FRIENDSHIP SYSTEMS

FRIENDSHIP-Framework | Technical overview

➲ General Modeling

General CAD functionality for conventional and parametric modeling is provided with focus on smart surface design, especially for subsequent geometry variations. The user is free to introduce sophisticated relationships and dependencies among objects.

Point Types

- 3D point
- Intersection between two curves
- Intersection between a curve and a surface
- Projection onto a surface

Curve Types

- Line
- Circle and ellipse, circular and conic arcs
- C-Spline approximation of point data
- Interpolation of point data
- Polynomial B-Spline and general NURBS
- 3D fillet between two 3D curves
- Fairness-optimized 2D F-Spline with user-defined tangent, area and centroid settings
- Poly curve for combination of a number of curves
- Generic curve for user-defined parametric 3D curves
- Offset curve, 2D normal offset / 3D Frenet Frame
- Intersection between two surfaces
- Surface curve via surface domain definition
- Projection curve
- NACA profiles (66, 4-Digit-Series)

Surface Types

- Polynomial B-Spline and general NURBS
- Ruled surface
- Lofted surface
- Surface of revolution
- Coons Patch
- Interspace surface for parametric interpolation between two NURBS surfaces
- Sub surface (e.g. for basic surface trimming)
- Poly surface for combination of a number of surfaces
- Developable surface
- Meta surface for generalized fully-parametric surface design

Mesh Types

- Mesh engine for general surface meshes (panels)
- Mesh engine for blade-specific surface meshes
- Handling of structured and unstructured volume meshes

Transformations

- Parametric translation, rotation and scaling
- Transformation chain
- Delta curve and surface shift for user-defined shape deformations
- Cartesian shift for radial deformations
- Spot shift, bell-shape deformation
- Delta sum and product for shift combinations
- Generalized Lackenby shift for hull deformations where e.g. displacement is kept
- General transformation matrix
- Cylindrical transformation e.g. for blade design

Parameters

- Double parameter for general expressions, e.g. mathematical formulas
- Series parameter for number sequences
- String parameter, e.g. for naming

➲ Image Technology

Existing geometry can be imported and instantly transformed by the transformation entities that are mentioned above. This allows efficient geometry optimizations in case no fully-parametric model is available or required.

For parametric models, images are utilized in the design process where quick transformation of geometry is needed while the dependency to the source geometry is kept.

Image Types

- Image point, curve and surface
- Image offset group and surface group
- Image surface meshes
- Image trimesh (triangulation) and solid
- Image volume grids

➲ Solids and Trimeshes

Closed volumes can be created and merged using Boolean Operations. The technique is based on the surface triangulations and allows watertight STL-export of the geometry e.g. for subsequent grid generation.
This works for automated processes, too: done once, snapping and merging is applied to all generated variants automatically.
Triangulations can be generated regarding to surface curvature characteristics. Collapsed or tiny triangles can be automatically removed.

➲ Maritime Hull Design

- Polygonal data type (offset)
- Section generation from surfaces
- Offset group and assembly
- 3D section visualization
- Hydrostatic calculation and visualization
- Lines plan generation

➲ Blade Design

Alongside general geometry types, specific entities are provided for turbomachinery, maritime and generalized blade design. High flexibility for e.g. individual profile design and radial functions results directly from the fully-parametric design paradigm of the FRIENDSHIP-Framework. Mathematical formulas can be applied to profile design, too.

Turbomachinery Blade Design

- Design of turbine and compressor blades
- Stream section for fully-parametric profile design in a length- (m,rθ) and angle-preserving (m',θ) system
- Fully-parametric design of mean camber or blade metal distribution and thickness distribution
- Arbitrary stacking axes and stream lines

Maritime Blade Design

- Generic blade for fully-parametric maritime propeller blades including parametric profile design and user-defined rake, skew and pitch distributions
- Multiple profile types within one blade via blending functions
- Ready-to-use NACA profiles
- Mathematical and geometric curve definitions of profiles, mean camber and thickness distributions

- Propeller entity, e.g. for automatic engineering drawing
- PFF-Import/Export (Propeller Free Format)
- Blade analysis of imported surface geometry e.g. for reconstruction of parametric models

General Blade Design

As a generalized case, any kind of blade can be individually parameterized via the combination of special surface types and the cylindrical transformation entity.

➲ Design Engines

A collection of selected variation and optimization algorithms is provided and can be used readily. These algorithms are coupled to geometry parts or even CFD configurations, e.g. for grid or speed studies. In general, any floating point number of the project can be linked to a design engine. The user is free to set up equality and inequality constraints that need to be involved and monitored.

The FRIENDSHIP-Framework includes an intuitive resource manager which easily allows distributing simulation analysis on grid systems. Synchronous and parallel computations are viable. CFD is configured and triggered from within the FRIENDSHIP-Framework and externally computed results are brought back for assessment.

Variation

- Exhaustive Search (domain subdivision)
- Ensemble Investigation (permutation of number sequences for different design variables)
- Sobol (Design of Experiments)
- Design Lab (slider-based variant creation)

Optimization | Single Objective

- Brent
- Nelder-Mead Simplex
- Tangent Search Method
- Newton-Raphson

Optimization | Multi-Objective

- NSGA-II Genetic Algorithm
- Multi-Objective Simulated Annealing

➲ Constraint Management

Equality and inequality constraints can be defined and involved for the variation and optimization process. Considered constraints are also monitored, e.g. violated designs are clearly marked both in the object tree and in generated tables.

➲ Variant Management

The entire data management for manual and automatic variant creation is provided. Tables are generated for variant details like values of design variables (free variables) and simulation results.

2D/3D diagrams and PDF reports can be produced. In particular, switching between variants is done via double-click and CFD results can be compared for different designs by browsing through the variant tree (e.g. comparison baseline vs. optimized design).

➲ Integration

A set of mechanisms allows the integration of external software that is required for the individual design process. Simulation data can be visualized directly within the FRIENDSHIP-Framework for each variant.

Coupling Interfaces

- Custom Integration: data exchange by means of standardized XML-interface (XFFL specification)
- Generic Integration: parsing, reading and replacement functionality for arbitrary ASCII input and output files, editor available in graphical user interface
- Feature Definition – I/O commands for parsing (string operations), reading, writing and generation of arbitrary ASCII files
- COM-interface for connecting to e.g. Microsoft Office applications like Excel
- Configuration Wizard for setting up input data for external software, e.g. for CFD solvers
- User-defined generic tables
- Postprocessing of result data, visualization of simulation data, e.g. as screenshots or fully interactive if given in the VTK format or as XML

➲ Feature Definitions

Feature definitions encapsulate arbitrary command sequences by using the command set of the FRIENDSHIP-Framework. The graphical user interface and its environment provide powerful scripting functionality for any purpose – including a step-by-step debugger.

Once created, the definitions can be documented with text and illustrations and exported for re-use, e.g. for future projects. Collections of such definitions might be stored on network PCs for centralized access by different users.

Selected Applications

- Encapsulate simple and complex geometric features for re-use (“CAD Feature”)
- User-defined functions with arguments and output
- Loop, If-Statement, Break, Goto
- Files: create, read, write, parse, find, replace
- External processes: create and start e.g. scripts or other software
- Global commands like sin(), cos(), sqrt(), pow(), round()
- User-defined import/export formats (ASCII)
- Individual GUI design e.g. of coupled external software or company-specific functionality

➲ Visualization

- Timed animations and user-defined camera paths and camera rotations
- Texture mapping onto surfaces
- Skyboxes for realistic views (sea, clouds)
- Grids for coordinate systems
- Legends, labels and bar charts
- Linear dimensions and angle notations
- Curvature visualization for curves and surfaces, e.g. Isophotes, Gauss, Mean

➲ Project Management

- User-defined embedded project and object documentation including text and pictures
- Overview and description of existing user projects
- Project navigation via dependency tree (client and supplier relationships)
- Automated generation of PDF reports

➲ Data Exchange | Import

- IGES: point, line, circular and conic arc, NURBS curve and surface, surface curve, ruled surface, surface of revolution, transformation matrix
- STL (different conventions, e.g. for OpenFOAM)
- PFF (Propeller Free Format)
- SHF offset data (NAPA/SHIPFLOW)
- OpenNURBS: point, line, NURBS curve and surface
- Wakefields
- SHIPFLOW configuration
- User-defined imports via Feature Definitions
- VTK (subset)

➲ Data Exchange | Export

- IGES: point, line, circular and conic arc, NURBS curve and surface, surface curve, ruled surface, surface of revolution, transformation matrix
- STL
- OpenNURBS: point, line, NURBS curve and surface
- PLOT3D
- SHF offset data (NAPA/SHIPFLOW)
- PFF (Propeller Free Format)
- User-defined exports via Feature Definitions
- GeomTurbo (NUMECA)
- VTK (subset)

➲ Data Exchange | Connectors

Connectors are used for large data sets for which efficient visualization and transformation is wanted. For instance, a connection to volume grids can be established for deformation purposes.

Available Connectors

Wavefront, 3ds Max, STL, Fluent Grid

➲ Supported Systems

Windows XP (32bit), Windows Vista (32/64bit), Windows 7 (32/64bit), Linux (32/64bit)

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