Title:
Computational Support to Aesthetics in Industrial Design

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Introduction:
Computational support is rarely available for aesthetic concept generation in industrial design. The reason for limited computational support to aesthetic design seems to be the lack of formal theory or methodology for 'Design for Aesthetics' (DFAe) paradigm [1]. Aesthetic concept generation involves complex interplay of the cognitive processes and experiential (tacit) knowledge in the shape generation and appreciation, which is quite tough to externalize in a formal model. Current CAD/CAS tools lack the consideration of the cognitive process in shape definition [2].
The present work aims to focus on the development of a formal model for DFAe, and based on this model; implement a knowledge based tool, which can actively support the aesthetic design process by capturing and externalizing the tacit design knowledge.

Main idea:
The proposed model is based on four axioms derived from various domains. These are: the axiom of objects [4[; the axiom of human knowledge,[5]; the axiom of cognitive structuring; and the axiom of cognitive transformation [3]. These axioms lead to the development of two important models; the aesthetic design complex and action grammar. The aesthetic design complex is derived from a more general and abstract model called general design complex derived from these axioms. The action grammar provides an alternative mechanism of shape description, taking the cognitive process in consideration. In this grammar, the cognitive actions leading to different shape characteristics are implemented as grammar rules. These rules parameterize the cognitive process involved in the shape generation. Fig. 1 (a) shows the cognitive processes in the shape of the car body profile. Fig. 1 (b) shows the action grammar based shape description showing the action rule vectors, which are analogous to the cognitive processes perceived in the form of car body profile.

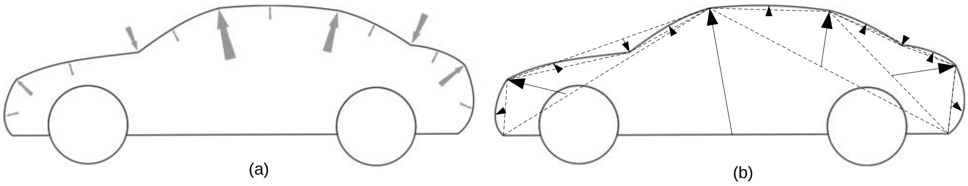

Fig. 1: The Cognitive processes and action rule vectors.

The action grammar can be considered as a formal model of design sketching process, as the sketching processes during the concept generation involves the cognitive processes like abstraction and reinterpretation. Thus, the action grammar can model the product shape description by parameterizing the cognitive processes involved in design sketching and shape evolution.
The aesthetic design complex involves many relationships among the entities participating in the aesthetic design process. These entities are the aesthetic form of the product, the shape characteristics and the aesthetic characteristics perceived in the product form. Various relationship among these entities formalize different aspect of the aesthetic design process like the design knowledge, design space search, design generation, aesthetic evaluation, design abstraction, design family etc. Fig2 shows the Aesthetic design complex.

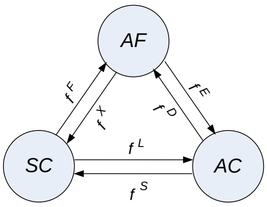

Fig. 2: The aesthetic design complex.

AF is the aesthetic form of the product, SC are the shape characteristics and the AC are aesthetic characteristics. Table 1 presents various relationships and their meaning in the aesthetic design complex.

Relationship in ADC	Meaning
$f^F: SC \rightarrow AF$	Design form plan or action
$f^E: AF \rightarrow AC$	Design evaluation
$f^S: AC \rightarrow SC$	Design knowledge search
$f^X: AF \rightarrow SC$	Design abstraction
$f^D: AC \rightarrow AF$	Artifact design process or case search
$f^L: SC \rightarrow AC$	Design knowledge

Tab. 1: Various relationships in ADC.

Soft computing techniques are used to implement various relationships in aesthetic design complex. The design knowledge is captured using artificial neural networks (ANN). The design space search is implemented using the genetic algorithm (GA). Principal component analysis (PCA) is used to externalize the tacit design knowledge in the form of heuristics.

Conclusion:

Initial experiments have lead to the conclusion that models developed in this research are able to capture the cognitive aspects of the aesthetic design process. The implemented software prototype is found to be useful in random and guided exploration of the vast designs space quickly. It also supports the assertion that aesthetic design knowledge can be capture and reused in a computational framework; and be externalized in the form of the semantic expressions as heuristics.

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