Book 1999

Computer support for design engineering and prototyping of the shape of ship hulls.
By H.J. Koelman, 1999.

This book is written by H.J. Koelman as a Ph.D. thesis for Delft University of Technology, and is published and distributed by SARC. The book can be ordered by E-mail or fax. The price is EUR 75,-- The book describes the design and development of a computer system which is useful for all shape aspects of a ship's moulded hull form, such as design, fairing, design modification, visualization, physical modelling and preparation for export to other general or specific CAD, CAE or CAM software.

Summary :

Based on an inventory of hull design methodology, the requirements for the system are formulated. Subsequently mathematical methods for representation of free form surfaces are investigated, and an overview is made of the methods used by existing hull form modelling software. It appears that the single-patch B-spline/NURBS surface method (or straightforward multi-patch extensions of it) is dominant, but a theoretical as well as a practical analysis of the capabilities of that method show that it is less appropriate for our purposes. The most important objection is the regularity of the network, which imposes severe limitations on the freedom of the system user. Furthermore, the system requirements imply a complete geometric model, which includes both geometry and topology.

So a novel system is designed, based on three core elements :

- A Boundary REPresentation, to represent topology. This BREP is extended with the capability to include continuous free form curves, and sequences of curves.
- For geometry representation this extended BREP uses NURBS-curves. This construction enables one of the most important properties of the new system, which is the use of an arbitrary, and coherent, composition of curves on the hull surface. The location and orientation of the curves is completely free. Surface generation based on transfinite interpolation of the curves, either with four-sided, or with N-sided (N<>4) patches.
- Interactive and semi-automatic fairing capabilities, with a weighted least-squares algorithm with automatic knot selection. The user can determine the balance between fairness and shape constraints, and the algorithm fairs the curve globally, taking into account the user's choices.

To accommodate all required activities with the hull form, the system is equipped with many supporting entities or functions, such as :

- Elementary curve shapes, e.g. to be used for waterline roundings.
- Interpolation of curves and surfaces.
- Developable surface representations.
- Export functions, for example to CFD or general CAD software.
- Visualization functions, such as lines plan generation.
- Physical modelling (rapid prototyping), including automatic decomposition into processable segments.
- Hull form transformation, and support for Sectional Area Curve.
- Hierarchical geometrical relations between curves.

The system has been implemented on a PC, and was baptized "Fairway". It has been applied for many designs, and eight of those, created by different designers, are presented in this thesis. These examples demonstrate the versatility of the system, and the variety of hull forms which can be handled. Using Fairway it also became apparent that satisfactory results could be obtained without explicit GC2 surface continuity.

The value of the approach is further investigated by an opinion poll among users of the system. One of the most important issues of the questionnaire was a comparison between a design made with and without the Fairway system. Grosso modo it appeared that either a Fairway design took less time for a comparable result, or it took comparable time for a more fair and a much more detailed result. In general the users reported quite positively about the system, but they also came back with tips for improvement, mainly concerning the user-interface and additional support functions.

Finally it is concluded that the methodology of our new system is a better solution for the ship hull subject than conventional approaches.