



Title:

Practical Procedure of a Sport Ship Surface Interpolation and its Application

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Introduction:

Nowadays, engineering design methodology is carried out by the help of many software tools and hardware devices. Those not only make the work much easier but even became essential. In this paper an example of reverse engineering devices is shown, shoulder to shoulder with product development procedure. The introductory part deals with 3D scanning procedure and 3D model creation. Next part focuses on generative model creating with possibility of its additional modification. Finally, possible applications of such a model are illustrated.

Problem Statement:

A Slovak ship producer assigned a task of improving hydrodynamic characteristics of a sport ship hull. As its manufacture is traditional, without any virtual product development, a task of analyzing the surface of ship's hull came about. For such a purpose, it was necessary to transform the real ship into a CAD model. An optical 3D scanning device was used to gather the cloud of points. After a mesh was generated, the segmentation of continuity boundaries could be applied. The entire shape of ship hull followed the generative algorithm. That allowed any changes based on hydrodynamic flow to be applied directly on surface.

Ship Hull 3D Scanning:

For the purpose of gathering cloud of points an optical 3D scanning device was used. In the laboratory of Generative Design, there are two optical sets of lenses. The first set is suitable for measured lengths relative to 125 mm with reference point diameter of 1.5 mm. The second set is suitable for larger scanned surfaces of lengths relative to 500 mm with reference point diameter 5 mm. This means that a better choice for this purpose is to use optics for 500 mm. The process of 3D scanning of the real ship hull is shown in Fig. 1. The main advantage of optical technology for 3D scanning is that only a small dimension error is possible to occur. On the other hand, there is a possibility of noise, which impacts result of meshed surface. [1]

Ship Hull Surface Interpolation:

Since there are different procedures for surface interpolation, firstly it was necessary to compare their pros and cons. Most of the shape tools work with 3D scanning device and process the scanned data without history. That is why there were many attempts made before the final transformation and interpolation. The main idea was to transfer a real space object into the CAD model as a freeform object. This would allow for additional changes to be applied on the ship hull surface according to hydrodynamic analyses.

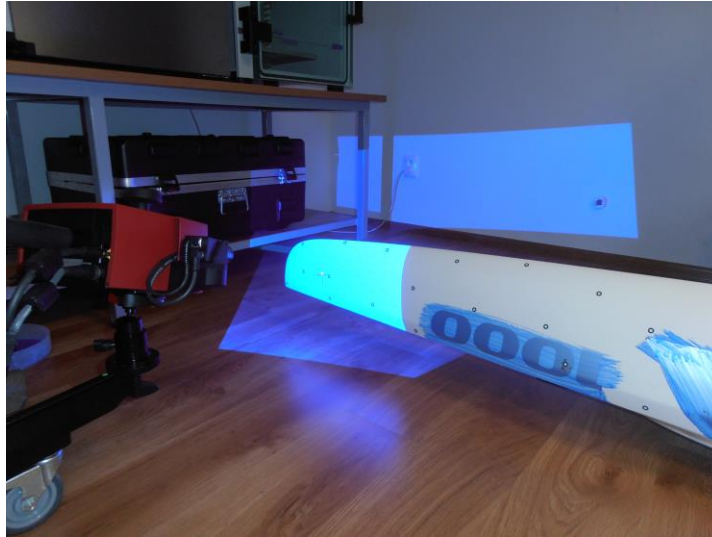


Fig. 1: Sport ship hull 3D optical scanning.

Process of a ship surface transformation [2,3]:

- Real space object with prepared visible class A surface and applied reference points,
- cloud of points directly in 3D scanning software,
- ASCII text file with the information of all points' positions,
- cloud of points imported to a higher CAD software (Fig. 2 (a)),
- creation of a meshed ship hull surface (Fig. 2 (b)),
- modification of the meshed surface (hole filling, manifold triangles edit...),
- curvature analyses and segmentation of the meshed surface,
- surface interpolation (Fig. 2 (c)),
- fillet creation and other preparation of interpolated surface,
- CAD model of a ship class A surface (Fig. 2 (d)).

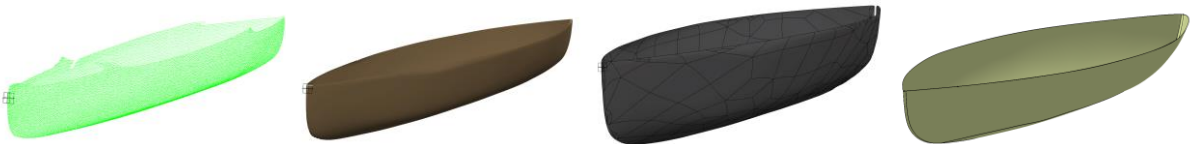


Fig. 2: Process of a ship class A surface transformation: (a) cloud of points, (b) meshed surface, (c) automatic surface interpolation, and (d) power fit surface interpolation.

Generative Design Used for the Purpose of a Ship Surface Digitization:

The procedure of ship surface interpolation has been investigated in a CAD laboratory specialized for Generative Design. Even though most of its research activities are focused on automotive parts design, there are some advantages suitable also for the case of ship hull digitization. It is important to prepare the surface to act as a freeform surface with additional changes possible [4]. Freeform surfaces, which are changeable according to external conditions, are shown in Fig. 3.

Basically, Generative Design is in some sense similar to Programmed Design or Knowledge Based Design. Different method is usually referred to a different kind of design under certain field of use. At the Laboratory of Generative Design it is possible to describe this method as: Generative 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. [1,2] In higher CAD software, interpolation means fitting meshed surface with the NURBS surface. Therefore, after interpolation, two parameters and their segmentation can provide freeform structure. Ship model was interpolated in two ways, but for the hydrodynamic analyses just the Power Fit model was used. One of the reasons was the result of deviation analyses. Deviation of automatic surface reached up to 12.007 mm and for the influenced area up to 4.543 mm. The overall length was approximately 5150 mm, depending on cut out of the top edge. More precise was the Power Fit interpolation with deviation less than 4.258 mm for the influenced area. Relative error 0.000827 was considered viable.

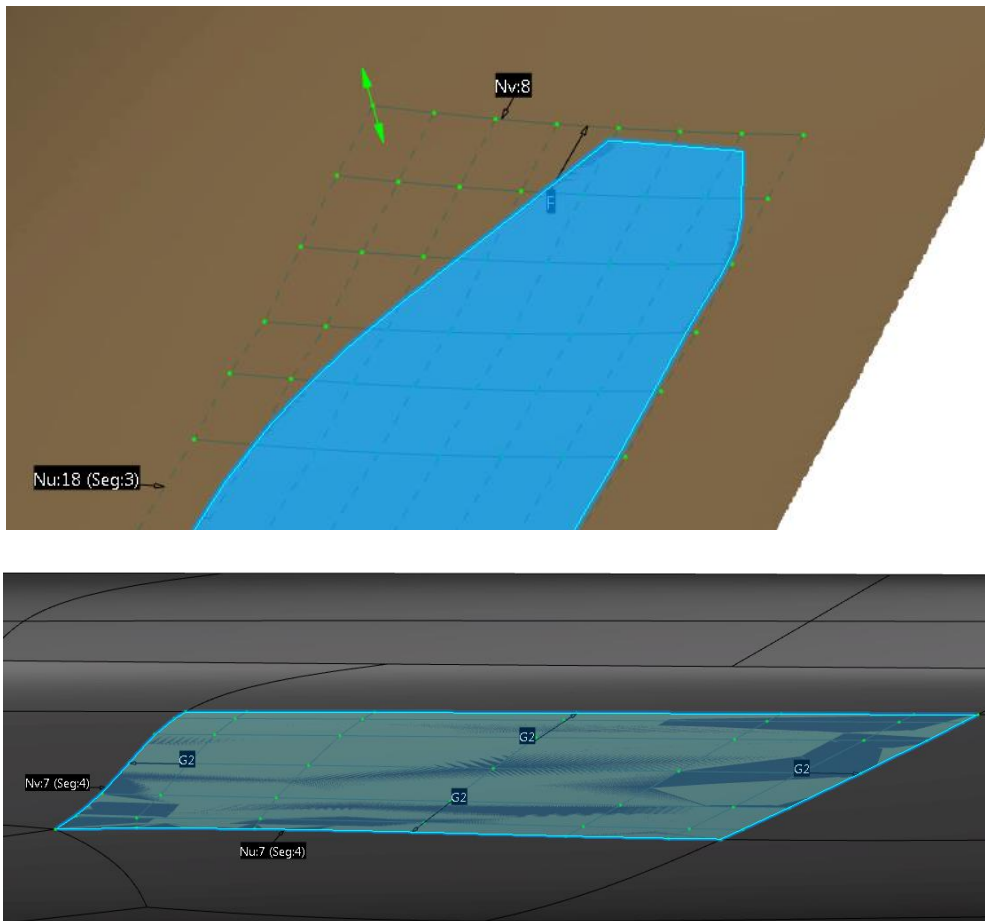


Fig. 3: Freeform surfaces adaptable via modification of the control polygon: (a) Power Fit interpolated freeform surface, (b) Automatic freeform surface.

Application of the CAD Model of Ship Hull Surface:

The CAD model of a ship hull surface was transformed into volume model of a water block, without the volume and surface of the ship hull. Half of the model was tested under certain conditions for water velocity and dynamic pressure. Fig. 4 shows the analysis of dynamic pressure along the ship.

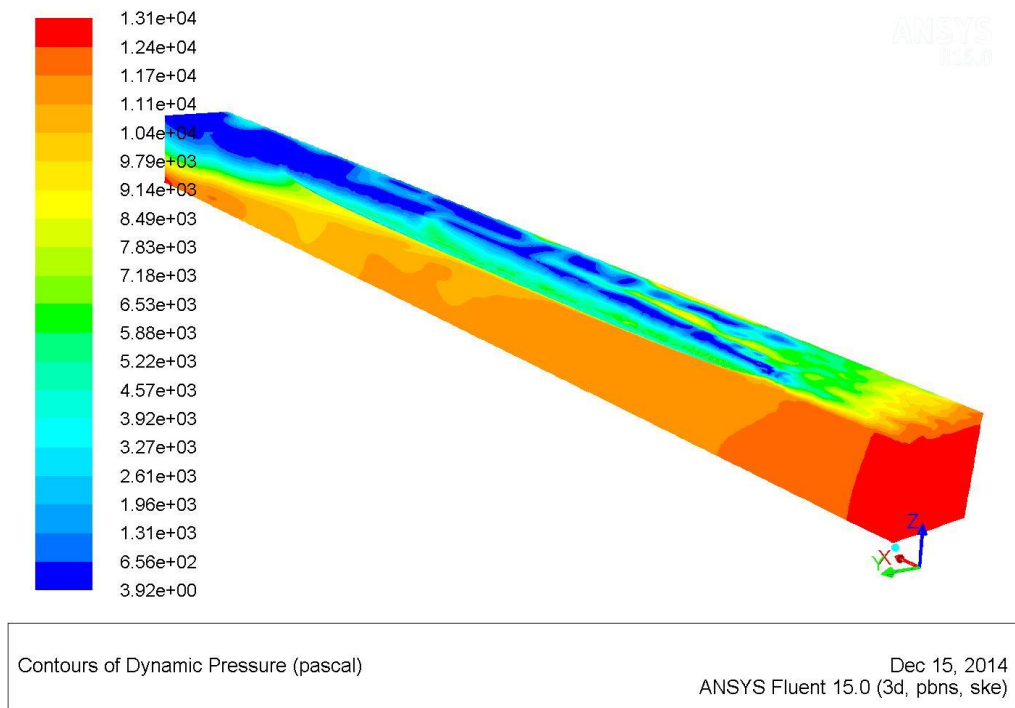


Fig. 4: Dynamic pressure analysis of the ship hull.

Conclusion:

The aim of this paper was to present the research activities at Institute of Transport Technology and Engineering Design, Faculty of Mechanical Engineering, Slovak University of Technology in Bratislava. It presented task for digitization and CAD interpolation of real shape of ship hull. As a higher CAD software CATIA V6 commercial license was used. Apart from the older versions of this software, it works with simplification of shape operations. Module FreeStyle or ICEM Shape Design provided control polygon to be used directly on interpolated surface. It was very convenient for ship producer to have a model adapted based on hydrodynamic properties. Power Fit model was selected due to the most suitable interpolating procedure. This term comes from the software tool "Power Fit" which is used for interpolation within CATIA. The attribute "Power" means it is better than the previous tools, but still asks for a lot of advanced preparations done by user. The final surface can hence have better quality than the automatically interpolated one. Finally, the complete CAD model was tested for hydrodynamic pressure in the ANSYS Fluent 15.0.

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