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Dynamic Surface: An Extrapolation of Biodesign
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PREFACE

At the outset, due homage must be paid to Luigi Colani, the visionary designer whose ideas form the springboard from which this project leaps. Much of the motivation to pursue this project stemmed from being long intrigued by the visceral quality of Colani's works, all the more impressive when seen in the context they evolved from.

It is difficult to specifically identify the seeds from which this project germinated. One of the most significant of them however, would be a growing feeling of dissatisfaction with the role of form in contemporary objects, from products to transport vehicles. While the issues which will be discussed do impact upon many designed objects, they can be seen at their most heightened stage of development in the area of transport design. Therefore, the views expressed in this paper should be seen chiefly in the context of contemporary transport design.

The tremendous strides in manufacturing technology and the pervasive use of the computer in the design process, along with other factors, have made a profound impact upon designed objects in at least two ways. Firstly, they have made it possible for the complex, fantastic designs to reach production. The days when a concept would be diluted to the point of being unrecognizable by the time it reached production are now gone. Secondly, these concepts can now reach production much quicker. Scarcely a year goes by before manufacturers
announce newer, more stylish models in their lineup. This is allowing consumers to get accustomed to a rate of change which is increasingly rapid.

One of the major implications of these factors, which perhaps lies at the very core of this project is something every economist is well aware of: the Law of Diminishing Returns. The sheer number of new concepts paraded each year with never-ending regularity, jostles for attention with hundreds of competitors, each rich with innovative new finishes, textures and detailing. This only adds to the number of hoops that the designers will have to jump through to grab attention for the next year’s concept.

Where does the timeless or classic design fit into this relentless picture? One avenue has already been exploited by some manufacturers with varying degrees of success- that of “re-interpreting” a particular classic model from the past, by keeping sufficient styling cues and proportions to “evoke” its timeless parent, although with contemporary treatment and technology. The contradiction inherent in this path is that as more manufacturers jump onto the bandwagon and re-introduce classic forms into the mainstream marketplace, this aesthetic too, thanks to its burgeoning numbers, will cease to differentiate itself from the herd and will ultimately be reduced to another outdated “look of the year.”

The self-defeating nature of this cycle was the cause of much soul searching, and eventually led to the following disturbing realization: The conventional idea of form as a means of providing satisfaction is in imminent danger of being exhausted. It is inevitable that the cliched paradigm must eventually shift.

It was pondering over this issue which, at some point, allowed the crystallization
of the ideas which came to form the basis of this project.

Owing to the extremely broad ramifications of an idea of this nature, it was decided to limit the scope of the project to an introduction and explanation of the thinking behind it. This would be accompanied by the preparation of a working physical model which would be used to demonstrate the basic proposal and gauge the general response to the idea. Since the matter begs for debate, it was further decided that the documentation would be in the form of an article for Innovation Magazine, the journal of the Industrial Designers Society of America, making brevity necessary.

I am grateful to the people whose invaluable assistance led me to consider many aspects I might have ignored. I would like to thank my advisors—Professor Craig McArt for his many probing questions and suggestions and bearing with many frantic phone calls, Professor Doug Cleminshaw for his steadfast encouragement and Visiting Professor Marcus Conge for his insightful guidance and advice on technical matters. I would also like to thank my friend Mary Rose Monkowski for her ever-present support and constructive criticism.
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To Cynthia
SECTION ONE
THE SOURCE OF THE STORM

It is arguable that most of the smoothly contoured, complex, sculpted surfaces that we take for granted in much of mainstream contemporary manufactured objects have at least some of their roots in Biodesign. This line of design thought was notably propagated by the colorful German born industrial designer Luigi Colani. Biomorphic forms were, however, not new to the visual arts. The forms and themes of nature had been explored with varying sensibilities in the past through the Arts and Crafts, Art Nouveau and Organic Design movements, as also in the works of designers such as Isamu Noguchi, among others. Nevertheless, if the attributes of contemporary Biomorphic product design are traced, their origins undeniably can be linked to the work of Luigi Colani.

Choosing to draw inspiration primarily from the sophisticated complexity present in natural forms, Colani claimed that “The earth is round, all the heavenly bodies are round; they all move on round or elliptical orbits...Why should I join the straying mass who want to make everything angular? I am going to pursue Galileo Galilei's philosophy: my world is also round....I do not more than imitate the truths revealed to me by nature!” His sources included anything from birds to strange deep sea creatures, which inspired all manner of objects from improbable automobiles to landmark cameras.
Those critical of these ideas held that Biodesign predominantly concerned itself with superficial formal exercises as a marketing ploy. While the issue is arguable from either perspective, because of the richness of its sources in nature, the movement effortlessly absorbed further developments in design such as advanced ergonomics, semiotics and ecological consciousness.

In describing today's highly sophisticated mass produced industrial sculpture, the designer who comfortably drops cliches like "aggressive stance" and "emotive qualities" knowingly or unknowingly acknowledges the influence of Biodesign and Colani.

There is however one crucial aspect of the living, animate world that remains to be thoroughly explored through manufactured objects. The surfaces of our objects, whether handmade, machined, molded or cast, are given their form only once. They retain their forms through their lives, until destroyed or recycled. Their "skin" is firm, unchangeable and unyielding unless it is subject to external forces.

Living creatures, on the other hand, possess a skin that is flexible, dynamic and ever-changing. It constantly stretches or shrinks to adapt to the movements of the skeletal and muscular framework that it envelopes. It conveys expressions, stance and attitude through its vast variability. It is this aspect of living skin that this project attempts to explore.
SECTION TWO

CLARIFYING THE CHANGEABLE

In the manmade environment, there are objects which at a primitive level, can effect modifications of their forms. This could be in the ubiquitous guise of “adjustability” for ergonomic or functional reasons. Examples would be chairs with variable height and back angle, a convertible automobile with a retracting roof, or it could be as trivial as a cell phone with different colored snap-on face plates. In all of these cases, the change in form occurs as a result of a change in configuration of, or the addition/removal of different elements. A notable design in this mode was the 1990 Yamaha Morpho II motorcycle concept, of which it was said, “Its configuration can be modified for either urban or motorway use….mechanical elements bring to mind muscles covered by skin….marks a significant advance in Biodesign, a trend launched by Canon in 1982…based on designs by Luigi Colani.”5 This project, however, is an exploration of dynamic form of a more advanced degree.
SECTION THREE
SKELETAL SIMILARITIES

It would be appropriate at this juncture to further clarify the perspective on “dynamic form” in the context of this exploration. To begin, it may be helpful to create an ad hoc classification system of objects in the man-made environment based on the presence of “surface” and “structure” in their composition, analogous to “skin” and “bone.” An attempt will be made to apply this system at a holistic level to a few random everyday objects to ascertain how far the analogy may be applied. It must be clarified here that the classification of a constituent element of an object as “skin” or “bone” will be based on visual as well as functional considerations. The element must suggest and also work as, “surface” or “structure.” It’s obvious that there will be situations where a neat division will not be possible and an ambiguous element will work as both or neither.

In the case of some classic designed objects, the Wassily chair by Marcel Breuer has surface fabric in the form of seat and back (skin), and a framework of legs and support members (bone). In this case, the skin is only supported by the bone and does not enclose or get influenced by it. Therefore, the analogy is limited. The Panton chair by Verner Panton is an excellent example of an object in which surface alone works as both skin and support structure. However, an automobile follows this analogy well, having a strong internal framework - the chassis, enveloped by the external surfaces of the body panels.
SECTION FOUR
DEFINING THE DYNAMIC

Based on the few observations cited, an extrapolation of surface to "dynamic surface" may now be attempted. Some basic attributes of dynamic surfaces may broadly be proposed as follows:

1. The surface of a single, distinct body must be able to alter its form in a controlled manner at the level of compound curvature without any break in surface continuity. This implies a surface which can successfully regain its original shape after undergoing complex deformation.

2. The change in form of the surface must occur independently of any direct, external, deforming force. Therefore, an upholstered seat which changes form by simply yielding to the weight of the user is not an example of dynamic surface.

3. The change in form of the surface may occur due to the movement of elements of the substructure which bear upon it, as in the case of the surface being a passive, flexible, stretchable membrane.

4. The surface may have special abilities which allow it to change form upon the application of certain conditions - an "active" surface. An example would be existing shape memory alloys which, after deformation, manage to "remember" and recover their original shape upon the application of heat.
SECTION FIVE
THE NATURE OF THE BEAST

Based on the attributes of dynamic surfaces as discussed above, a three dimensional artifact would be fabricated as a means to demonstrate dynamic surfaces. Digital animation was not pursued as a demonstration tool because for most people, seeing an object change shape - "morph"- on screen would be attributed more to special effects and thus have lower credibility. To enunciate the impact of the concept, a real, tangible, three dimensional object with a surface that would change form "in the flesh" was essential.

What would be the nature of the beast? What kind of object would effectively demonstrate dynamic surfaces? An automobile project would lend itself very well to the development of dynamic surfaces due to its strong roots in Biodesign and rich associations with animate attributes like motion, agility, beauty and aggression.

For the sake of simplicity of execution, limited resources and time, the configuration of the model would be a substructure comprising rigid, sculpted surfaces, covered with a flexible, stretchable, passive membrane. The controlled movement of strategically placed elements in the substructure would alter the form of the membrane. These moving elements could be simply activated mechanically or electrically.
An analysis of some simple ways of changing surface attributes results in their classification as follows:

Positive:

1. The addition of visual mass/surface - the increase of “bulk.”
2. The emergence of protruding isolated elements.
3. The appearance of defining edges on smooth surfaces.
4. The development or increase in area of openings.

Negative:

1. The reduction of visual mass/surface - the increase of “leaness.”
2. The retraction of protuberances.
3. The dissolution of defining edges to yield smooth surfaces.
4. The closing or reduction in area of openings.

The contents of this list were based on the relative ease with which they could be achieved in a simple physical model. Using this visual language, it was desired to achieve real time changes in the model’s “facial expression,” “muscular development” and aerodynamic properties. Based on these guidelines, a physical model was constructed (Fig. 1 - Fig. 8).

At this juncture, some thought was given to how this could be achieved in reality. A few ideas were:

1. It is conceivable that in the near future, it could be possible and practical to develop elastomers which have the ability to alter their hue as well as their opacity at the application of certain conditions. This could add another dimension to the role of the skin.
2. Waste engine exhaust pressure could be used to pneumatically move elements to effect the surface.

3. Parts of the automobile which move during normal operation such as the tires moving vertically to absorb road irregularities could be used to cause these surface deformations.

4. Fluids could be used to inflate and deflate strategically placed sacs to evoke the flexing of muscle, based on engine revs.

5. Surfaces could change to effect aerodynamic behavior, depending on wind movement and turbulence generated at different speeds.

6. Opening panels like doors could have the surface continue over the hinged sides, stretching to allow movement.
SECTION SIX
PROMISING NEW AVENUES

An article published in the May 21st, 2001 issue of U.S. News and World Report on future airplanes described one of NASA’s recent projects as “…a morphing airplane, a shape shifting craft that seems more flesh-and-blood bird than machine... engineers aim to build airplanes with mechanical muscles under taut, skinlike membranes, forming seamless wings that bend, stretch, fatten, sweep back...flies like a biological creature.” The materials being experimented with for this breakthrough included shape memory alloys of Nickel and Titanium.

NASA’s research opens an entirely new avenue for dynamic skin - that of locomotion in fluids. It has already been mentioned that dynamic skin could be used to influence the aerodynamic behavior of automobiles by adapting to air flow and reducing turbulence. This obviously has far reaching implications for aircraft. However, to take this function to its logical conclusion, it might be possible for dynamic skin to cause forward motion in liquids, similar to the propelling methods of aquatic life. A small submarine which morphs to mimic the movements of a shark may surpass the centuries old spinning propeller and rudder.

A new material which holds great promise in this area is Artificial Muscle, a family of polymers which exhibit qualities similar to muscle. These have the ability to contract with load-bearing strength comparable to human muscle on the
application of certain conditions. They are being researched at the University of New Mexico among other institutes.

Both of the above materials are examples of an “active” surface, one that has the ability to alter its own form without the need for extraneous distorting elements. While the thesis model used only a passive membrane because of various limitations, it seems likely that the future will see the refinement of breakthrough materials of a dynamic nature which will transform the way we give form to our objects.
SECTION SEVEN

IMPLICATIONS

Advanced consumer societies exist in a never-ending cycle of planned obsolescence and the ubiquity of the new. Dynamic skin affords a new conception of objects which can alter their visual characteristics at will, thus questioning the idea of “visual outdatedness.” This offers a possible means of breaking free of the “outdatedness” cycle.

This mode of thinking also has implications on the design and manufacturing process of complex surfaces, as it nullifies the need for a single, final, formal resolution and instead proposes a dynamic palette which allows itself to be reinvented. This may allow designers the luxury of indecision - the privilege of incorporating different conceptual treatments into one object.

It is also possible to foresee that this proposal may allow people to relate to the objects in their environment at more complex levels which are not based on steadily increasing familiarity. It may be possible instead to promote a constantly evolving interaction between two dynamic entities - the user and the object.
Fig. 1. Concept development sketches. The final direction at bottom right tended towards a feline character in keeping with Biodesign roots. The form was kept simple to accentuate changes in the dynamic surface.
Fig. 2. Model: Front three quarter and left side views.
Fig. 3. Model: Rear three quarter and overhead views.
Fig. 4. Model: Display case showing the control lever and front-left closeup.
Fig. 5. Dynamic skin I: Positive rib development on doors.
Fig. 6. Dynamic Skin II: Tail-light and edge development.
Fig. 7. Dynamic skin III: “Eyes” bulge and “teeth” develop in the front grille.
Fig. 8. The making of the model. The bodywork was divided into separate sections based on the changes their surfaces would have to convey. These parts were modeled in foam and recesses were carved in to accommodate the moving elements which would effect the skin. Surgical latex was stretched taut over the exterior surface and pinned to the underside, leaving the form intact but now covered with skin. After the parts were assembled together, a cable operated system of mechanical linkages and levers was fabricated inside the model to operate specific elements which would move and alter the skin surface.
NOTES

1. For an introduction to and images of Noguchi's works, visit <http://www.noguchi.org/biomorphic.html> The site also contains links to many of his writings and proposals.

2. Quote from Luigi Colani's website <http://www.colani.ch> It also contains some images of his projects.

3. The Canon website has a detailed section on the company's projects with Luigi Colani and also has information on his design process. Visit <http://www.canon.com/camera-museum/design/kikaku/t90/03.html>


6. For an introduction to Shape Memory alloys, visit <http://www.sma-mems.com/intro.htm>


8. For more information, images and animations of actual tests, visit the Artificial Muscle Research Institute's website at http://www.unm.edu/~amri/