus, the interactive evolutionary computation (IEC) is proposed, which can solve that problem by taking user's evaluation of each individual as fitness function [2].

In the meantime, to guarantee the performance of EC, it is desirable to maintain the population of evolution as large as possible. It is also required to afford many generations enough to let the population converge. Unfortunately, these requirements cannot be satisfied in IEC applications because it relies on user's evaluation for every individual. Human operators cannot evaluate large number of individuals nor hundreds of generations, which limits the population size and generation length. We propose the direct manipulation (DM) of evolution as a solution of the limitation. The DM of evolution efficiently remedies the shortcoming of IEC that lacks of the capability of local search while having a merit in global search.

To show that the DM of evolution is useful for the IEC application we have applied the DM interface to a fashion design aid system based on IGA and had some experiments.

2. Fashion design system using IGA

We have developed fashion design aid system using interactive GA, to solve the problems of conventional systems such as Creative Designer System from Gerber [3] and Virtual Reality [4, 5]. Their problem was too hard to use for non-professionals. Some other systems developed by Nakanishi using interactive EC [6] solved that problem, but most of its productions were somewhat impractical due to the lack of realistic knowledge on the domain of fashion. Our system provided a solution to encode domain specific knowledge into the system [7].

The system uses IGA to get a preferable design by user. There is a database of partial design elements. Each design is stored in 3D model as an OpenGL [8, 9] list converted from 3D Studio MAX modeling file. System selects the model of each part according to the decoded information from individual chromosome, and combines them into a number of individual designs. There are 34 parts of neck and body, 12 parts of arm and sleeve and 9 parts of skirt and waistline. Each of them can take their own color out of 8. Therefore the size of search space amount to 1,880,064 resulted from $34 \times 8 \times 12 \times 8 \times 9 \times 8$.

The system searches the best designs out of 1,880,064 candidates according to user's feedback on preference and emotion. After user does some evaluation to each individual, system reproduces the population proportional to the fitness value of each design, and applies crossover and mutation operators to make the next population. Iteration of these processes can produce the population having higher fitness value, namely better designs. Through this process, user's emotions reflect to the evolution. He gives fitness values according to his emotions felt from seeing and evaluating each design. As the result, selected characteristics influenced by user's emotion will appear at the next population with large possibility. Therefore, the population evolves based on user's emotion.

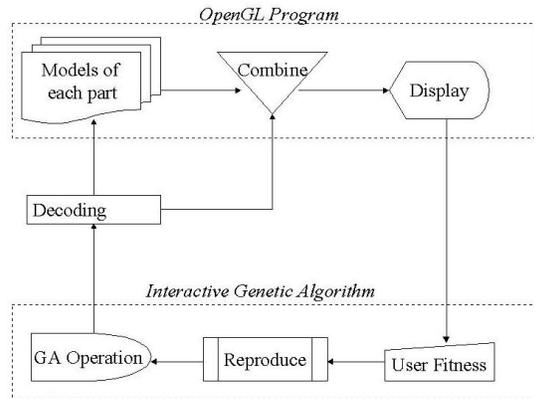


Fig. 1. System overview

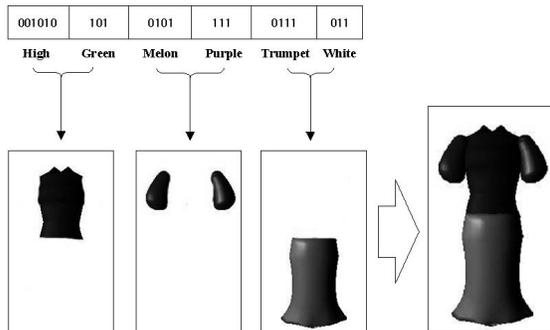


Fig. 2. 3D model gene encoding



Fig. 3. Program Interface

3. Direct Manipulation for IGA

Direct manipulation (DM) is a style of human machine interaction (HMI) design which features a natural representation of task objects and actions promoting the notion of people performing a task themselves (directly) not through an intermediary like a computer [10]. The DM is being studied extensively and many applications are being developed [11].

EC algorithm is advantageous in global search caused by using probabilistic operators on a population. However, that fact can be a defect in local search such as deriving an exact solution from near-solution. It becomes worse in IEC application, which possesses limitation on its generation length. Therefore, this paper proposes and implements a DM interface in the IGA fashion design aid system to solve such a problem. The approach leaves the local search to the user's direct manipulation while evolutionary operators perform the global search. So we can expect efficient retrieval performance within a short generation length of IEC application.



Fig. 4. Direct manipulation interface

'off' is. Then, the system changes that automatically from '000100' appropriate to the double design to '001101' appropriate to the off design.

We have implemented the DM with a pop-up style interface (Fig. 4) to meet our several requirements. User can manipulate the individuals without knowing the foundation of genotype because the interface shows the characteristics of the design such as detail name or color of it, not the genotype itself. If a user wants to change the body design from the 'double' to the 'off', he just selects the off design in the pop-up menu though he does not know what the genotype of the 'double' or the

4. Experimental results

To show the usefulness of DM interface, two experiments have been conducted. We check the possibility of reduction of generation by DM and investigate user's satisfaction for using DM. Every experiment has been operated under the same condition of 0.5 crossover rate, 0.05 mutation rate and elitist preserving strategy. We limit the total generation as 20 for the first experiment, and 10 for the second experiment.

For the first experiment, we have asked subjects to continue retrieval until their preferable design of cool-looking comes out not using DM and examine intermediate designs that can jump to user's final design by applying just one direct manipulation. We count the generation steps to be able to shorten by using DM. For the second experiment, we check the DM number of times and cancellation number of times to validate user's manipulation. We have informed the subjects of the existence and the function of DM interface, including that they can apply the undoing if they are not satisfied with the result of DM. After that we have asked them to find their own cool-looking design using the system and the DM interface. During the search we have recorded the frequency of activation and cancellation of DM. Among the total 10 results of first experiment, we use only 7 results except 3 because 1 result converged too fast to use DM and 2 results did not converge till 20 generation.

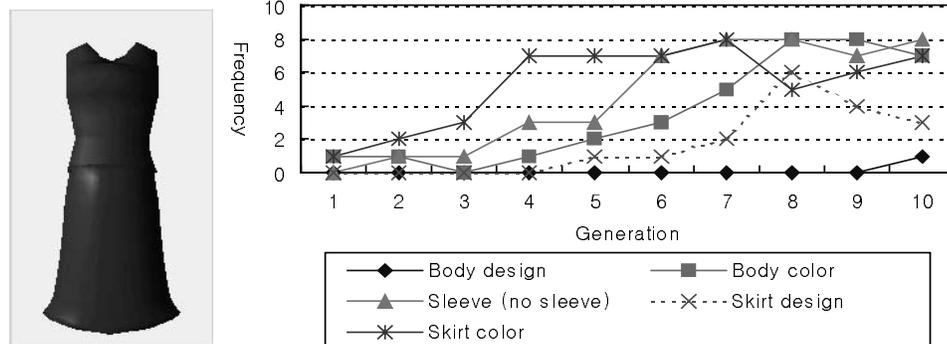


Fig. 5. An example of transitions of schemata in approximated solution for each generation

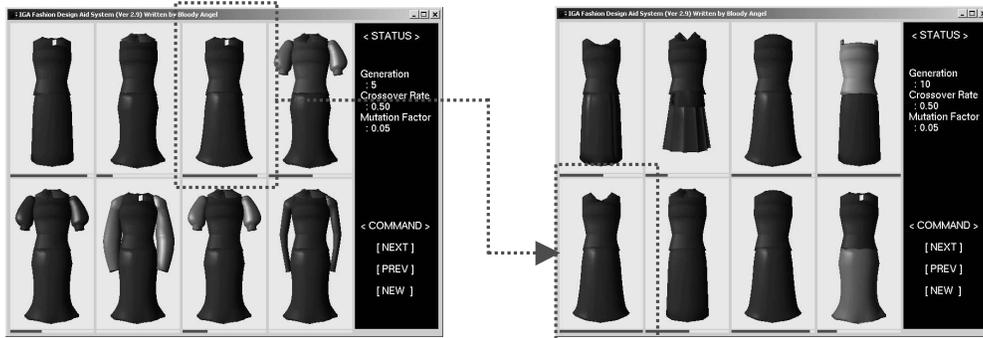


Fig. 6. Captured pictures of the 5th and 10th generation of the same example of Fig. 5

Fig. 5 is one result of the first experiment that shows a transition of schemata in approximated solution, and Fig. 6 shows captured pictures of the 5th and the 10th generations. The 10th generation has the approximated solution of subject, and we can see the fact that there are some possibilities of reduction of generation from the 5th to the 10th if subject uses DM. Table 1 shows a minimum, maximum and average generation lengths to be shortened by DM according to the 7 results of the first experiment.

Table 1. Generations shortened by direct manipulation

Minimum	Maximum	Average
3	9	6.57

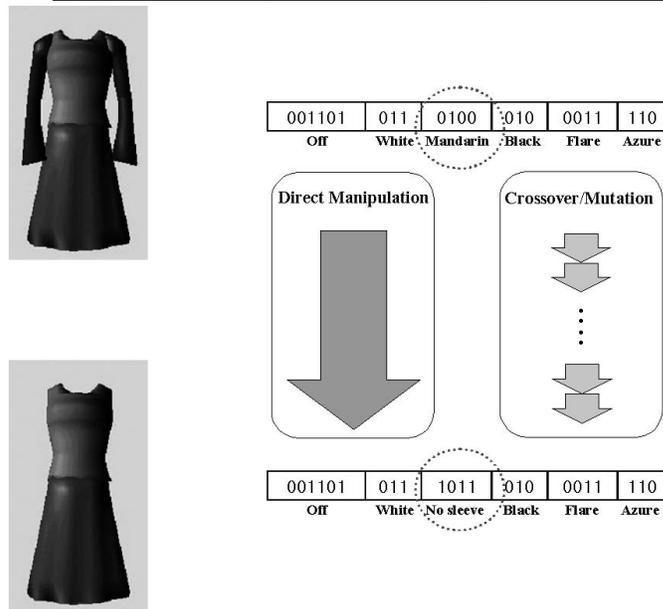


Fig. 7. An example of DM of evolution with respect to corresponding genotype

Fig. 7 shows one example of DM performed by one subject in 9th generation of the second experiment, and it explains how the DM helps the evolution in local search. Users derive a better individual from near-solution by DM. In that example, the sleeve design of the individual is 'Mandarin' before manipulation is marked as 4 bits '0100' on genotype. The user replaced it with a new design 'No sleeve' resulting bits change to '1011', which gives the user more cool feeling. If he had to get it with normal GA operators such as crossover and mutation, he must have searched for a long generation to be selected by the probability as we have shown in the first experiment. Therefore, using DM to change some design parts of fashion or colors can be efficient in local search in the fashion design system.

Table 2. Percentage of valid manipulation

Maximum number of available manipulation	Average number of direct manipulation	Average number of cancellation	Percentage of cancellation	Percentage of valid manipulation
10 times	9.3 times	0.9 times	9.68%	84.0%

From the results we can reach several conclusions. First, we can save time and effort to retrieve if we use DM to reduce generation length. Intuitively it is reasonable and experimental results also support that assertion. Second, we can say that the subjects were significantly satisfied with the result of DM, from the fact that they have hardly canceled their DM. Third, we can state that the DM interface leads the subjects to perform the evaluation actively, which is usually boring and tiresome for them, from the fact that they were still using the DM interface in the last generation at second experiment. From these assertions we can conclude that the application of DM to the IGA fashion design aid system was very promising, and the users can find their own preferable design more rapidly by avoiding shortcoming.

5. Concluding remarks

We have proposed DM of evolution for an IGA application, It means originally a direct control of objects without visible interface in the field of HCI. We have modified this concept and provided a prototype interface of that, which allows users to manipulate the genotype directly instead of relying on the probabilistic GA operators. The proposed DM interface improves the local search performance of IGA, leaving the global search to the original GA operators. With an experimental result we could assert that it was promising.

There remain several points to improve our method. First of all, the theoretical proof of effectiveness of DM is needed. We are studying about the fitness landscape method such N-K fitness landscape to prove that. Second, the balance of IGA search and DM must be studied more extensively. It is important to keep a balance of IGA search and DM, avoiding any reduction of global search performance of GA. Third, we have to prove that the proposed DM approach is desirable for an IGA application by applying it to other IGA systems. There are many IEC applications such as music or drawing, and we need to check the possibility of using DM concept to those applications of other fields.

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