A shape grammar approach for automotive styling: the case of the French cars

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Abstract:

Today, an important quality of a brand or a strong family is its clear and precise identity. Moreover, in order to obtain a winning brand, the company managers should continuously be innovative without forgetting the product history of the brand and should use the culture of the country like a value system and as inspiration background. In this paper, we analyze a selection of French cars from the Peugeot, Citroën and Renault branch. The proposed methodology is based on the extraction and the analysis of characteristic styling lines of the cars. We deducted from this approach that a French identity is available. With the comparison with the German lines, we exposed that specific lines are particular to French car. We have considered that the characteristic lines of the car, the joint elements and the connection elements formalize a French language. The finite generic description of this language was done by a car grammar. To maintain and develop the French identity of a brand or a family brand, a computer based system of future lines based on elementary primitives reflecting the car identity is under development.

Keywords : CAD, Design, brand identity, shape grammar

1   Introduction

The main objective of a brand is to give an identity to a product and maintain a difference from each other. Therefore, a brand or a strong family brand should have a clear and precise tonality. This tonality is build by the identity of a strong brand: be the only one on the top and specific (Kapferer, 2002). Indeed, a brand identity is installed through the association of the physical quality of the product, the experiment and the appreciation of the brand by the final consumer or simply be the success of the brand itself. (Cagan J. and Vogel C., 2002). The fundamental value of the brand forms the brand identity. That is why, today, a brand identity can be today the foundation of design strategies of a brand product. Thus, these design strategies drive the aspects and constrains of the future product, defining also the brand identity.
In the case of a collaborative and distributed design process, if all involved expert actors work actively on the design and the development of the product, according respectively the aspects and the constrains of their expert area, the specific style of the product establishes, in the first hand, the connection between actors, and in the second hand, between the brand and the consumer (J.P. McCormack and J. Cagan, 2001). That is it how the brand identity is defined by the style and the structural points of views. In a collaborative and distributed design process, the actors' interaction is the central key of the success. In most cases, the results obtain by interactions need to be consensual in order to be accepted (Movahed-Khah et al.

2010, Ostrosi et al. 2012). This interaction is mainly formed by the communication performed through the actors (Chiu 2002). Designers spend, on the one hand, 80% of the time generating and retrieving their data, and on the other hand, 93% of the time assessing information on a non-quantitative level of abstraction (Baya and Leifer, 1995).

In fact, the actors involving in this kind of process are experts in a particular domain like the styling, the fabrication, the assembly, the recycling, etc. In this case, on the one hand, they share expert constrains through the specific form of the product, and on the other hand, they share the emotional impacts to the consumer. Therefore, successful brands performed this strong link between the emotional and dedicated relation and the consumer (De Charnatony, 2001). Moreover, to propose a strong brand, actors need to propose frequently innovation in according the brand history (Fanning, 1999). Based on this argument, the brand identity should be focused on a design process oriented to his specific styling.

In the automotive industry, a pertinent modeling of a car family should represent the complex link between both the car components and the family of cars. Moreover, this model should integrate its evolution in order to perform a variety model. Based on this modeling, the styling step has to reinforce and represent the brand identity. A car of a brand should evolve prudently according the history of the car model in order to minimize the impact of the consumer and its impact on his cognitive process. In fact, each brand should know the elements of its kernel (Kapferer, 2002).

In this context, we can propose the following working hypothesis:

1. *Generation hypothesis*: a car styling is defined like a structured system, with its own internal mechanism purposing its own evolution.
2. *Primitives hypothesis*: the evolution of a family car can be used in order to identify and extract specific primitives, relevant for the identity and the discrimination, at macro and micro level.

The work presented in this paper represents a research undertaken to identify and extract specific primitives, relevant for the identity of French car brands, like Peugeot, Citroën and Renault. This research work is oriented to a specific country because the culture is the value system which is based to inspirit a brand (Kapferer 1998). The comparison is performed with a German brand, Volkswagen.

2   Proposed methodology

The exploratory study presented in this paper will be divided into three steps. The first step will be dedicated to the definition of characteristic styling primitives from existing car architectures. Then, the second step will be consecrated to the extraction of the styling primitives from three French cars and three German cars in order to allow a comparison of styling approaches. The last step will be allowed to interconnect the styling primitives extracted in the previous step in order to build a "reference" trim representing the French car identity.

2.1   *Data extracting : brand and car models*

Concerning the car models, we choose to study city and compact French cars. Indeed, from a long time, the French brands are excellent in these domains and purpose a large amount of vehicle. This amount allows us a large panel of studied models.

2.1.1   *Model description*

Brand	Model	Production years	Number of sales	Picture
Citroën	2CV	1948 - 1990	5 114 961	
Citroën	C3 I	2002 - 2009	2 765 150 (All C3 models)	
Peugeot	205	1983 - 1998	5 278 000	
Peugeot	206	1998 - Today	7 700 000	
Renault	R5	1972 - 1985	5 580 00	
Renault	Clio 2	2001 — 2004	5 480 650 (all clio models)	

Table 1: Proposed French cars for the study

Brand	Model	Production years	Number of sales	Picture
Volkswagen	Golf 2	1983 - 1992	25 000 000 (all golf models)	
Volkswagen	Golf 4	1997 - 2004	25 000 000 (all golf models)	

Table2: Proposed German cars for the study

2.1.2 *Extraction of the characteristic lines.*

We decide to study the following seven specific lines: *{C1= upper lateral profile; C2= lower lateral profile ; C3= door profile; C4= roof profile; C5= upper grille profile; C6= lower bumper profile; C7= right (or left) lateral profile }*. This lines are illustrated on the table 2.
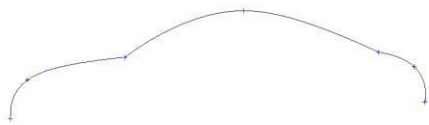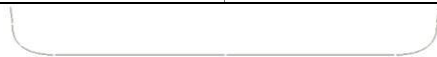
Name	Description	Illustration
C1	*upper lateral profile*	
C2	*lower lateral profile*	
C3	*door profile*	
C4	*roof profile*	
C5	*upper grille profile*	
C6	*lower bumper profile*	
C7	*right (or left) lateral profile*	

Table 3: characteristic lines of a car

2.2 Research of the characteristic lines of each brand

In this section, we will obtain the average lines (table 3) from each characteristic line of the different model from one brand. The average line will represent the characteristic line of a brand. To understand the table, for the Peugeot brand, the first line (in blue, large size) is an extract from de 205 model, the third line (in red, medium size) is an extract from de 206 model and the second line (in green, small size) is the average line between the two previous extractions. For the Citroën brand, the first line (in blue, large size) is an extract from de 2CV model, the third line (in red, medium size) is an extract from de C3 model and the second line (in green, small size) is the average line between the two previous extractions. For the Renault brand, the first line (in blue, large size) is an extract from de R5 model, the third line (in red, medium size) is an extract from de Clio 2 model and the second line (in green, small size) is the average line between the two previous extractions. For the Volkswagen brand, the first line (in blue, large size) is an extract from de Golf 2 model, the third line (in red, medium size) is an extract from de Golf 4 model and the second line (in green, small size) is the average line between the two previous extractions.

Specific line	Peugeot	Citroën	Renault	Volkswagen
C1				
C2				
C3				
C4				
C5				
C6				
C7				

Table 4: characteristic lines of French and German cars

2.2.1 *Discussion about the upper lateral profile*

This line has a relative dynamism. In fact, the front of this line is low with a continuous curve upward to the rear. This line is apparent to a continue and large radius giving to the hood and the windshield a large dynamism. After this point, she declined slowly but always with a

regular curvature and always similar to a radius, but smaller than the first one. This new curvature gives always to the tailgate a relative dynamism and separates it from the general curvature of the car. This type of curvature can be recognized on a number of French automotives currently on the market, for instance, on the Renault Megane II and the Clio III but also the 308 and 208. This style is a little less recognizable on Citroen automotives, but the lines of the new C4 and C6 are approaching greatly.

2.2.2 Discussion about the lower lateral profile

This curve is split into two parts: the front wheel and rear wheel arches. We note that for the front, the curvature given by the radius is larger than the rear. This means that the front arche is greater than rear (it is usually the case on most recent and old cars because the front wheels turn and therefore need a larger space). One can also notice that the starting point of the rear bumper is higher (vertically) than the front bumper. That was a typical feature of French cars but it is now changing on new models like the Clio and 207.

2.2.3 Discussion about the door profile

This curve has a curvature similar to a large radius. This curvature is regular and the main specificity is that it is slightly tilted backwards. This specificity shows the dynamism of French cars and is in adequation with the general curvature of the car. Moreover, it is very uncommon that this curve is very steep, even on sport cars.

2.2.4 Discussion about the roof profile

This curve is relatively flat, with a very large radius. Moreover, we need to note that this curve is not different from the next, because this curve does not change from one brand to another.

2.2.5 Discussion about the upper and loxer grille profiles

These curves have a profile oriented down. We can see that the top of the headlights (ends of the curves) is above the top line of the upper front grille. This shows that the headlights follow the main curvature of the car, especially in hood. We can also remark that the headlights and upper front grille favorites to the dynamism of the car by the continuity of its general curvature in order to not break the lines.

2.2.6 Discussion about the right (or left) lateral profile

This curve has a regular curvature, also based on a large radius. However, we can see that this curvature is regular and has no other features. This confirms that few French cars have fender flares in order to keep the profile curves of the car. But this type of features is more found on new foreign cars or on old French cars, in sports category, like for the Renault 5 GT Turbo, Peugeot 205 or Citroen AX Sport. with the evolution of the french style, these fender flares have disappeared in order to be replaced by smoother and less pronounced curves.

2.3 Comparison of French and German lines

After the porposal of an average line for each caracteristic line of a car, we choose to generate an average line of French cars and to compare it with the average lines of the german car (table5). This step was performed by an optimization software integrated in a CAD system. To understand the table, the French lines are in green (small size) and the German lines are in black (large size).

Ci	French line	French line/ Volkswagen line
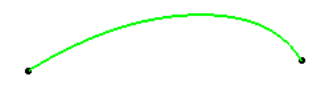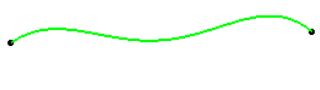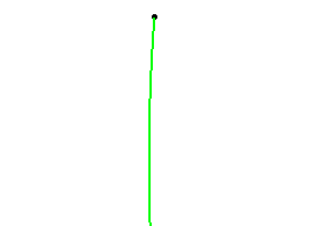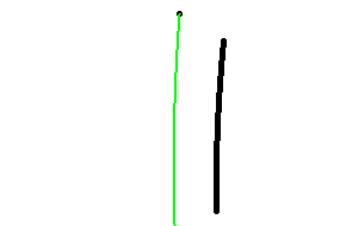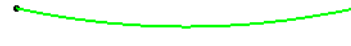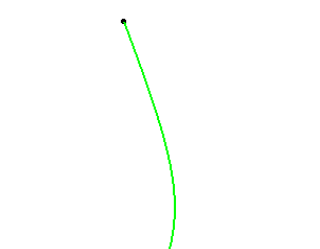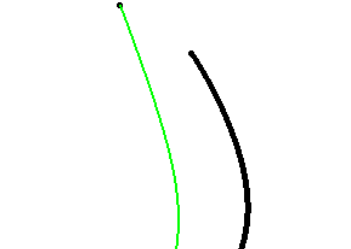
C1		
C2		
C3		
C4		
C5		
C6		
C7		

Table 5: Comparison of the characteristic lines

After the development of the French type curves and their utilization, we decided to compare them to a foreign brand: Volkswagen, world-renowned German brand. As you can see above, we used the same approach in order to obtain the typical curve of the mark, using two cars (Golf II Golf IV). For the legend of the curves, the French curves are blue and the German curves are black. We can now make a comparison between the curves in order to differentiate the French style of the German style.

2.3.1 *Discussion about the upper lateral profile*

We can note on the German curve the stalls between the upper grill (vertical), the profile (slope) and the trunk (also vertical). In comparison, the French design is much more fluid. It may sound like a drop of water on the side or, by analogy, a "dolphin profile". We also can see a stall on the upper grill, but very similar to the profile of the lower grille that will be seen later. The rear has an exponential curve which is starting in the front of the car. We can also say that we have with this curve a curvature that is representative of the French spirit.

2.3.2 Discussion about the lower lateral profile

There is a more present symmetry of the average curve of the German cars than on the French cars wich the curvature is more flared at the rear. We can also note that the starting points and the arrival points start lower on the German curve than the French, reflecting a longer apron on French models. We can also deduce that the wheel arches on German vehicles are much more present that this features on French cars, although that the current trends are to generalize the body understructure.

2.3.3 Discussion about the door profile

We can see that the difference between "french style" and the average curve of German cars is not very important. In all studied cars, the roof is straight with a slight curvature. Also, this is not a determining factor in the French style.

2.3.4 Discussion about the upper and loxer grille profiles

We can note that the upper grille profile clearly different between French and German: the Germanic lines are broken at the upper grill, while the French line is marked by a line strongly curved with a high radius. Also, this line can be considered as a characteristic of the French style.

Regarding the line of the lower grill, the Germanic line stand again by their angles between bottom and side (headlights) while overall lower grille of French cars are softened. We can see three distinct parts: a nose dipping, followed by a curve with a large radius and completed by an another curve leading to the fender. The headlights are integrated directly into the bodywork and its main lines. The obtain curve is also important in the French style.

2.3.5 Discussion about the right (or left) lateral profile

However, the difference is obvious on these lines. Overall, the French design tends to elongated forms, with a high curvature radius on the fender and went right straight through to the side windows. In contrast, the difference on the German models is clearly visible by its fender flares (at the wheels), but also by a broken straight line (for windows) which gives the sharp angle at the top of the curve. The French style is more fluid in its contours.

3   Car grammar formalization

Based on our working hyphotesis, we consider that a virtual product is a final structure which is the result of the ideal evolution of an assembly of relevant structures. The evolution needs the folowin properties (Ostrosi et Ferney, 2006) :

Property 1: *Each primitive structure, designed to satisfy elementary or primitive functions, is provided with a set of particular features, called tie configuration features.*

Property 2: *A new structure is generated from the interconnection and the interaction of primitive structures and/or non-primitive structures. Interconnection of primitive structures and/or non-primitive structures and their interaction is done by their tie configuration features, which produce joint configuration features and tie configuration features of the new generated structure.*

Property 3: *The interconnection between structures can be done if and only if the structures satisfy some constraints defined on the geometric and topological domains.*

Thus, the characteristic lines of the cars, the junction elements and the connecting elements, formalize a car language. The finite generic description of this language is done by a grammar. In this case, we are focused on the formalization of a car grammar, which is the generic and productive description of a car language. A grammar is a formal system composed by an axiom and rules called production rules. Mathematically, a grammar is a quadruplet :

$$G_i = \left\{ V_i^T, V_i^N, S_i, P_i \right\} \tag{1}$$

Where :
- G_i is the grammar for the i class
- V_i^T is the terminal vocabulary of G_i, a non empty finite set
- V_i^N is the non terminal vocabulary of G_i, a non empty finite set
- $S_i \in V_i^N$ is called axiom structure
- P_i is a finite set of structures productions rules of G_i.

Three grammar are defined for $i \in \{ structure, tie, join, \}$: *the structure grammar* $G_{structure}$, *the tie grammar* G_{tie}, *the join grammar* G_{join}. The structure grammar $G_{structure}$, the tie grammar G_{tie} and the join grammar G_{join} provide, respectively, the generic and productive description of the generation *of the structures of the characteristic lines , the join elements* and the *tie elements*. In this context, we consider a *grammar of characteristic line* like a formal system represented by a 3-plet of three related grammars:

$$G_{characteristic\,line} = \left\{ G_{structure}, G_{tie}, G_{joint} \right\} \tag{2}$$

where:
- $G_{structure}$ is the structure grammar. It describes the generation of the structures of the characteristic lines;
- G_{tie} is the tie configuration grammar. It describes the generation of the tie elements;

- G_{join} is the joint configuration grammar. It describes the generation of joint elements.

Following up the same reasoning, we consider a car grammar like a formal system represented by a 3-plet of three related grammars:

$$G_{car} = \left\{ G_{characteristic\,lines}, G_{tie}, G_{join} \right\} \tag{3}$$

For instance, with the help of the French characteristic lines, the terminal vocabulary of $G_{structure}$ in $G_{characteristic\,lines} = \left\{ G_{structure}, G_{tie}, G_{joint} \right\}$, we generate a French car (Figure 1). This

model, in the general lines, is really similar to another car from the Renault brand: the *Scénic* model.

Figure 1: Generated model

4   Conclusion

Today, an important quality of a brand or a strong family is a clear and precise identity of the brand or family brand. Moreover, in order to obtain a winning brand, the company managers should continuously be innovative without forgetting the product history of the brand and use the culture of the country like a value system and as inspiration background.

In this paper, we analyze a selection of cars which had an historical commercial success in France and Germany. The result of this analyze shows a French style. It was determined by the extraction of average lines, based on the selected car profiles. After this step, we obtained specific lines for each car using a specific optimization tool developed for this exploitation. Thus, we obtained a French style by comparison and optimization of the models. Based on this methodology, we extracted a German style in order to allow us to do a comparison between these two styles.

We deducted from this approach that a French identity is available. With the comparison, we exposed that specific lines are dedicated to French cars, like the upper lateral profile, the upper lateral profile, the upper and lower grill profiles and the right (or left) lateral profile.

We have considered that the characteristic lines of the car, the junction elements and the connection elements formalize a French language. The finite generic description of this language was done by a car grammar.

To continue our research project, we are working on the extraction of primitives at a lower level. In fact, our objective is to develop a computer based system which can assist designers toward the future lines design reflecting the car identity for each brand, and for each country.

5   References

Baya V. and Leifer L. (1995) "Understanding design information handling behavior using time and information measure", *Proceedings of the 1995 Design Engineering Technical Conferences*, ed. A. C. Ward, ASME DE-Vol. 83,

Vol. 2: 555-562.

Chiu M.(2002) "An organizational view of design communication in design collaboration" *Design Studies*, Vol. 23, Issue 2: 187-210.

Movahed-Khah R., Ostrosi E., Garro O. (2010) Analysis of interaction dynamics in collaborative and distributed design process. Computers in Industry 61(1):2-14.

Ostros E, Haxhiaj L., Fukuda S. (2012) Fuzzy modelling of consensus during design conflict resolution. Res Eng Design 23(1):53–70.

Ostrosi E. and Ferney M. (2006), "Inference of feature grammars for feature based modelling in CAD systems", International Journal Integrated Computer-Aided Engineering (ICAE), 13(2):113-131.

Stempfle J. and Badke-Schaub P. (2002) "Thinking in design teams- an analysis of team communication" *Design studies 23*: 473-496.

De Chernatony L. (2001) "A model for strategically building brands" *Brand Management, 9(1)*: 32-44.

Fanning J. (1999) "Tell me a story: The future of branding" *Irish Management Review, 12(2)*: 3-15.

Kapferer J-N. (2002) "Les marques à l'épreuve de la pratique" Editions d'Organisations.

Claudel J., Siret A., and Castro A. (2005) "Etude des profil des voiture" *Rapport TN51-1, UTBM*.

Bluntzer J-B., Autret M., Ballin J-C et Ulrich . (2005) "Le « French Identity » : extraction et analyse du design français actuel", *Rapport TN51-2, UTBM*.

Colmek S., et Gommé G. (2005) "Etude sur les profil de voitures française afin de ressortir les courbes qui se référent au « French Identity »", *Rapport TN51-3, UTBM*.

J.P. McCormack and J. Cagan (2001) "Speaking the Buick language: capturing, understanding, and exploring brand identiy with shape grammars" *Design Studies, Vol. 25, No. 1*: 1-29.

McCormack J.P. and Cagan J. (2001) "Speaking the Buick language: capturing, understanding, and exploring brand identiy with shape grammars" *Design Studies, Vol. 25, No. 1*: 1-29.

Cagan J. and Vogel C. (2002) "Creating breakthrough products: innovation from product planning to program approval", *Financial Times,* Prentice Hall, Upper Saddle River, NJ.