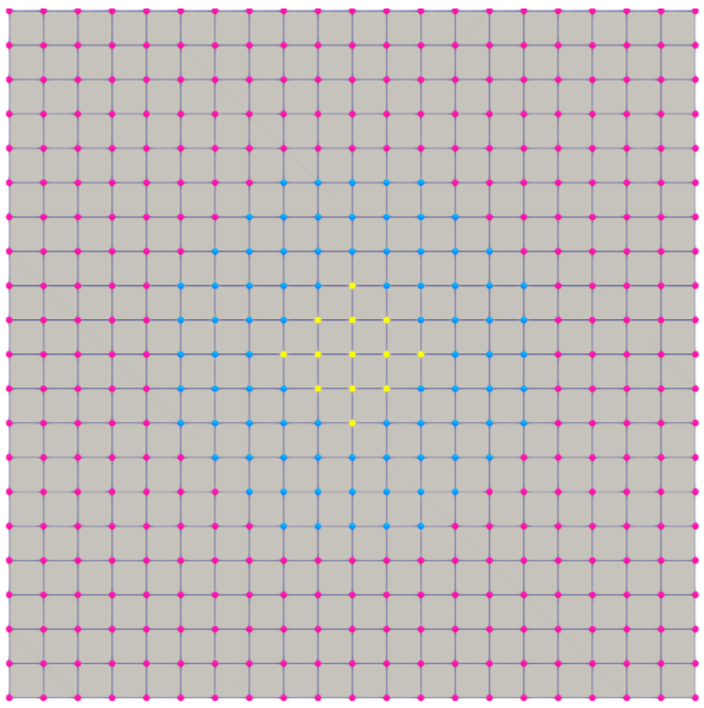
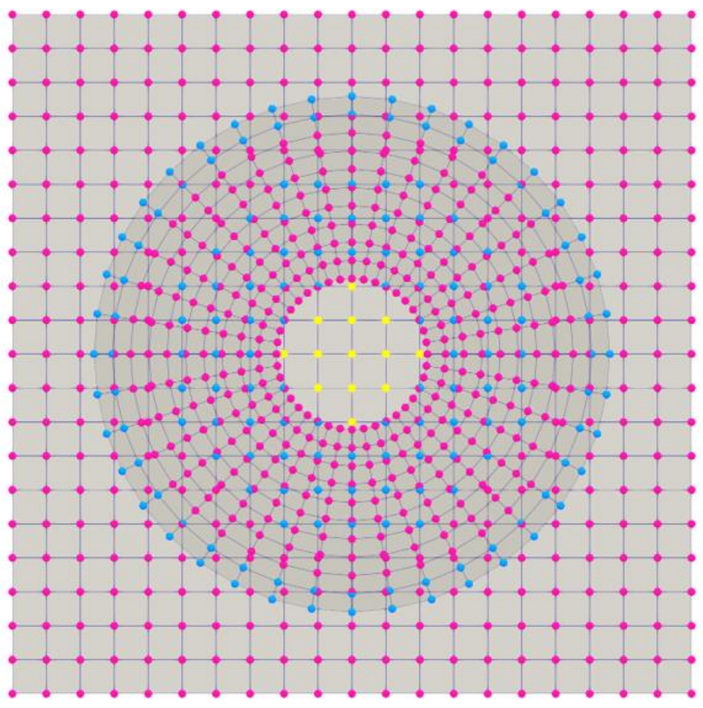
HSLU Hochschule Luzern

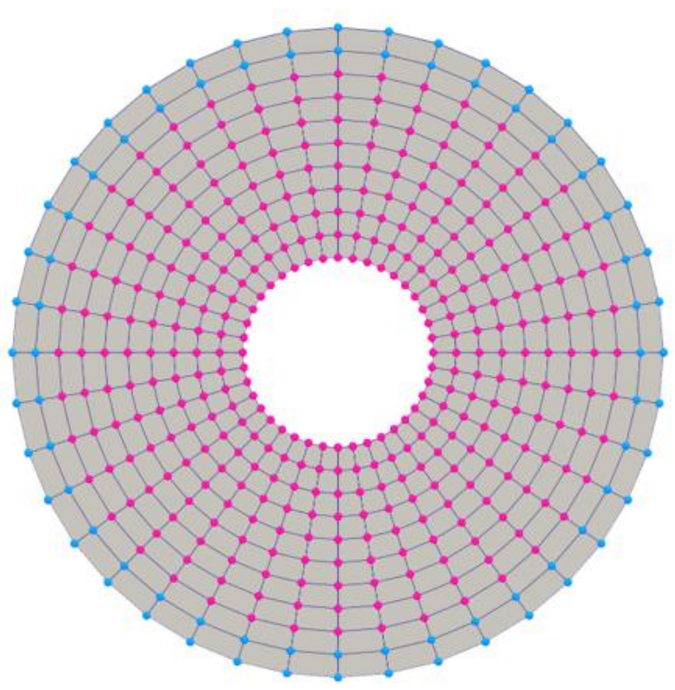
Technik & Architektur
Mechanical Engineering

Master-Thesis Studiengang Maschinentechnik

Implementation of Chimera framework in CVFEM based code

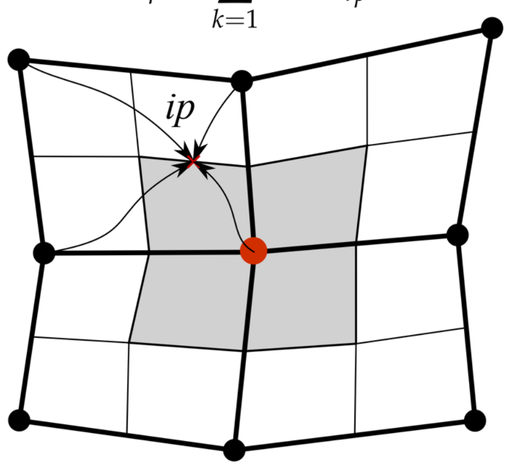


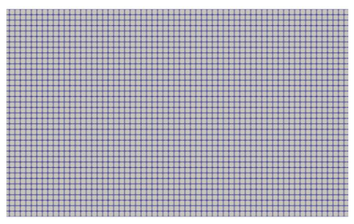


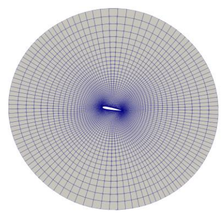


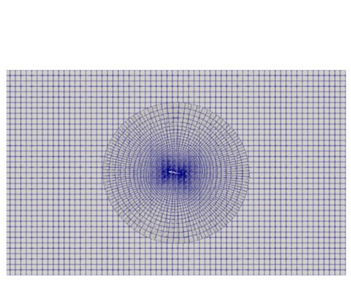
$$\phi_{ip} = \sum_{k=1}^{n} N_k|_{ip}\phi_k$$

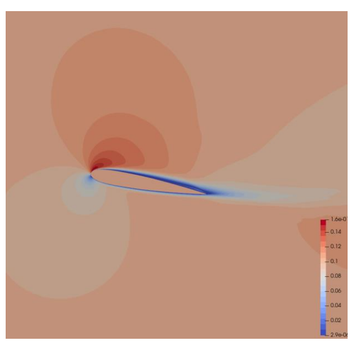
$$\nabla\phi_{ip} = \sum_{k=1}^{n} \nabla N_k|_{ip}\phi_k$$

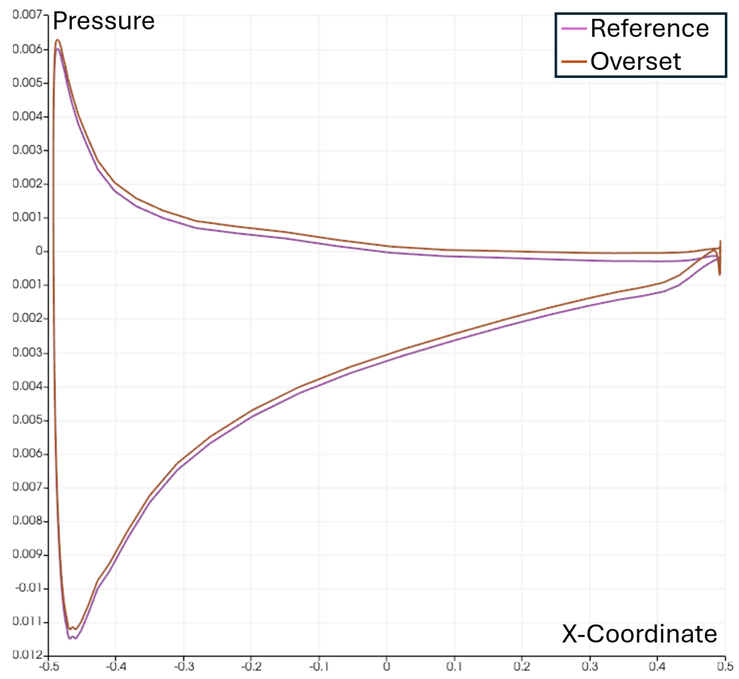












Problem statement

This thesis aimed to integrate the Chimera framework into ACCEL, an in-house CFD code developed by the Department of Fluid Mechanics and Numerical Methods at HSLU. ACCEL employs the Control Volume Finite Element Method (CVFEM), a hybrid technique combining finite volume and finite element methods, to solve the Navier-Stokes equations in a pressure-based, fully coupled, and implicit manner. Traditionally, CFD simulations require discretizing the computational domain with a single mesh. The Chimera framework allows the domain to be represented using multiple, non-conformal grids, simplifying mesh generation and enabling dynamic mesh simulations without deforming the mesh cells.

Solution Approach

The Chimera implementation in ACCEL involves two main processes: mesh preparation and matrix manipulation. Initially, mesh nodes are classified as either interpolation or hole nodes—the former are actively used in calculations, while the latter, located within solids, are ignored. For interpolation nodes, the surrounding cell is identified, and values are interpolated using ACCEL's CVFEM shape functions, ensuring precise data transfer across multiple meshes. Following this, the defined nodes influence the CSR (Compressed Sparse Row) method used to manipulate and manage the assembled matrix efficiently.

Results

The implementation of the Chimera framework into ACCEL was successful, supporting the coupled solver in a fully implicit manner. Figure 2 shows an example simulation involving three meshes (one background and two overset) demonstrated the effective solution of the convection-diffusion equation. Despite overlapping meshes, the mesh preparation step accurately mapped nodes to the appropriate elements. This achievement highlights the framework's capability to handle complex mesh configurations

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