Speaking the Buick language: capturing, understanding, and exploring brand identity with shape grammars

Jay P. McCormack and *Jonathan Cagan,* Department of Mechanical Engineering, Computational Design Laboratory, Carnegie Mellon University, Pittsburgh, PA 15213, USA
Craig M. Vogel, School of Design, Carnegie Mellon University, Pittsburgh, PA 15213, USA

Developing and maintaining a consistent brand statement is an important aspect of developing a successful product. However, maintaining that statement is difficult due in part to the inconsistent and often insufficient understanding of brand by marketing, engineering, and industrial design. This paper presents shape grammars as a method for encoding the key elements of a brand into a repeatable language, which can be used to generate products consistent with the brand. A detailed investigation into the history of Buick styling reveals the brand characteristics of the front view of Buick vehicles, which are then captured in a shape grammar.
© *2003 Elsevier Ltd. All rights reserved.*

Keywords: shape grammars, logic of design, aesthetics, collaborative design, design tool

An important quality of a strong brand is the presence of a clear, well-defined brand identity. The brand identity is the set of desired associations with the brand that strategists working with the brand wish to establish and maintain[1]. The brand identity uses the physical qualities of the product as well as the company's mission statement, corporate identity, customer experience, and the perceived success of the company by others to represent what the brand stands for[2]. While the brand identity is a combination of factors, none of which can be ignored, the products themselves express the values of the brand with their form. Brands such as Coca-Cola have successfully established a shape (the contour bottle) that is integral to the brand identity and have maintained a consistent statement of form throughout the evolution of the product.

1 Aaker David, A *Brand leadership* The Free Press, New York, NY (2000)
2 Cagan, J and Vogel, C *Creating breakthrough products: innovation from product planning to program approval* Financial Times Prentice Hall, Upper Saddle River, NJ (2002)
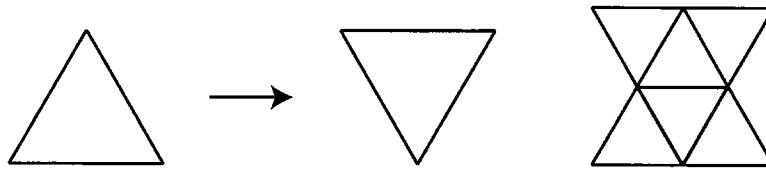
1

Brand strategists work closely with a brand or family of brands to determine the aspects that define brand identity and connect the brand to the customer. Other members of the product team, outside marketing, must also share that vision of the brand, understand the identity, and work towards fulfilling the brand identity through their effort relating to the product. If the whole of the design team is to participate in producing a product with the desired brand statement, communication about the brand, specifically product form and how it relates to the brand identity, must be supported. The brand identity of Coca-Cola has been maintained throughout advancements in packaging from the original contour glass bottles to plastic bottles of today. This could not be done without engineering and design understanding the importance of the shape and working towards maintaining that form. Engineers must express manufacturing constraints to studio, studio needs a logical framework to express form in a method that is comfortable for engineering, while marketing needs to understand the emotional impact of shapes and combinations of shapes that compose the brand. All too often, engineering and design do not realize that the product, and thus their effort, is core to the brand[2]. A system providing a common platform for product form discussion as it relates to brand, accessible to workers of various backgrounds, would be a valuable tool.

We propose that a system for capturing the essence of brand be created based on shape grammars. Shape grammars provide the means to capture and articulate brand in a concise and repeatable language because shape grammars: (1) directly model a parametric geometry, (2) operate directly on geometry to generate shapes, and (3) provide emergence of shape. Because of the importance of brand identity, clear communication of issues pertaining to brand throughout a company is a valuable asset. The shape grammar-based tool provides additional benefits by further enabling the company to understand how far its brand can be stretched and still maintain the core brand statement and also the ability to merge historical reference with contemporary exploration within a brand context.

Auto companies each possess complex brand portfolios, as well as relations between those brands and the varying roles that each serve as a part of the overall brand architecture1. Consistent product form needs to represent and reinforce the brand identity of an individual vehicle brand as the product evolves with advancing technology and other factors to connect to the customer, and similarly for other products. However, an inconsistent view of the customer often exists among studio, marketing, and particularly engineering. Careful preservation of historical elements of the brand should be carried through from studio to manufacturing. A shape grammar can provide a common language that supports all facets of the design by sup-

porting all participants of the design process in the preservation of brand identity. This language is also known as 'brand DNA'.

An exploratory project was performed in conjunction with General Motors to capture the Buick brand from a front-end view with a shape grammar whose rules are defined by shapes inherent to the brand and then explore the ability of the shape grammar to generate Buicks. Generation of a vehicle with the shape grammar always results in a Buick, as the essence of the grammar consists entirely and completely of Buick form. This is in contrast to previous attempts to capture brand within shape grammars, which defined brand through constraints applied to a more general grammar. Within a 2D, front-end grammar, some prominent Buick brand features such as side portholes and the wave shaped bodyline are not visible, but some 3D influences are still incorporated. This 2D single view grammar is a first step toward demonstrating that brand decomposition, or DNA, can be captured in generative shape grammar rules.

The remainder of this paper first reviews shape grammars and their context in product development. Next our analysis of the history of the Buick brand is summarized and categorized into sub-components that are mapped into shape grammar rules. The shape grammar is then presented along with several grammar-generated vehicles that recreate known Buicks or introduce new Buick concepts.

1 Background

A shape grammar[3] is a set of rules, based on shape that is used to generate designs through a series of rule applications beginning with an initial shape. Rules take the form of $a{\rightarrow}b$, where a and b are both shapes. A rule is applicable if the left-hand side shape, a, can be found in the design shape c by applying a set of transformations to shape a. One such rule and design shape is shown in Figure 1. If the rule is applied, the left-hand side shape is subtracted from the design and the right-hand side is added to the design $c-\tau(a) + \tau(b)$, where shapes a and b undergo a transformation τ according to the transformation required to make shape a a sub-shape of shape c. Figure 2(a) shows one potential shape match (highlighted in bold) of the 24 possible for shape a in shape c from Figure 1. The shapes in Figure 2(b) are some shapes in the language defined by the initial shape (shape

3 Stiny, G 'Introduction to shape and shape grammars' *Environment and Planning B: Planning and Design* Vol 7 (1980) 343–351

c) and rule in Figure 1. The bold shapes show where the rule is applied in each sequence.

Parametric shape grammars[3] are an extension of shape grammars in which shape rules are defined by a general schema and are applied by filling in the open terms. Given a rule $a \rightarrow b$, an assignment g which gives specific values to all the variables in a and b determines a shape rule $g(a) \rightarrow g(b)$ which can then be applied on a shape to generate a new shape.
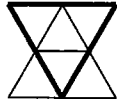
Shape grammars, having their roots in the architectural literature[3–4], have found application in engineering and design. For example, Agarwal and Cagan[5] introduced the coffeemaker grammar (Figure 3(a)), Brown et al.[6] the lathe grammar, Shea and Cagan[7] the truss grammar, Agarwal et al.[8] the MEMS resonator grammar, McCormack and Cagan[9] the inner hood panel grammar, and Pugliese and Cagan[10] the Harley motorcycle grammar (Figure 3(b)). In the Harley grammar, brand was captured through constraints applied to a grammar that generated motorcycles while in the current work the essence of Buick is captured within the shapes that define the rules of the grammar. Defining a brand through representative shapes indicates a more detailed understanding of shape computation and can produce more elegant grammars. For further reference and discussion on engineering shape grammars see Cagan[11].

The implementation of shape grammars as computer tools requires a shape grammar interpreter program, which performs the shape recognition, addition, and subtraction necessary for application of a rule. An interpreter was created by McCormack and Cagan[12] which handles parametric shapes composed of straight line segments. Parametric shape recognition is performed by decomposing shapes into a hierarchy based on line relations (e.g. perpendicularity, symmetry) and performing search with transformations that do not destroy the relations. The shape grammar interpreter requires extensions to handle shape grammars consisting of curved line segments.

2 Buick brand research

The Buick auto company was founded by bathtub maker David Buick in 1903. Six years later, a merger with Olds, gave birth to General Motors, the second largest auto company in the United States. By identifying the public's demand for styled, comfortable, and luxurious vehicles over sterile, homogeneous ones, General Motors cut Ford's market share by two-thirds in the 1920s. This styling push led to the creation of the Art and Color Section, the first auto styling division in the United States. The leader of Art and Color was the first of GM's five (as of 2001) styling chiefs, Harley Earl. Earl was a flamboyant Hollywood designer who was hired by

4 Stiny, G and Gips, J 'Shape Grammars and the Generative Specification of Painting and Sculpture' in **C V Freiman** (ed.) *Information Processing 71*, IFIP, North-Holland Amsterdam (1972) pp 1460–1465

5 Agarwal, M and Cagan, J 'A blend of different tastes: the language of coffee makers' *Environment and Planning B: Planning and Design* Vol 25 (1998) 205–226

6 Brown, K N, McMahon, C A and Sims Williams, J H 'A formal language for the design of manufacturable objects' in **J S Gero and E Tyugu** (eds) *Formal design methods for CAD (B-18)*, North Holland, Amsterdam (1994) pp 135–155

7 Shea, K and Cagan, J 'Innovative dome design: applying geodesic patterns with shape annealing' *Artificial Intelligence in Engineering Design, Analysis, and Manufacturing* Vol 11 (1997) 379–394

8 Agarwal, M, Cagan, J and Stiny, G 'A micro language: generating MEMS resonators using a coupled form-function shape grammar' *Environment and Planning B: Planning and Design* Vol 27 (2000) 615–626

9 McCormack, J P and Cagan, J 'Designing inner hood panels through a shape grammar-based framework' *Artificial Intelligence in Engineering Design, Analysis and Manufacturing* Vol 16 No 4 (2002) 273–290

10 Pugliese, M and Cagan, J 'Capturing a rebel: modeling the Harley–Davidson brand through a motorcycle shape grammar' *Research in Engineering Design* Vol 13 (2001) 139–156

11 Cagan, J 'Engineering shape grammars: where have we been and where are we going?' in **E K Antonsson and J Cagan** (eds) *Formal engineering design synthesis*, Cambridge University Press, Cambridge, UK (2001) pp 65–92

12 McCormack, J P and Cagan, J 'Supporting designer's hierarchies through parametric shape recognition' *Environment and Planning B: Planning and Design* Vol 29 (2002) 913–931
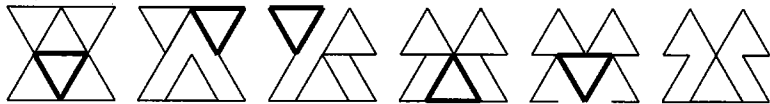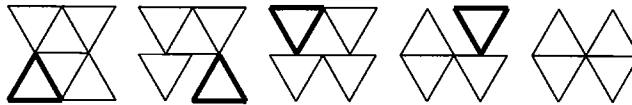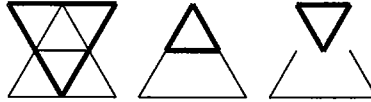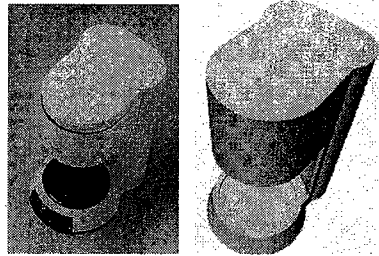
(a)

(b)

Figure 2 (a) A shape match of shape a in shape c is shown in bold. (b) Designs in the language defined by the rule and initial shape in Figure 1
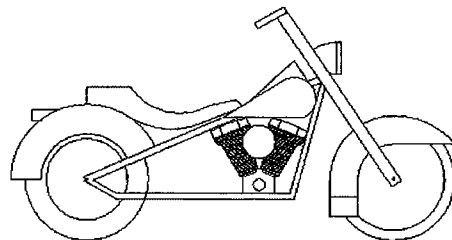
(a)

(b)

Figure 3 (a) An actual and grammar-generated coffee maker (b) and Harley–Davidson

Speaking the Buick language

5

GM in 1926 after a GM executive noticed his customized Cadillac designs. After an initial power struggle between styling and engineering, Earl and his styling studio became the undisputed king of the GM design process[13].

The divisions of Buick, Cadillac, Chevrolet, etc., which were originally differentiated by price and number of features moved towards separate divisions, which each satisfied a consumer demand. The feelings of sport (Pontiac), reliability (Buick), and elegance (Cadillac) took shape as the flowing lines of the body and the features such as the grill that defined a vehicle. Beginning with the early styling efforts, clear strides were made to direct the styling towards a specific target, thereby infusing value for that buyer. Buick evokes feelings of security, reliability, and American tradition, which were and must continue to be present in Buick vehicles. This is done yearly by using traditional forms that established the Buick essence while adapting for current styling preferences and technological advancements.

In order to identify, classify, and represent the Buick brand, we began by reviewing the history of Buick vehicles. By examining that history, features that establish the brand can be extracted. In addition to simply extracting features, the relations between the features must be determined while establishing a hierarchy of brand from sub-elements to gestalt. Single shapes that represent multiple versions of each feature can then be created and used in the shape grammar rules.

Evolution of the Buick front-end vehicle design can be broken down into periods of several years separated by a year of more prominent change. Because of the physical similarities, a single composite front-end can represent each of the 13 thematic eras of form as seen in Figure 4. Transitions from one thematic era of form to another were caused by changes in technology, design philosophy, studio leadership, and the control of the company. Perhaps the most prominent change occurred in 1958 when the transition from Earl to Bill Mitchell produced dramatic change in both the vehicle lines produced and the styling philosophy.

This coarse view of a product as complex as an automobile allows for the isolation of key features present in a prominent role across time as opposed to features which made limited appearances. The features selected (Figure 5) fall into a brand hierarchy. The grill has traditionally been the primary brand element maintaining a rounded shape with some type of embellishment upon the top and a strong vertical emphasis with the grill bars. The secondary brand elements are the hood flow lines, the outer hood, and the fenders, which have taken different shapes throughout the Buick history

13 Gartman, D 'Harley Earl and the art and color section: the birth of styling at General Motors' in **D Doordan** (ed.) *Design history: an anthology*, MIT Press, Cambridge, MA (1995)
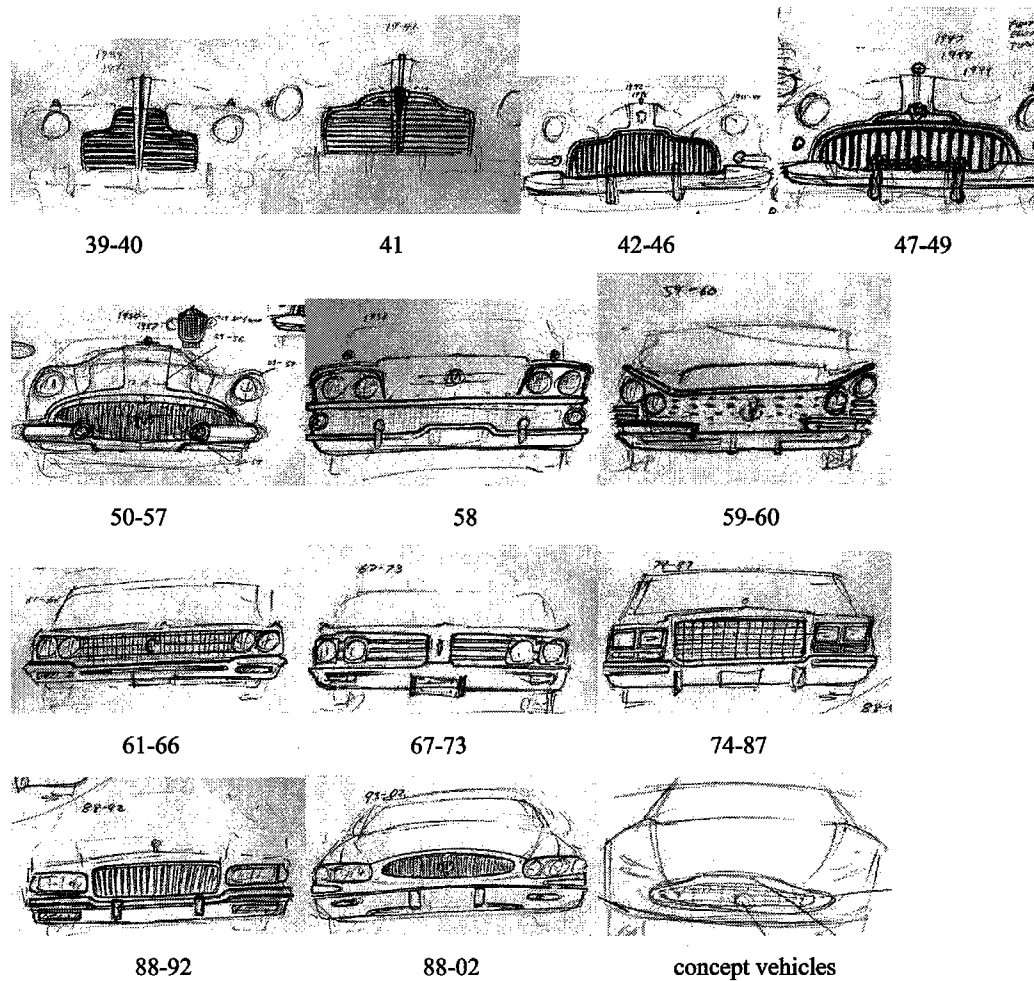
39-40   41   42-46   47-49

50-57   58   59-60

61-66   67-73   74-87

88-92   88-02   concept vehicles

Figure 4 The thirteen thematic eras of form of Buick from 1939–2002 and recent concept vehicles (sketches by Dave Aliberti)

but have been prominent features. Finally the tertiary element, the middle hood section, supports the secondary elements through its adjacency to the curves that define the outer hood section. The Buick history could then be represented with a chart (Figure 6) of each component from each thematic era. The chart in Figure 6 shows a portion of the representation of the history of Buick. Each box represents a component from the listed year (the grill from 42 to 46 for example) while the lines connecting the boxes show which components were historically grouped together. By comparing the shapes of features across years, similar forms can be grouped together and eventually represented as a single parametric shape grammar rule. Grouping features results in another chart (Figure 7) in which there is no longer a box for each component per year but now only one box for each
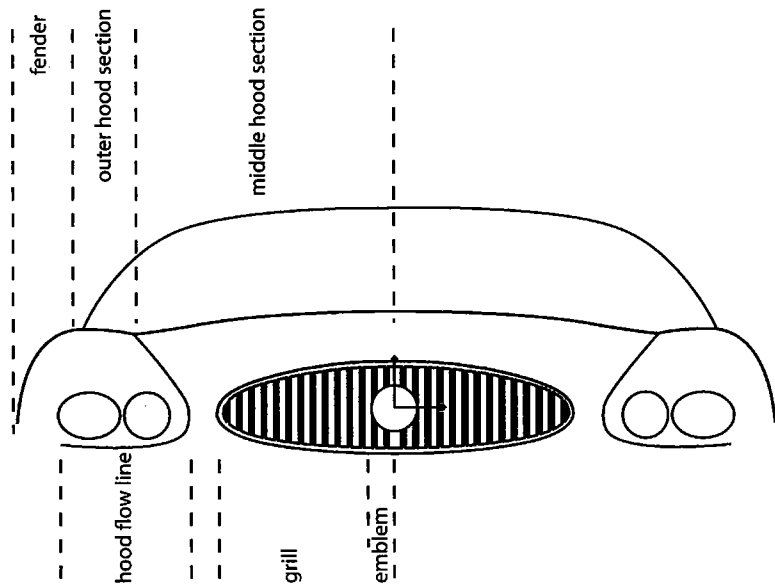
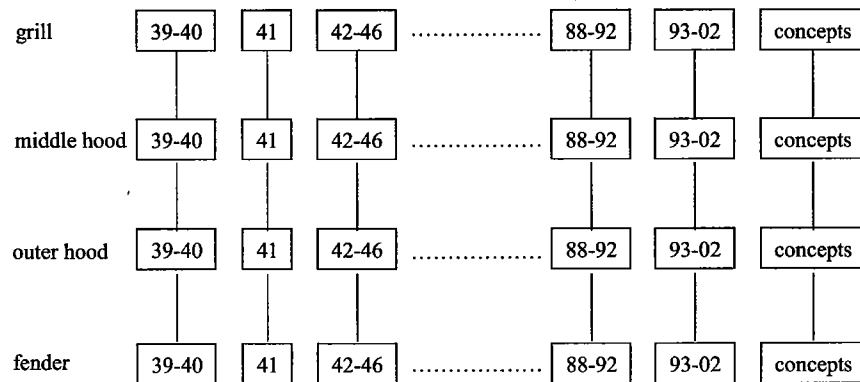*Figure 5 The key elements containing the Buick brand of a front view*

grill							
	39-40	41	42-46	....	88-92	93-02	concepts
middle hood	39-40	41	42-46	....	88-92	93-02	concepts
outer hood	39-40	41	42-46	....	88-92	93-02	concepts
fender	39-40	41	42-46	....	88-92	93-02	concepts

Figure 6 A summary of the key elements of the Buick brand for each thematic form era

distinct component shape. Lines between boxes note the historical pairing of component shapes. When choosing the shapes of features, only the components connected by lines can be selected to create a historically accurate Buick. Hence the 'branches" form a tree of decisions for the user to select component shapes that make up a Buick. This decision tree provides the structure for the Buick shape grammar, when historical accurate designs are desired. The hood flow lines were not included in the charts in Figures 6 and 7 because of the direct dependence of the hood flow lines upon the fender and outer hood section interaction.

By choosing points on the tree structure, features are selected that represent

grill	1947-1957, 1993-2002, concepts				1939-1946, 1958-1992	
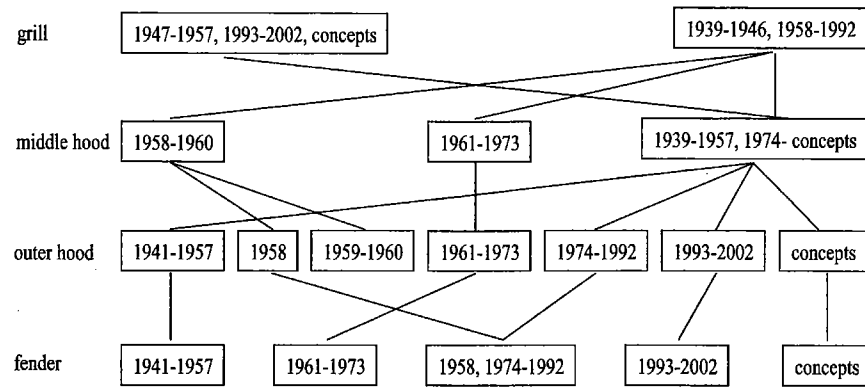
Figure 7 A representation of the history of Buick by combining similar shapes of Figure 6
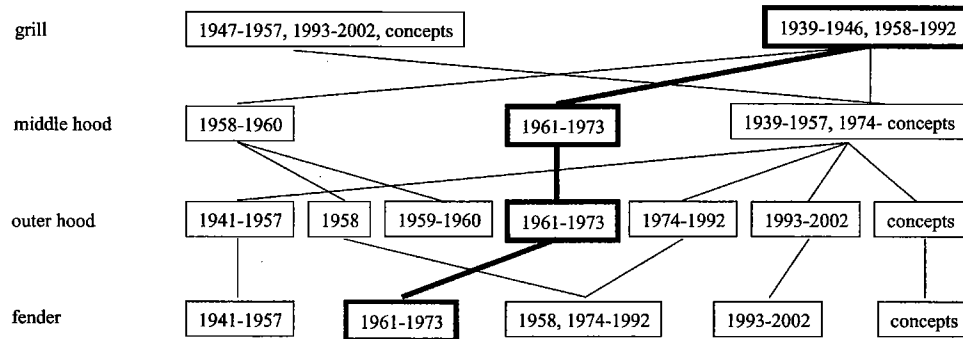

Figure 8 Choices leading to a 1961–1973 Buick design

the topology of a vehicle. By applying the rules corresponding to the selected nodes and instantiating any open parameters, the geometry of the design is set. A selection of historically paired features is highlighted in Figure 8. Applying the rules corresponding to the features in Figure 8 can result in a representation of the 1961–1973 Buick (Figure 9) with appropriate
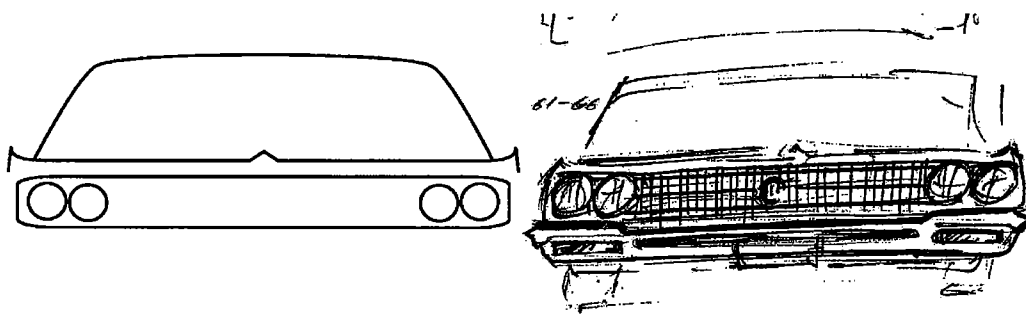
Figure 9 A representation of the 1961–1973 Buick form

parameter instantiation. Similarly, other vehicles from the thematic form eras can be generated by choosing the nodes corresponding to the years desired. By following a path connecting features from different eras, novel designs can be created.

3 The Buick shape grammar

Once the key elements of the brand were extracted and characterized with representative shapes, the Buick DNA was encoded by a shape grammar. Rules of the Buick grammar fall into two general categories: feature creation and feature modification. The creation rules of the Buick shape grammar take on the structure of the chart in Figure 7, where each box corresponds to a rule and each connecting line represents the pairing of historically accurate features, while modification rules act upon the shapes generated in the creation rules. By using the modification rules on the shapes generated, a large number of similarly shaped features can be represented without explicitly including a rule for each differently shaped feature from each year. All rules in the grammar are parametric, allowing for infinite variability within the language of Buick and the ability to capture a range of form within each rule.

From Figure 10, the grills of Buick fall into two broad categories: a rounded grill with an additional bump on the top and a rectangular grill, that are centered on the origin when their rule is applied. The origin serves as the initial shape for the Buick grammar. The rounded gill (rule 1) is representative of the later years of Harley Earl styling (1947–1957), the contemporary styling in the Wayne Cherry era (1993–present), including the styling seen in the recent concept vehicles, while the rectangular grill (rule 2) was used in the years between Earl and Cherry. In this figure the reflected right half of the shape is shown for completeness. Symmetry is assumed and the grammar only captures one half of the vehicle, as shown in the remainder of the rules. After choosing one of these two starting points in the grill design, the user can apply a variety of rules that change
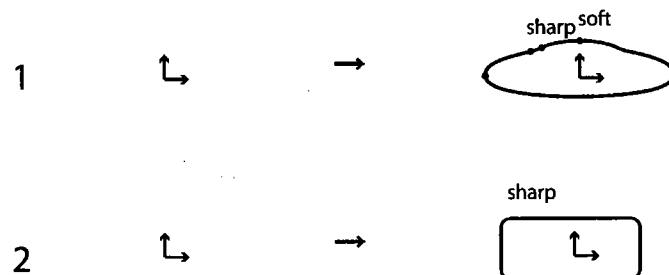

Figure 10 Grill generation rules, the reflected right half of the grills are shown in addition to the left for clarity

the grill. The modification rules for the grill are shown in Figure 11. Rule 3 creates a rectangular feature on the top of the rectangular grill (of rule 2). This addition models the grills that appeared on Buicks from 1930 to 1946. Rules 4 and 5 change the height and width of the feature on the top
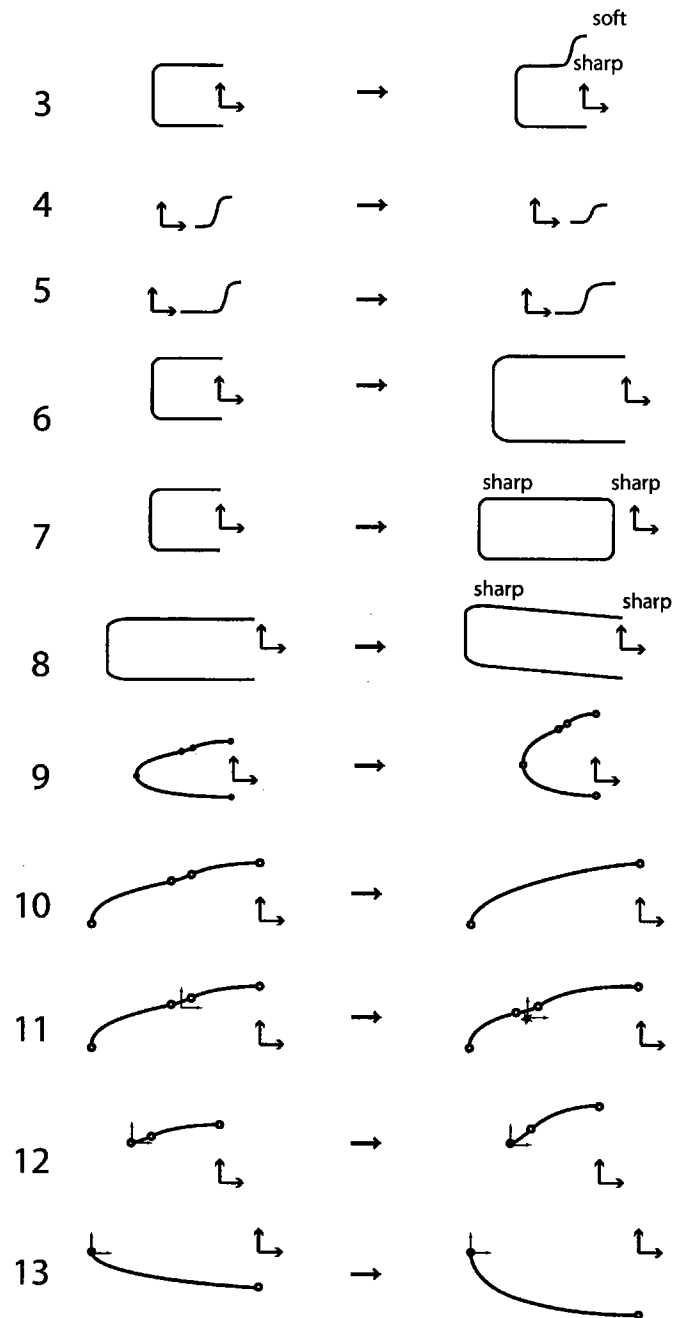

Figure 11 The grill modification rules

of the grills of 1930–1946. Rule 6 changes the scale of the rectangular grill. Rule 7 splits the rectangular grill as was done in 1968 and 1969 and rule 8 alters the grill to make a 'V' shape as was done in 1971 through 1975. Rule 9 changes the vertical scale of the rounded grill while rule 10 removes the top bump from the rounded grill, a common feature of many Buicks of the mid to late 1990s. Rule 11 allows the width of the bump feature atop the rounded grill to be changed while rule 12 allows the height of the same feature to be changed. Rule 13 changes the height of the line that represents the bottom of the grill.

The final step in designing the grill is creating the grill bars and the emblem. A set of rules generates vertical lines of varying line weight and spacing that express Buick with an elegant, sporty, or rugged feel. Rules can be accompanied by a descriptive term, which would express the emotional impact of applying the rule. Describing the impact of shape in words aids in communicating the importance of that shape to the brand. The emblem is represented with a circle. The interior detail of the emblem is omitted for simplicity. Rule 14 (Figure 12) adds the emblem at the origin. Rule 15 allows the user to modify the emblem diameter and rule 16 allows the user to change the vertical location of the emblem with respect to the origin.

Other features of the front-end view are handled in the same manner, a set of rules provides a starting point while others produce variations of that feature. There are three entry points into designing the center section of the hood, which place the representative line above the origin, according to a distance parameter determined by the user. Rule 17 (Figure 13) encapsulates the middle hood section of Buicks from 1939 to 1957, 1974–2002, and recent concept vehicles by generating curved hoods. Modification rules change the hood through altering scale, length, and control points that
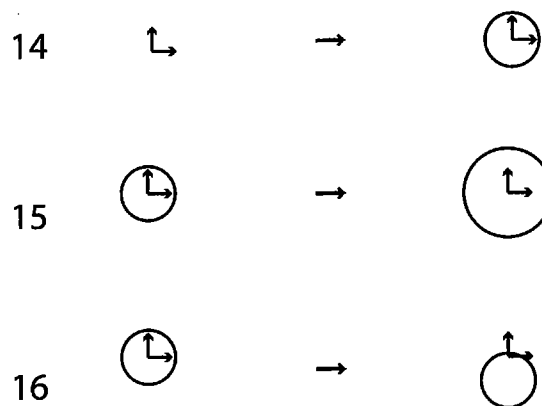

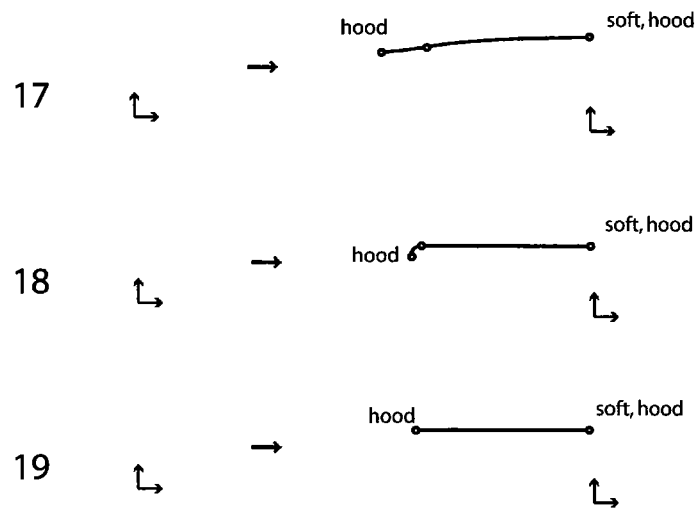*Figure 12 Emblem creation and modification rules*

17 → hood ●——○———————● soft, hood

18 → hood ●——————————● soft, hood

Figure 13 Middle hood sec-
tion generation rules

19 → hood ●——————————● soft, hood

define the curved line segment representing the hood. Rule 18 (Figure 13) encapsulates middle hood sections from 1958 to 1960, and rule 19 captures 1960–1971. The transition years between Harley Earl and Bill Mitchell, Harley Earl's successor, produced distinct designs: a flat hood with a tight curve moving into a vertical side element that produced the look of the heightened hoods previous to 1958 on what was then a very low car. The hood of the late 1950s quickly became a mostly flat surface, which lasted for more than a decade.

Rules for modification of the center hood section are shown in Figure 14. Rules 20 and 21 vertically scale the center hood sections of contemporary styling and those of the 1958–1960 style. Rules 22–24 horizontally scale the center section of the hood, each rule corresponding to a center hood style. Rule 25 adds a bump feature to the center hood section. This feature is featured on the Cielo concept vehicle (Figure 33). Rules 26 and 27 change the dimensions of the bump feature created by rule 25. Similarly, rule 28 creates a center ridge as seen on many Buick models of the 1960s. The features included in rules 25 and 28 are examples of features that can be added to the grammar structure for generation. Other features can be included to add more detail to areas of interest of the user.

The Buick outer hood section is represented with seven rules that generate the seven unique shapes extracted from the thematic eras of form shown in Figure 7. Each outer hood rule matches with its historically paired middle hood section. Rules 29–35 in Figure 15 represent the outer hood sections from 1941 to 2002 and recent concepts, divided into seven rules. Modification rules also exist that can scale the feature, change the depth
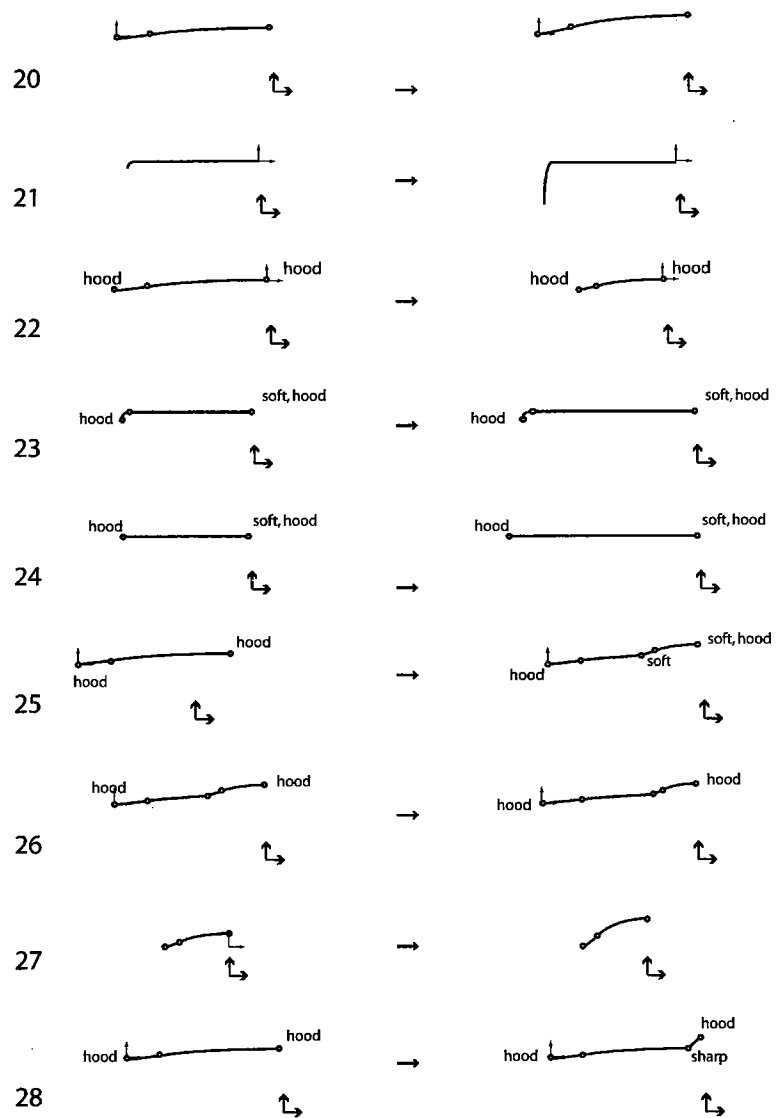
20

21

22

23

24

25

26

27

*Figure 14 Modification
rules for the center hood*

28

or accent of the inner fender, or rotate the section about its intersection with the middle hood. The outer hood rules require the recognition of the middle hood section to determine the placement location of the outer hood line and to determine which outer hood rule can be applied. This shape recognition can be done in a number of ways. The middle hood section can be located by simply labeling the end points of the middle hood line segment and then searching for those labels or alternatively, a matching of the straight and curved line segment can be performed by allowing for the transformation of the middle hood line segment in the rule to match
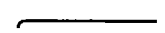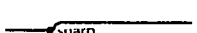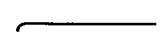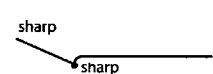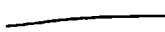
29	→	soft	1941-1957
30	→	sharp	1958
31	→	sharp / sharp	1959-1960
32	→	soft	1961-1973
33	→	soft	1974-1992
34	→	sharp	1993-2002
35	→	soft	concept

Figure 15 Outer hood generation rules

Figure 16 A middle hood rule that relies on label matching to determine applicability

hood1 → fender1 hood1
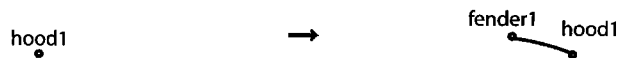
any possible variation of the middle hood section in the design. Labels are letters or symbols that are associated with a geometric entity to express information not expressed through the geometry itself. Figure 16 shows an outer hood rule that uses label matching to determine applicability. If a point exists in the design that is labeled hood1 (a hood section endpoint), then the rule can be applied and a line representing the outer hood is added to the design. Application of the rule in Figure 17 requires that the middle hood line on the left side of the rule be an equivalent match to the middle hood line in the design where the rule is to be applied. This is of course a more time consuming check than simple label matching but the rule can

Figure 17 A middle hood rule that relies on shape matching to determine applicability

hood ———— hood → f1 hood ———— hood / f2

Speaking the Buick language

be applied with a recognition of the form of the middle hood line, allowing for more precise control of continuity or relative scale.

If the shape matching criteria on the outer hood section rules are relaxed to allow for matching of more than historically paired middle and outer hoods, some creative designs can be produced. In general, label matching is simpler to implement, but shape recognition holds the potential for the emergence of new shapes and thus is the approach selected. A selection of modification rules for the outer hood section is shown in Figure 18. For each outer hood type there is a rule for vertically and horizontally scaling
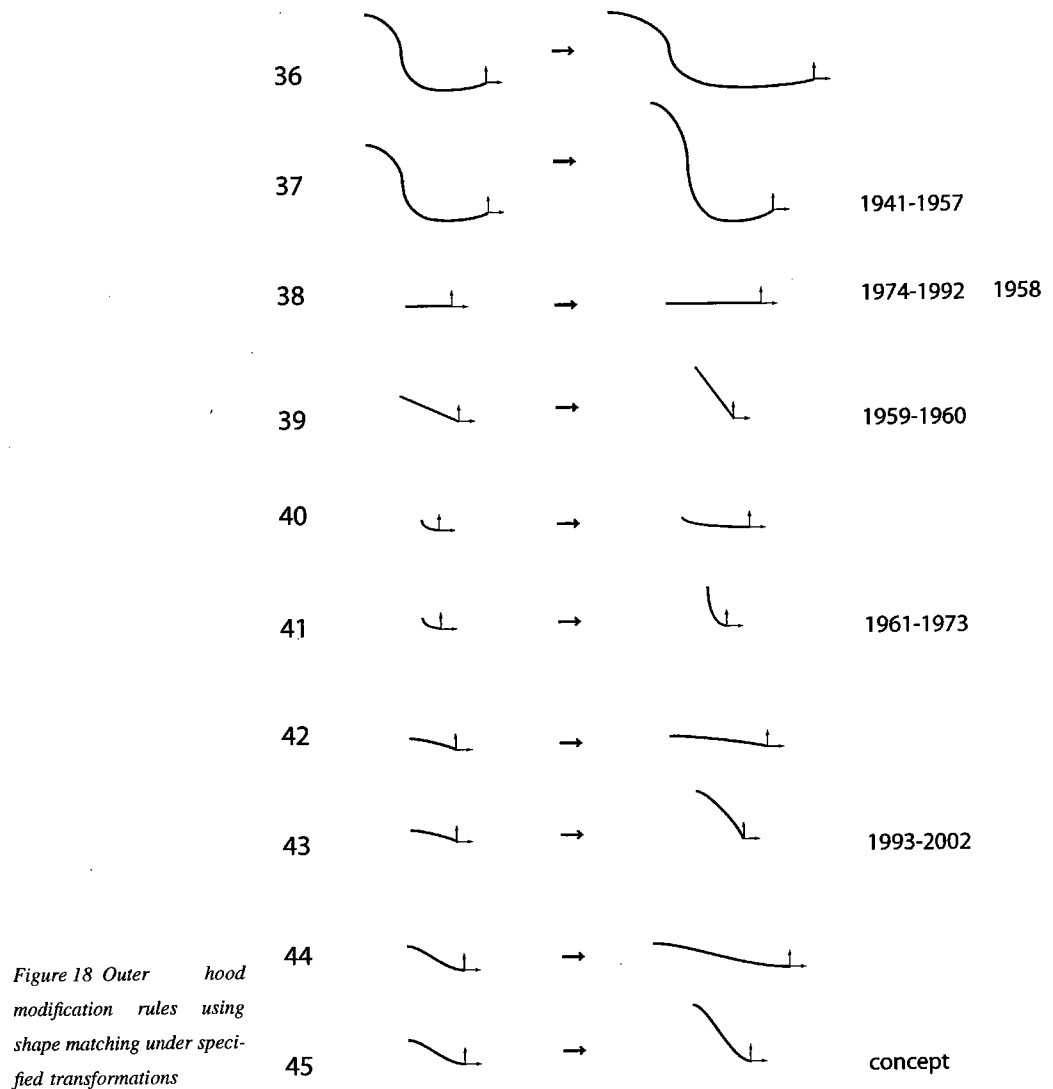

Figure 18 Outer hood modification rules using shape matching under specified transformations

the representing line where rule applicability is determined by matching shapes with a set of transformations specified by the user.

The fender representations (rules 46–50, Figure 19) are created using five rules that operate similarly to the outer fender rules. Recognition of the proper outer hood section allows for the generation of a now completed hood/fender assembly. Again relaxing the shape matching criteria can produce creative designs. There are two fewer fender rules than outer hoods because the 1959 and 1960 Buicks do not have a separate outer hood and fender section according to the part definition and the 1958 and 1974–1992 Buicks have the same fender shape, which can be captured with one rule.

Another of the key features of the Buick is the hood flow line, an extension of the wave shaped bodyline. Buick has maintained a defined bodyline at the intersection of the outer hood and fender that moves from the windshield, down the hood, over the front, ending at the grill or curving around the lights. The hood flow lines are most prominent on the Buick Riviera line and LeSabre, but are present on most Buicks although they cannot be seen on Buicks of the 1960s and 1970s from the front view because the hood surface is parallel to the ground. Starting and ending points of hood flow lines are defined by points labeled soft and sharp, which are added to the design as the grill, hood, and fenders are generated. A soft point falls at the intersection of two line segments that meet with a continuous
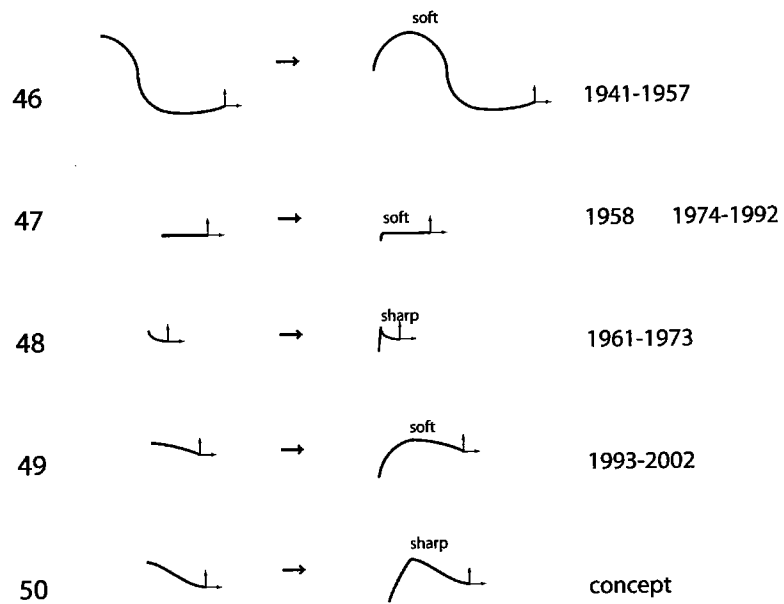
46			1941-1957
47			1958 1974-1992
48			1961-1973
49			1993-2002
50			concept

Figure 19 Fender generation rules

curve while sharp points result in intersections of lesser continuity. Rules 51 and 52 (Figure 20) connect a set of sharp or soft points with curves that represent the hood flow lines while rule 53 generates a flow line around the headlights. A flow line can also terminate at the centerline, creating a
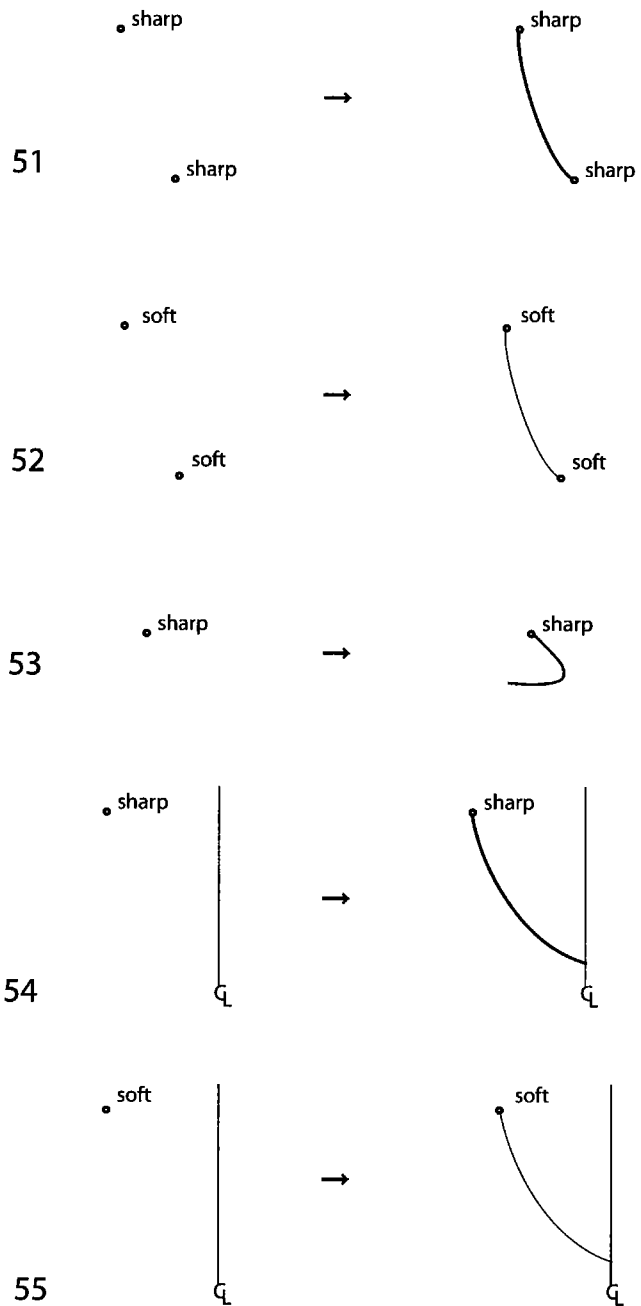
51

52

53

54

55

Figure 20 Hood flow line generation rules

raised feature down the hood. Rules 54 and 55 create this feature and can be used in conjunction with rule 25 to create a hood treatment as seen on the Cielo (Figure 33). The hood flow lines also carry a line weight, which is used to differentiate between a sharp ridge or valley and softer one. Modification rules can be applied to alter the depth and accent of the curve.

Modification of the hood flow lines is performed with two pairs of rules. Rule 56 in Figure 21 sharpens the flow line around the headlights to create a more aggressive look while rule 57 softens the curve providing a more stable conservative appearance. Rules 58 and 59 allow the user to modify hood flow lines with a defined starting and ending point. The depth of the
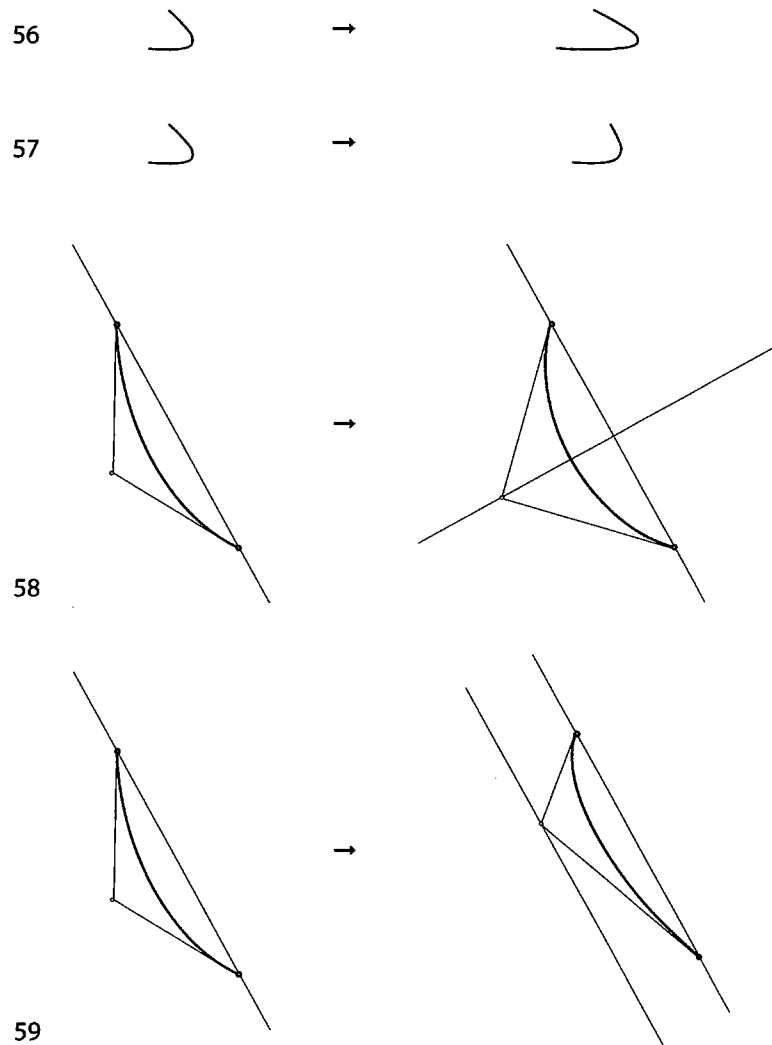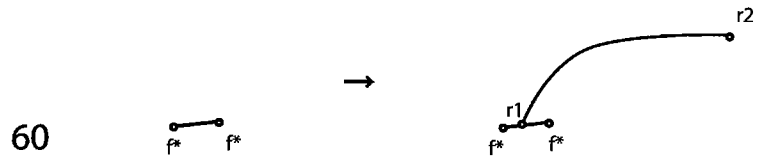

Figure 21 Hood flow line modification rules

hood flow line can be altered by using rule 58 and the accent of the curve can be changed with rule 59.

Additional rules are included in the grammar to create other vehicle features that have lesser impact on the brand such as roofline and headlights. A sample roof creation rule (Rule 60) is shown in Figure 22. A selection of rules for the creation and modification of headlights is shown in Figure 23. Rule 61 creates a circular headlight while rule 62 adds a second circular headlight to form a pair. The round headlights can be altered by rules such as rule 63, which changes the circle into an ellipse. In total, the Buick grammar is composed of 70 rules with an additional 21 for generating headlights and eight for grill bar patterns. Some details in the rules have been omitted for clarity such as the notation that prevents reapplication of rules. It is also important to note that, despite not being stated in this paper, there are constraints on the parametric variations of the shapes created and modified by the Buick shape grammar. The precise values of the limitations were not calculated completely and hence were not stated. These 91 rules can generate all Buick front-ends from 1939 through the current concept vehicles and an infinite number of new vehicles. The methodical process used to generate representative shapes already discussed in this paper supports this statement. As each rule is selected, it is applied symmetrically from the centerline.
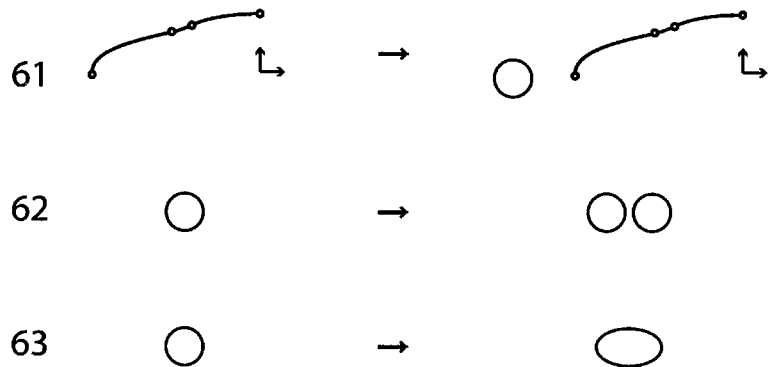
4 Generating Buicks

As a first check of the Buick grammar an existing vehicle was selected and recreated. This by itself does not prove completeness of the grammar but provides insight into possible grammatical errors. A representation of the 2002 Buick Regal was created by following the grammar, choosing the rules that generated features of the proper year, and selecting parameters that instantiate the shapes generated by the rules in the style of the Regal specifically. The vehicle was created through 14 rule applications (Figure 24) beginning with the initial shape, the origin, then adding each feature using the rule corresponding to the contemporary instance of that feature. Parameters for instantiating the rules were selected by the user to resemble the Regal. The first rule application in Figure 24 adds the rounded grill from rule 1, the basis for all contemporary grills. In step 2 the line representing the bottom of the grill is altered with rule 13, which changes the height of the line and allows the bottom corners of the grill to be sharpened. Application of rule 10 in step 3 removes the bump feature from the top of the grill. Rule 17 is applied in step 4 to create a contemporary middle hood section. Step 5 creates a second grill outline to highlight the grill shape using a rule not presented in this paper's selection of rules. Rules 34 and 49 add the contemporary outer hood section and fender line and are applied in steps 6 and 7, respectively. The next rule (rule 53) applied in step 8 adds the flow lines that move down the hood and eventually 'frame' the headlights. The hood flow lines are sharpened in step 9 by using rule 56. Rule 14, applied in step 10, creates the emblem centered in the grill. The grill bar pattern featuring a pair of heavy horizontal pieces and a single vertical member in the center is added to the grill in step 11. Grill patterns are generated separately, using rules not presented here, and are then imported into the Buick designs. A single circular headlight is created in step 12 using rule 61 and a second circular headlight is created
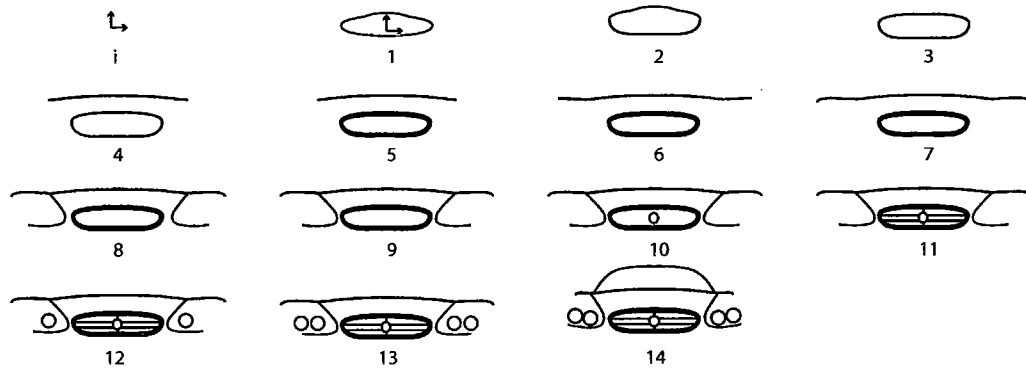

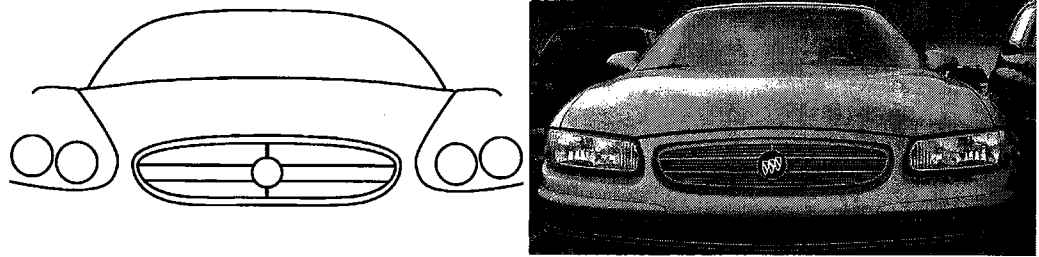*Figure 24 Creation of the 2002 Buick Regal using the Buick shape grammar rules*

Figure 25 Comparison of the grammar-generated Buick Regal and actual Buick Regal

in step 13 using rule 62. The final step is to add the roofline in step 14. Figure 25 compares the actual 2002 Buick Regal with the grammar-generated vehicle. Another test was performed to recreate the 2002 Buick LeSabre with the Buick grammar. The vehicle was created through 14 rule applications (Figure 26) beginning with the origin and moving to the grill, hood, fenders, and headlights. Figure 27 compares the actual 2002 Buick LeSabre with the grammar-generated vehicle.

The Buick shape grammar was used by industrial designers and engineers to explore the Buick brand by creating some novel vehicles. Rules were selected by the designer to satisfy individual tastes while supporting the vehicle's role (sport utility, family car, etc.), as were any parameters required to instantiate a rule. Elements characteristic of contemporary Buicks were used to create the vehicle in Figure 28. This vehicle takes cues from the LeSabre in its hood flow lines, fender, and hood structure but is more exaggerated. The roof is taller and more narrow than most
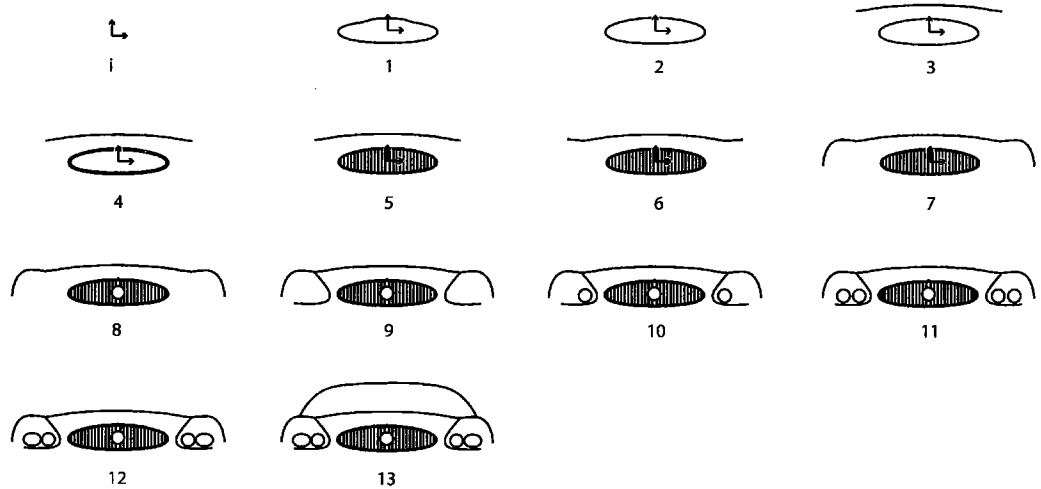

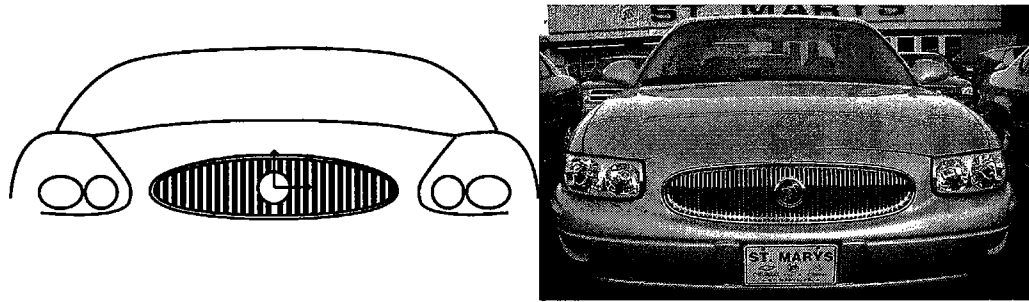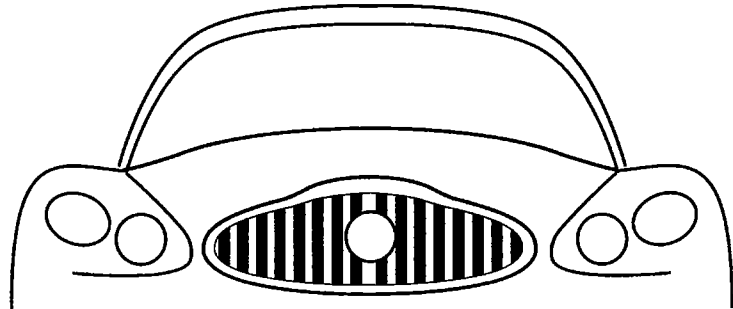*Figure 26 Step by step generation of a 2002 Buick LeSabre*

Figure 27 Comparison of grammar-generated LeSabre and actual LeSabre

*Figure 28 Novel Buick design for the small SUV market*

Buicks and this, coupled with the rugged feel of the heavy grill bars, gives this generation the look of a cross-over vehicle such as the new smaller SUVs based on minivan platforms. Figures 29–31 feature vehicles created using elements of the Buick grammar throughout the Buick history. Shape matching criteria were relaxed to allow for pairing of features from different eras. The design in Figure 29 was created by applying rules that correspond to the contemporary hood and fender elements, but parameters were chosen to form more rounded features. A modern grill was added to the design using rule 1. Rules were then applied that allowed the designer to alter parameters related to the width and height of the grill bump feature.
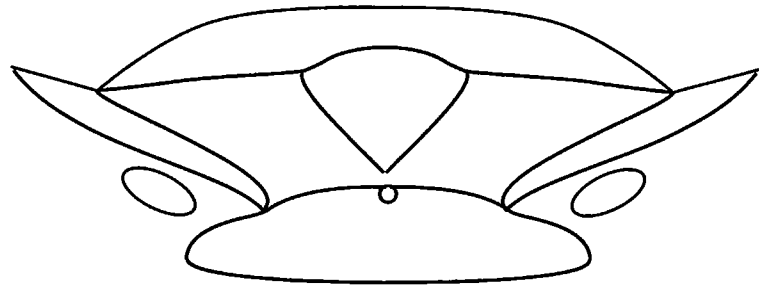

Figure 29 Novel design taking cues from concept vehicles and contemporary design

Speaking the Buick language
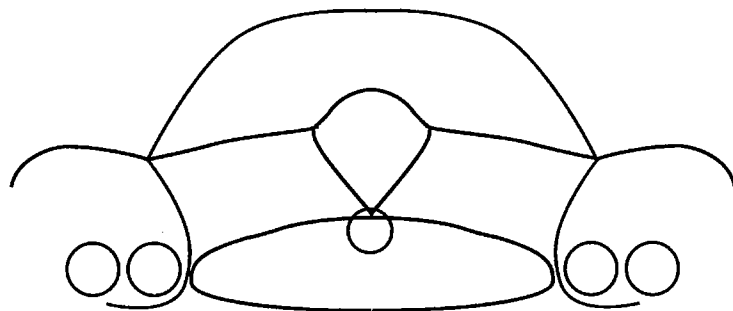
Figure 30 Novel design using fender shapes of the 1960s
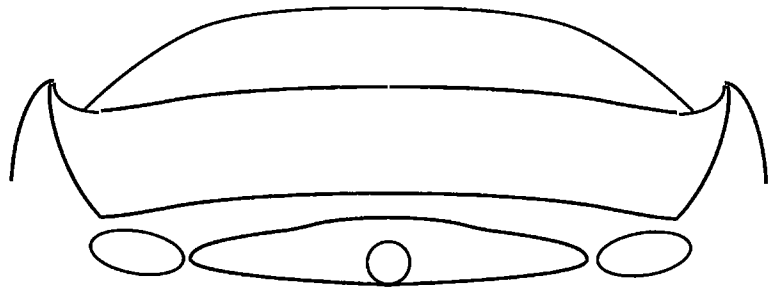
Figure 31 Novel design exploring the surface created by hood flow lines

The resulting grill resembles the grill from the Buick LaCross (Figure 32) concept vehicle. The bump in the center of the hood was generated using a rule 25 to create a hood feature like that on the Buick Cielo concept (Figure 33).

The vehicle in Figure 30 mixes contemporary elements with retro fenders. A contemporary middle hood section (rule 17) provides a wide gentle
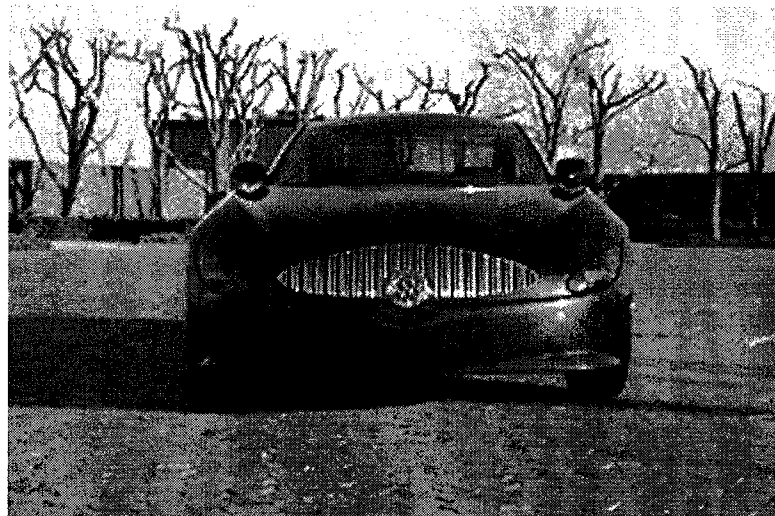
Figure 32 The Buick LaCross concept vehicle

Figure 33 The Buick Cielo concept vehicle

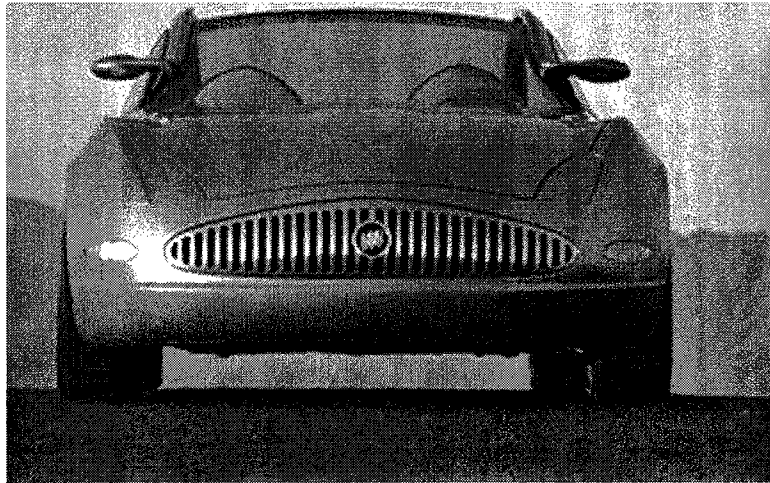curved hood. Rule 31 was then applied to add an outer hood line from a 1961–1973 Buick. Adding a fender from the concept vehicles (rule 50) completes the hood–fender line. Smooth hood flow lines move down the peak of the fenders and end at an abrupt transition to the front-end, which is created by applying the hood generation rule closer to the origin. Again the grill creation begins by applying rule 1 to create a contemporary grill. Parameters that define the shape of the grill were then altered by applying rules that decrease the vertical scale, increase the bump width and add depth to the bottom curve that defines the grill.

Figure 31 again uses the center hood bump from the Cielo adorning a contemporary middle hood section, but the outer hood rule used generates outer hoods from 1959 and 1960. Hood flow lines are then used to create a surface like those seen on the recent concept vehicles. The grill was created with the contemporary grill as the starting point. Rules were then applied to increase the scale of the grill and flatten the bottom curve. Finally, angled elliptical headlights accentuate the aggressive styling established with the hood flow lines.

A sample of additional novel Buicks is shown in Figure 34. Designs (a) and (b) were generated with the intention of being small SUVs. Both vehicles feature contemporary hood and fenders but are parameterized differently. Vehicle (a) uses the hood flow lines to establish an aggressive appearance that is reinforced by an elongated, angular grill, similar to those seen on the concept vehicles. In contrast, vehicle (b) uses the hood flow lines and grill to establish a subtle ruggedness. Designs (c) and (d) were created as an exercise in exploring the surfaces created by several hood flow lines. Vehicle (c) is a low to the ground sporty car inspired by the
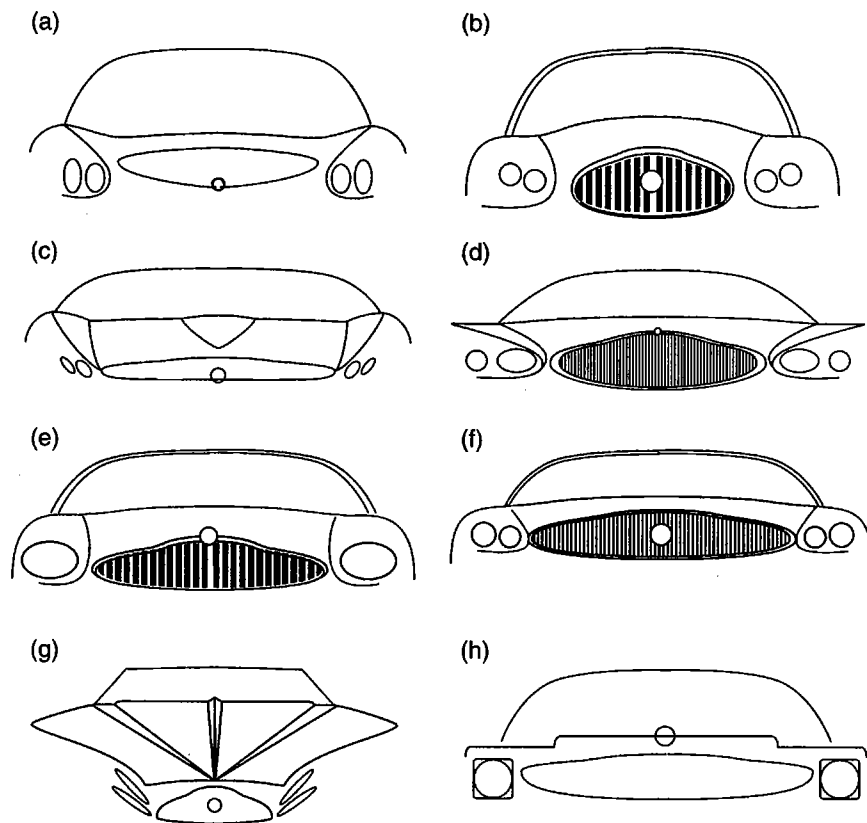
Figure 34 A sample of novel Buicks created to fill a specified need. (a,b) small SUVs; (c,d) sporty Buicks and exploration with the hood flow line; (e,f) large luxury vehicles; (g,h) angular designs using Bill Mitchell era shapes

Cadillac Cien while vehicle (d) incorporates fenders from 1959 to 1960 and uses the flow lines to transition the fender surface over the front of the vehicle and frame the headlight area. A pair of luxury vehicles was generated using the grammar in Figure 34(e) and (f)). Both cars are low and wide with contemporary grills differing in the types of the grill bars, headlights, and location and size of the emblem. The vehicles in Figure 34(g) and (h) primarily use elements of the Mitchell designs resulting in angular forms. Both designs feature hoods from 1958 to 1960 but design (g) uses sharp hood flow lines, eliminating the box like shapes of the 1958–1960 era vehicles, giving the vehicles a more contemporary look while design (h) incorporates a less rounded version of the modern grill.

There is an endless list of interesting experiments that can be performed with the grammar. How would a Mitchell era grill fit into the organic forms of a high end, contemporary Cherry Buick? What historical fender types

26

can add to the sense of ruggedness on a small SUV? What are the limits on the width to height ratio of the elliptical grill in order to maintain the Buick brand? How would a full sized SUV carry the Buick tradition to a new platform? Through experimentation, not only is innovation found, but also the Buick brand becomes more clearly defined for the user.

5 Additional uses of the brand grammar

There are additional applications of the grammar for studio, engineering, and marketing in addition to exploring within the brand by generating vehicles with the grammar (as in Section 4). Through additional vehicle generation, the bounds of the Buick brand can be stretched and tested, examining the limits of a feature in the context of a Buick vehicle. The current popularity of cross-over vehicles presents an interesting challenge in evolving and testing the brand on a platform that is just now emerging.

Not wanting to place designers under constraints, studio would have informal as well as the customary structured applications of the grammar that allow exploration but are grounded in the core brand elements. Sketches can be generated similar to those in Section 4 to provide a springboard for designers into a more focused form study. The grammar also serves as an interesting catalog of features and form that have defined Buick, accessible in an informal manner or as a set of generative rules. Marketing could make use of the brand by connecting consumer perception to elements of the brand through surveys and studies, ensuring that the brand still connects to the values of the consumer. Tying an emotional descriptor to application of a rule or parameter selection would provide a connection between marketing and studio by allowing a rule to be referenced by the feeling that it evokes through shape. One way to achieve this may be through a description grammar[14] operating in parallel with the shape grammar.

Engineering can use the grammar to express the brand in terms of manufacturing constraints, communicating to studio the limits that technology places on a part or feature. Through the grammar, brand is presented to engineers in a logical framework, which decomposes the brand into sub-elements, making the brand more accessible and understandable to a group which is not trained in brand and esthetics. By receiving the brand in small chunks, backed with the marketing's justification from the public perception, all parties will share in the understanding of the brand and the importance of preserving the identity. As engineering makes changes downstream the grammar is used to ensure that the brand is maintained; no changes are made unless they are captured in the grammar. Increased understanding and communication of brand among engineering, studio, and marketing help retain the emotion infused by studio into a computer model, then sheet metal, and finally onto the road.

14 Stiny, G 'A note on the description of designs' *Environment and Planning B: Planning and Design* Vol 8 (1981) 257–267

6 Concluding remarks

Brand identity is composed of several factors, but it is the product itself that carries the essence of the brand to the customer, particularly through its form. Success is achieved when brand is developed with care and purpose to connect to the user and is maintained through the evolution of the product. Developing a shape grammar that captures this brand essence requires in-depth research and understanding of the decisions made that shape the product. A shape grammar tool can help to build or maintain a strong brand that fulfills the brand identity and appeals to the customer. Other brands can be modeled with shape grammars once an understanding of the brand and shapes forming the product that contain brand essence are uncovered. Once established, a shape grammar focused on brand has several uses all of which contribute to the communication and understanding of brand among studio, marketing, and engineering in an effort to create a consistent view of the product.

The Buick shape grammar has been used effectively to model shapes inherent to the Buick brand. The grammar provides the means for studio, engineering, and marketing to communicate about brand by supporting the styles of communication appealing to each discipline. The shape grammar is guaranteed to generate a Buick, composed of contemporary features or features of another era. As auto companies influence each other's styling over time, it is possible that a vehicle generated with the grammar may resemble another vehicle type, especially in the secondary and tertiary brand features. As the grammar extends to other views, the revealing Buick features such as the portholes and the wave shaped bodyline would further set it apart. Limits exist on each parametric feature that, if exceeded, would exclude it from the Buick brand. Discovering the limits of a feature by stretching its parameters must be done within the context of a Buick vehicle, as the brand is a gestalt of features, together defining the brand.

The Buick grammar has not been implemented on a computer. The technology of shape recognition of curved line segments is an ongoing research project that will allow for immediate and straightforward use of the grammar that includes the ability to add new rules when new forms evolve in the Buick brand. By making the brand accessible and understandable, shape grammars can help achieve a shared vision of the product, brand, and customer.

Acknowledgements