Title:
Generative Engineering Design methodology for the development of surface-based components

Authors:
Jana Gavačová, jana.gavacova@stuba.sk, Slovak University of Technology in Bratislava
Ladislav Gulan, ladislav.gulan@stuba.sk, Slovak University of Technology in Bratislava
Michal Forrai, michal.forrai@stuba.sk, Slovak University of Technology in Bratislava
Mario Hirz, mario.hirz@tugraz.at, Graz University of Technology

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Introduction:
The presented paper describes methodology of Generative Engineering Design of surface-based components in the automotive development and its general use. Tools of complex CAD systems suitable for this method are described. The presented paper describes possible loop of Generative Engineering Design methodology. Application of presented methodology is shown within the development of a class A surface of a sport vehicle front part. Generative Engineering Design methodology provides an automatic adaptation of detailed design, in case of styling modification. It means when designer's styling (CAS) is changed, any linked features such as components boundaries are recreated automatically.

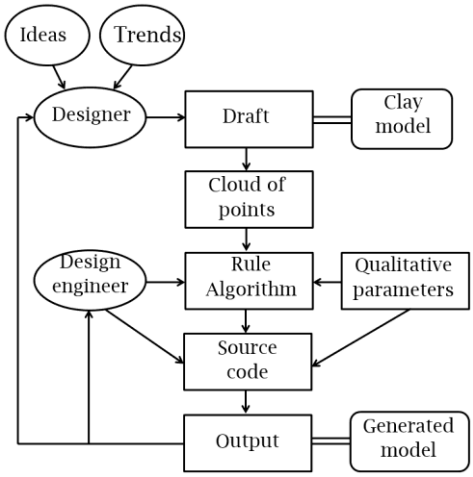

Fig. 1: The loop of Generative Engineering Design procedure suitable for surface-based car components in general.

Description of Generative Engineering Design methodology:
During dozens of years in CAD research, there appeared a space for improvement of product development in several fields. Advanced methods of designing are relevant and effective only for the

complex products. Development of vehicle prototype is then the perfect field for the Generative Engineering Design methodology to be applied.

The procedure described in following sentences refers to Generative Engineering Design methodology of surface-based components. It can be characterized as the ability to generate shape features and their sets through input and output data with evaluation of their relevance in a closed loop. Such a loop is shown in

Fig. 1. This procedure allows realization of dynamical solution, which is able to absorb and share information back to this process so that further optimisation can be accomplished. Deterministic and heuristic features of engineering design are applied during the preparation of this process. According to previous efforts several definitions have originated in the field of automatized designing. For the purpose of Generative Engineering Design described in this paper, it is possible to abstract the following definition:

Generative Engineering Design is a process in which the draft or model is made based on quantitative and qualitative parameters or aesthetic inputs, using algorithms created by individual human intervention for the purpose of generating a variable set of subsequent models following accurate relations and according to hierarchical connections.

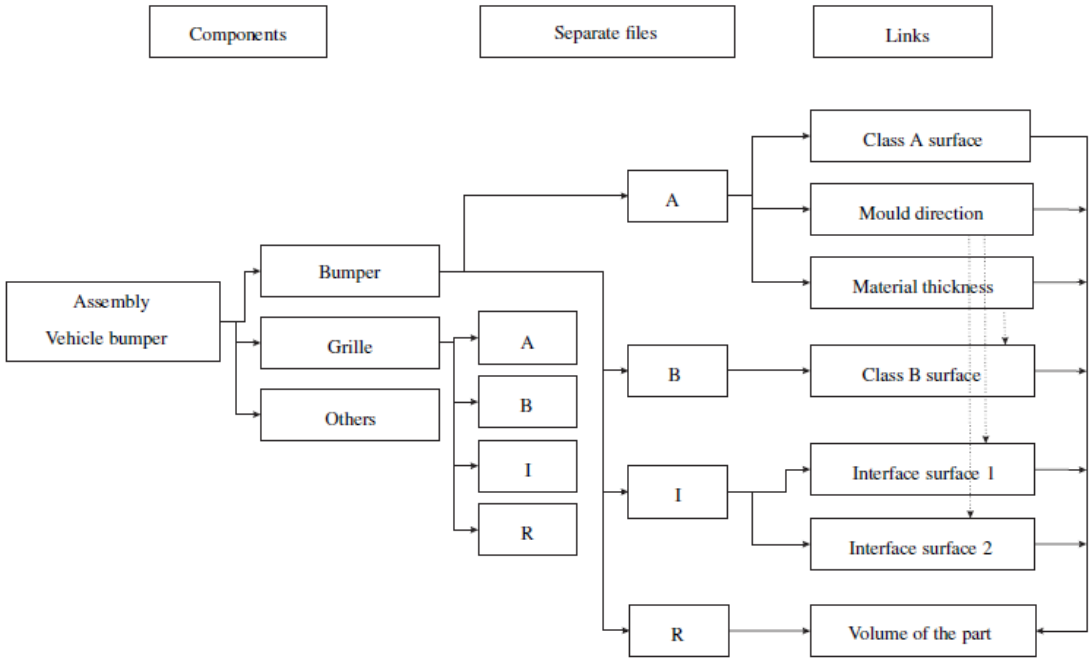

Fig. 2: Assembly of vehicle bumper development with separate files and links.

Application of Generative Engineering Design methodology in the automotive industry:

Advanced methodology of designing process is only suitable for tools of complex CAD systems. Effectivity of surface-based components development is supported by advanced tools such as logical algorithms/rules, mathematical rules, geometrical and topological rules, groups of geometrical entities and links.

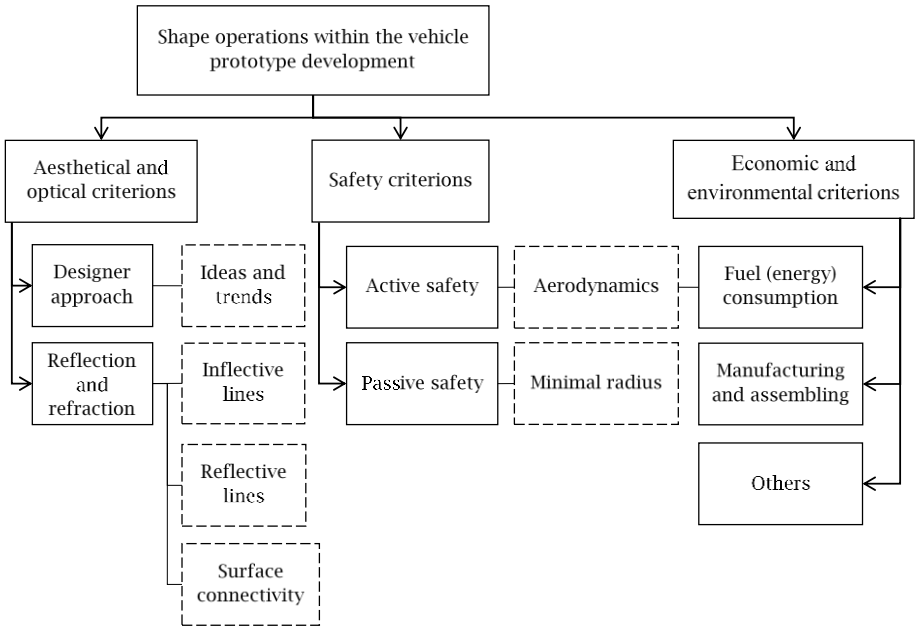

Fig. 3: Examples of different shape analyses based on three main groups of criterions.

The main advantage of surface-based components development lies in the use of separate files. It means the whole design involves files with group of surfaces. Those files are divided as follows:

- A - Class A surface – visible surface of component;
- B - Class B surface – internal/functional surface of component;
- I - Interface – surface of contact between components;
- R - Result – the final closed volume of component.

Fig. 4: Styling of a sport vehicle.

An example of separate files creation for vehicle front part or bumper is shown in Fig. 2. In practice, there are changes of any entity automatically updated in the whole assembly. For example, an engineer changes a position of hole on bumper and any connected component such as grille has generated position of clip automatically. All the commands follow the structure which was built previously.

The development of a class A surface of a sport vehicle front part

Surface analyses are important to optimize an output of class A surface. It is possible to consider them from three main points as it is shown in Fig. 3. First point refers to aesthetical and optical criterions. Second point refers to safety criterions. Third consider economic and environmental aspects.

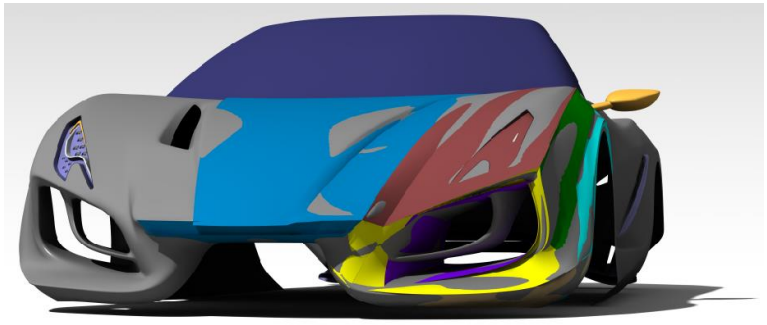

Fig. 5: Extracted patches from a styling.

Development of the class A surface described in this paper is based on styling (CAS – Computer Aided Styling) from artistic designer. It is shown in Fig. 4. Such a styling consists of many patches of approximated freeform surfaces, which can be modified by positions of control points. Mathematical description of styling is not appropriate for CAD development of a class A surface. It is then created by tools of complex CAD system or specialized software. Engineer modifies new surface based on analyses either by considering quantitative parameters (minimal radius, class of continuity) or qualitative parameters (shape of inflective lines, continuity boundaries).

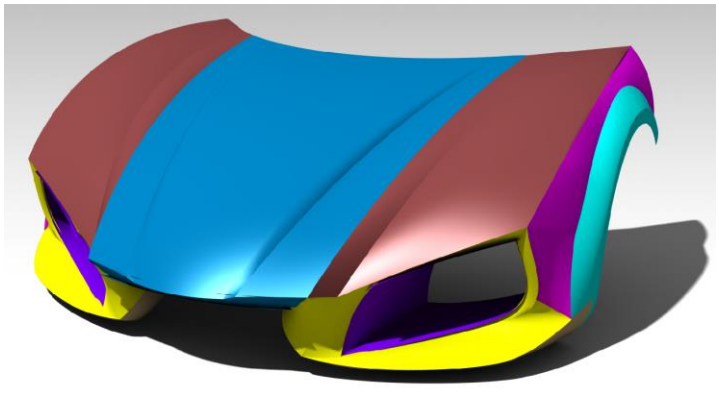

Fig. 6: Sport vehicle front part with class of continuity C^0 and C^1 between patches.

Generative Engineering Design methodology enables automatic control of those parameters with minimal human intervention. Procedure of CAD surfaces (or patches) creation is as follows:

- Specialized class A surface software or module loads data from styling as a package of frozen surfaces (Fig. 4);
- Patches of some surface areas are extracted to be able to be formed as freeform surfaces (Fig. 5);
- Patches are connected with lower class of continuity such as C^0 or C^1 to form an intermediate model with sharp connections (Fig. 6)
- Interfacing curves are built on patches with respect to the shape of future output model;
- Connecting surfaces of patches are created with boundary of interfacing curves with higher class of continuity such as C^2, C^3, or higher (Fig. 7).

Presented class A surface was developed by using Generative Engineering Design method. So if there is a change of any patch, all the connected patches are adapted automatically following proper quantitative and qualitative parameters.

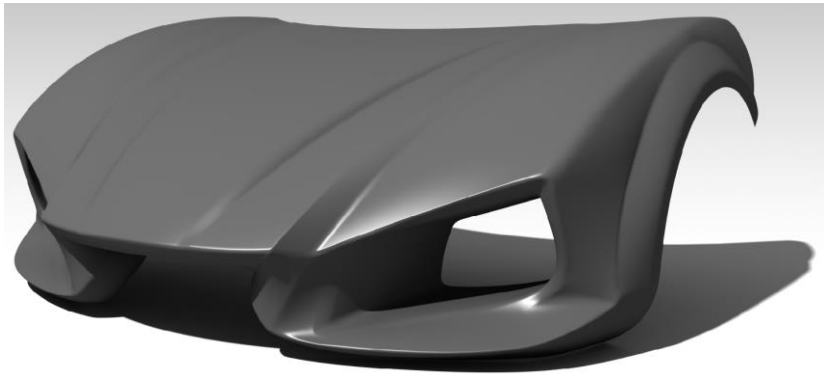

Fig. 7: Complete sport vehicle front part with smooth continuity.

Conclusion:

The new age of CAD application should adapt to market needs. It means the development of surface-based components should be reduced. The most time-consuming part of engineer's work is to change overall design of the component or to check mistakes. The new Generative Engineering Design methodology describes links and tools, which should be involved in the designing process to reduce time for development. Even though nowadays are many attempts to reduce time for designing process, there has not been defined a proper methodology for surface-based components. Presented paper describes steps, which can be involved in CAD systems used nowadays with some remarkable improvements.

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