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FASHION SKETCH DESIGN BY INTERACTIVE GENETIC ALGORITHMS

P. Y. Mok*, X.X. Wang, J. Xu, Y.L. Kwok

Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong
tracy.mok@inet.polyu.edu.hk

Abstract: Computer aided design is vitally important for the modern industry, particularly for the creative industry. Fashion industry faced intensive challenges to shorten the product development process. In this paper, a methodology is proposed for sketch design based on interactive genetic algorithms. The sketch design system consists of a sketch design model, a database and a multi-stage sketch design engine. First, a sketch design model is developed based on the knowledge of fashion design to describe fashion product characteristics by using parameters. Second, a database is built based on the proposed sketch design model to define general style elements. Third, a multi-stage sketch design engine is used to construct the design. Moreover, an interactive genetic algorithm (IGA) is used to accelerate the sketch design process. The experimental results have demonstrated that the proposed method is effective in helping laypersons achieve satisfied fashion design sketches.

Keywords: Sketch design, Product design, Interactive genetic algorithms
PACS: **87.55.de**

1. INTRODUCTION

In fashion design, the most natural way for a designer to create a new fashion is with a pencil and a sheet of paper. Sketch-based modeling is a relatively new research area. Some researchers proposed methods to model 3D clothes for virtual character based on sketching [1][2]. Although sketch-based modeling of 3D garment as free-form objects attracted much research attention in the past few years, the technology is not mature enough for apparel manufacturing applications. 3D or sketch-based CAD systems suffer from one major drawback, the resulting 3D objects trade accuracy with appearance effects, so that the 2D patterns flattened from the 3D clothes are not "usable" for actual production due to lack of accuracy. This is because a very important step in fashion design was skipped and free-hand sketches were used directly to build 3D garments.

In the fashion industry, free-hand sketches, also called conceptual sketches, are only used for addressing the design concept of silhouette and, perhaps, some detailing. Upon which, working sketches (sometimes called flats or specs) must then be developed with proportioned drawing showing exact details of seam lines and trimmings so that the patternmaker can use as a guide to create design patterns in 2D [3]. If this step is missing, which implies the detailed measurements are absent, then the generated patterns cannot be accurate at all.

In this paper, a sketch design system is proposed for generating proportioned flats (working sketches) from designers' illustrative sketches. Designers' illustrative sketches can be in form of scanned drawings. The proposed method applies genetic algorithm (GA), one of the intelligent computational techniques, in sketch design, aiming to streamline the garment product development process and facilitate quick response along fashion supply chain.

Holland [4] first proposed GA in 1975 as computer programs that mimic Darwinian's evolutionary processes in nature. GA is stochastic search algorithms based on the mechanism of natural selection and natural genetics [5]. Although there are numerous GA-based applications, the applications in creative industry, such as architecture, art, music, and design, are still very limited. One reason is that GA lacks the capability to utilize human intuition and emotion appropriately. Another important reason is that it is difficult to define fitness functions for these problems. Therefore, a new approach called interactive genetic algorithm (IGA) [6] is proposed as an alternative to solve creative solution problems. IGA differs from GA in the fitness evaluation method. Unlike GA, in which each individual's fitness value is evaluated by calculating a fitness function; in IGA, users' subjective evaluations decide the fitness for each individual [7]. Details about the interactive evolution can be found in [8]. A review of research efforts related to IGA was summarized by Takagi [6]. There are more than 100 publications to tackle different issues using IGA, which can be briefly partitioned into three categories: artistic, engineering and edutainment fields. [6]

Since IGA can perceive the fitness directly from human evaluation, instead of computing some predefined function, it can reflect personal preference. In addition, a standard of "goodness of design" needs not to be defined in an IGA system, which means ranking designs is not necessary, thus diversified designs are encouraged. As a result, IGA

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is a good solution for fashion design. Applications of IGA to fashion design problems can be classified into two major classes. One is applications of IGA in fashion design. The other is developing a fashion design system based on the techniques of IGA. The focus of the former is IGA, while the focus of the latter is cloth style design system.

Regarding applications of IGA in fashion design, Gong, Hao, Zhou and Sun [9] established a model for IGA with multi-population and designed a strategy for individuals' migration. In addition, this algorithm was applied in fashion design in order to demonstrate its effectiveness. In Gong, Guo, Lu, and Ma [10]'s study, an adaptive interactive genetic algorithm with individual interval fitness was proposed which an individual fitness is expressed by an interval. The algorithm proposed in this paper was also applied to a fashion evolutionary design system.

As pointed out in Takagi's paper [6], IGA provides two advantages over GA: the first one is that it performs optimization with human evaluation, and the second one is that it reflects personal preference. Although IGA has some advantages, developing a fashion design system based on the techniques of IGA is a complex task. As a result, only a few attempts to develop garment style design system using IGA were reported in the literature. For instance, Inui [11] constructed an apparel design system, in which combined genetic algorithm with apparel computer aided design system to produce apparel design that the system users prefer. Nakanishi [12] developed a fashion design aid system using genetic programming, which evolved each dress design according to the user's selection. However, most of its productions were impractical designs because they did not consider domain-specific knowledge. To solve this problem, Kim and Cho [13] proposed an effective human-oriented evolutionary system based on the knowledge of fashion design to encode genotype with OpenGL design models in order to produce more realistic and reasonable design. Unlike traditional approaches that attempt to model the dress design by several spline curves, Kim and Cho [13] provided a new encoding scheme to describe a dress with three parts: neck and body, sleeve, and skirt. Cho [14] also used a new encoding scheme to fashion design system. In their study, with IGA some combination that produces the user preferred design was found out. Nevertheless, this encoding approach results in a very large search space. Moreover, Ogata and Onisawa [15] designed a cloth design support system based on IGA which could help laypersons design clothes reflecting their ideas and help arrive at unexpected design candidates by only evaluating various candidates. However, the jacket candidates were generated by combination of each part of a jacket, which also leads to a very large search space. As a consequence, it is impractical to implement their algorithms due to their computational complexity for large and complex data sets. Although Sugahara, Miki and Hiroyasu[16] proposed a Japanese Kimono design system that adopts IGA to create a Japanese Kimono that accommodates user's taste, in comparison to other popular fashion products, a Japanese Kimono is a special product. Hence, this proposed Japanese Kimono design system cannot deal with more complicated fashion products.

In this paper, a new sketch design system is developed which integrates a sketch design approach and an interactive genetic algorithm. The system is easy for laypersons to use, also quickly converges to the target style. The remainder of the paper is organized as follows. Firstly, a brief description of the sketch design problems is given in section I, and a new methodology is outlined in section II. Secondly, a sketch design approach is presented in detail in section III. Thirdly, in section IV, an interactive evolutionary strategy is used to accelerate the sketch design process. Fourthly, the effectiveness of the proposed methodology is illustrated in section V. Finally, conclusions are summarized in section 6.

2. METHODOLOGY

In this paper, as shown in Figure 1, a general methodology which combines a sketch design approach and an interactive genetic algorithm is proposed to help laypersons design clothes reflecting their preference. For the sake of simplicity, skirts (Independent clothes covering the lower half of one's body, or a part of clothes under waistline) [13] are used as examples to illustrate the proposed sketch design system. Needless to say, the proposed sketch design system can deal with more complicated fashion products such as jackets and suits.

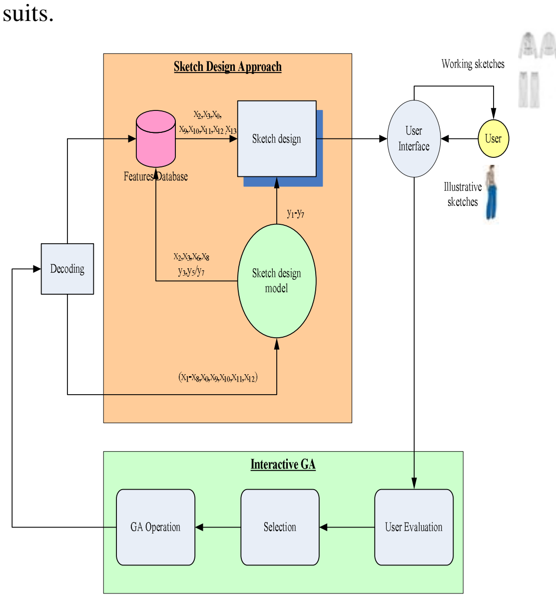

Figure 1.System architecture

The sketch design approach consists of a sketch design model, a database and a multi-stage sketch design engine. A sketch design model based on the knowledge of fashion design is developed to describe skirt styles and characteristics by using parameters. A database as shown in Table 1 contains general style elements about skirts. A multi-stage sketch design engine is developed to construct clothes sketches. The proposed sketch design method can be used for laypersons to design sketches reflecting their own preferences. Moreover, an interactive genetic algorithm (IGA) is used to accelerate the sketch design process. The outline of this sketch design system is as follows:

1) A user subjectively chooses the waist level and skirt length of skirt candidates.
2) A sketch design model creates skirt silhouette shape, waist style and key style elements in the database according to decoding of the skirt style information, the multi-stage sketch design engine combines them according to decoding of the skirt style information in order to generate the skirt candidates, and then the skirt candidates are displayed on screen for users to evaluate.
3) A user subjectively evaluates the skirt candidates and chooses the more favorite ones.
4) The system modifies skirts according to users' evaluations by using genetic operations of crossover and mutation, and the modified skirt candidates are displayed again for evaluation.
5) The system iterativelyimplements procedures (2) and (4) to produce skirt candidates for user's subjective evaluation. If a user is satisfied with some designed skirts, the system can terminate the design process.

Table1.Skirt classifications

The contributions of the proposed methodology are listed as below:

1) A sketch design model based on the knowledge of fashion design is developed to create various skirts and to overcome the impractical designs. In particular, instead of deciding skirt styles according to experienced designers' experiences, skirt styles are determined by input parameters and output parameters for silhouette. It is obvious that it provides an effective means to help laypersons obtain preferred clothes.
2) A multi-stage sketch design method is developed in order to help laypersons achieve satisfied clothes without compromising the computational effort and expense.
3) An interactive genetic algorithm is used to accelerate the sketch design recognition process. This IGA is different from previous research in four aspects: first, in order to ensure a good compromise between the computational time and the quality of solution, an appropriate population of 9 individuals is chosen to ameliorate the shortcomings of a large population size and a small population size. Second, unlike other studies [13-15], in our method, the value encoding approach is developed to diminish the size of the search space. Third, users are allowed to select one to three individuals per generation so as to achieve a good balance between design variability and rapid convergence. At the same time, users are allowed to lock (i.e., reserve) more than one individual for each generation in order to improve convergence speed while maintaining design variability. Finally, all the individuals for each generation are reserved in order to prevent premature convergence of the population.

3. SKETCH DESIGN APPROACH

3.1.SKETCH DESIGN MODEL

The mathematical model governing the sketch design has the following form:

Evaluate Y = F(X)

where X represents the vector $X=(x_0, x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13})$. Y represents the vector $Y=(y_1, y_2, y_3, y_4, y_5, y_6, y_7)$. The vector of $A=(a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13})$ and $B=(b_0, b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}, b_{11}, b_{12}, b_{13})$ are the low and upper bound of X. The first parameter (x_0) is used to describe the skirt silhouette type. Each skirt silhouette shape is represented by the following eight parameters ($x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$) shown in Table 2. Table 3shows the seven output parameters ($y_1,y_2,y_3,y_4,y_5,y_6,y_7$) for silhouette. The waist type and hem type are determined by the tenth parameter (x_9) and the eleventh parameter (x_{10}), respectively. The following two parameters (x_{11}) and (x_{12}) are introduced to define the key style elements such as dart, yoke, pleat, panel, and gathers. The last parameter (x_{13}) indicates additional detail features such as slit and the number of ruffles for hem.

Subject to: $A \le X \le B$ (1)

$$x_9 = \begin{cases} la_9 & if \quad 0.6 \le x_2 \le 0.85 \\ na_9 & if \quad 0.85 \le x_2 \le 1.1 , \\ ha_9 & if \quad 1.1 \le x_2 \le 1.5 \end{cases} \quad (2)$$

Where la_9=(1,2,3,5,7,12,13),

na_9=(1,2,3,5,7,10,11,12,13) and ha_9=(2,4,6,8,9,10).

$a_{10} \le x_{10} = c_{10} \le b_{10}$ and $a_{11} \le x_{11} = c_{11} \le b_{11}$ and $1 \le x_{12} \le 5$, $\forall$ y3, and $\forall$ y5 or y7 (3)

Table2.Input parameter forsilhouette

Parameters	*Description*
x_1	symmetry
x_2	waist level ratio
x_3	hem level ratio
x_4	design ease at hip
x_5	hem width ratio
x_6	flag
x_7	style point level ratio
x_8	style width ratio

Table3.Output parameter for silhouette

Parameters	*Description*
y_1	vertical scale
y_2	ease at hip
y_3	hip ease ratio
y_4	to define key style elements
y_5	to define different silhouette and key style elements
y_6	to define style point
y_7	to define key style elements

The sketch design model based on the knowledge of fashion design is developed to describe the characteristics of a skirt by using parameters so as to create various skirts and to overcome the impractical designs. As shown in Figure 2, this sketch design model is composed of five portions: skirt silhouette shape, waist level and waist style, skirt length and hem style, key style elements, and additional detail features. Key style elements portion consists of dart, pleat, panel, yoke, and gathers. Constraint (1) ensures that each parameter will not exceed the appropriate ranges. Constraint (2) makes sure that each waist type can be assigned to which waist level. For instance, if 0.5≤x2≤0.9, then the waist level of this skirt is low waist, x9=la9=(1,2,3,5,7), which indicates that one waist style is selected randomly among five waist styles (i.e.,waist1/waist2/waist3/wiast5/waist7). Constraint (3) indicates hem style and key style elements options.

3.2. FEATURES DATABASE

A database of general elements about skirts is shown in Table 1. At the first level, the outline silhouette of skirts is categorized into seven classes. At the second level, waist styles are further classified into twelve classes, and then hem style are further classified into five classes; while five key style elements is further classified into classes, respectively.

3.3. MULTI-STAGE SKETCH DESIGN

The procedure of sketch design is composed of five stages: Stage 1 for users to select the waist level and skirt length, Stage 2 for generating the skirt silhouette shape, Stage 3 for generating waist style, Stage 4 for generating hem style and the key style elements, Stage 5 for combining. In particular, instead of deciding skirt styles according to experienced designers' experiences, skirt styles are determined by input parameters and output parameters for silhouette.

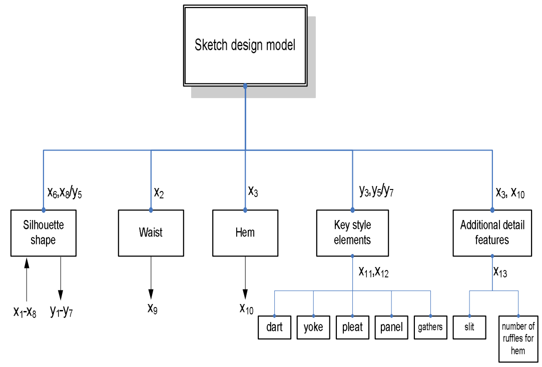

Figure 2.Sketch design model

4. INTERACTIVE GENETIC ALGORITHM

In this section, an interactive genetic algorithm is introduced to accelerate the sketch design process. Unlike genetic algorithms, a standard of "goodness of design" needs not to be defined in IGA. In other words, it is not necessary to organize the fitness function as the algorithm perceives the fitness directly from user. As a result, it reflects designer's preference in sketch design directly. . Assuming that the current generation is t and the current population is represented by X(t).

4.1 STRUCTURE OF THE INDIVIDUALS

Although there are many different representations to implement interactive genetic algorithm, the most natural representation for the skirts design problem is the value encoding representation [17]. In this study, the information contained in an individual is used to construct a feasible solution which corresponds to a unique skirt.

In this research, chromosome representation as shown in Figure 3 is composed of two portions: a set of genes in the first portion of the string indicates the information about silhouette, in which the first gene is an integer number to indicate the different skirt silhouette shape, the following eight genes is a set of real numbers to represent the eight input parameters for silhouette. And a set of genes in the second portion of the string comprises four genes to represent waist, hem and other five key style elements: the first gene and the second gene of this portion of the string are integer numbers contain the information about waist style and hem style, the third gene is an integer number to describe the key style elements such as dart, yoke, pleat, panel, and gathers, and the forth gene is an integer number to decide which key style element type such as straight dart, curve dart, tuck dart and so on. The last gene of the string indicates additional detail features such as slit and the number of ruffles for hem. For instance, Figure 4 shows a chromosome decodes an Aline skirt including waist band and flounce hem.

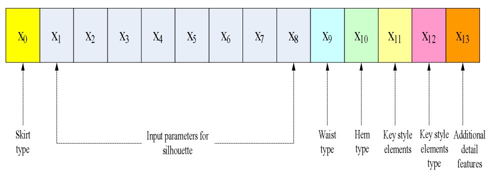

Figure 3. Chromosome encoding

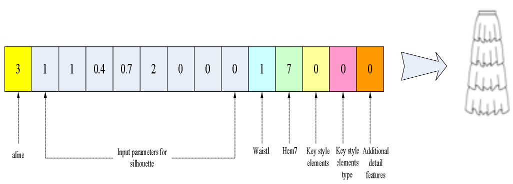

Figure 4. Decoding of a chromosome

4.2. POPULATION SIZE

An important point for any genetic based algorithms is to define the population size. A large population size could allow the algorithm to search a large area of “design space” at each generation in order to achieve a faster coverage. However, it is obvious that the user may be fed up to wait for the preferred designs. Alternatively, a smaller population size is accessible, but it leads to fast convergence rate, which means that the search process is trapped into a local optimum very rapidly owing to insufficient exploration of the solution space. This phenomenon known as “premature convergence” has misled the genetic search process to converge to wrong regions in the solution space. In order to avoid this undesirable result, the convergence rate should be slowed down by increasing the population size. It can be noted that increasing the population size reduces the convergence rate. However, the computational time of the genetic search process could be severely lengthened. In this research, an appropriate population of 9 individuals is chosen in order to ensure a good compromise between the computational time and the quality of solution.

4.3. INITIALIZATION

Although the initial population is generated randomly in traditional genetic algorithms, in this study, an initial population of 9 individuals is created by a predetermined method. This initial population differs from other traditional genetic algorithms and interactive genetic algorithms in that it consists of two parts: user preferred individuals (i.e., users select the waist level and skirt length) and randomly generated individuals. The former one is used to provide the user all the preferred features of the preferred designs by subjectively choosing waist level and skirt length so as to achieve a faster coverage; whilst the other one is adopted to improve the diversity of individuals. The number of the user preferred individuals is larger than the number of the randomly generated individuals, that is to say, the user preferred individuals will occupy the major part of the initial population.

4.4. SELECTION OPERATION

Meghna and Barbara [18] developed a method called “human ranks”, which provides feedback to designs by using 5-point scale (i.e., 1-5). The advantage of this method lies in its accuracy. But it leads to overwhelming to the user due to cognitive overload. Alternatively, in this algorithm, the user is allowed to select one to three individuals per generation without giving human ranks to these designs so as to limit user fatigue without compromising the diversity of individuals.
In the case of selection operation, three selection schemes are implemented. Firstly, if one individual is selected, then the selected individual will be cloned eight times. These eight individuals will be placed into a pool where the mutation operation is performed. Secondly, if two individuals are selected, then one individual is randomly selected within the two selected individuals to clone the third individual, then these three individuals will be placed into a pool where the genetic operations of mutation and crossover are performed. Thirdly, if three individuals are selected by the user, then the three selected individuals will form a pool for crossover and mutation operations, In the second and third schemes, what operation is performed is determined by the user. That is to say, crossover and mutation operations are employed together, or only one operation is applied. At the beginning of the search process, the crossover operation is employed to explore as much the search space as possible. Once the individuals are closest to the target, the mutation operation is applied to allow more fine tunings. Unlike the elitist strategy [19] of genetic algorithms, rather than reserving the single best individual with the highest fitness value in parent population; with this algorithm, the user is allowed to select one to three individuals per generation so as to guarantee the diversity of individuals and maintain a fast convergence. Indeed, it regulates a balance between design variability and rapid convergence.

4.5. CROSSOVER OPERATION

In this study, no crossover operator is employed before the “ip8” gene in order to avoid changing the skirt silhouette shape. For the genes of the chromosome beyond the “x8” gene, multi-point discrete crossover operator is applied to recombine the individuals. The procedure of the crossover operator is presented below:

Step 1. Select two parents randomly from the mating pool.

Step 2. Fill in positions in the offspring chromosomes before the "x_8" gene by copying corresponding elements of the parent chromosomes.

Step 3. Randomly generate a decision string with the same length as parent chromosomes. The genes before the "x_8" genein the decision string can take avalue of 0. Each gene after the "x_8" genein the decision string can take a value of 0or 1. A value of"1"indicates that the corresponding components of the first offspring chromosome are copied from the second parent chromosome; otherwise, it represents that the positions in the first offspring chromosome are filled with the elements of the first parent chromosome.

Step 4. Fill in some positions after the "x_8" gene in the first offspring chromosome with corresponding elements of the first parent chromosome associated with a "0" in the decision string. The remaining positions after the "x_8" gene in the first offspring chromosome are filled by copying from the corresponding elements of the second parent chromosome whenever the decision string contains a "1".

Step 5. With reference to the second offspring chromosome, the procedure is similar as the first off spring chromosome.(i.e., *Step 4*).

4.6. MUTATION OPERATION

When the crossover process is completed, the mutation operator will be used to guarantee population diversity. In this research, for the seven genes (i.e., x0, x4, x5, x9, x10, x11, x12), the Gaussian mutation operator is employed. Let X denote the value to be mutated, and the notation XM denotes the value after mutation, which is a random value (normal probability distribution):

$$X^M = G\ (X_{min}, X_{max})$$

Where X_{min} and X_{max} are the lower and upper bound, respectively

The crossover rate and the mutation rate are not fixed throughout the experiments. The crossover rate and the mutation rate could be changed by the user. At the beginning of the search process, the increase in the crossover rate and in the mutation rate can gradually reduce the convergence rate of the genetic search process. Once the individuals are closest to the target, the crossover rate and the mutation rate should be reduced to allow more fine tunings.

4.7.NEW POPULATION

All the newly generated individuals and the locked individuals are then collected to form the new population known as **X(t+1)**, which will replace **X(t)** and serve as the population of individuals for the next generation t+1. Unlike the elitist strategy [19]of genetic algorithms, in this study, all the individuals for each generation are reserved to preserve diversity of designs, whilst these reserved individuals can be re-evaluated for some generations by the user in order to prevent premature convergence of the population (i.e., prematurely losing useful designs early in the search process) [18].

4.8. TERMINAL CRITERION

In this algorithm, the iteration is stopped when the user is satisfied with the created individuals. In such case, the search process is terminated and the user preferred solution is returned as the final solution.

The steps for implementing this IGA are outlined clearly in Figure 5. The crucial factors of the proposed interactive genetic algorithm are presented in detail as below.

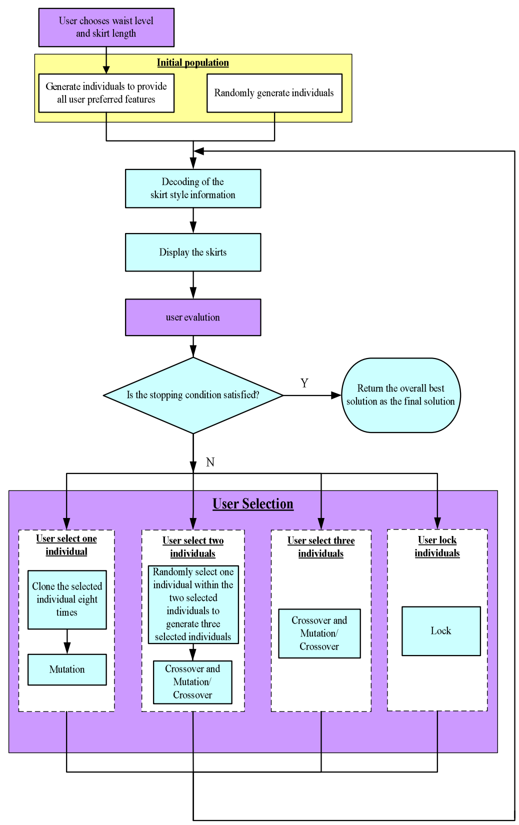

Figure 5.Block diagram of the interactive genetic algorithm

5. EXPERIMENTAL RESULTS

In this section, subjective experiments are performed to verify the proposed methodology, which helps laypersons design clothes reflecting their own preferences.

In this study, ten subjects are requested to design skirts reflecting their own preferences by using this system. In all the experiments, the genetic parameters adopted for the interactive genetic algorithm are Population size = 9, Maximum number of generations = 15. Crossover rate = 0.7, Mutation rate = 0.9. The crossover rate and the mutation rate are not fixed at 0.7 and 0.9, respectively throughout the experiments. The crossover rate (i.e., “feature swap” menu on the interface) and the mutation rate (i.e., “random factor” menu on the interface) could be changed by the user.

Due to space limitation, we only use one example to present the procedure of implementing the proposed methodology. Figure 6 shows the initial population. Here, the initial population consists of two parts: user preferred individuals and randomly generated individuals. For instance, as shown in Figure6, if high waist level and short skirt length (i.e., the length of a skirt is above knee) are chosen by the user, all the four waist styles corresponding to the high waist level (i.e., waist4, waist6, waist8, waist9) should be involved in the initial population (i.e., Design 1#, Design 2#, Design 3#, Design 4#).

Figure 6.Initial population

At the start few generations, feature swap function (i.e., crossover operation) is performed to get more different designs; as the design converges to a target, the random factor function (i.e., mutation operation) is applied to obtain more fine–tunings. If the user is satisfied with the major features of the individual, then this individual in parent population is locked (i.e., reserved) and is copied directly into the new population. Figure 7 shows the generated designs after four generations, and also shows that Design 3# and Design 5# are locked by the user. In this algorithm, the iteration is stopped when the user is satisfied with the created individuals. In such case, the search process is terminated and the user preferred solution is returned as the final solution. Figure 8illustrates the final generation and the final design is presented in the flying window.

In addition, subjects are asked to answer questionnaires as shown in Table 4 with 5-point scale (i.e., -2 to +2) after experiments, that is to say, +2: I think so very much, +1: I think so, 0: neutral, -1: I don’t think so, -2: I don’t think so very much. Table 5 summarizes questionnaire results. The second row (i.e., Question 1) and the third row (i.e., Question 2) refer to the user interface of the proposed system, which reveals that it is simple to use. The following two rows (i.e., Questions 3 and 4) show that the average evaluation over one for each evaluation item, which indicates that subjects can design and obtain skirts with high satisfaction degree by using the proposed system.

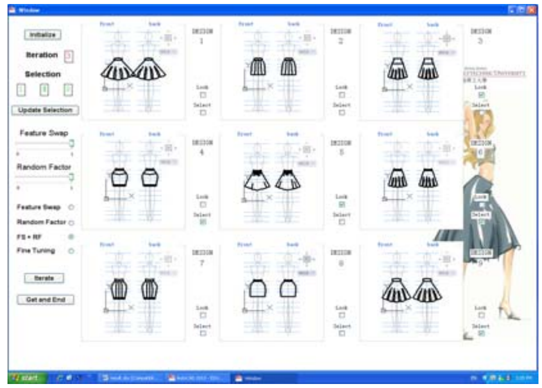

Figure 7.Generated designs after four generations

Figure 8.Final generation and final design

From the result of Question 5, it is found that there are many subjects who had not have a general image of their preferred skirts. The last question in the list indicates that it is difficult for subjects to design their favorite skirts without any design support systems. As the previous presentation, it can be noted that even if subjects who have an ambiguous image of a favorite skirt cannot design skirts without any design support systems, they can design a satisfied skirt by using the proposed system. Indeed, the proposed methodology is effective for non-professional users to design and obtain skirts reflecting their preference.

Table4.Questionnaire

No.	Questionnaire
1	A user interface is simple to understand.
2	A user interface is simple to use.
3	Satisfied skirts are obtained by using this system.
4	It takes short time to design satisfied skirts.
5	You can image the features of a skirt which suits your preferred design before experiment.
6	You can design skirts by yourself without this system.

Table 5.Questionnaire results

No.	Subjects 1	2	3	4	5	6	7	8	9	10	Ave
1	2	2	1	2	2	1	2	2	2	2	1.8
2	2	2	1	2	1	0	1	2	2	2	1.5
3	2	1	2	2	1	2	2	1	2	2	1.7
4	2	2	0	0	1	1	2	2	2	2	1.4
5	1	0	0	2	1	0	0	1	2	1	0.8
6	-2	-2	0	-1	-1	0	0	-2	-2	-2	-1.2

6. CONCLUSION

In this study, a sketch design approach based on an interactive evolutionary strategy has been proposed for laypersons to design clothes reflecting their preference. This system possesses several advantages over the existing fashion design systems. Firstly, a sketch design model based on the knowledge of fashion design is developed to create various skirts and to overcome the impractical designs. In particular, skirt styles are determined by input parameters and output parameters for silhouette instead of deciding skirt styles according to experienceddesigners' experiences. Secondly, a multi-stage sketch design method is developed to help laypersons achieve satisfied clothes without compromising the computational effort and expense. Finally, an interactive genetic algorithm is used to accelerate the sketch design process. The subjective experiments results have shown that the proposed methodology has provided an effective means to help laypersons get satisfied clothes according to the laypersons' preference.

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