Automatic Generation of Aesthetic Images for Computer-Assisted Virtual Fashion Design

Mickaël NAUD, Msc, Paul RICHARD, PhD,
Prof. François CHAPEAU-BLONDEAU, Prof. Jean-Louis FERRIER
Laboratoire d'Ingénierie des Systèmes Automatisés (LISA), University of Angers, Angers, France
e-mail: {mickael.naud, paul.richard, chapeau, jean-louis.ferrier@univ-angers.fr)

Abstract

The paper presents both a theoretical framework and software developments for the creation of aesthetic images in the context of virtual fashion design. Image generation involves different approaches such as iterated fractal systems (IFS) and nonlinear trajectory models. Both model parameters and colour space exploration is performed through a simple user interface. Interactive mapping of the generated images is realized on virtual clothes, and realistic rendering techniques are used for 3D visualisation. The results contribute to promote both computer assistance and mass customisation for fashion design.

1. Introduction

There is a multitude of domains in which aesthetic component plays an important role. For example to estimate the interest of solutions proposed in architecture, product design, interior decoration, or in the field of fashion design. Automatic or computer assisted generation of solutions is a promising domain. However, we are confronted with the difficult problem of the formalization of aesthetic criteria. Moreover, the aesthetic interest of a solution generated by a computer lies in the way the human perceived it.

In the context of fashion design, Virtual Reality (VR) techniques provide a very efficient way of visualizing clothes with different texture images on virtual mannequins in both static and dynamic situations (catwalks). However, fashion design VR applications allow only to show 3D clothes models with predefined texture images. We believe that the integration of "on-line" creation modules may stimulate creativity of the designers or customers and reduce the number of physical prototypes. Indeed, such modules could propose some efficient functionalities for automatic generation of digital patterns with aesthetic qualities. Aesthetic may be defined here by some geometrical properties such as symmetries or regularities in scale.

In this paper, we present mathematical models that allow automatic generation of aesthetic images in the context of fashion design. Our current approach involves both iterated fractal systems (IFS) and nonlinear trajectory models. In section 2, we describe the proposed methodology and analyze two of the most interesting mathematical models we use. In section 3, we present two software applications that allow easy creation of aesthetic textures images and 3D mapping onto the clothes of a virtual mannequin. The paper ends by a conclusion and gives some tracks for future work.

2. Methodology and models

The contribution of this work is multiple and involves three complementary steps:

1 - the identification or development of mathematical models showing some potentialities for generating complex patterns with aesthetic qualities,

2 - the implementation of the identified or developed mathematical models for computer-aided exploration of their potentialities,

3 - the integration of the mathematical models in a flexible software platform offering multiple interactive capabilities for virtual fashion design.

2.1 Methodology

The developed methodological approach is illustrated in Figure1. This approach is based on two modules:

- The exploration module allows the user for fast exploration of the mathematical models parameters.

- The visualization module allows visualizing the generated images onto clothes of a virtual mannequin. The generated images may be correctly placed and/or scaled directly on the clothes. The user is also allowed to rotate and zoom on the mannequin using the computer mouse. In this way, he/she could get better appreciation of the final result.

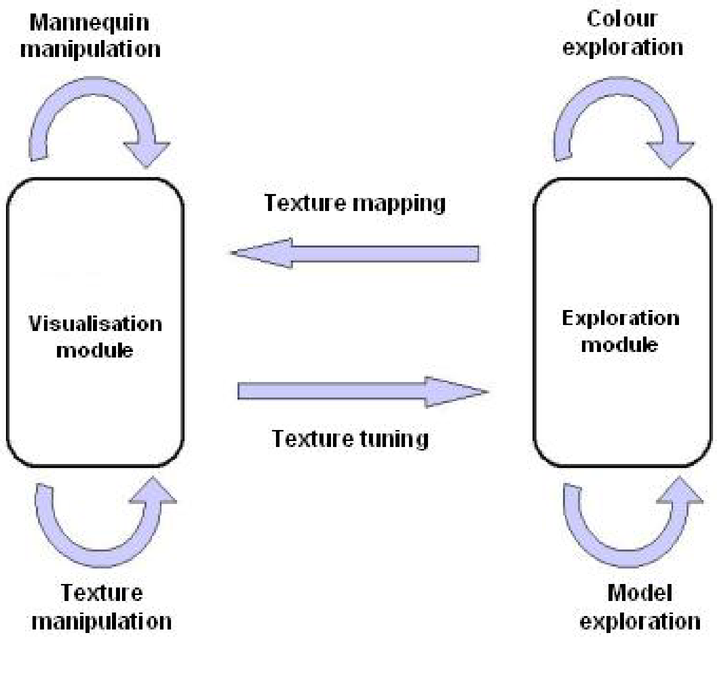


Fig.1: Methodological approach for the design of texture images for fashion design

2.2 Iterated fractal systems

Iterated fractal systems (IFS) are formed by systems of functions which are iterated to converge to fractal attractors. They have been introduced in the context of fractal geometry as models to construct fractal patterns. In the context of image processing, they have found applications for image synthesis and image compression [1-4]. IFS contain rich potentialities to be explored, particularly in the context of fashion design. Indeed, automatic generation of fractal image could stimulate creativity and allow fast exploration of solutions space of a given IFS. Here, we describe and analyze a basic model of IFS and address the issue of fast generation of the fractal images they generate. We consider the set *I* of two-dimensional images gray-level $s(x,y) \in$ IR with spatial coordinates (x,y) defined over the support $S = [0,1[\times [0,1[$. A transformation T is introduced which maps an initial image of *I* into a final image of *I* [5,6]. The final image is obtained as the union of 4 sub-images defined over the 4 quarters of support S, i.e. $[0,1/2[\times [0,1/2[= S_1$, $[1/2,1[\times [0,1/2[= S_2$, $[0,1/2[\times [1/2,1[= S_3$, and $[1/2,1[\times [1/2,1[= S_4$, over which each sub-image is a contracted version of the initial image with affinely transformed gray levels. Explicitly, the union of the four sub-transformations defines transformation T as:

$$S \times \mathrm{IR} \rightarrow S_1 \times \mathrm{IR}$$
$$((x,y), s(x,y)) \rightarrow ((\frac{x}{2},\frac{y}{2}), a_1 s(x,y)+b_1 +c_1 x+d_1 y) \qquad (1)$$

$$S \times \mathrm{IR} \rightarrow S_2 \times \mathrm{IR}$$
$$((x;y); s(x;y)) \rightarrow ((\frac{1}{2}+\frac{x}{2},\frac{y}{2}), a_2 s(x,y)+b_2+c_2 x+d_2 y) \qquad (2)$$

$$S \times \mathrm{IR} \rightarrow S_3 \times \mathrm{IR}$$
$$((x,y), s(x,y)) \rightarrow ((\frac{x}{2},\frac{1}{2}+\frac{y}{2}), a_3 s(x,y)+b_3+c_3 x+d_3 y) \qquad (3)$$

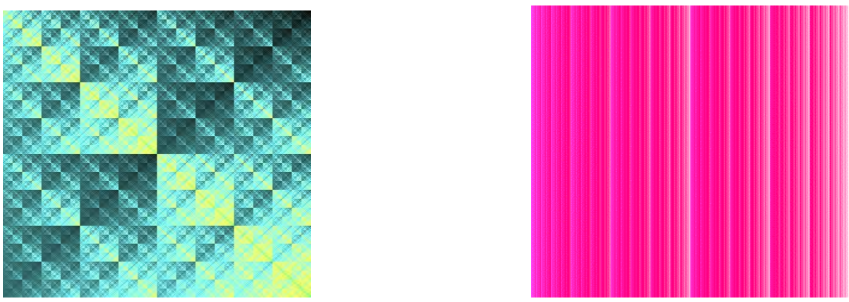
and

$$S \times \mathrm{IR} \rightarrow S_4 \times \mathrm{IR}$$
$$((x,y), s(x,y)) \rightarrow ((\frac{1}{2}+\frac{x}{2},\frac{1}{2}+\frac{y}{2}), a_4 s(x,y) +b_4+c_4 x+d_4 y) \qquad (4)$$

with real coefficients a_j, b_j, c_j and d_j verifying $0 < |a_j| < 1$, for $j = 1$ to 4, so as to have contractive mappings.

The transformation T defined by Eqs.(1)–(4) implements on both the spatial coordinates (x,y) and the gray level $s(x,y)$, contractive affine transforms. Consequently, the mapping $s(x,y) \rightarrow T[s(x,y)]$ is also a contractive affine transform. It results [2] that $s(x,y) \rightarrow T[s(x,y)]$ admits one single fixed point, i.e. an image $\sigma(x,y)$ verifying $T[\sigma(x,y)] = \sigma(x,y)$ also called the attractor of transformation T. Starting from any initial image $s_0(x,y) \in I$, iterative application of the transformation T defined by Eqs. (1)–(4) realizes an IFS. The process converges to a unique attractor $\sigma(x,y)$ that is completely determined by the set of 16 parameters $\{(a_j,b_j, c_j,d_j), j =1...4\}$.

The attractor, solution of the fixed-point equation $T[\sigma(x,y)] = \sigma(x,y)$, is endowed with a self transformability property which confers to it a self-affine or fractal character. This translates into complicated shapes for $\sigma(x,y)$, with structures or details occurring at all scales, as visible on the image of $\sigma(x,y)$ shown in Figure 2a.
Depending on the parameters, the generated images can display more or less prominently their inherent fractal structure. For instance the apparent homogeneity of the image shown in Figure 2b produces a relatively poor visual traduction of the fractal structure. By contrast, Figure 2a provides a very vivid traduction of this fractal structure. This shows that certain sets of parameters are more suited than others for a prominent traduction of the fractal structure. The achievement with fractals of aesthetic criteria and the exploration of the solutions thus rest on the capacity to control in a precise way the parameters of the IFS.



(a) **(b)**

Fig. 2 : Examples of attractors $\sigma(x,y)$ of the IFS of Eqs. (1)–(4) obtained with a given set of parameters $\{(a_j,b_j,c_j,d_j), j = 1 \dots 4\}$.

Determining how to choose the parameters $\{(a_j,b_j,c_j,d_j), j = 1 \dots 4\}$ of the IFS in order to impose prescribed properties onto its attractor is a very difficult problem which would require to explicitly solve the fixed-point equation $T[\sigma(x,y)] = \sigma(x,y)$ in a parametric form. Another possibility is to start with a given set of parameters $\{(a_j,b_j,c_j,d_j), j = 1 \dots 4\}$ and to iterate Eqs. (1)–(4) to converge so as to exhibit the resulting attractor. It is this constructive approach, based on manual exploration of the parameters space via a user interface, that we currently investigate.

2.3 Nonlinear trajectory models

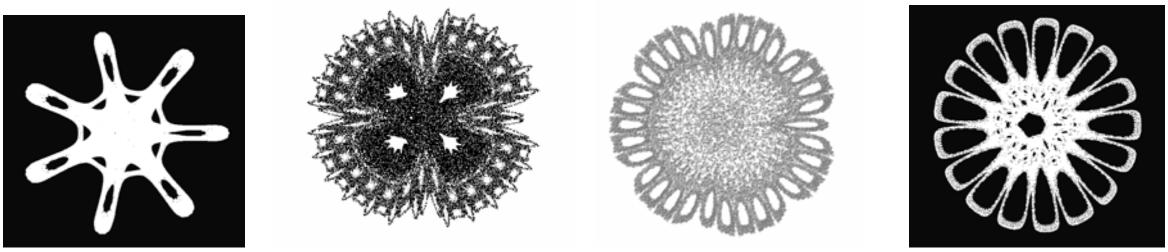
Different nonlinear mathematical models which exhibit rich and complex properties exist in the literature. Some of them may reveal some aesthetic potentialities and are therefore interesting to study in the context of this work [7-8]. Among these models, one of the most interesting is the Mira-Gumowski model (Eq. 6) [9]. Iterations defined by Eq. 7 produce different kind of cellular patterns such as illustrated in Figure 3.

The Mira-Gumowsky model has been introduced for modeling and study accelerated particles trajectories at CERN in 1980. More recently, their aesthetic quality has been identified.

$$F(X) = AX + \frac{2(1-A)X^2}{1+X^2} \qquad (6)$$

$$X_{n+1} = BY_n + F(X_n)$$

$$Y_{n+1} = -X_n + F(Y_n) \qquad (7)$$



A = 0.79, B=1 | **A = 0.43, B=1** | **A = 0.22, B=1** | **A = 0.39, B=1**

Fig. 3 : Examples of patterns obtained using the Mira-Gumowski model.

3. Automatic generation and 3D visualisation

Automatic generation of images and their 3D mapping on virtual clothes are achieved using the software applications illustrated in Figures 4 and 6. The monitor screen is divided in two parts: (1) a left part (visualization module) containing the 3D layout and (2) a right part (exploration module) containing both the generated images and a control interface. The visualization module, developed in C language, is common to the two software applications. It allows to load any 3D model in .3DS format.

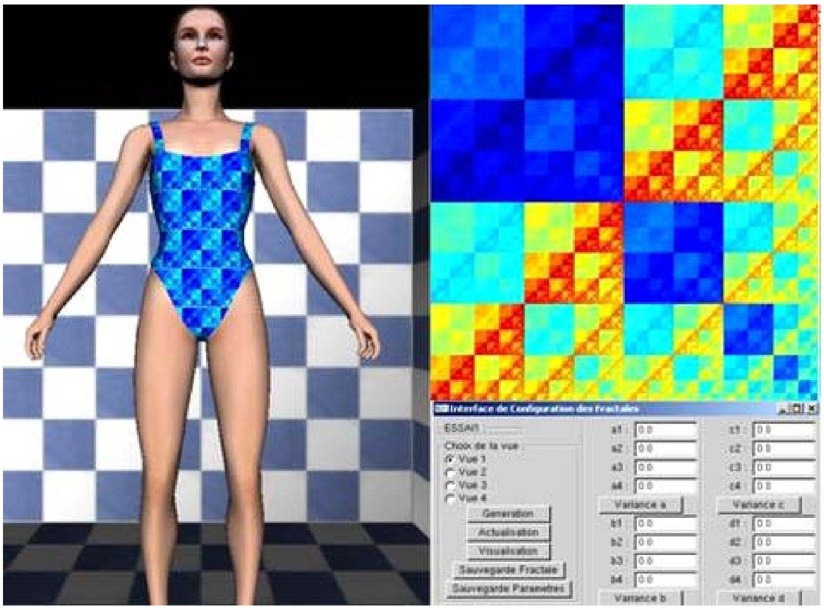
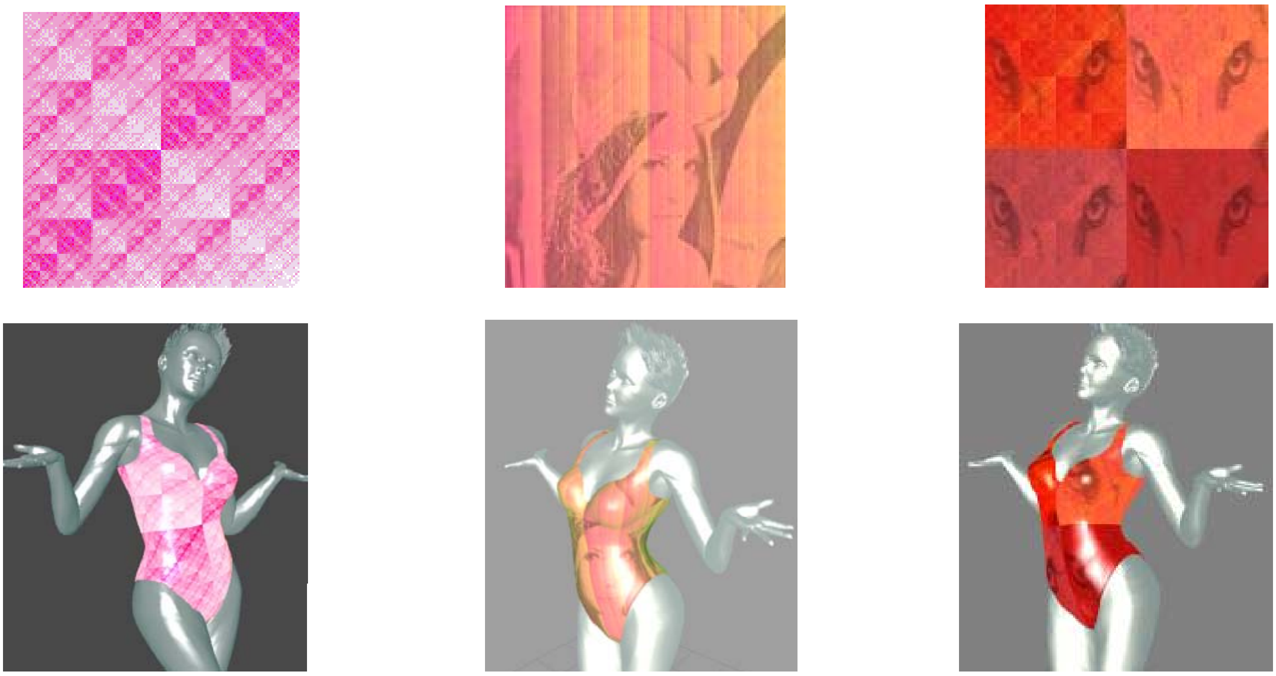


Fig. 4 : Screen shot of the software prototype developed for automatic generation of IFS images based on the attractor σ(*x,y*) of the IFS of Eqs. (1)–(4).

3.1 Generation of IFS images

The control interface allows the user to select one out of four predefined sets of parameters by clicking on given “motif” buttons. A button provides an easy way to configure any color pallet. These pallets may be made from two to four different colors.
A colour configuration interface can be launched from the main control interface. The user may also launch another window that allows individual tuning of the 16 IFS parameters through scrolling buttons. This window also displays the numerical values of these parameters. An example of IFS image and its mapping on a virtual swimming suit is given in Figure 5a. In order to increase customisation of the generated images, we add the possibility to mix any image or picture with an IFS image. Some examples are given in Figures 5b and 5c.



(a) (b) (c)

Fig. 5 : Examples of images based on σ(*x,y*) and their 3D mapping: raw IFS image (a), grayscale Lena picture mixed with an IFS image (b), composite image based on a grayscale lion picture mixed with an IFS image (c).

3.2 Generation of Mira-Gumowski images

The generation of texture images based on the Mira-Gumowski model and some other non-linear models is achieved using a software application illustrated in Figure 6. This application, developed in C# language, allows to generate both centred-pattern images and multi-pattern images such as the one illustrated in Figure 6. As shown on the bottom right part of the Figure 6, other nonlinear models such as Pickover or De Jonc ones may be chosen by the user. For all selected models, colour space is automatically explored, based on random or pre-selected colours. In both cases, a given colour is associated to a given number of iterations, this number being specified by the user. As illustrated in

Figure 7, generated images may contain a single centred pattern, or be made of different patterns from the same or from a different model.

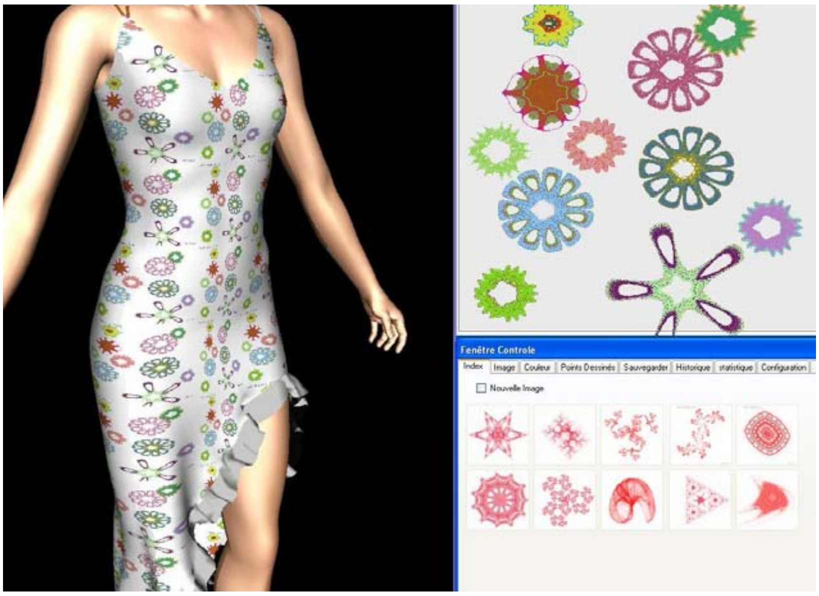


Fig. 6 : Screen shot of the software user interface developed for automatic generation of images based on nonlinear trajectory models.

(a) **(b)** **(c)**

Fig. 7 : Texture images based on the Mira-Gumowsky model, mapped on a virtual dress.

4. Conclusion

We present both a theoretical framework and software developments for the creation of aesthetic texture images in the context of virtual fashion design. The developed image generation techniques involve different approaches based on iterated function systems (IFS) and on non-linear models. Both models parameters and colour space exploration is realized through a simple user interface. Interactive mapping of the generated images is realized on virtual clothes, and realistic rendering techniques are used for 3D visualisation. The results contribute to promote both computer assistance and mass customisation for fashion design. Concerning the presented IFS, our objective is to try to progressively increase the aesthetic performances of the generated images. We plan to automatically explore model parameters space by seeking to optimize the value of quantitative criteria measuring the aesthetic qualities of the images.

ACKNOWLEDGEMENTS

This work was partially supported by the Communauté d'Agglomération du Choletais and the Lycée de la Mode de Cholet, France. Many thanks to Carole Roque from Emode (http://www.emode.fr) for the prints of our digital images on fabrics. The 3D character model was exported from the OPTITEX software and provided by the Institut Français du Textile et de l'Habillement (IFTH).

REFERENCES

[1] Peitgen H., and Richter P., (1986). *The Beauty of Fractals*. Springer-Verlag, Berlin.

[2] Barnsley M. F., (1993). *Fractals Everywhere*. Academic Press, New York.

[3] Lu, N. (1997). *Fractal Imaging*. Academic Press, New York.

[4] Turner M. J., Andrews P. R, Blackledge, J. M. (1998). *Fractal Geometry in Digital Imaging*. Academic Press, New York.

[5] Portefaix C., Cavaro-Ménard C., Chapeau-Blondeau F., (2002). *Identification and modelling of fractal signals with iterated function systems*. pp.185–188. Proceedings of the 11th European Signal Processing Conference, Toulouse, France.

[6] Portefaix C., Cavaro-Ménard C., Chapeau-Blondeau F., (2003). *Modelling of fractal images with iterated function systems: moment matching, continuity of attractors*. pp. 113–116. Proceedings of the 3rd International Symposium on Physics in Signal and Image Processing, Grenoble, France.

[7] Pickover, C. "A Note on Rendering 3-D Strange-Attractors." *Comput. & Graphics* 12, 263, 1988.

[8] http://local.wasp.uwa.edu.au/~pbourke/fractals/peterdejong/

[9] Gumowski I, and Mira L. (1980) Recurrences and Discrete Dynamical Systems, Lecture Notes in Mathematics No. 809, (Springer-Verlag), New York,