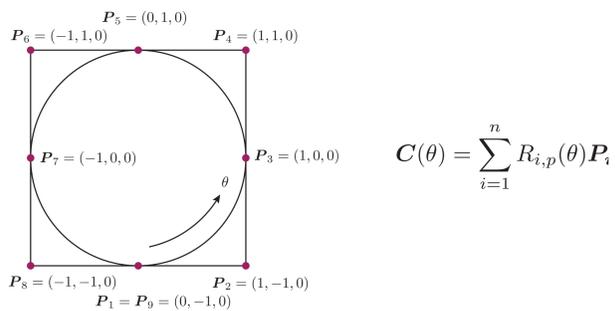


NURBS-based Approaches in Fluid-Flow

NURBS



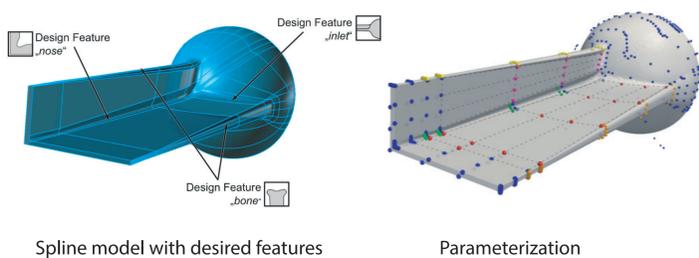
Important **specifications** during the historical development of **NURBS** were to generate a curve:

- whose smoothness is completely under user control,
- which occupies a predefined space,
- which allows for local shape control, and
- which is able to represent both free-forms and analytical shapes.

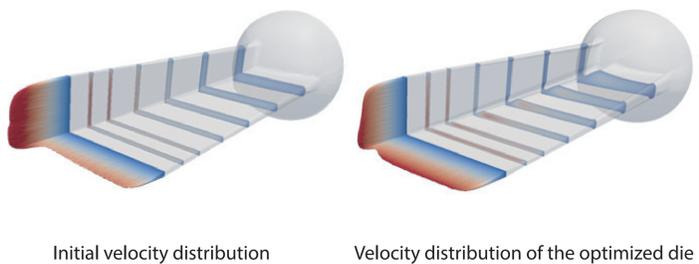
Splines as an aid in analysis

- Geometric information is computed from a NURBS representing the boundary
- NURBS-enhanced finite element method (Huerta et al.)
- Isogeometric Analysis (Hughes et al.)

NURBS in Shape Optimization

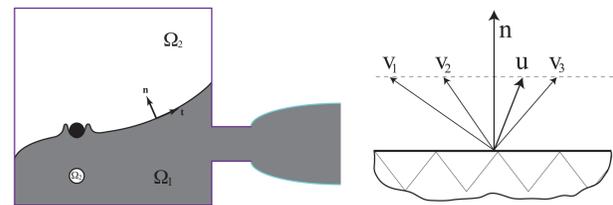


- Every point on the boundary of the finite element mesh is connected to a corresponding point on the NURBS surface.
- Control points serve as design vector.

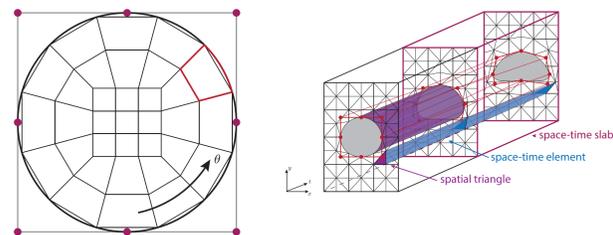


NURBS in FEA

- Free-surface flows



- **Free-boundary problem:** along with the flow solution, the domain shape is also unknown
- Governing equations of **fluid flow** are **coupled** with a **domain deformation approach**
- As the free-surface evolves, the mesh deformation is connected to the flow solution by the **no-penetration** boundary condition $\mathbf{v}(\mathbf{x}) \cdot \mathbf{n}(\mathbf{x}) = \mathbf{u}(\mathbf{x}) \cdot \mathbf{n}(\mathbf{x})$

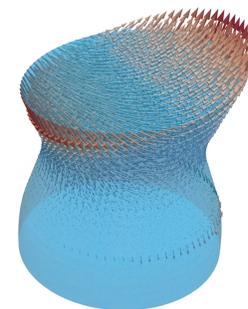


- The elements, which do not touch a NURBS boundary, are treated as standard finite elements.
- The elements on the NURBS boundary represent the exact geometry.

- Fluid-structure interaction

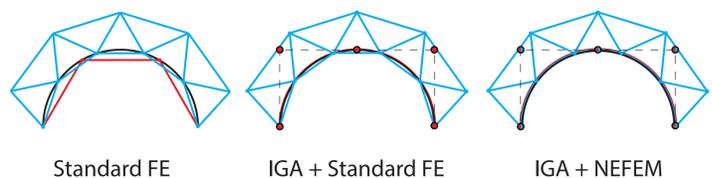
Requirements

- free-surface flow
- deformable domain with arbitrary wall shapes
- deformable structure



Methods

- interface tracking
- NURBS-enhanced finite elements
- arbitrary boundary description through NURBS
- Isogeometric Analysis for elastodynamics



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 - Diploma and PhD in mechanical engineering
 - Chief engineer at RWTH Aachen University
- Research interests
 - Numerical design of engineering components
 - Free-surface and two-phase flows
 - Spline based space-time finite element methods