FIORES-II:
A quantitative approach of aesthetic notions

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RESUME : Ce papier présente les premiers résultats d'un projet européen dont le but est d'identifier et de réaliser le prototype d'une approche innovante dans le domaine du style (esthétique) assisté par ordinateur. Malgré l'existence d'outils sophistiqués de modélisation, il reste encore des problèmes importants à résoudre pour satisfaire les besoins de créativité et de communication des utilisateurs stylistes. Les résultats présentés sont basés sur une analyse des activités de conception de stylistes et d'opérateurs CAO ("*surfacers*") appartenant à l'industrie automobile (BMW, FORMTECH, PININFARINA, SAAB) et aux biens de consommation (ALESSI, EIGER, FORMTECH). Quelques-uns des critères et propriétés esthétiques identifiés et utilisés par les stylistes pour apprécier des formes sont présentés, notamment des outils de modifications de courbes basés sur des critères de perception esthétique. Il ne s'agit pas d'outils de jugement de valeur esthétique mais de moyens de communiquer de façon quantitative des notions habituellement considérées comme qualitatives.

Mots clefs : style, critères et propriétés esthétiques, perception des formes, modélisation géométrique.

ABSTRACT: This paper presents the outcome of an international research project, aimed at identifying and implementing an innovative approach in Computer Aided Aesthetic Design. Despite the availability of sophisticated modelling tools, there are still critical issues to be faced in order to achieve a functionality really suited to the users' creativity. The presented results are based on the analysis of the design activities carried out with stylists and Computer Aided Styling operators (*surfacers*) both in the automotive field (BMW, FORMTECH, PININFARINA, SAAB) and in the field of household appliances (ALESSI, EIGER, FORMTECH). Some of the identified aesthetic features, used by designers to judge the shape, are discussed. In particular some free–form modelling tools for curve modification driven by aesthetic properties perception will be presented. It is not a matter of aesthetic judgment but rather a means to communicate in a quantitative way about notions that are usually considered as qualitative only.

Keywords: Aesthetic design, aesthetic features and properties, shape perception, geometric modelling.

1. INTRODUCTION

Styling is a creative activity and a **social construction** where the designer's goal is to define a product that evokes some *emotion* while satisfying imposed ergonomics and engineering constraints. Currently, the adopted computer aided design tools offer functionality mostly based on low level geometric elements, therefore an understanding of the underlying mathematical representation is often required to know which elements have to be changed for obtaining the desired model modifications.

The objective of the project is to improve the industrial design workflow by defining innovative digital tools closer to the users' creativity, able to support them in an easier way to attain a model with a certain emotional character and to preserve it during the required model modifications. In order to identify a proper class of properties, linked to geometry but more directly connected to the design intent, the possible relations between shape geometry and aesthetic character have been investigated. The formalization of these relations as items of knowledge to be processed by a computer system might allow the designers' aesthetic intent to be communicated and/or preserved throughout a product industrial process.

Several studies aiming at identifying the relations between the characteristics of a product shape and its emotional message have been carried out. For a detailed discussion of them see [Gian03] from which this paper is inspired, but in substance they conclude that:

- There is no simple mapping and the relations are context dependent, therefore rather than to give an absolute definition of aesthetic characters, it is preferable to specify how to increase or decrease the characters of a given object.
- The choice of the aesthetic variables depends on the product, thus an effective system needs to incorporate subject dependency.

At the same time, they also indicate a way for identifying aesthetic characteristics and their correspondence with shape properties.

In the European Project FIORES-II (Character Preservation and Modelling in Aesthetic and Engineering Design) [FIO02] a wide research has been carried out to identify possible relationships between shape geometry and emotional character. Fourteen partners have been involved, whose expertises range from geometric modelling theory and algorithm development, multi-criteria optimisation and artificial intelligence methods, to cognitive psychology and styling. Documents, brochures and company briefings describing products from an aesthetic and emotional point of view have been analysed. Then a set of web questionnaires and person-to-person interviews (mainly addressed to designers) have been performed by psychologists, with the objective to identify:

- terms used in styling activities to describe the aesthetic aspects of a product and terms used in marketing to describe a product from an emotional point of view.
- the main elements used to evaluate the aesthetic of a product (i.e. character lines, silhouettes, reflection lines and other significant curves).

This work allowed the identification of a twofold mapping (see Fig. 1) that are covered by the *Designer Language* and the *Marketing Language*.

- Designer Language covers a mapping between geometric properties and styling evaluation.
- Marketing Language covers a mapping between styling evaluation and emotional character.

To overcome the Marketing Language context sensitiveness, due to fashions and trends, the "learning capabilities" of CBR (Case Based Reasoning) [CBR02a, CBR02b] technology are applied to deduce existing relationships [Sta01].

The paper covers the Designer Language aspect especially the modelling operators defined in correspondence with the styling terms and briefly how it is related to the Marketing Language via the CBR.

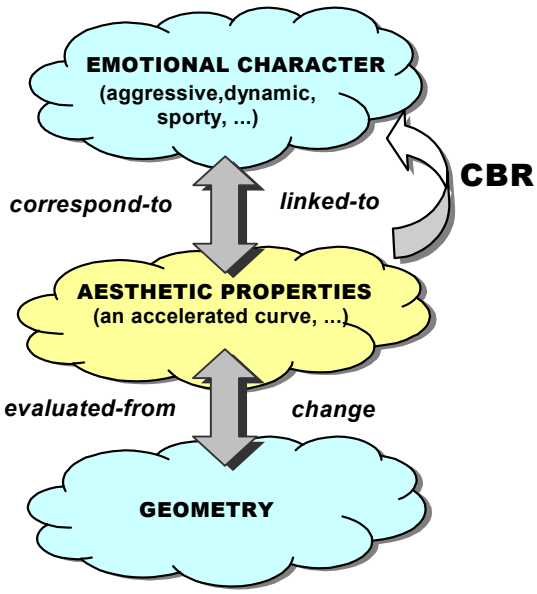


Fig. 1

2. DESIGNER LANGUAGE AND MARKETING LANGUAGES

Aesthetic character refers to the global impression the product suggests. It could be related to emotional feelings or reveal the belonging to a specific producer and family of products. For instance in the automotive field, designers normally recognize a company style from a few curves. The example in Fig.2, provided by SAAB, shows the few lines which are sufficient to provide the company feeling.

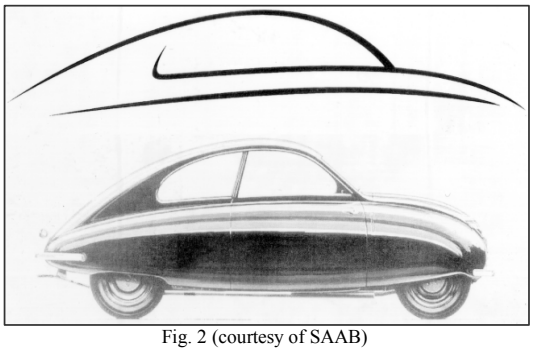


Fig. 2 (courtesy of SAAB)

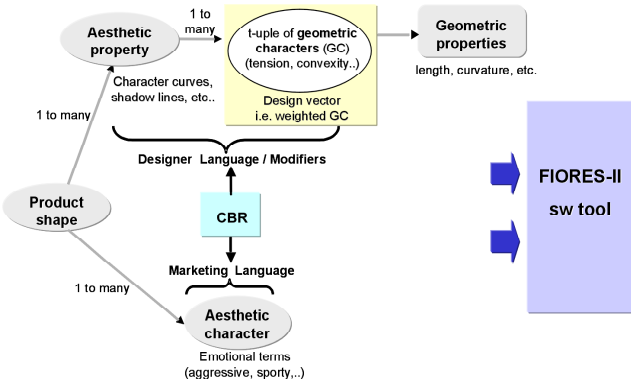
Understanding which are the characteristics of underlying curves that provide such information to an expert's eye is not so easy. Stylists are able to see and recognize the characters but not to describe them in terms that could be coded in a software tool. However they use a set of

specific terms to describe and modify curves and shape. This is the Designer Language.

From the various interviews carried out with the designers of the partner companies, it emerged that stylists use different languages when speaking with marketing people and when working at the definition of the digital model with *surfacers*. In the former, called the Marketing Language, they use terms related to emotional aspects, expressing somehow the objective, in other words, the character that the final product must have. In the latter, i.e. the Designer Language, they adopt a restricted set of terms, corresponding to shape properties, to provide instructions for modelers or surfacers about how elements have to be changed to enforce/modify a given/target character to fulfill marketing directives.

It results that the mapping between aesthetic characters and geometry could be better achieved by understanding and using the geometric properties underlying the terms used by designers when evaluating/modifying the shape. In the remaining of the paper, these terms are indicated as *aesthetic properties*. [Pod02b]

To this aim, the project worked on the identification of the most meaningful aesthetic properties, which are recurrent during the model style refinement. In correspondence with them, innovative modelling functions were implemented. Complementary a CBR part allowed to establish a context sensitive correspondence between sets of valuated aesthetic properties and sets of emotions (declared or to be retrieved).



3. AESTHETIC PROPERTIES

When looking at a drawing or a 3D digital model, designers concentrate on how specific important characterizing lines (both real or defined by the light effects) behave. Their experience in clay modelling helps them to imagine what these lines look like in the real 3D world.

In order to understand which properties are important, we analysed the process and the rationale behind followed by designers and CAD operators for achieving the desired product via person-to-person interviews. Some of the terms used to indicate how to act on several geometric properties simultaneously have been selected. After

the translation into English and some harmonisation (mainly due to the differences of the considered application fields) we implemented the following properties:

Convexity / Concavity	*Acceleration*	*Sharpness / Softness*	*Tension*

Based on the value of these properties in comparison with the neighbouring area and with the whole object, additional qualitative judgment is usually performed. For instance a car roof can become *flat* if the value of the tension is too high with respect of the dimension, or a concave section can appear *hollow* if its concavity is too small with respect to the whole section. These marginal situations are not treated at present but using the CBR tool with a sufficient number of cases it could be possible to identify the corresponding property value ranges. Moreover, from the end-user activity analysis it emerged that it was worthwhile to implement as well *Crown* and *Lead-in* operations.

A description of the selected properties and operators is [Pod02a].

Convexity / Concavity

Classically, a curve is *convex/concave* if the curvature along the curve has the same sign. In our case, it has a more specific meaning i.e. the more a curve is convex the closer to a semi-circle.

Acceleration

The acceleration is related to how much the curvature is balanced along the curve. The closer the higher values are to an extremity the more designers perceive it as accelerating. Symmetric curves have no acceleration.

Sharpness / Softness

It is used to describe transitions between curves or surfaces. The sharpness between surfaces / curves is due to the emergence of a visible edge /. vertex on it while the softness increases with the vanishing of the edge / vertex on it.

Tension

Tension can be understood (up to some extent) from the physical analogy of applying tension to a steel spline. Increasing the tension of the curve leads to a larger part of small curvature.

Crown

To make a part more crown results in raising a certain part of a curve in a given direction without changing the continuity at the extremity points. It can be better understood from the physical analogy of blowing up the curve.

Lead-in

It is a particular way of connecting two curves. Designers talk about creating a lead-in when they want a better transition by "preparing the eye for the shape that follows".

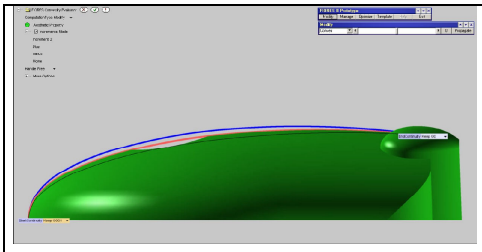
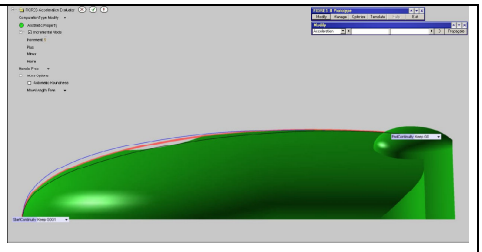
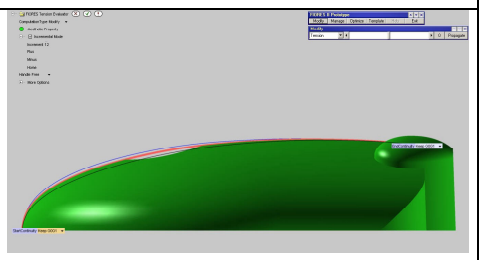
4. AESTHETIC PROPERTIES MODIFIERS

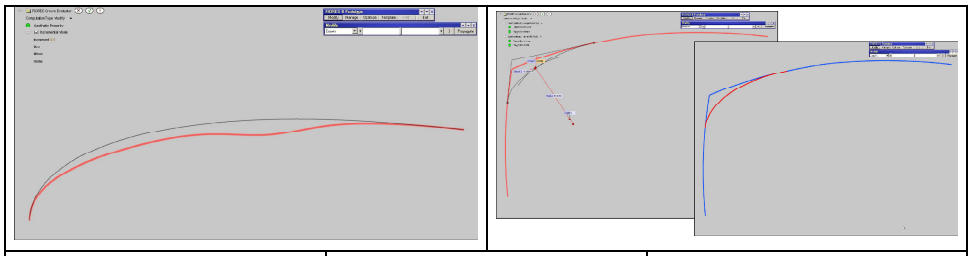
The identification of the above described properties allows the formalization of aesthetic features and the development of modelling tools, called *modifiers,* that directly act on the related properties. Using the modifiers, CAD operators or any optimisation loop can control the shape with a target intent.

These aesthetic properties can also represent a tool for shape comparison purposes. This led us to define an evaluation measure for each of them by solving the following problems for each considered property:

- Definition of its meaning from the designer's point of view: What shape is the designer expecting when the modifier value changes? Which are the geometric properties that are affected by the modifier?
- Evaluation of a measure of the aesthetic property.
- Specification of the mathematical function producing the expected shape modification and the related domain of application, i.e. hypothesis / restrictions on the curve in order to have the possibility of applying the modifier.
- Identification of the required parameters to be provided by the user or automatically specified by an algorithm in case of character preservation. This also includes the specification of which parameters can be used within the optimisation process and in which way.

The following pictures illustrate influences of above mentioned modifiers. Some differences are subtle but exist i.e. characters can change with slight modifications.

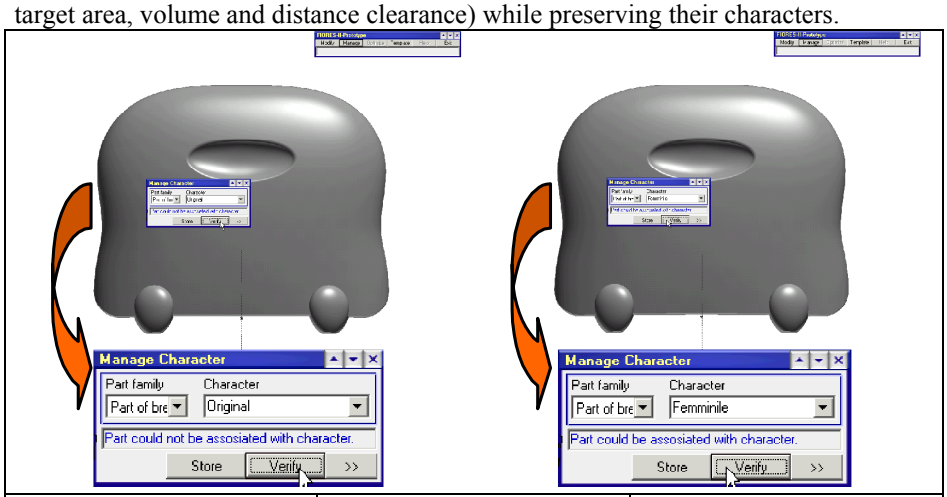
	
Convexity / Concavity	Acceleration
	
Softness / Sharpness	Tension



Crown	Courtesy of ALESSI and IMATI	Lead-in

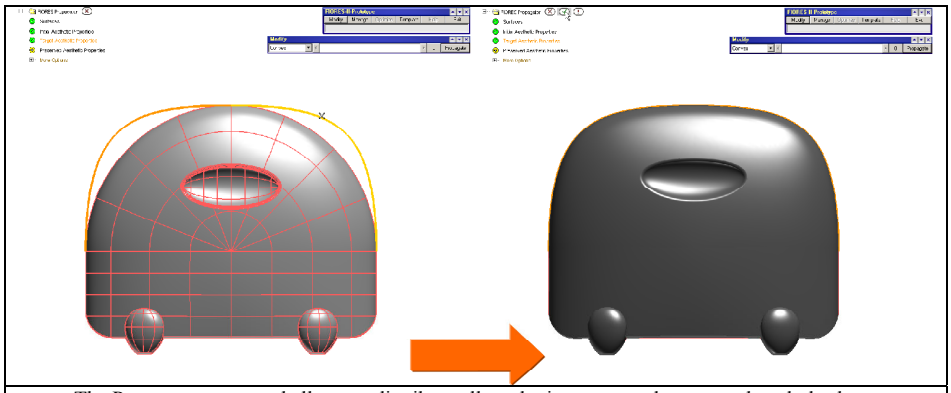
5. THE SOFTWARE PROTOTYPE

A software prototype is in testing use. It is composed of several components operating through a common user interface and connected via Product Data Channel (PDC – from CAxOPEN); its current implementation platform is thinkdesign™ (copyright of think3) and it can be connected to any other CAD system via the PDC. A CBR component allows end-users to customize their understanding of shape characters. For this purpose end-users must fill-in a data base with cases. The more the number of cases the better the reasoning. This prototype allows to retrieve and compare shapes and to optimise them to reach engineering constraints (such as target area, volume and distance clearance) while preserving their characters.



The character is NOT recognized	Courtesy of ALESSI	The character IS recognized

In manual mode the user can change the shape applying the modifiers to selected aesthetic properties and *propagate* the modifications to the whole shape.



The Propagate command allows to distribute all aesthetic property changes to the whole shape

In automatic mode the propagation is made at each optimisation loop, after the new aesthetic properties have been updated to reach the engineering target. The ranges of the modifier variations that are extracted from the CBR database constitute the way to preserve the shape characters.

6. CONCLUSIONS

In this paper, we described some objectives of the European Project FIORES-II and its current outcomes especially some identified and formalized aesthetic properties and their corresponding modelling tools. Currently the software prototype is under testing at the end-user sites. The first results confirm its potentiality for:

- providing end-users with aesthetic features manipulators for better and faster achieving the desired changes in the geometric model, conforming to their intent;
- a deeper comprehension of the geometric characteristics influencing the perception of shapes and of their similarities from an aesthetic point of view;
- an end-user quick acculturation; which is somehow a proof of adequacy versus user's needs.

In accordance with the identified standpoint, further activities are foreseen in order to validate the defined measures of the aesthetic properties and to develop their usage for defining a proper aesthetic similarity criterion.

7. ACKNOWLEDGMENTS

This work is supported by the European Commission under the GROWTH Programme within the Project FIORES II, *Character Preservation and Modelling in Aesthetic and Engineering Design*, G1RD-CT-2000-00037. Our thanks to project partners for the provided material.

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