

## **Industrial design of free-form shapes by computer aided interpretation of 2D sketches**

### Project summary

*Industrial design* is an important part of computer-aided design and manufacture. In spite of the incredible progress in CAD/CAM, current commercial modelers are hardly capable to build complex, *free-form shapes* from designers' sketches in an efficient way. To define free-form objects as the composition of surfaces based on planar curves is generally not sufficient; instead, real spatial curves, curve nets and surfaces interpolating these are needed. The current project aims at elaborating a special method to define 3D curve networks and surfaces intuitively using the 2D screen of computers. Another essential problem to be solved is to import the *designers' free-hand sketches* into the computer in a consistent manner, while the requested user efforts are minimized. The present grant application focuses on the research and development related to the above tasks.

The current consortium consists of two members, Cadmus Consulting and Development Ltd. and the Department of Product Design at the Hungarian University of Crafts and Design (DPD-HUCD). Cadmus, (a spin-off company of MTA SZTAKI), is the primary participant in informatics with an international reputation in solving difficult geometric modeling problems and developing various application systems. DPD-HUCD is the centre for educating Hungarian designers, being devoted to the training and researching of new methods for industrial styling. Consequently, DPD-HUCD is an ideal partner to formulate the requirements of the new, planned technology and evaluate its practical usage.

Both members of the consortium have come across with design problems in the automotive industry. Cadmus has been intensively involved in the mathematical and implementational problems of 3D industrial design in cooperation with a U.S. startup company called Curventa Softworks. Important partners from the automotive industry (BMW, DaimlerChrysler) have also expressed their serious interest in this new, design paradigm. It has become clear that one important technological step – *designing 3D models directly from sketches* – is missing. The experiments of DPD-HUCD, gained in the course of projects with various European partners, also support the above idea. The attached letters of recommendation welcome the investigation of the proposed topic, and consider this as an important step forward in the design of car bodies.

The planned research and development project aims at producing a prototype software system, called *Sketches*. The 3D designing technology to be accomplished is based on a special tool called *3D construction box* by means of which the sketches are embedded into a unified coordinate system. The construction of the curve net takes place in such a way that the 3D curves are brought into correspondence with the given orthogonal and perspective sketches as much as possible. After the image processing steps (edge and contour enhancing) special free-form curve and curve net operations need to be applied. The created curve net is of general topology, i.e. not only the conventional four-sided surface elements, but general  $n$ -sided patches are used together with vertices of arbitrary valency. Assuring that certain smoothness conditions of the curve net are satisfied, the curves and their associated cross-derivative functions define a composite, smooth free-form surface. The whole 3D construction is performed within a uniform graphic framework system. Of course, the system will be capable of solving 3D design tasks other than car body design.

The basic elements of the proposed concept is demonstrated by the figures in Section 9.

The *Sketches system* will be realized within a process based on information exchange between the developer party (Cadmus) and the designer/user party (DPD-HUCD). We plan to integrate our new sketching concept into the design system of Curventa. Moreover, we would like to interface *Sketches* to the systems most widely used in the automotive industry (StudioTools by Alias Wavefront and CATIA by Dassault Systèmes). In order to export the surface models of *Sketches* into these systems, a module that produces output in standard data formats needs to be added.