Avances en Generación de Mallas con el Método del Mecano

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Seminario de Cómputo Científico, Departamento de Matemáticas,
Facultad de Ciencias - UNAM
Ciudad de México, 9 de Noviembre de 2017

Integración de Nuevas Metodologías en Simulación de Campos de Viento, Radiación Solar y Calidad del Aire

SIANI INSTITUTO UNIVERSITARIO INGENIERÍA COMPUTACIONAL

GOBIERNO DE ESPAÑA | MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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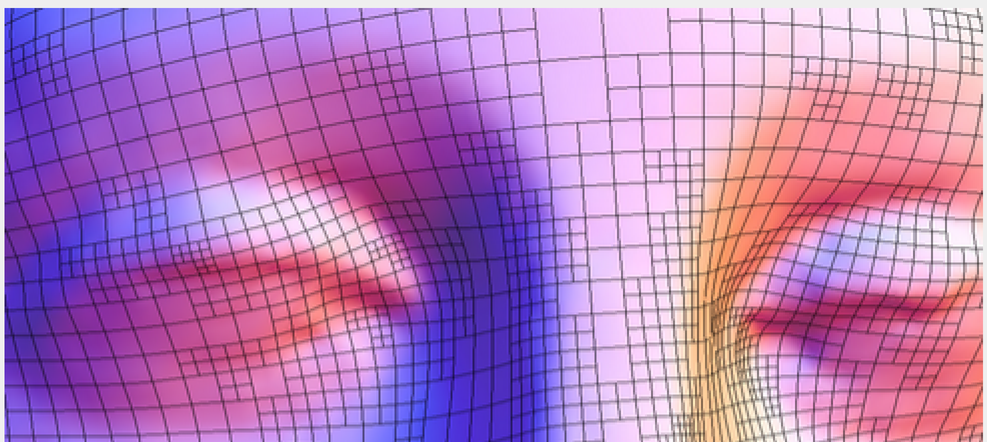
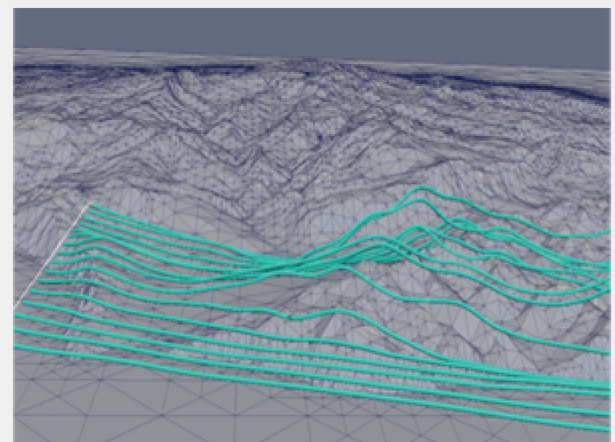
Ministerio de Economía y Competitividad y FEDER
Referencia: CTM2014-55014-C3-3R
Plazo de Ejecución: 01/01/2015 - 31/12/2017

Descripción del proyecto

Este Subproyecto de Investigación de la Universidad de Las Palmas de Gran Canaria, titulado "Integración de nuevas metodologías en simulación de campos de viento, radiación solar y calidad del aire", con referencia 604155032-55032-45-514, se enmarca dentro del Proyecto Coordinado: "Integración de nuevas metodologías para gestión medioambiental", con referencia CTM2014-55014-C3-1-R, financiado por el Ministerio de Economía y Competitividad y FEDER a través de la convocatoria 2014 de proyectos I+D+i del programa estatal de Investigación, desarrollo e innovación orientada a los retos de de la sociedad. Adjudicado para el periodo 2015-2017.





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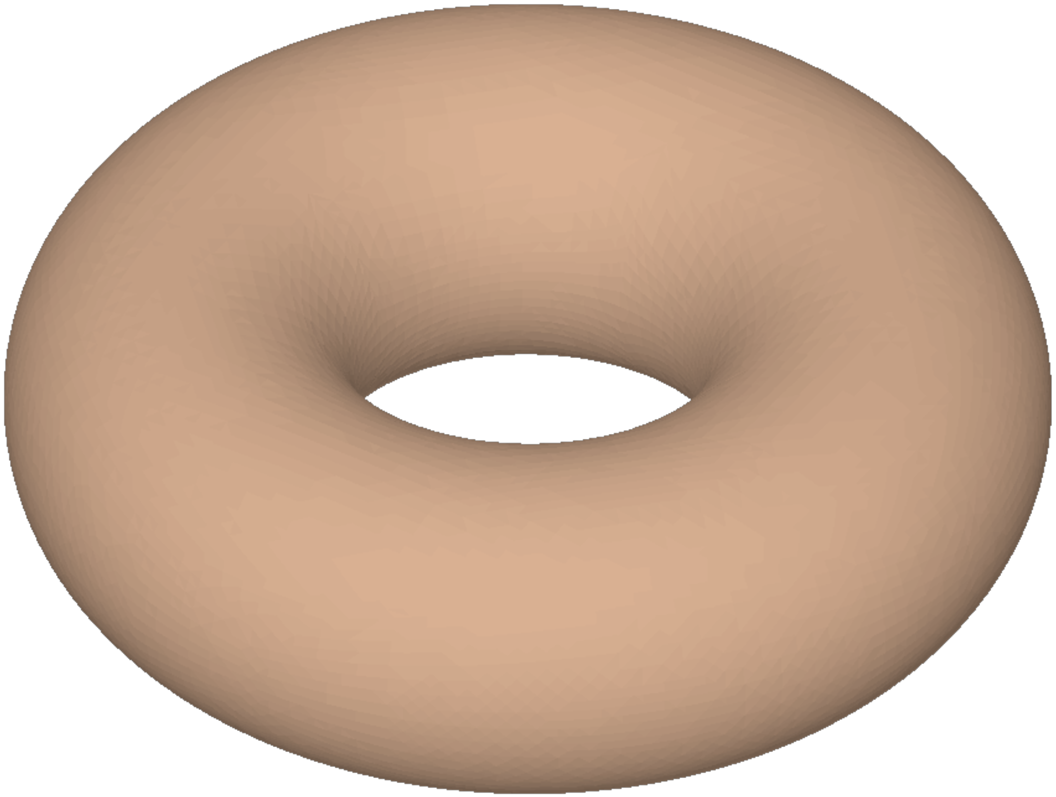
- The Meccano Method for 3-D Mesh Generation
  - The idea and the algorithm (16th IMR, 2007, APNUM 2009,…)
- Past Involved Algorithms
  - Kossaczky's local refinement algorithm (JCAM 1994)
  - Floater's parametrization of surface triangulation (CAGD 1997)
  - Our tetrahedral mesh untangling and smoothing (CMAME 2003)
  - Smoothing/Alignment of surface triangulations (IJNME 2006, EWC 2011)
- The Meccano Method and Isogeometric Analysis (CMAME 2011,…)
- Applications
- Final Comments

The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Torus example



The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Surface triangulation as input data

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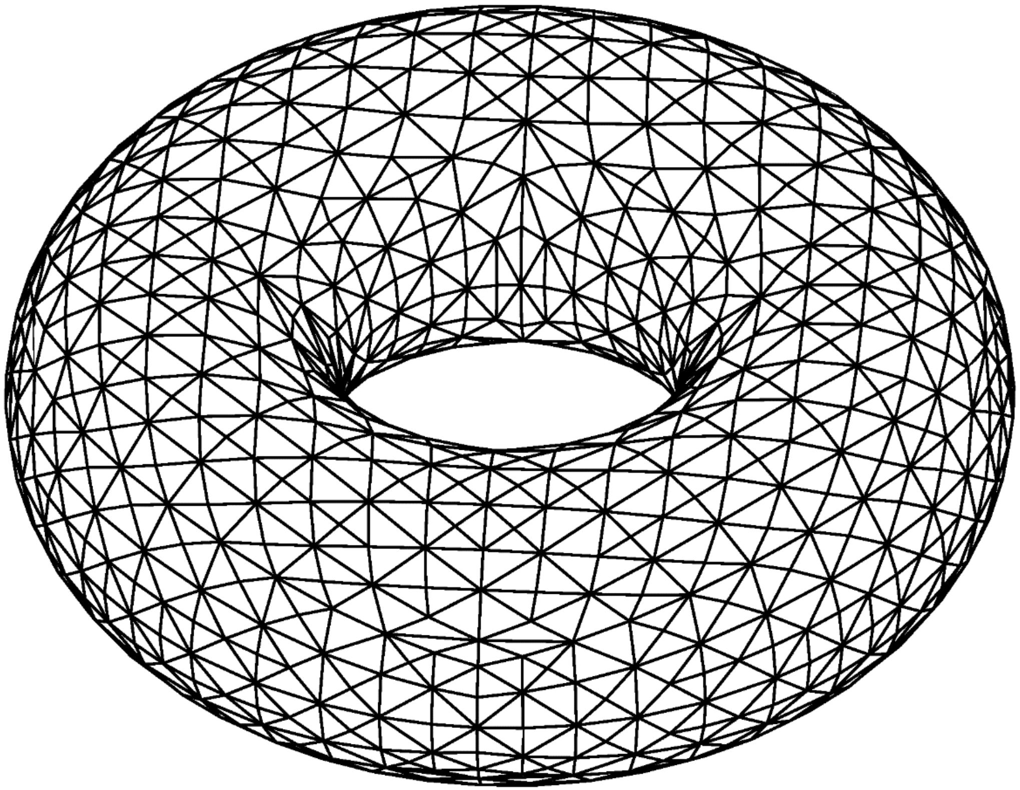
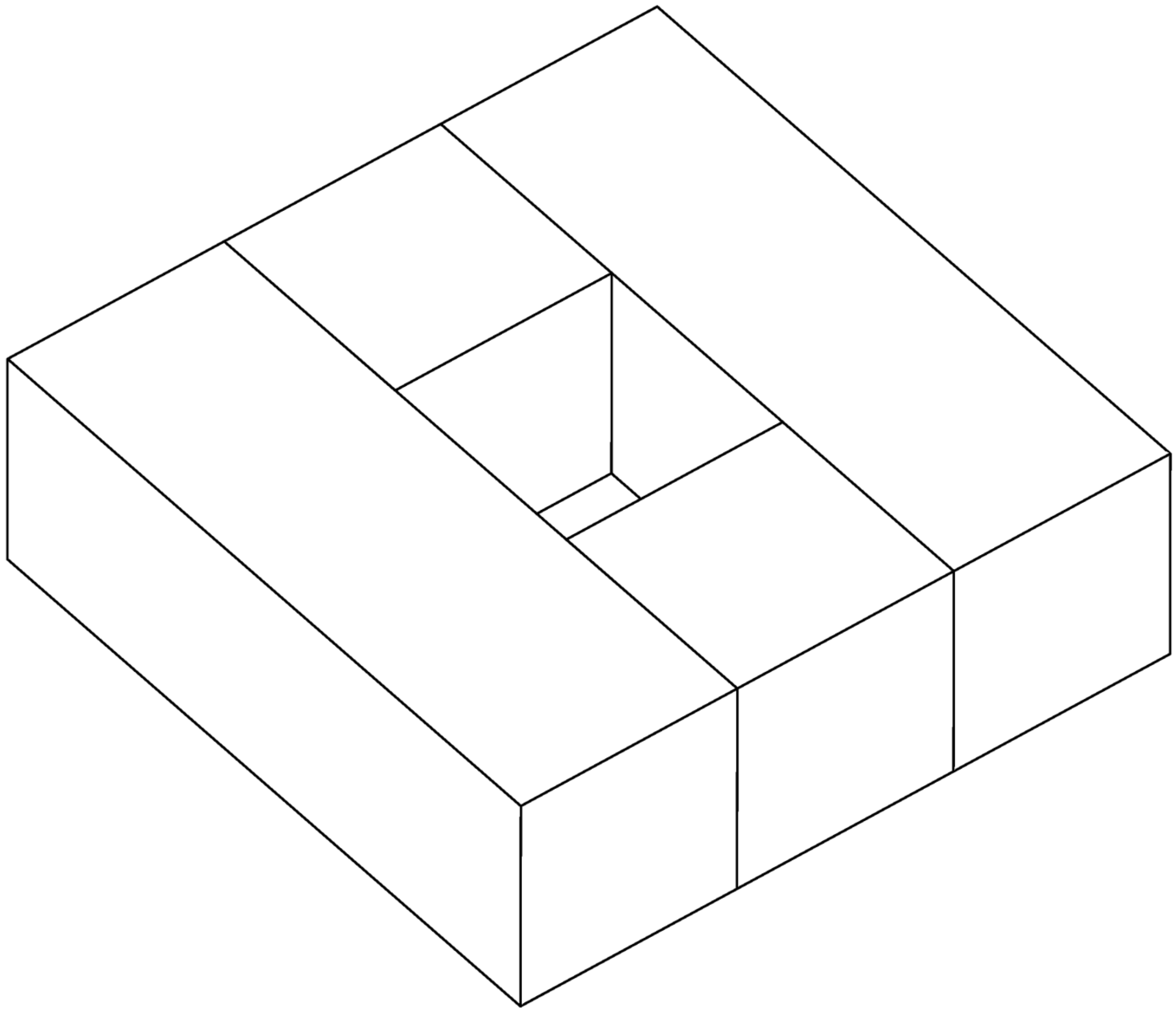


The Meccano Method for 3-D Mesh Generation

Algorithm Steps: The meccano approximation



The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Admissible mapping between meccano and solid boundaries

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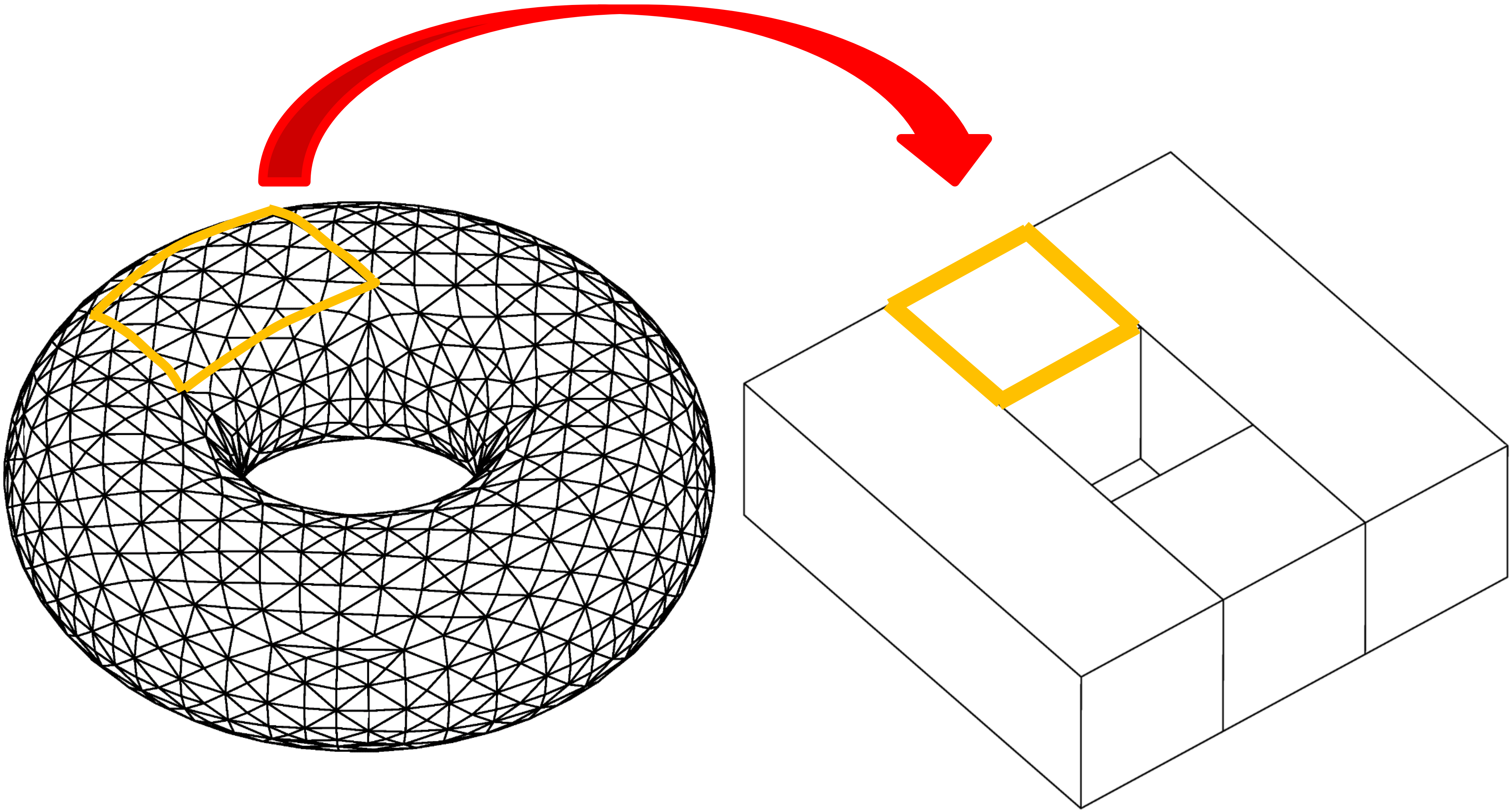
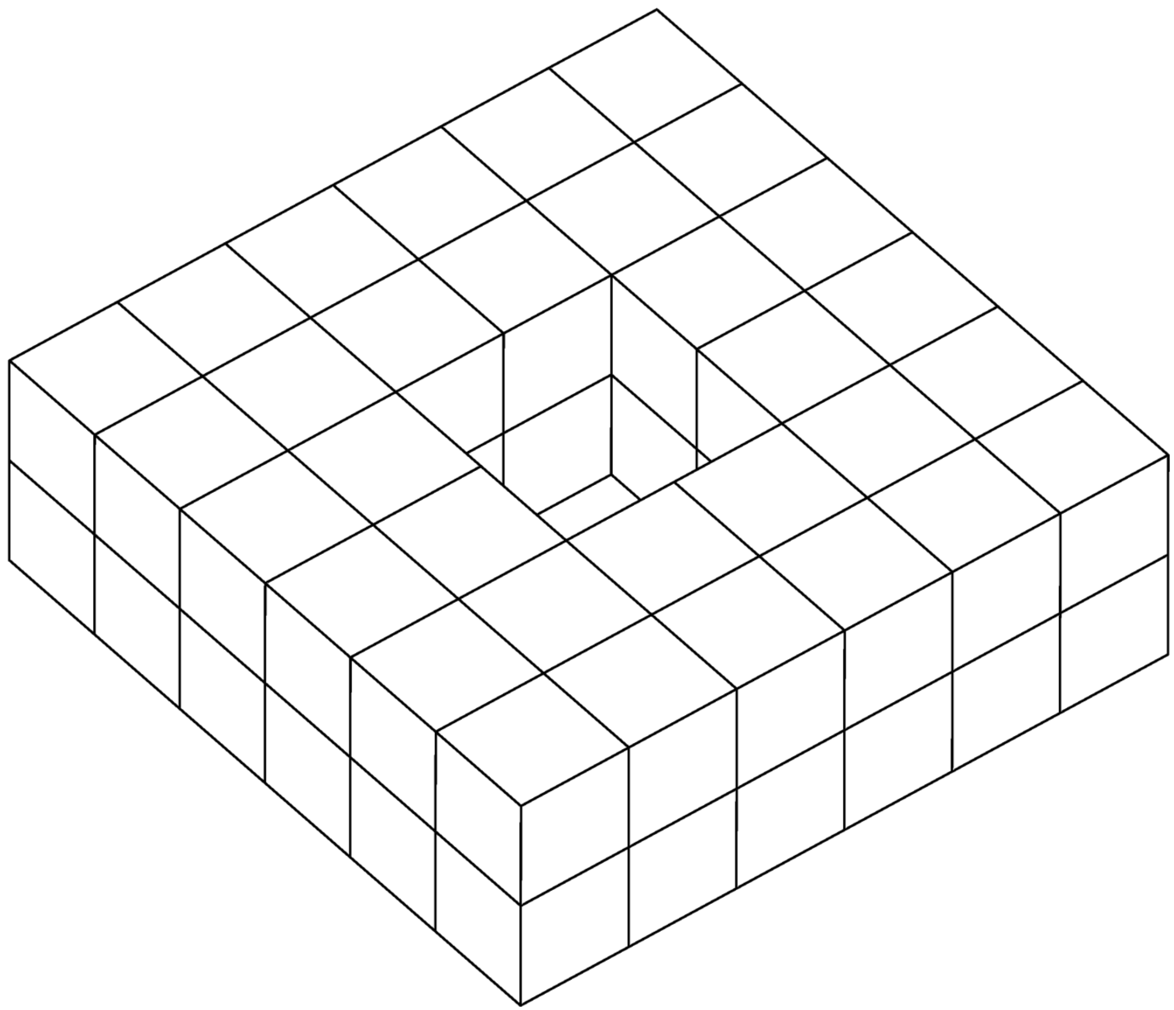


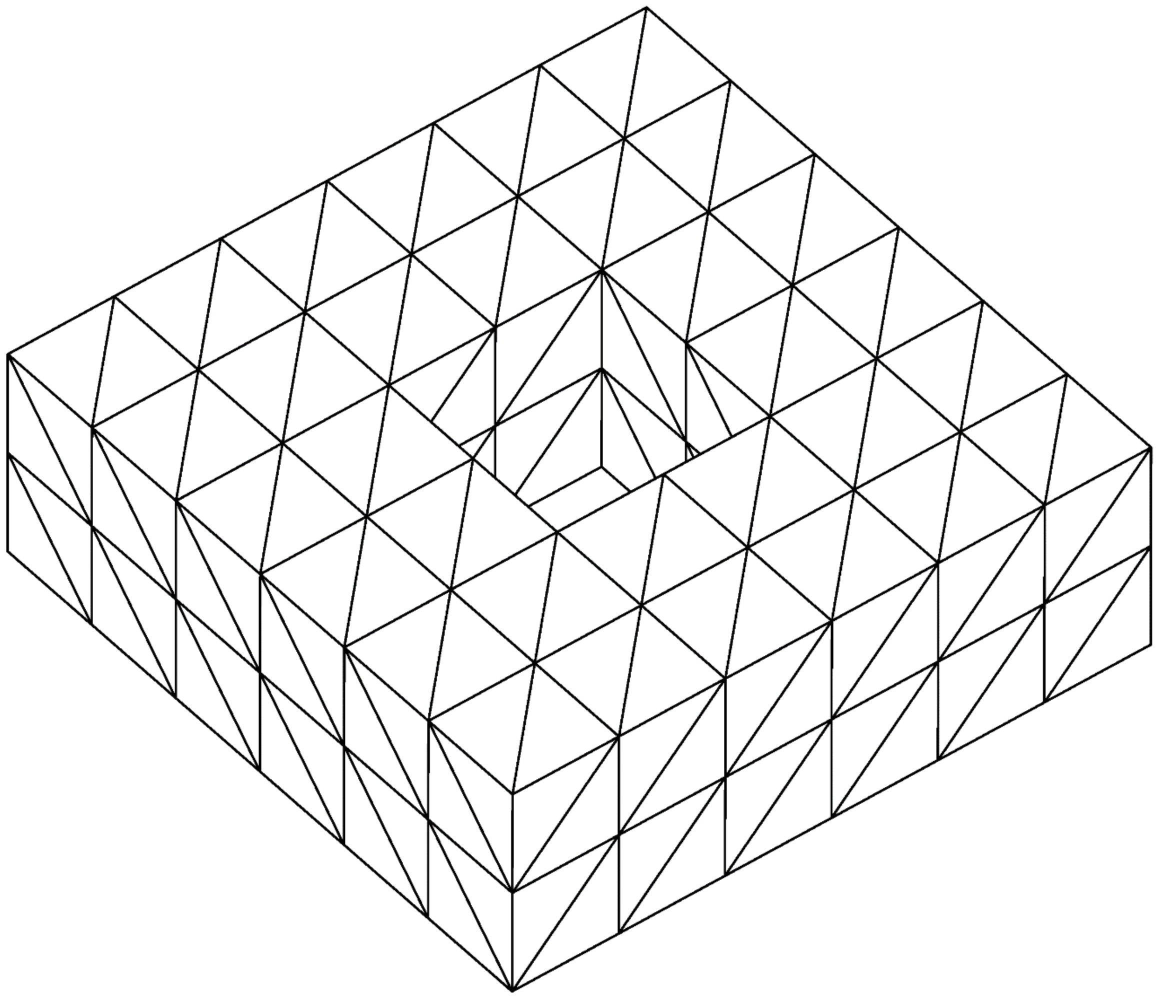
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Polycube pieces



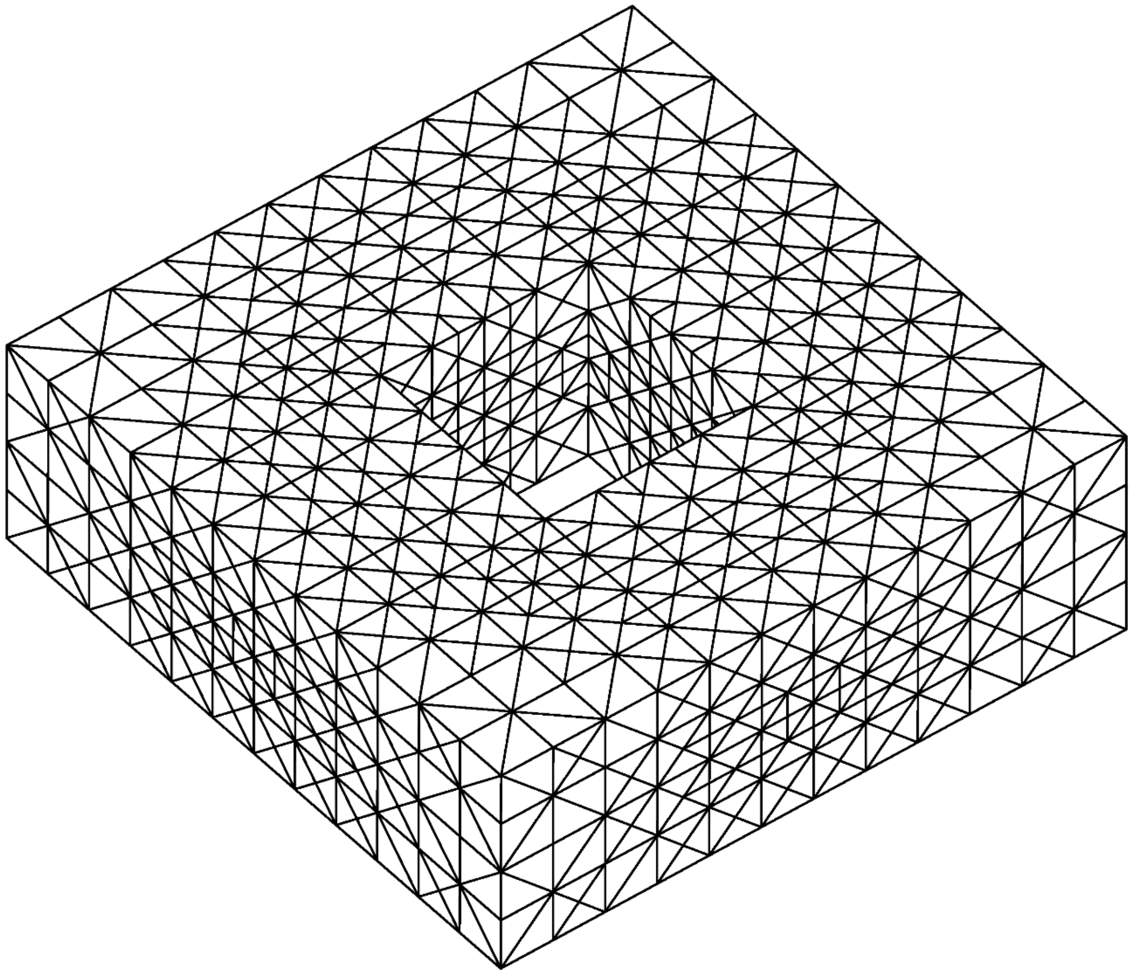
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Coarse tetrahedral mesh



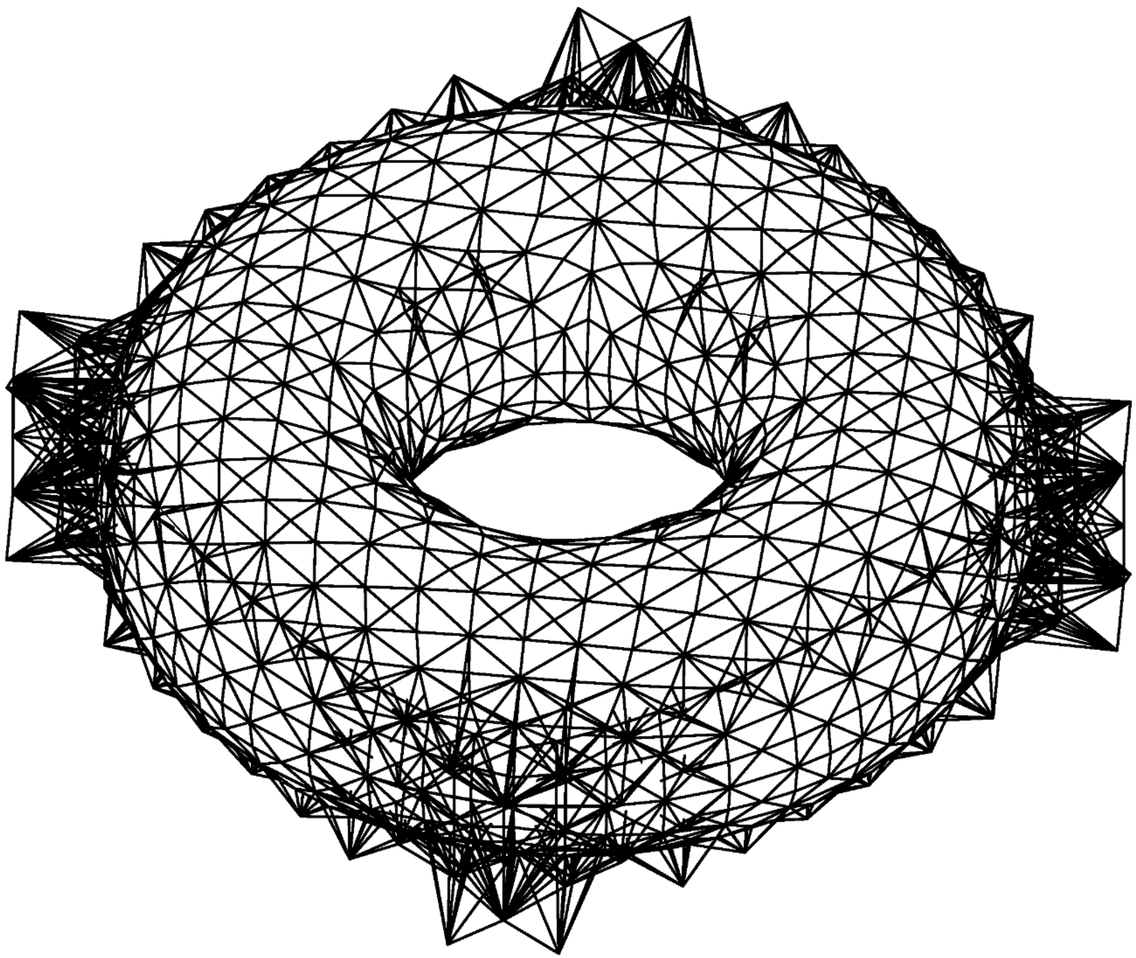
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Local refined mesh



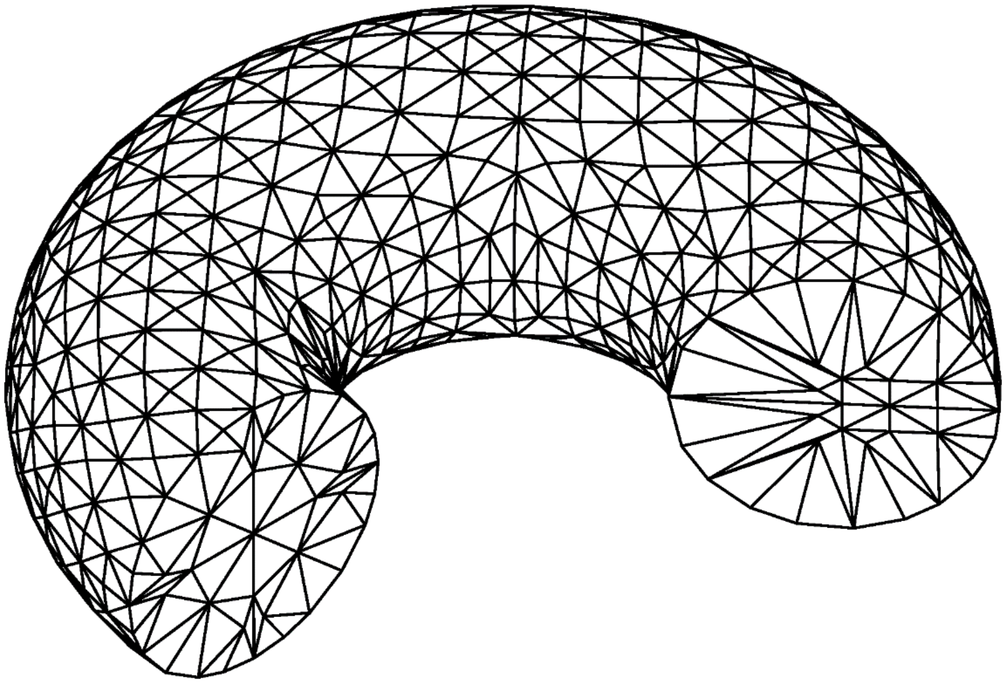
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Move the meccano boundary nodes to the solid surface



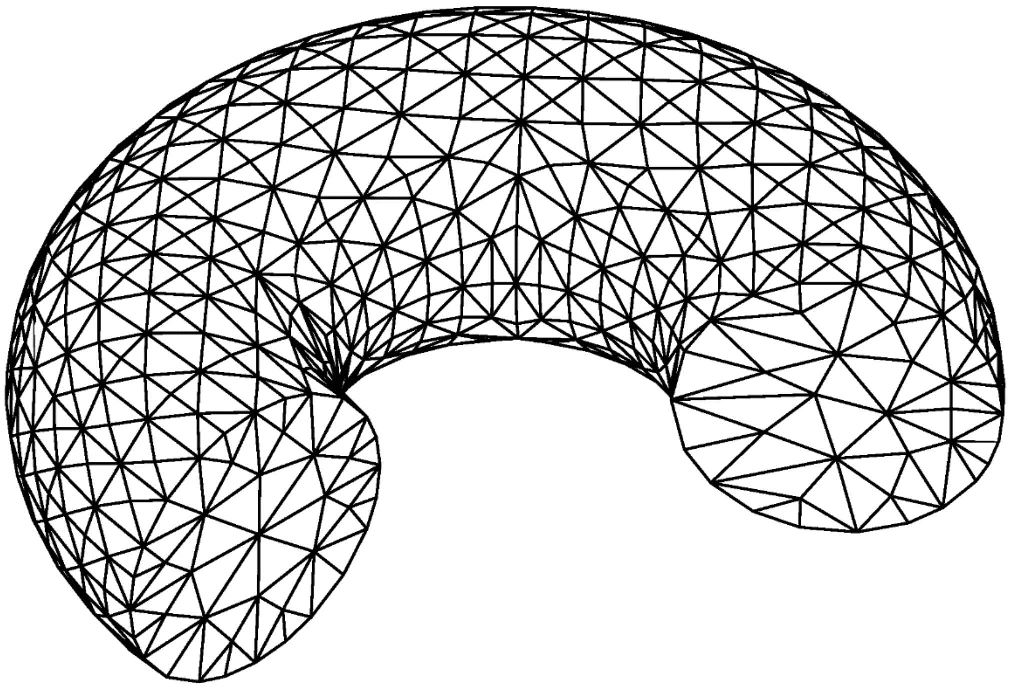
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Relocate the inner nodes of the meccano



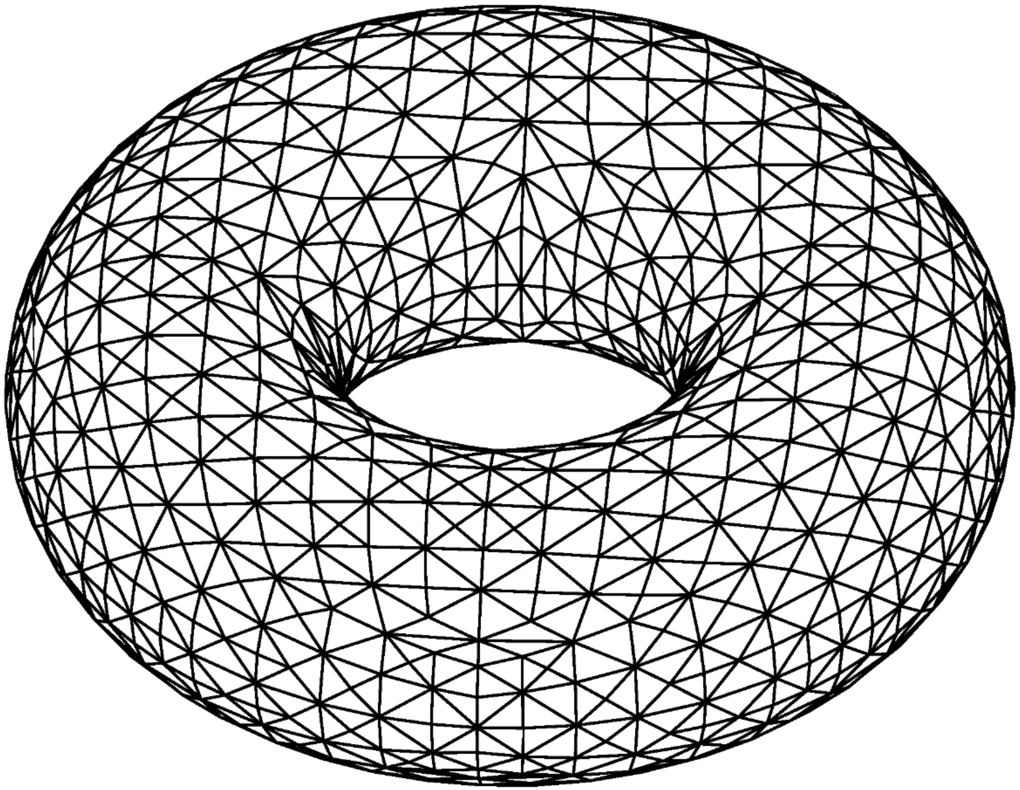
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Simultaneous mesh untangling and smoothing (SUS)



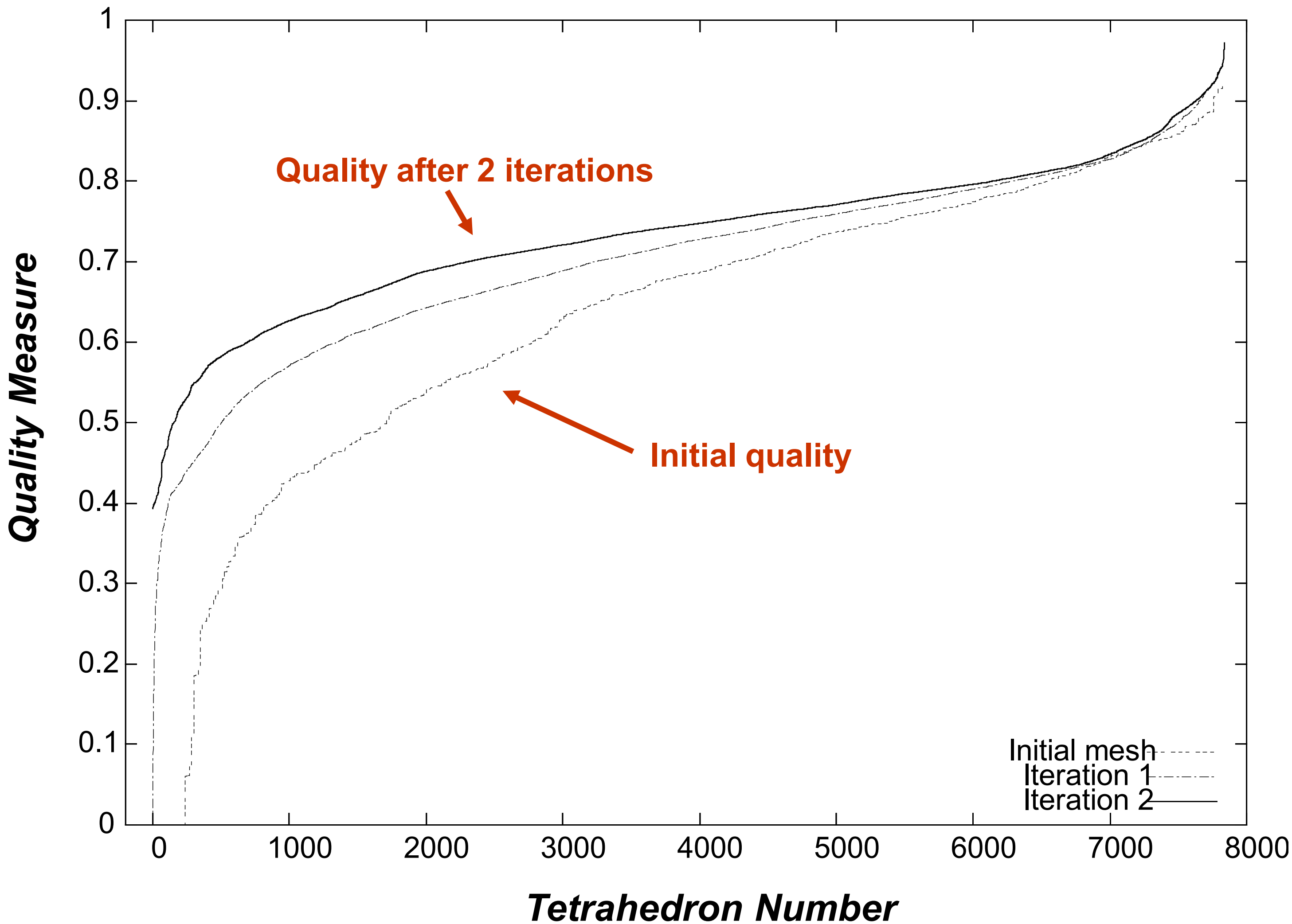
The Meccano Method for 3-D Mesh Generation

Algorithm Steps: Final tetrahedral mesh



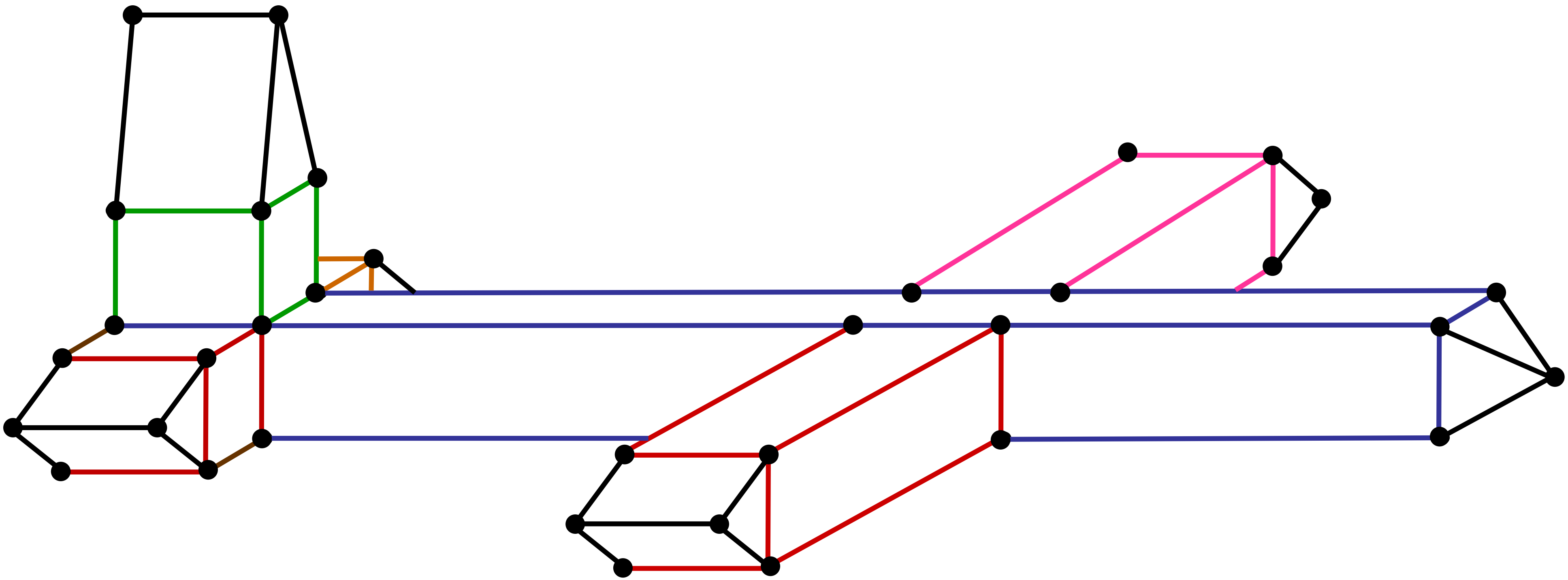
The Meccano Method for 3-D Mesh Generation

Quality curves during the mesh optimization process for the torus example



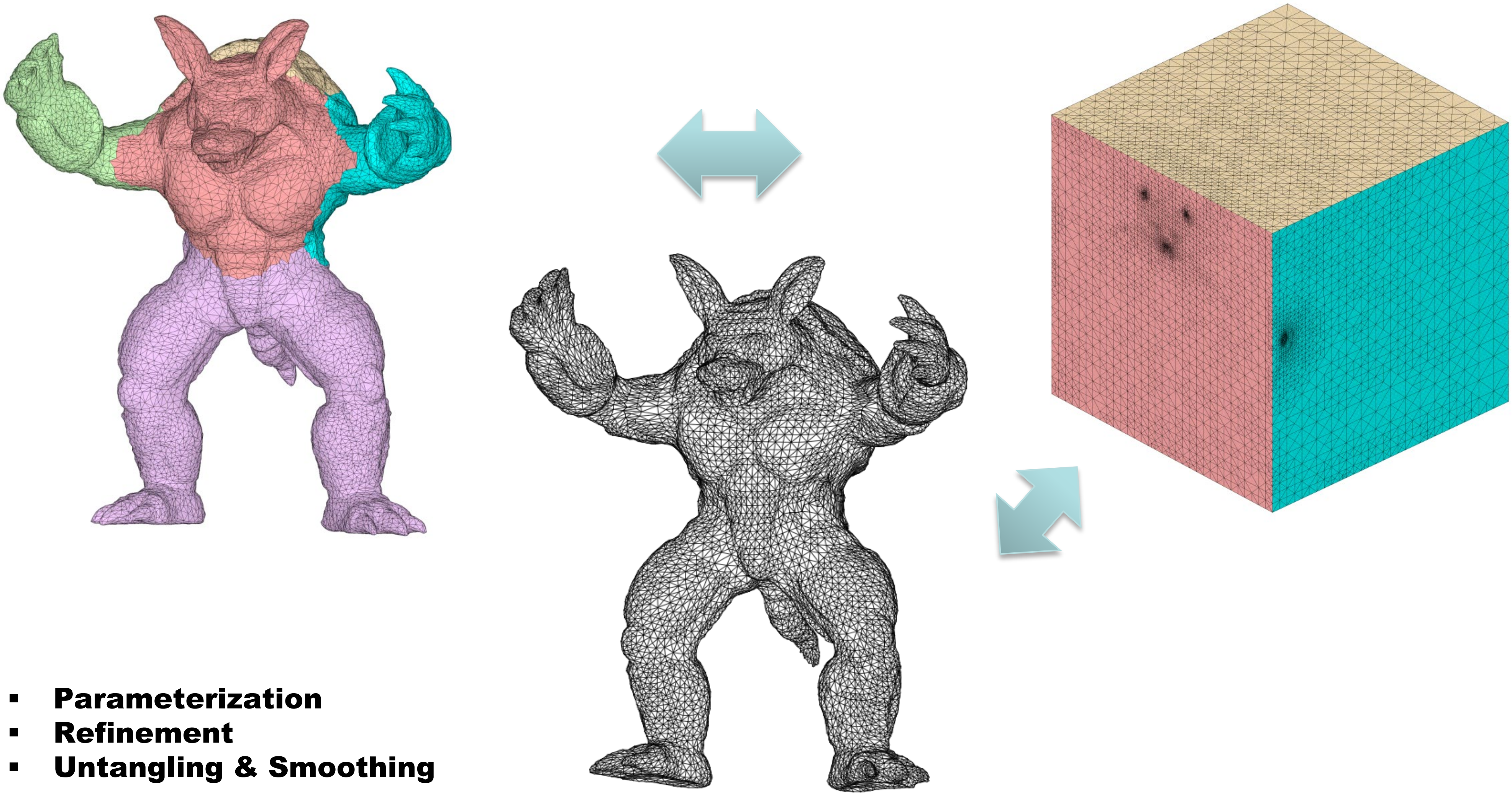
The Meccano Method for 3-D Mesh Generation

The idea: Approximation of the solid by a meccano of polyhedral pieces



Automatic Meccano Method for Genus-0 Solids

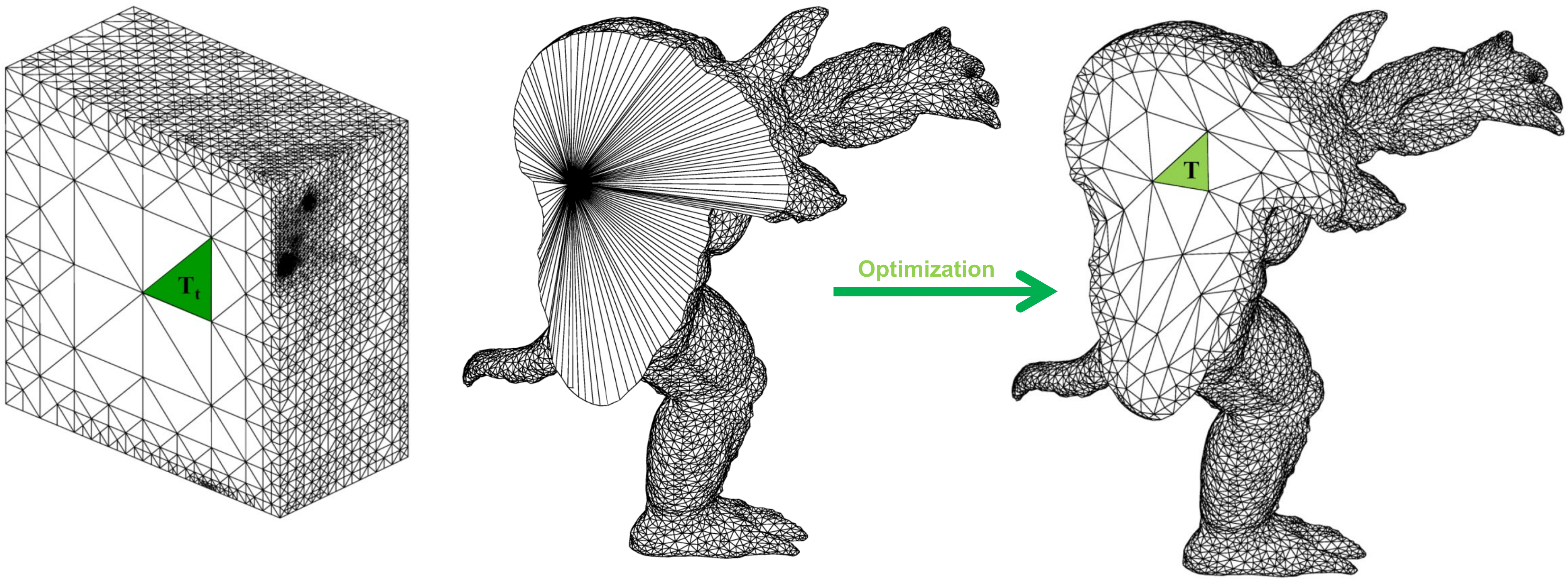
Simultaneous mesh generation and volumetric parameterization



- **Parameterization**
- **Refinement**
- **Untangling & Smoothing**

Automatic Meccano Method for Genus-0 Solids

Key of the method: SUS of tetrahedral meshes



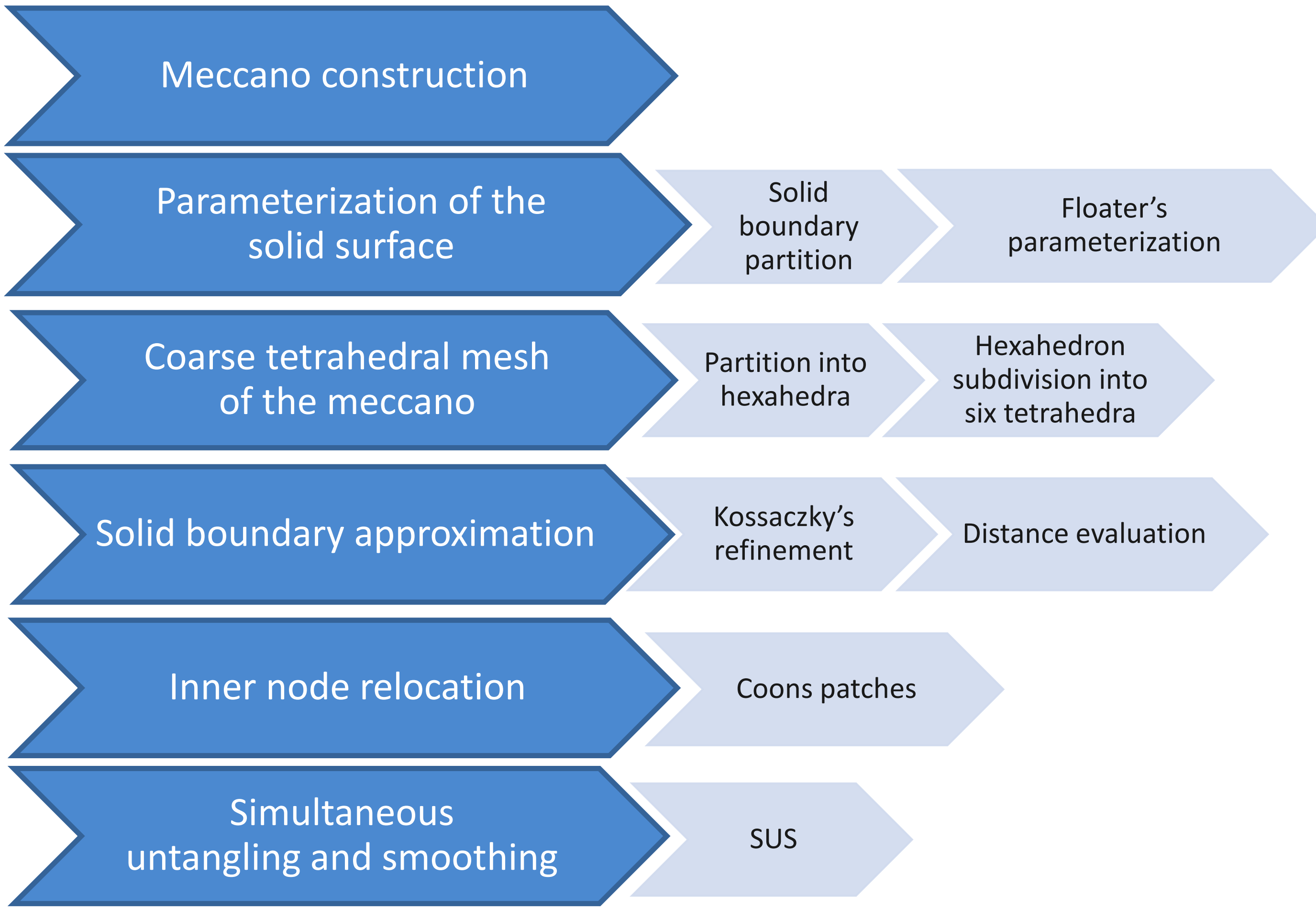
Parameter space (meccano mesh)

Physical space (tangled mesh)

Physical space (optimized mesh)

Meccano Method

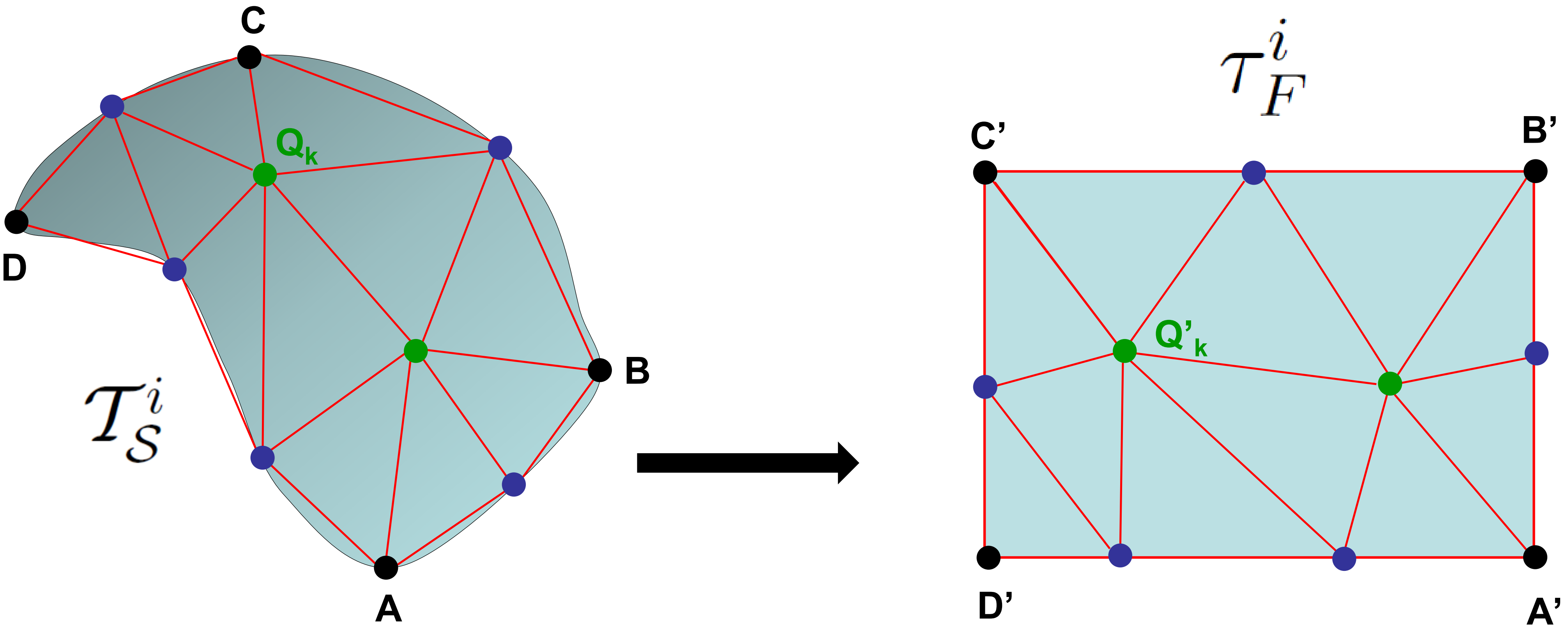
Algorithm steps



Surface Parameterization of M.S. Floater (CAGD 1997)

From a the *i-th* solid surface triangulation patch to the *i-th* meccano face

http://www.sintef.no/math software, GoTools from SINTEF ICT



Physical Space

Fixed boundary nodes,

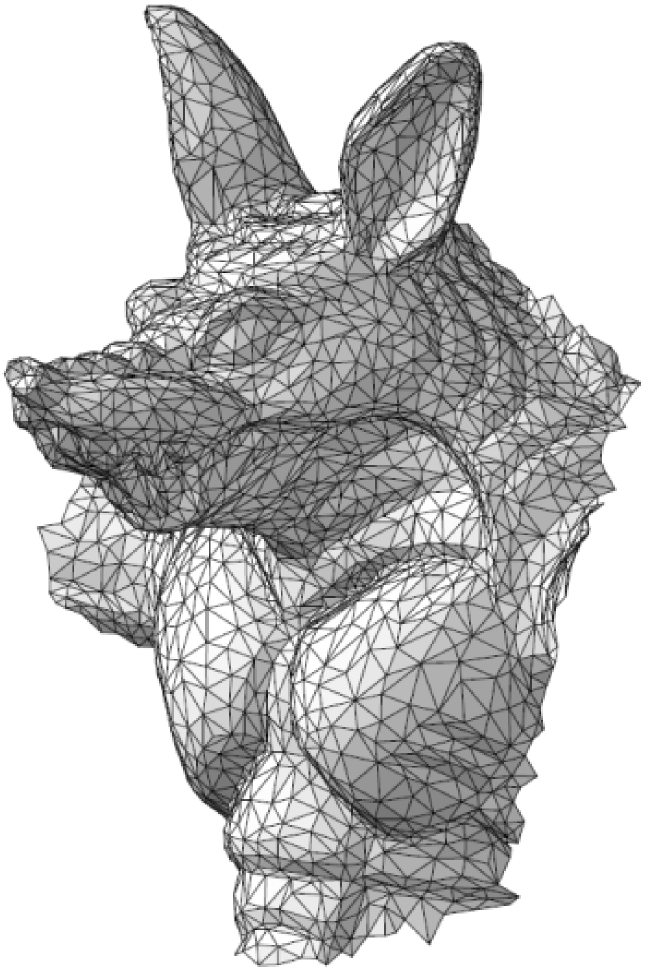
$Q'_k = \sum_j \lambda_{j,k} Q'_j$

Parametric Space

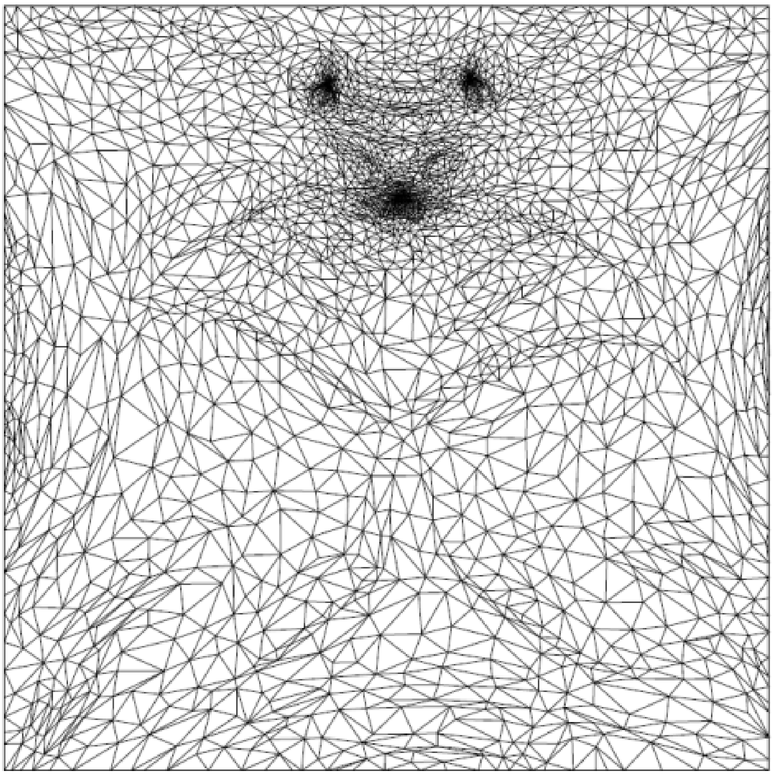
Surface Parameterization of M.S. Floater (CAGD 1997)

From a the *i-th* solid surface triangulation patch to the *i-th* meccano face

http://www.sintef.no/math software, GoTools from SINTEF ICT



Physical Space



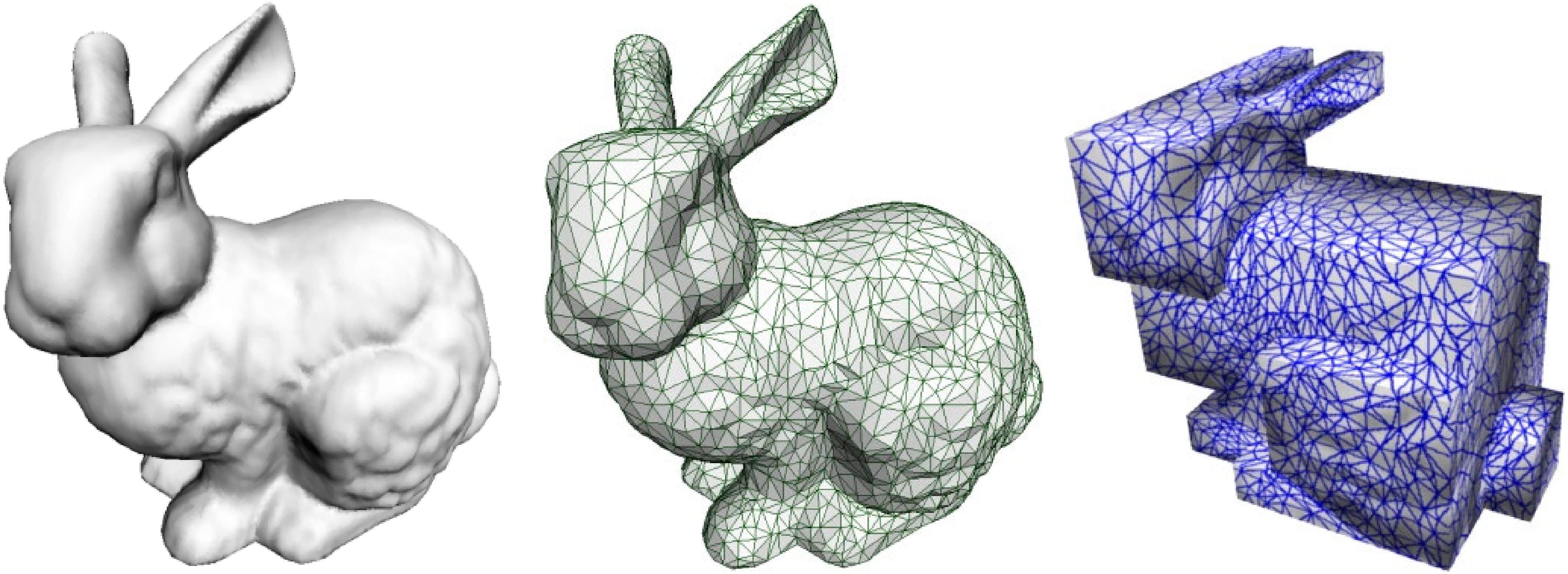
Parametric Space

PolyCube-Maps

(ACM Trans. Graph, Siggraph 2004)

Marco Tarini · Kai Hormann · Paolo Cignoni · Claudio Montani
Visual Computing Lab · ISTI · CNR · Pisa, Italy

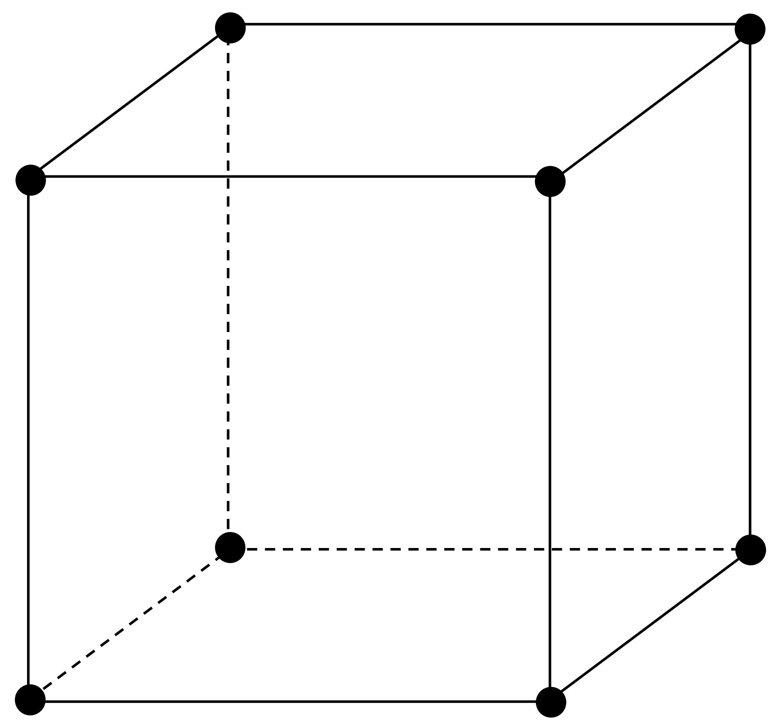
http://vcg.isti.cnr.it/polycubemaps/



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

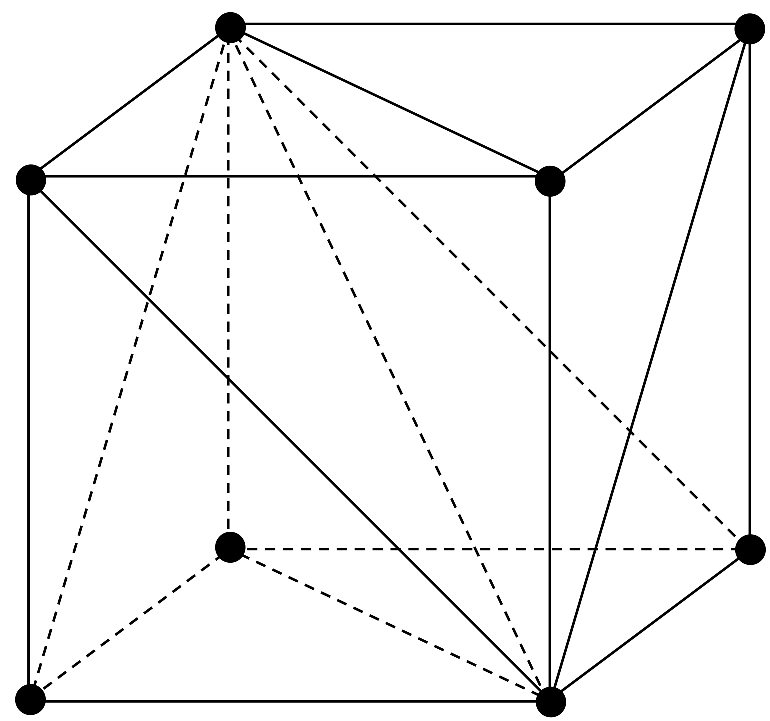
http://www.alberta-fem.de/, ALBERTA code



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

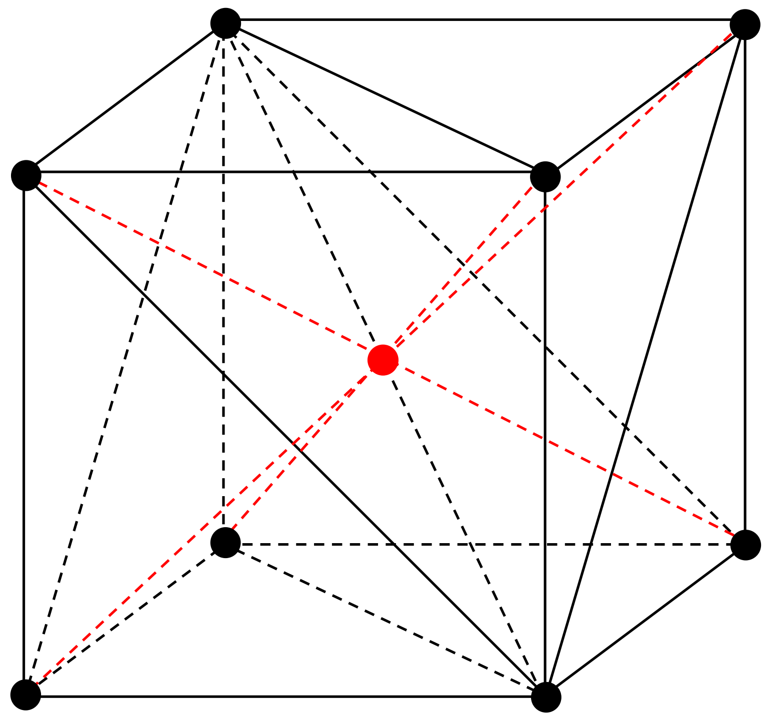
- Cube subdivision into six tetrahedra



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

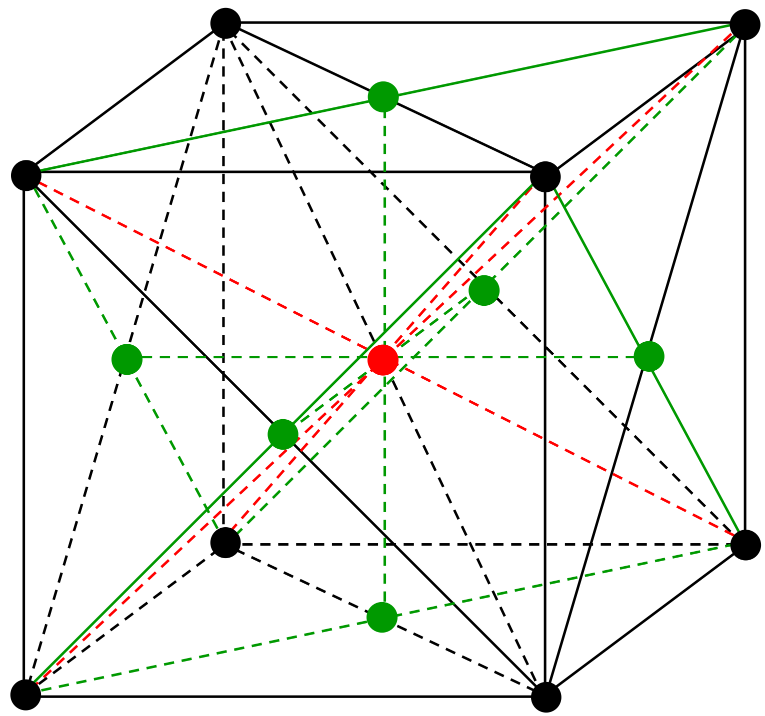
- First bisection: Subdivision of the main diagonal



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

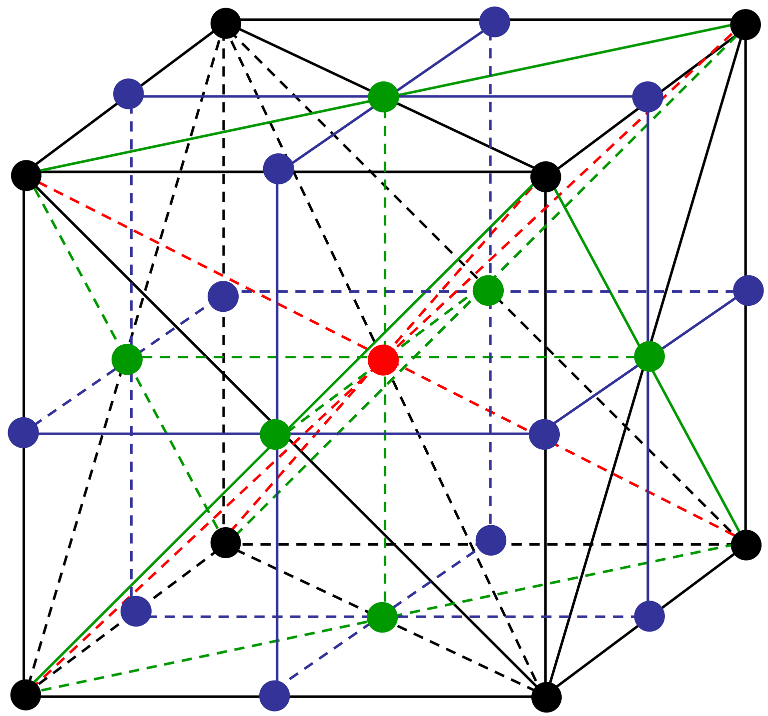
- Second bisection: Subdivision of diagonals of cube faces



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

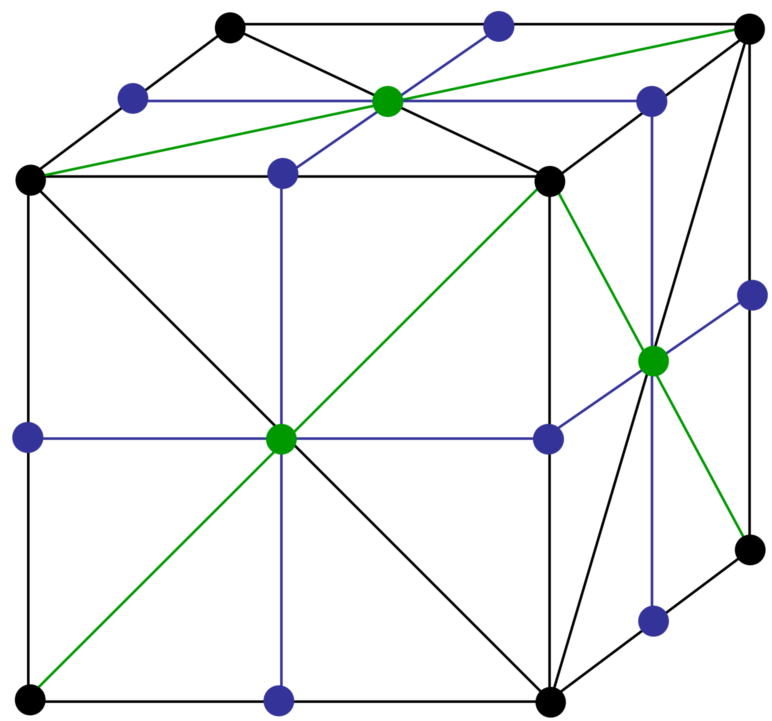
- ❑ Third bisection: Subdivision of cube edges



Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

- ❑ Initial cube is subdivided into 8 small cubes with 6 tetrahedra



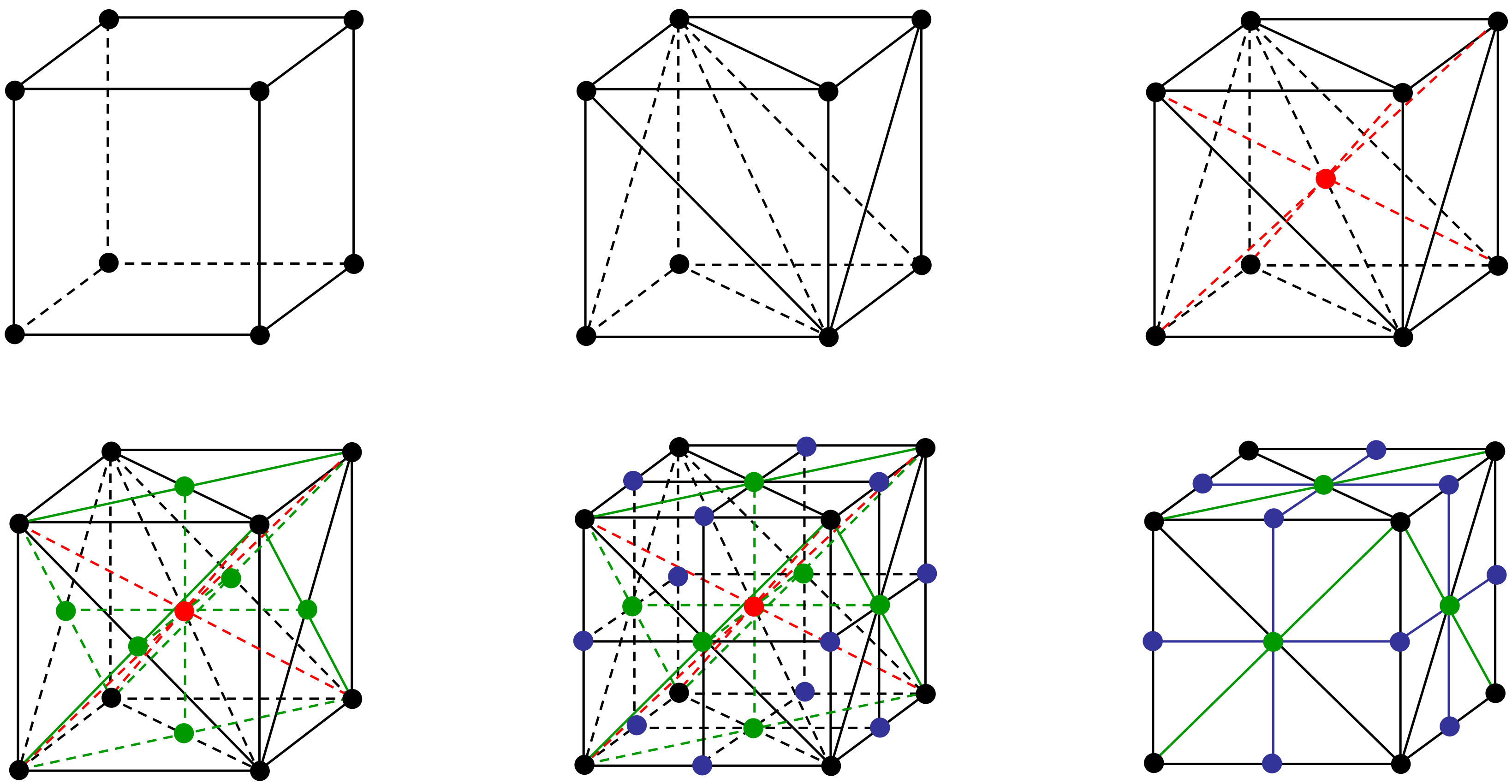
- ❑ External view of the subdivision of the initial cube (Rivara 4T)

Local Refinement: Kossaczky's Algorithm (JCAM 1994)

Refinement of a cube

http://www.alberta-fem.de/, ALBERTA code

- Initial cube and its subdivision after three consecutive tetrahedron bisection



Refinement Criterion in the Meccano Tetrahedral Mesh

Volumetric distance ε between the solid surface Σ and its piecewise approximation

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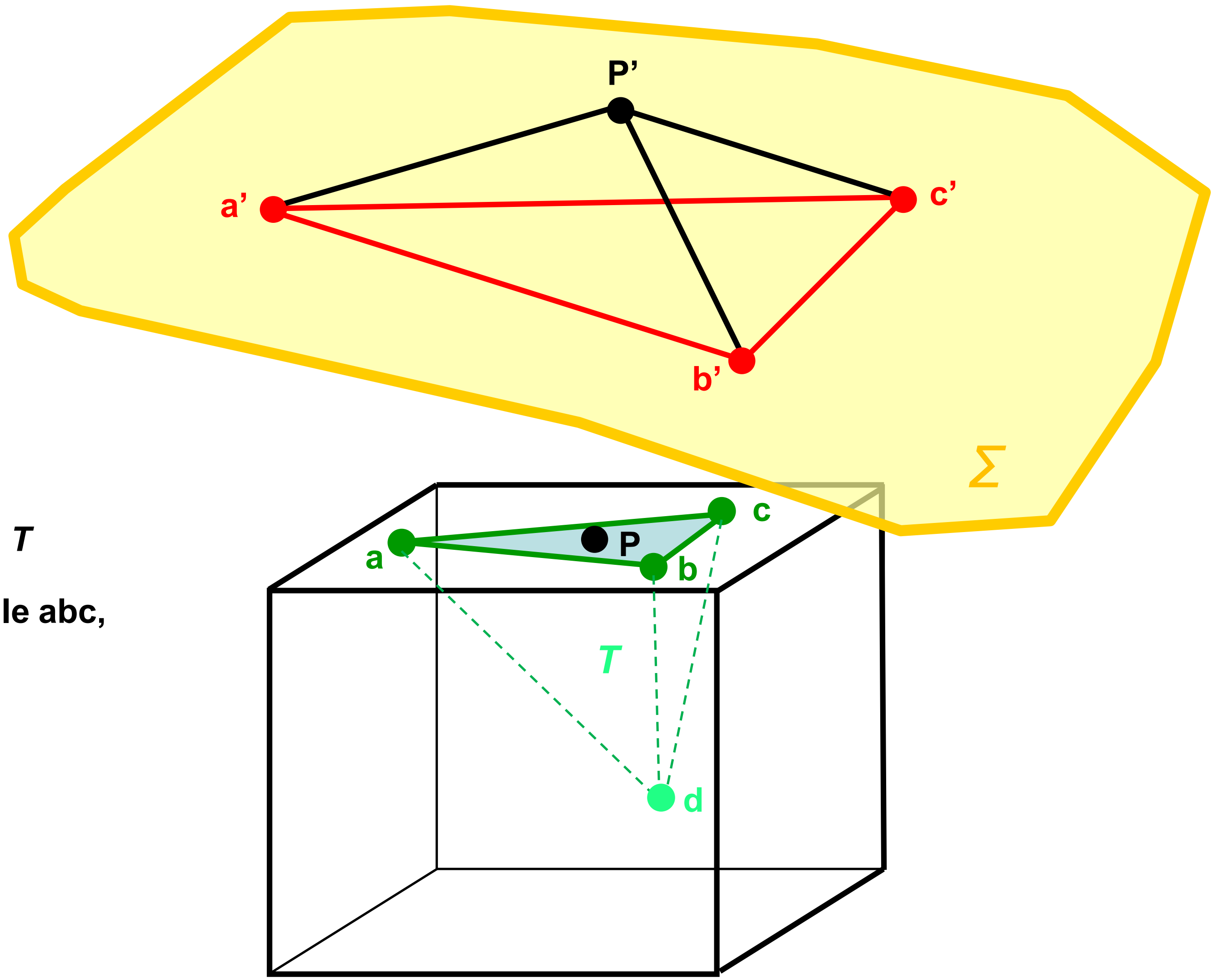


- Given a Kossaczky tetrahedron *T*
- Given a Floater node P in triangle abc,

→ **We refine *T* if**

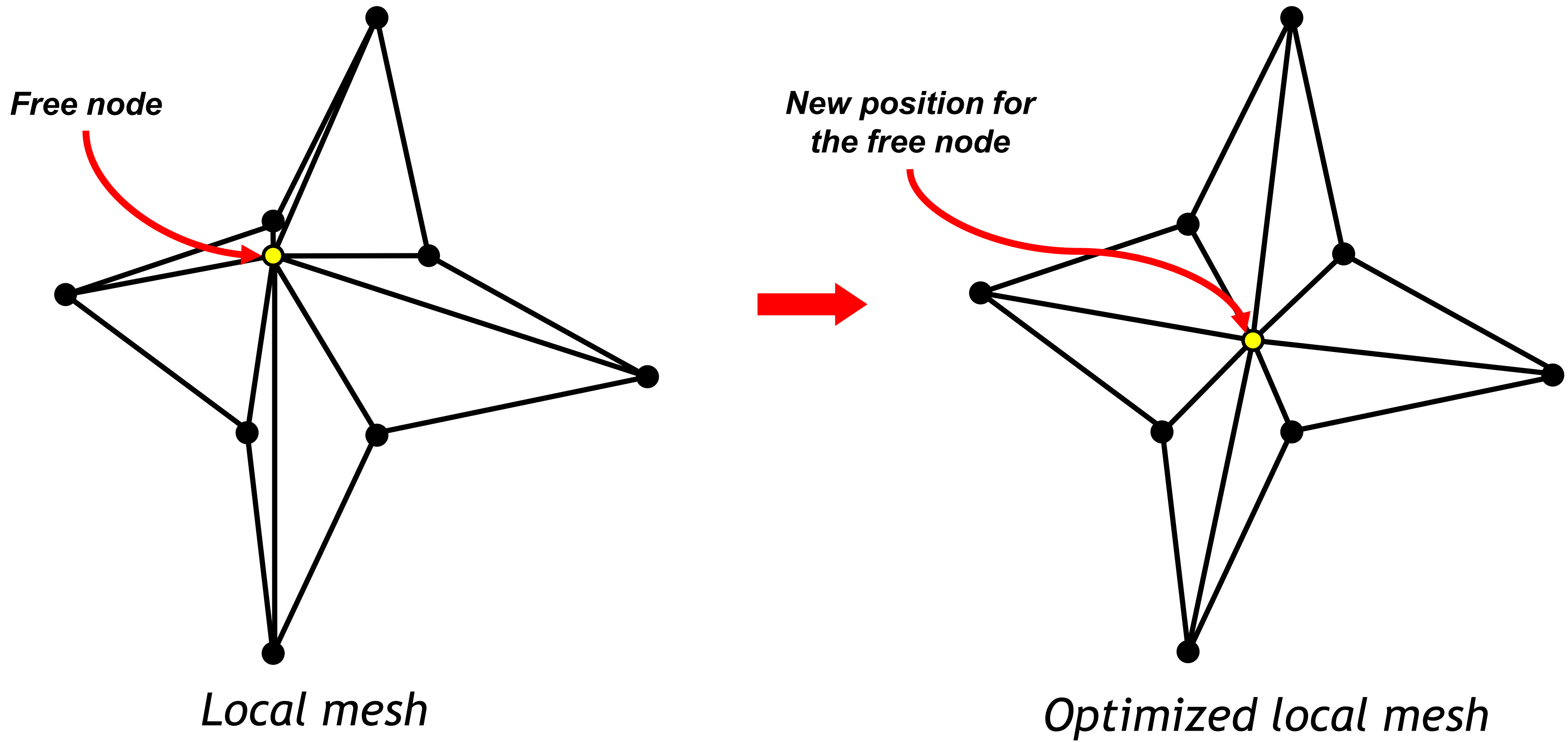
Volume (a'b'c'P') > ε

Simultaneous Untangling and Smoothing (CMAME 2003)

Case of plane triangulations

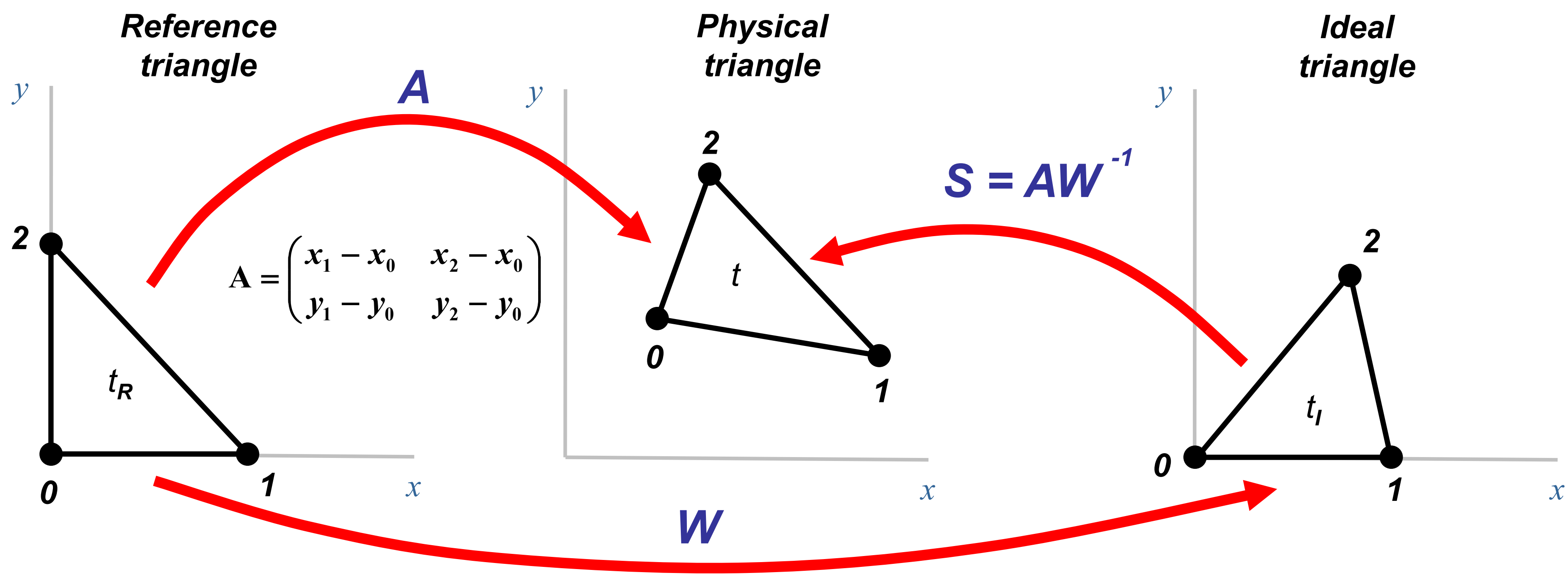
Local optimization

Objective: ***Improve the quality of the local mesh by minimizing an objective function***



Simultaneous Untangling and Smoothing (CMAME 2003)

Weighted Jacobian Matrix on a Plane



$t_I \xrightarrow{S} t$ $S = AW^{-1}$: **Weighted Jacobian matrix**

Algebraic shape quality metric of t (mean ratio)

$$\mathbf{q} = \frac{2\boldsymbol{\sigma}}{\|\mathbf{S}\|^2} = \frac{1}{\eta}$$

where:

$$\|\mathbf{S}\| = \sqrt{\mathbf{tr}\left(\mathbf{S}^T\mathbf{S}\right)}$$

$$\boldsymbol{\sigma} = \det(\mathbf{S})$$

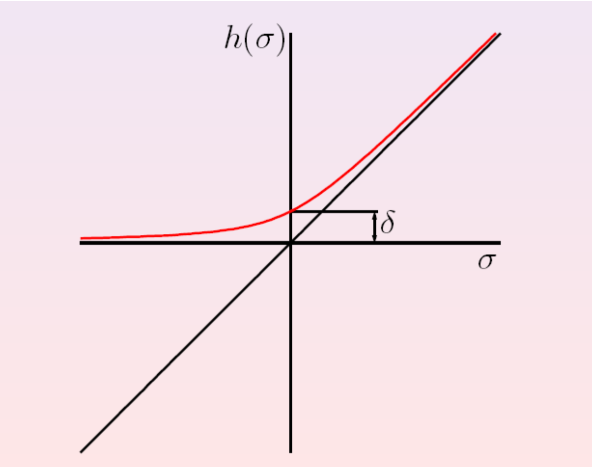
Simultaneous Untangling and Smoothing (CMAME 2003)

Local objective function for plane triangulations

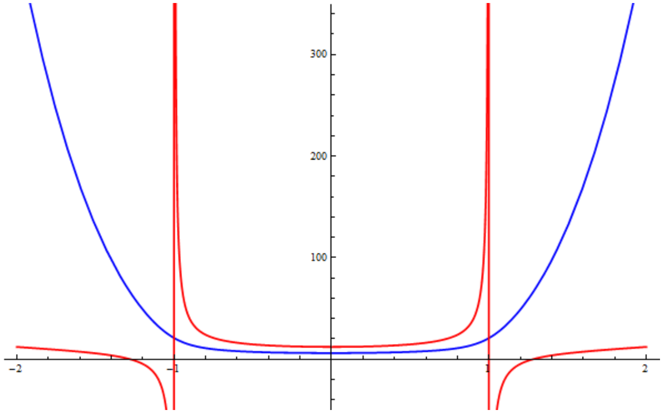
SUS Code: Freely-available in http://www.dca.iusiani.ulpgc.es/proyecto2015-2017

Original function: $$K(\mathbf{x}) = \sum_{m=1}^{M} \frac{\|S_m\|^2}{2\,\sigma_m}$$

Modified function: $$K^*(\mathbf{x}) = \sum_{m=1}^{M} \frac{\|S_m\|^2}{2h(\sigma_m)}$$



$$h(\sigma) = \frac{1}{2}\left(\sigma + \sqrt{\sigma^2 + 4\delta^2}\right)$$



Modified function (blue) is regular in all R^2 and it approximates the same minimum that the original function (red). Moreover, it allows a simultaneous untangling and smoothing of triangular meshes

The extension to tetrahedral meshes is straightforward:

$$\eta_m = \frac{|S_m|^2}{3[h(\sigma_m)]^{\frac{2}{3}}}$$

Parallel Implementation of SUS

Shared-memory (IMR 2013) and distributed-memory (IMR 2017)

CPU-Time for distributed-memory: From 10 minutes (sequential) to 10 seconds (150 cores), approx.

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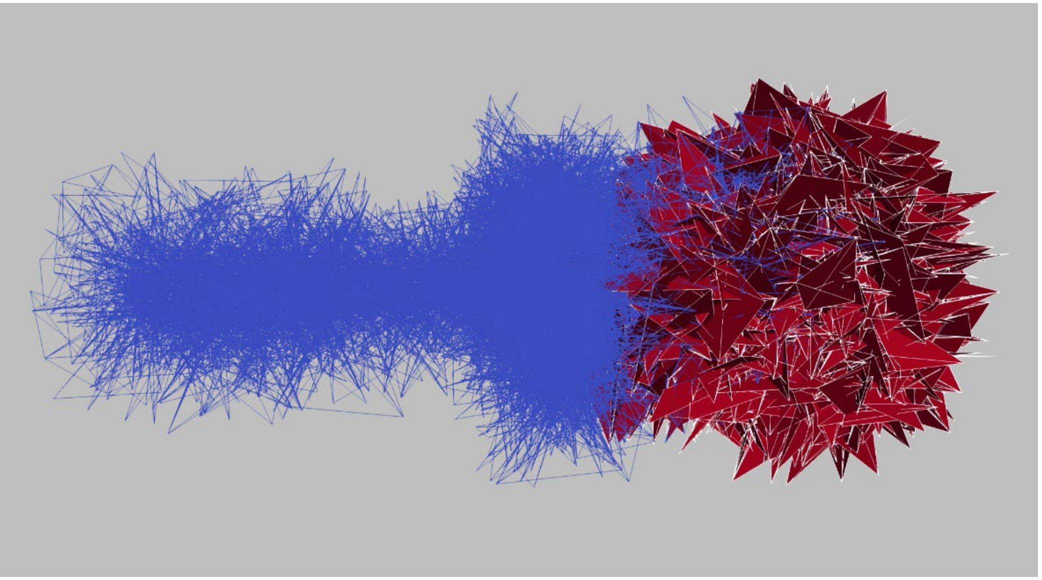
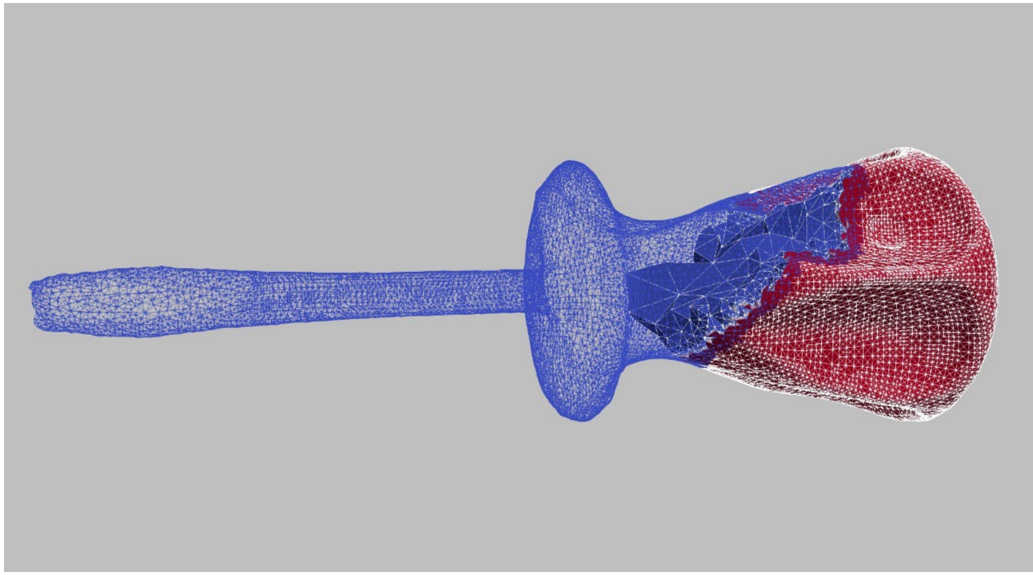
Screwdriver mesh for 2-core experiment with 169.000 elements (49% tangled)



Tangled mesh

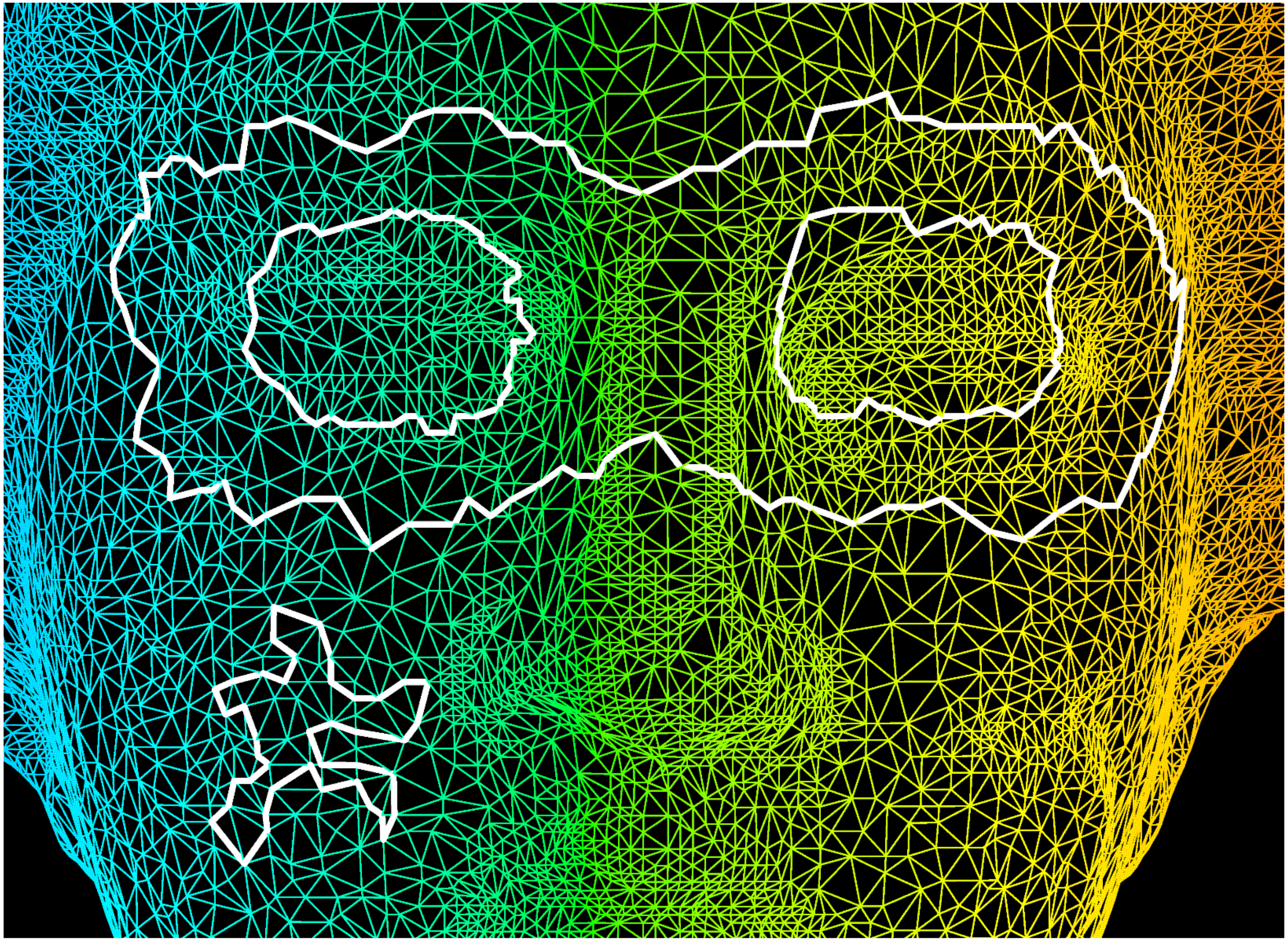


Untangled mesh

Smoothing Surface Triangulations (IJNME 2006, EWC 2011)

Simultaneous Alignment with Interior Curves (maintaining the mesh topology)

http://www.cyberware.com/



Smoothing Surface Triangulations (IJNME 2006, EWC 2011)

Simultaneous Alignment with Interior Curves (maintaining the mesh topology)

Adaptive Finite Element Solution

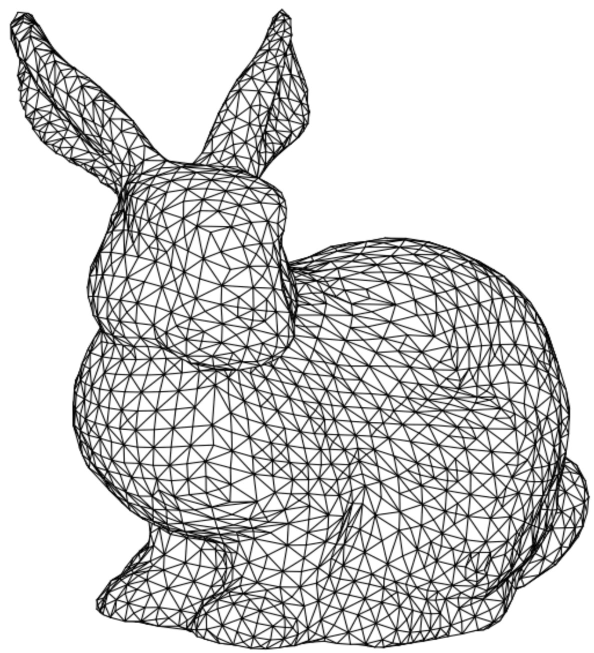
Stanford Bunny Example

Parabolic Problem:

$$\begin{aligned} \partial_t u - \Delta u &= f && \text{in } \Omega \times (0,T), \\ u &= 0 && \text{on } \partial\Omega \times (0,T), \\ u &= 0 && \text{on } \Omega \times \{0\}, \end{aligned}$$

Adaptive Algorithm: Solve $\rightarrow$ Estimate $\rightarrow$ Mark $\rightarrow$ Refine/Derefine

3-D Domain:

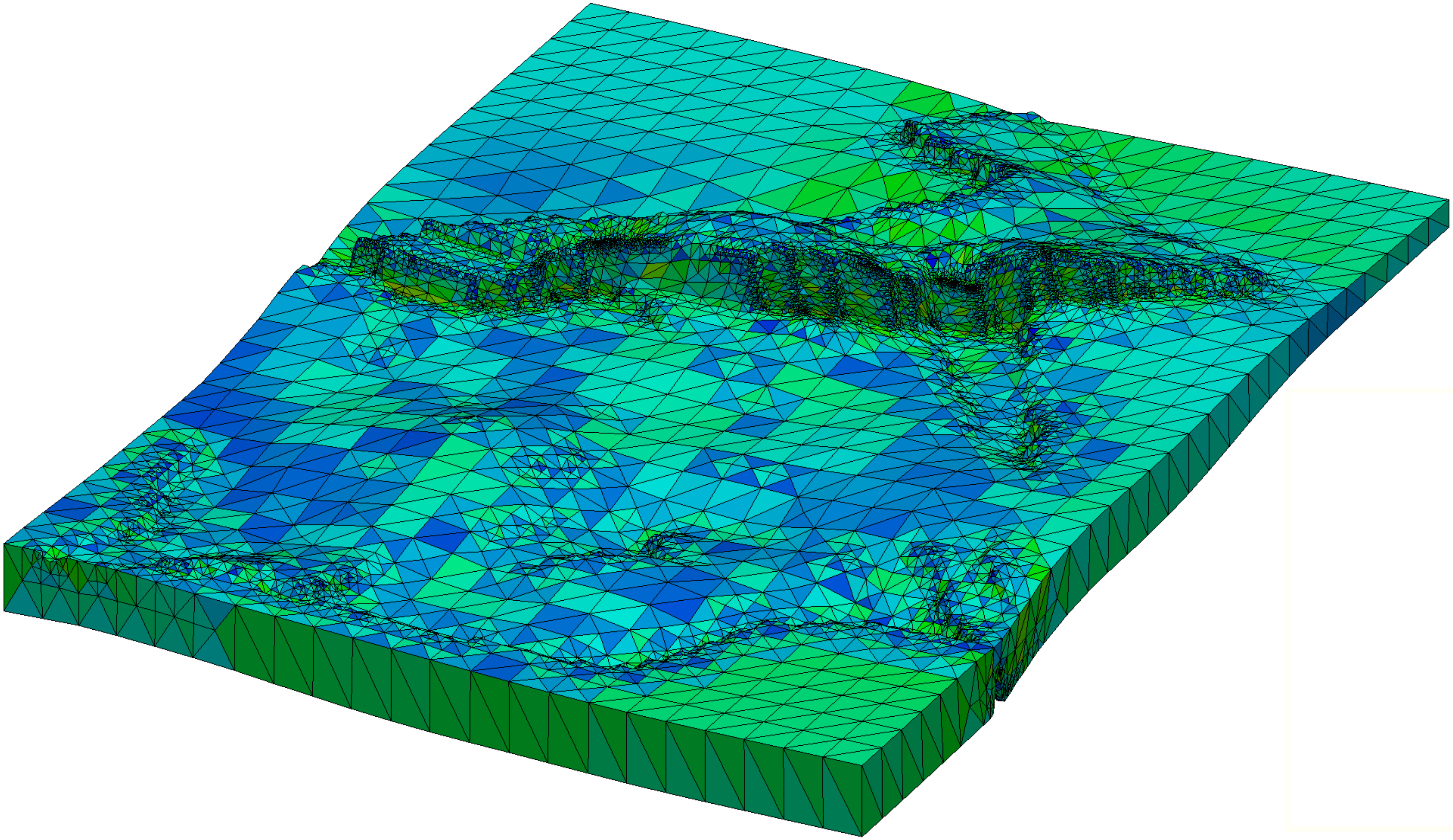


Stanford bunny

Modelización de Yacimientos de Petróleo

Aproximación con Tetraedros de un Estrato del Subsuelo

Proyecto de la CONACYT mexicana 2012-2015



Modelización de Yacimientos de Petróleo

Aproximación *Octree* de un Estrato del Subsuelo y de Pozos

Proyecto de la CONACYT mexicana 2012-2015

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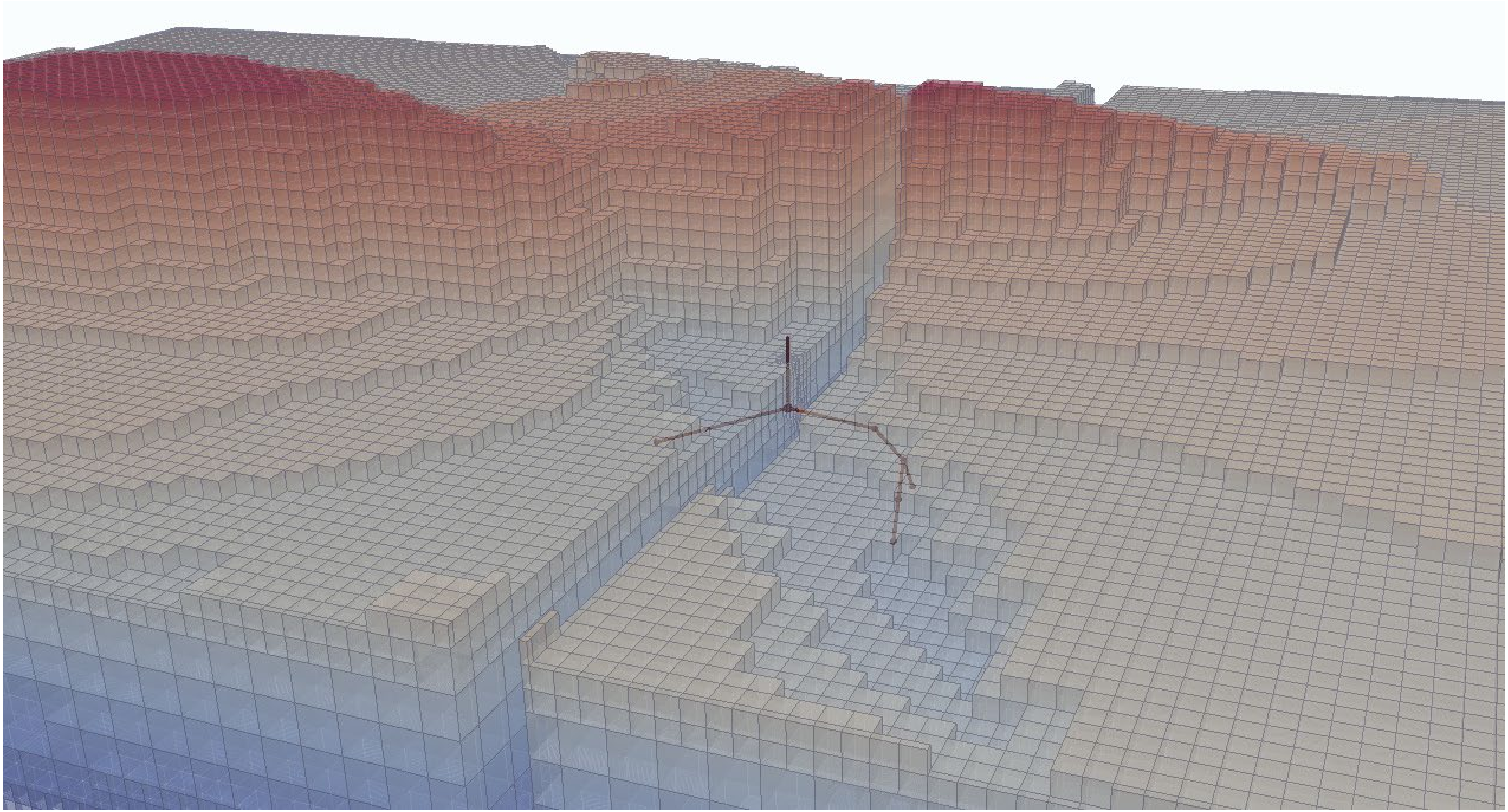

Modelización de Yacimientos de Petróleo

Aproximación *Octree* de un Estrato del Subsuelo y de Pozos

Proyecto de la CONACYT mexicana 2012-2015

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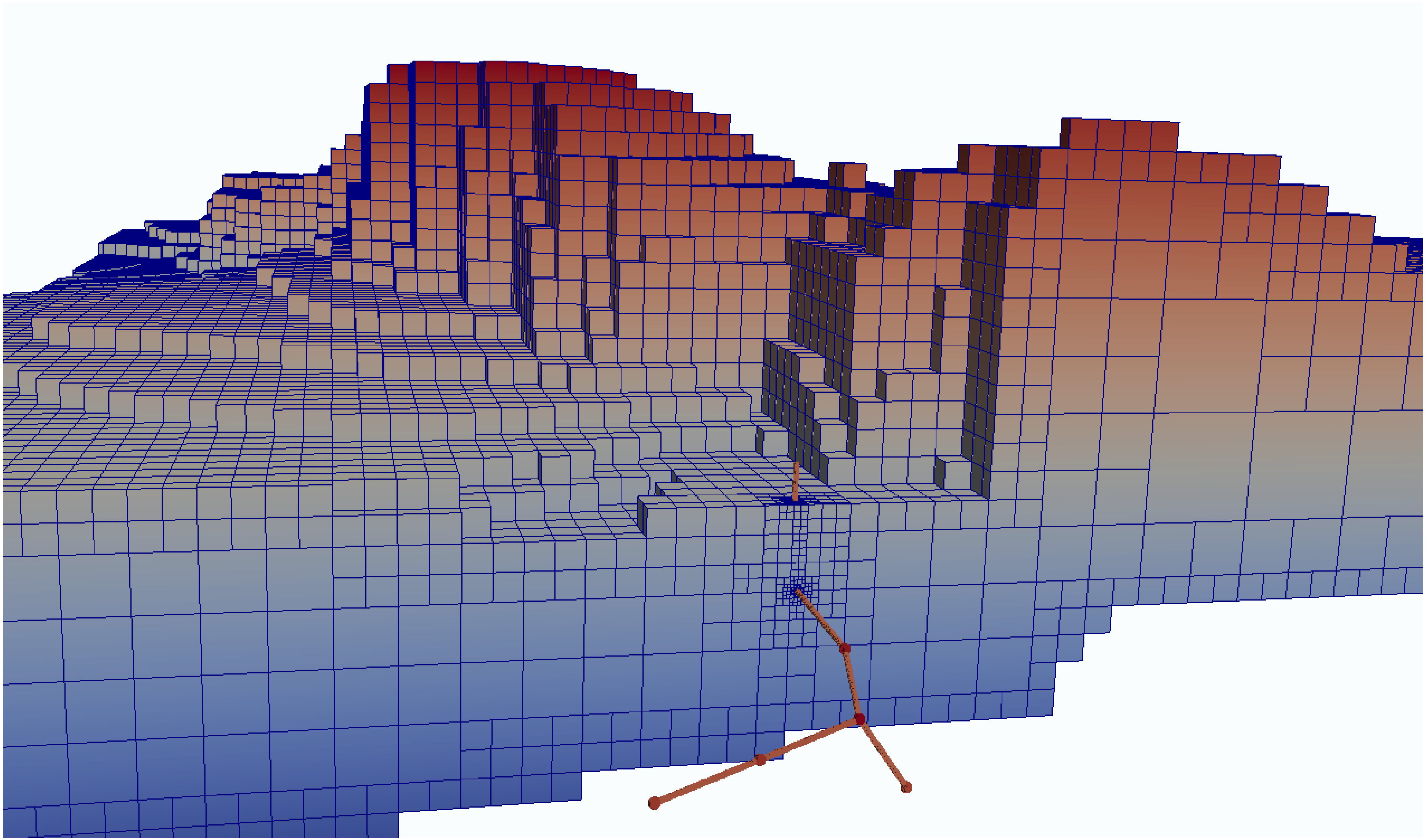

Modelización de Yacimientos de Petróleo

Aproximación *Octree* de un Estrato del Subsuelo y de Pozos

Proyecto de la CONACYT mexicana 2012-2015

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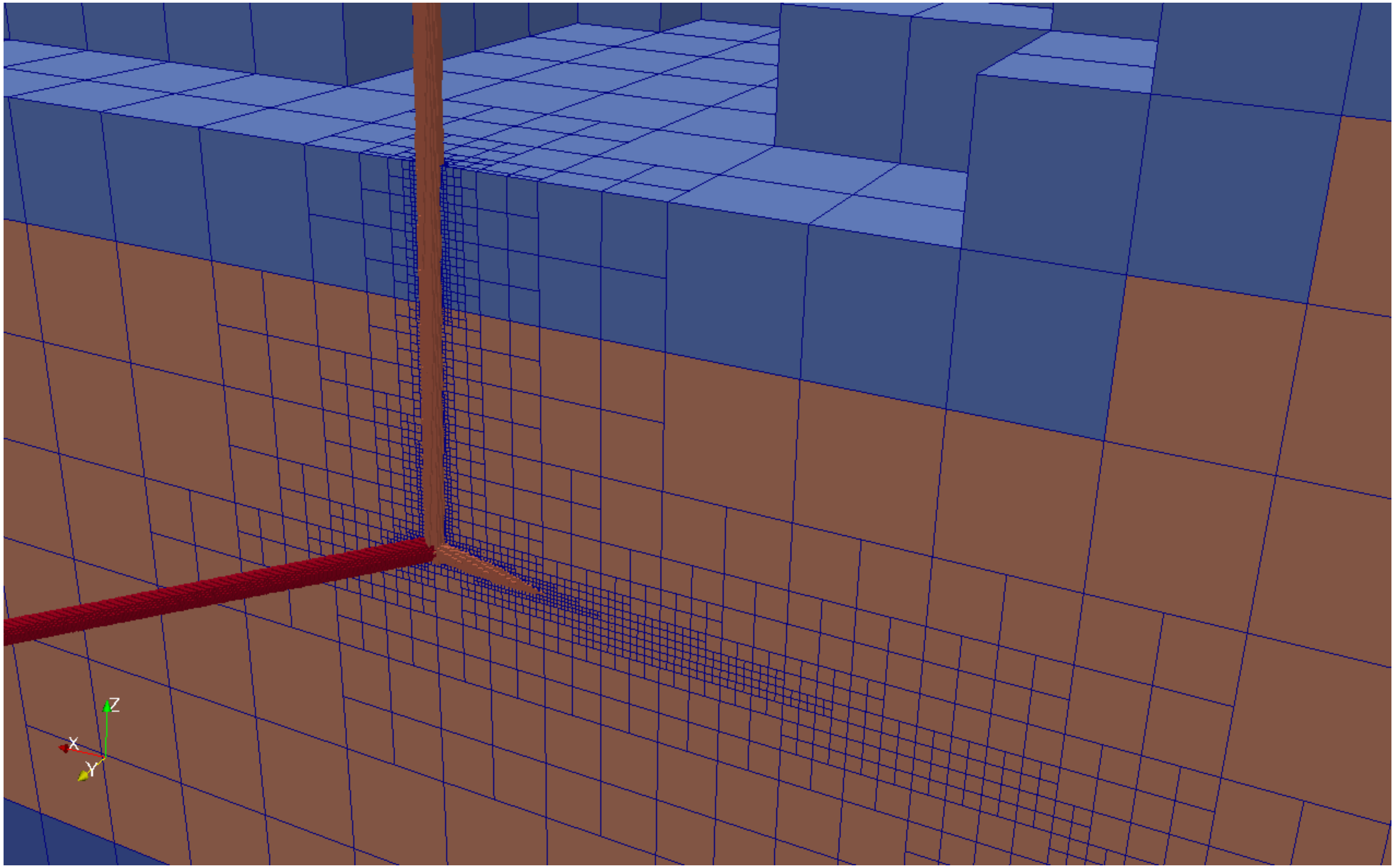
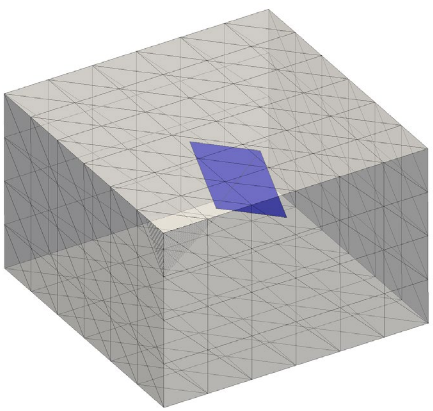


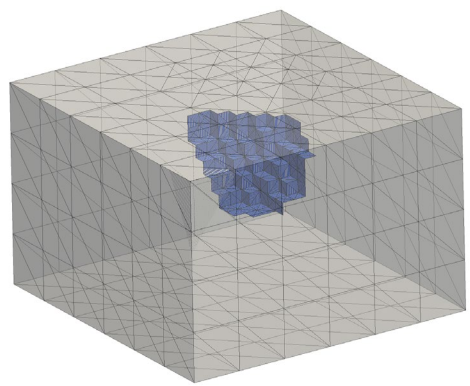
Insertion of Surfaces Into a Meccano Mesh (IJNME 2017)

Algorithm steps

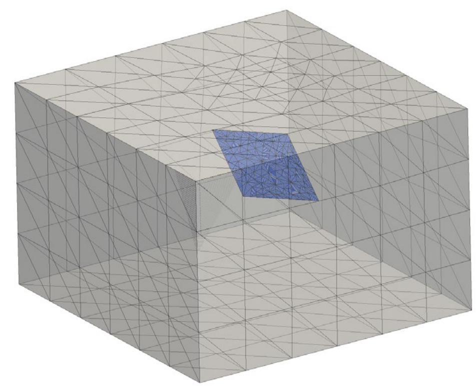
- **Initial approximation**: Mesh-surface intersection → Volumetric Approximation → Surface approximation
- **Parameterization**: Surface parameterization → Approximation parameterization
- **Smoothing**: Projection → SUS



Real surface
(input data)



Initial rough
approximation

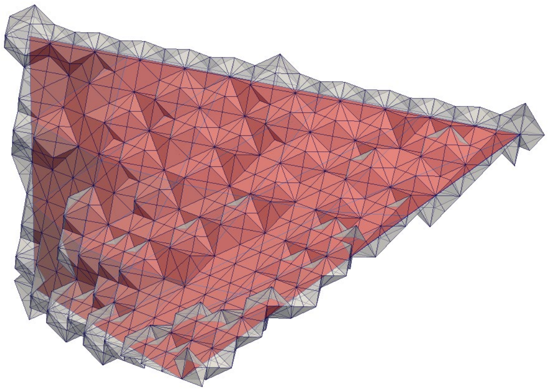


Surface projection
and smoothing

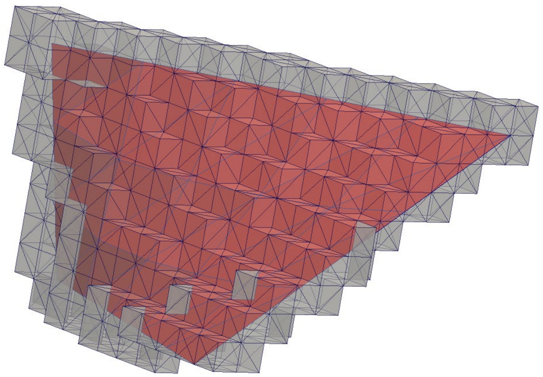
Surface initial approximation

Volumetric and surface approximations

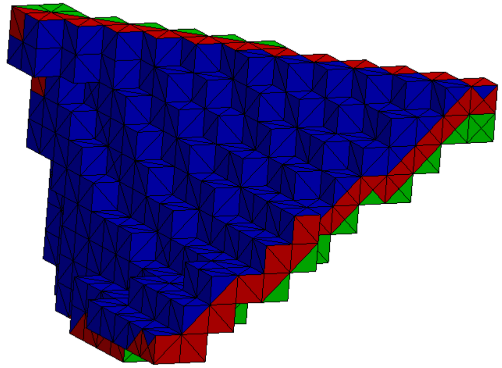
1. Refinement around immerse surface



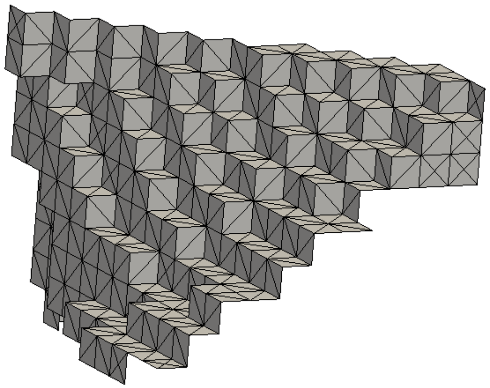
2. Repair volumetric approximation



3. Select faces on one of the sides

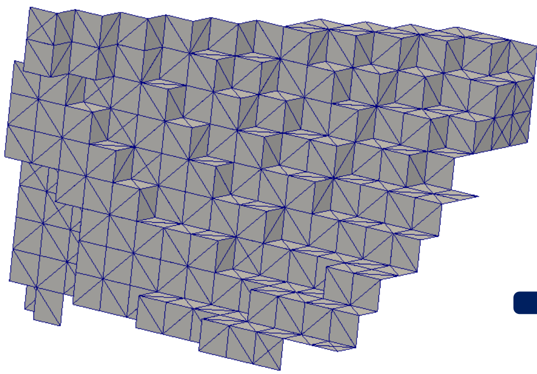


4. Repair surface approximation

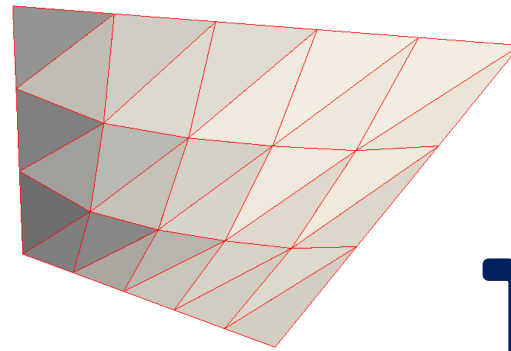


Surface parameterizations

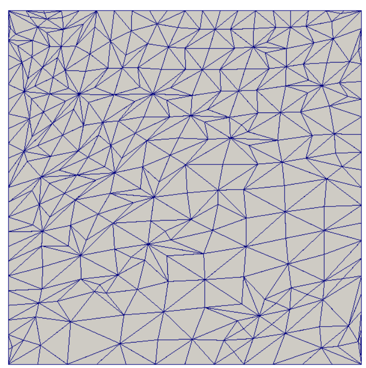
Parameterization of actual surface and its approximation



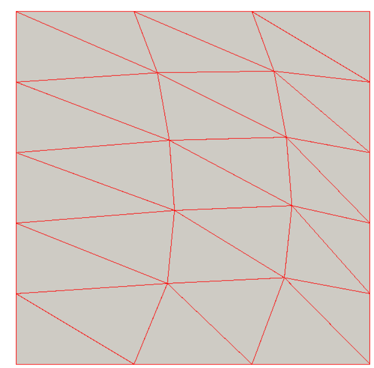
approximation (physical domain)



surface (physical domain)



approximation (parametric domain)

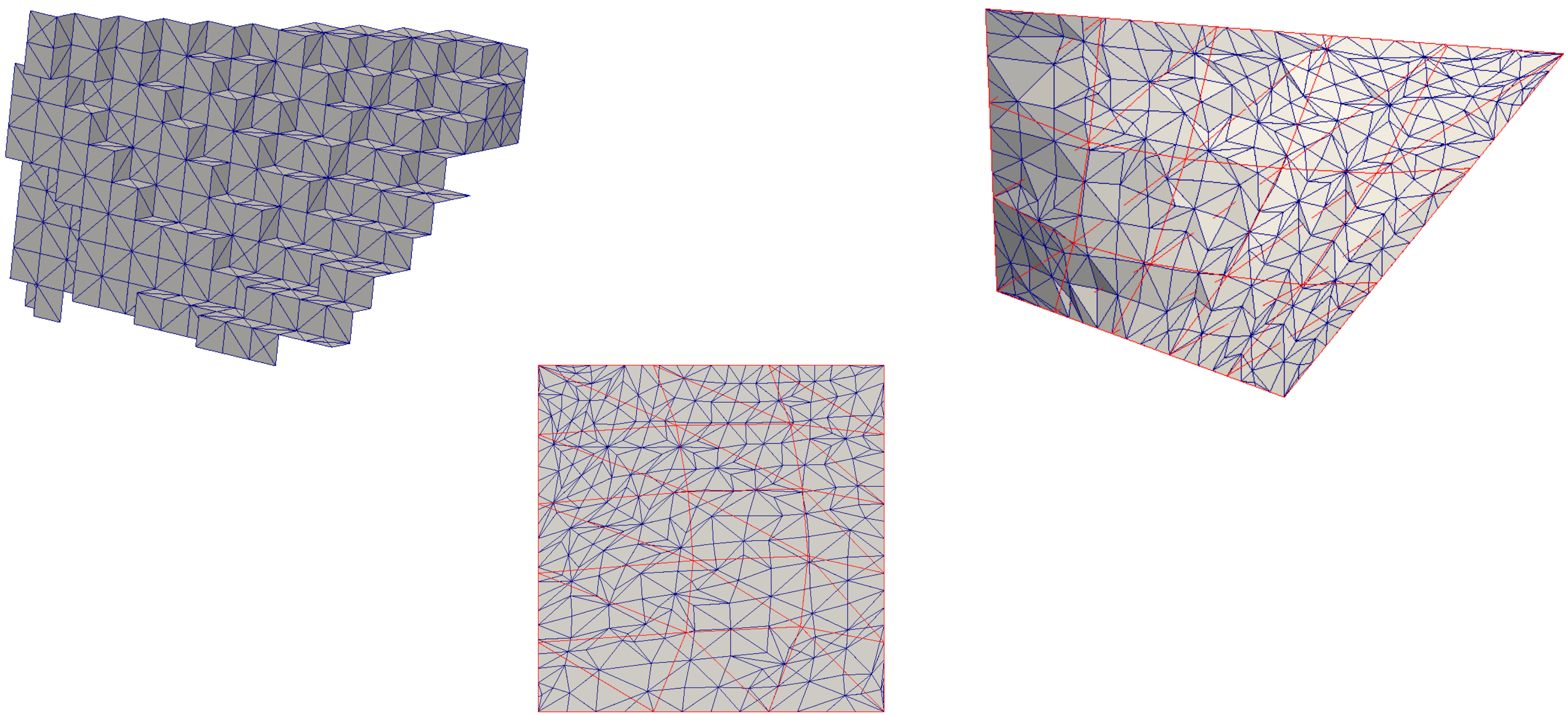


surface (parametric domain)

Projection

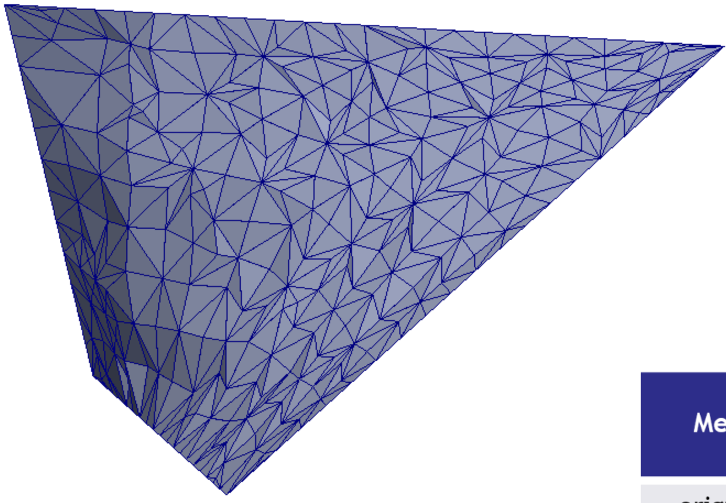
Simultaneous parameterization to project nodes

- **Simultaneous parameterization of the immerse surface and its initial approximation to the same parametric domain provides an initial location for nodes in the actual surface.**



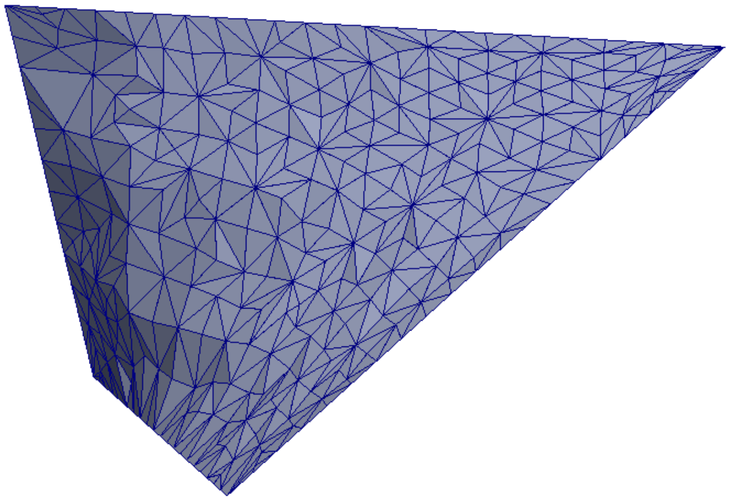
SUS of the 3-D mesh. Surface nodes move on surfaces

Surface approximation. Triangle Quality.

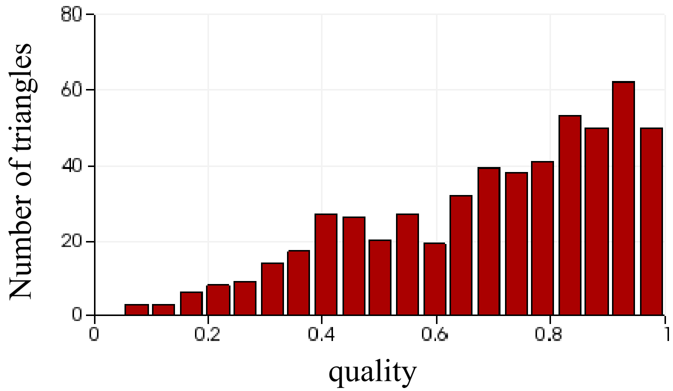


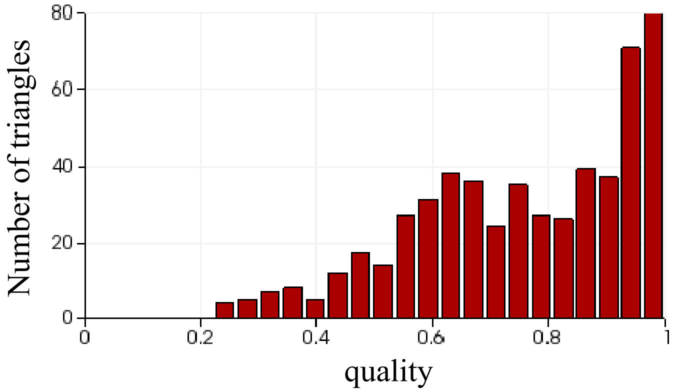
Before

Mesh	Triangle quality		
	Min	Mean	Max
original	0.050	0.694	0.999
smoothed	0.221	0.755	0.999



After

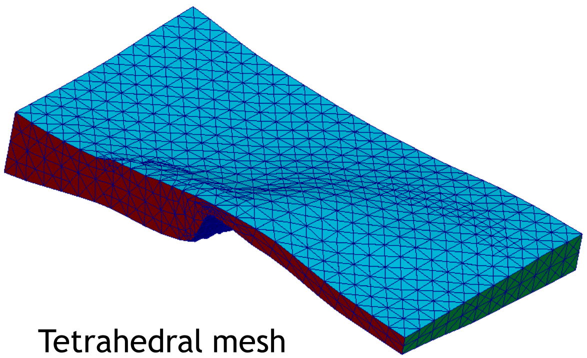




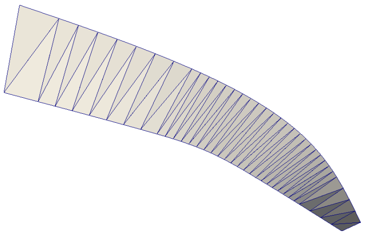
Application to Fault Approximations in an Oil Field

Goal: Capture a fault in a subsoil stratum

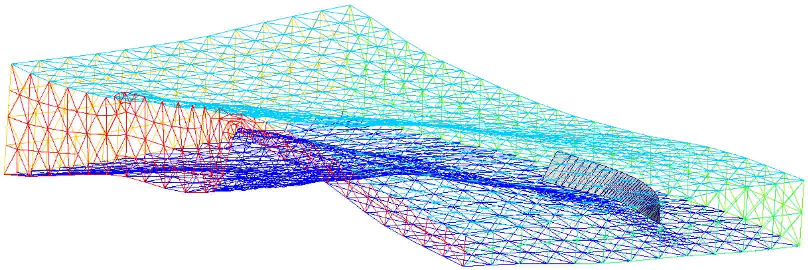
- **Input data**
  - Meccano tetrahedral mesh of the oil field
  - Immerse surface description



Tetrahedral mesh



Detail of fault triangulation

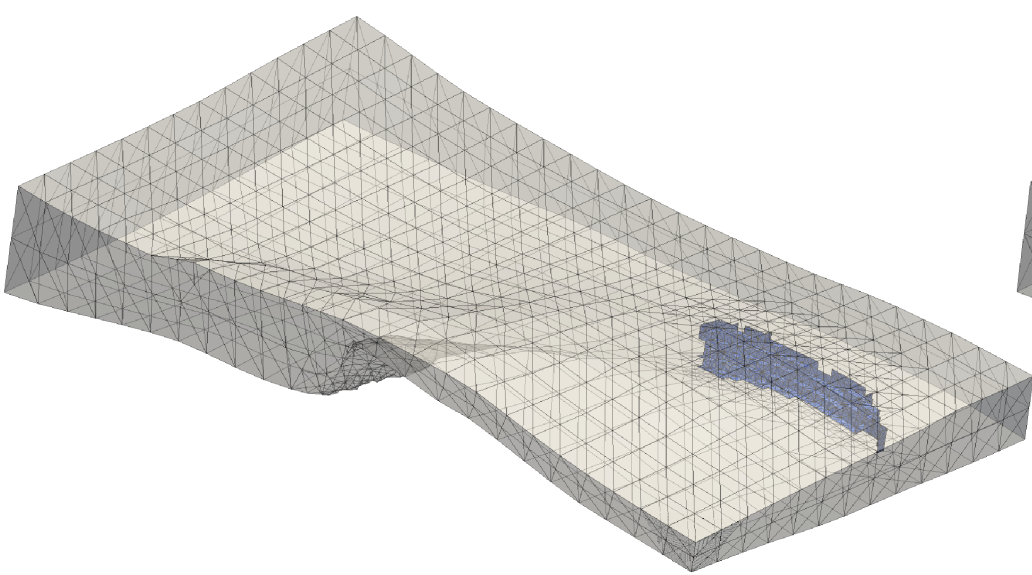


Immersed fault surface

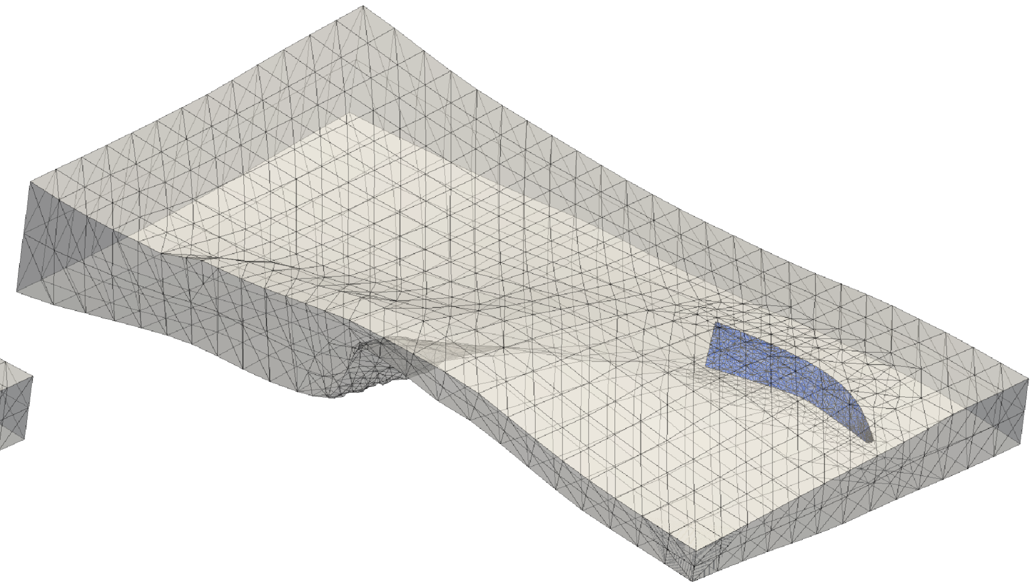
- **Output requirements**
  - Good quality tetrahedral mesh and smooth surface approximation
  - The triangles of the surface approximation are faces of the tetrahedral mesh.

Application to Fault Approximations in an Oil Field

Goal: Capture a fault in a subsoil stratum



Rough approximation



Smooth approximation

Mesh size
5850 nodes
25559 cells

Cell quality		
Min	Mean	Max
0,209	0,725	0,983

Application to Fault Approximations in an Oil Field

Goal: Capture a fault in a subsoil stratum

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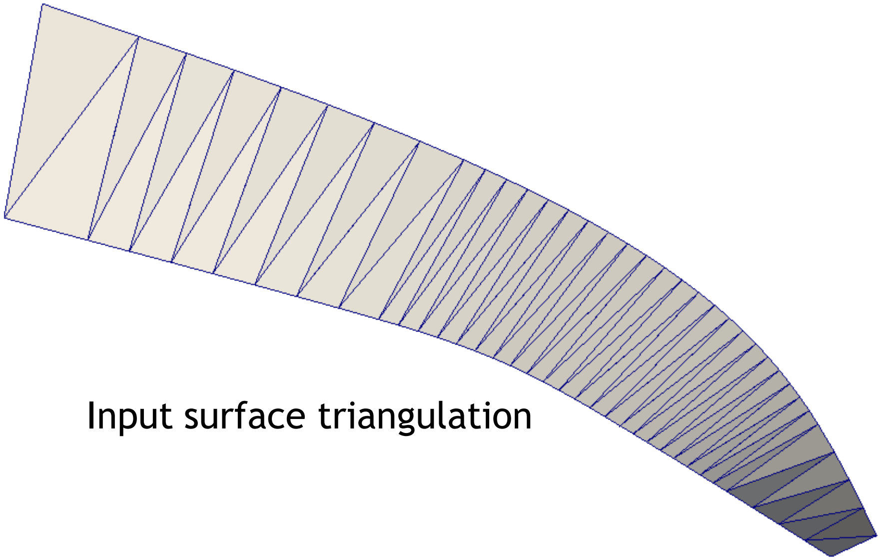
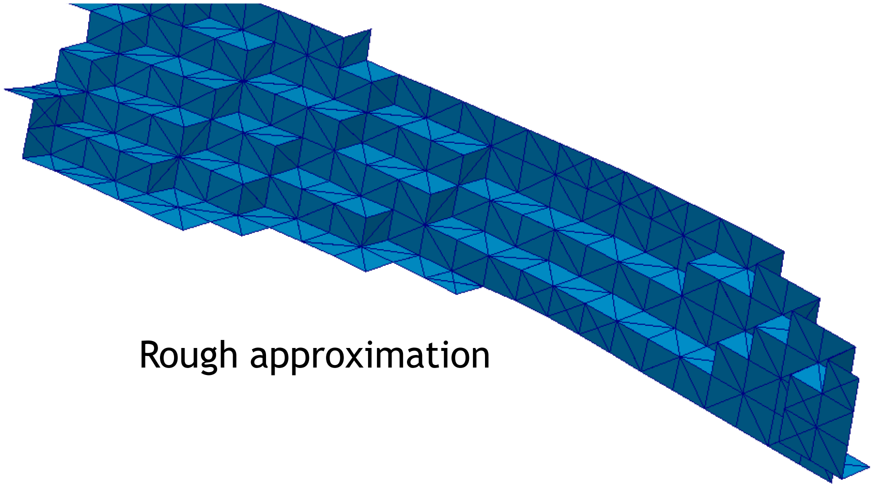
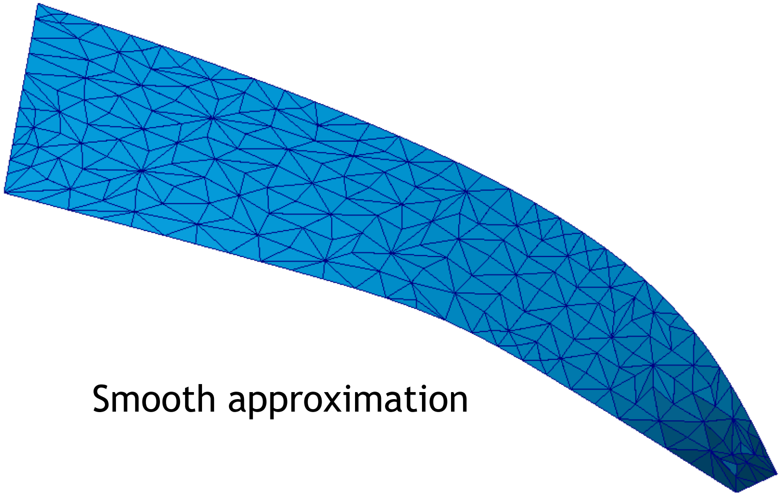


Input surface triangulation

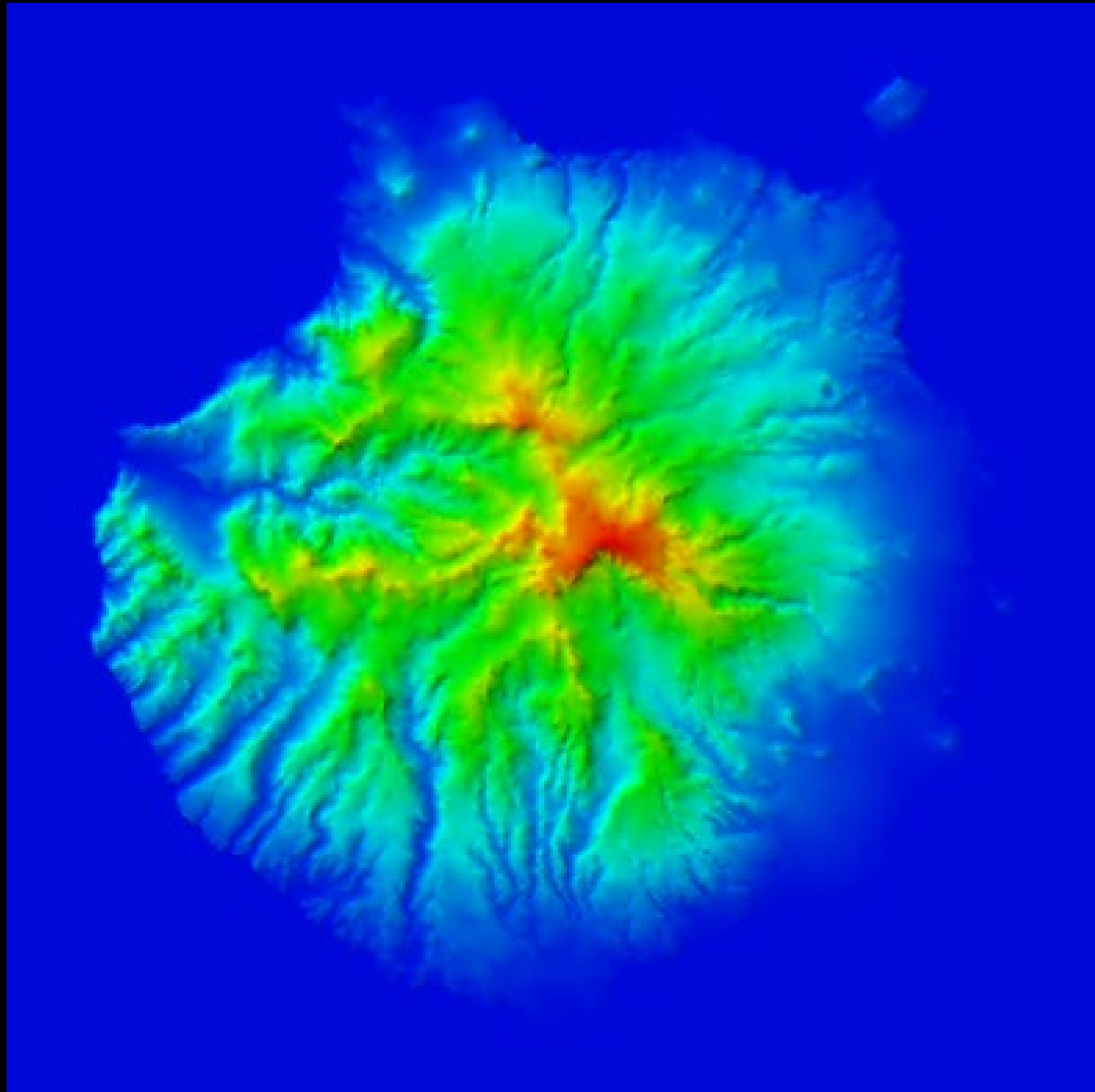


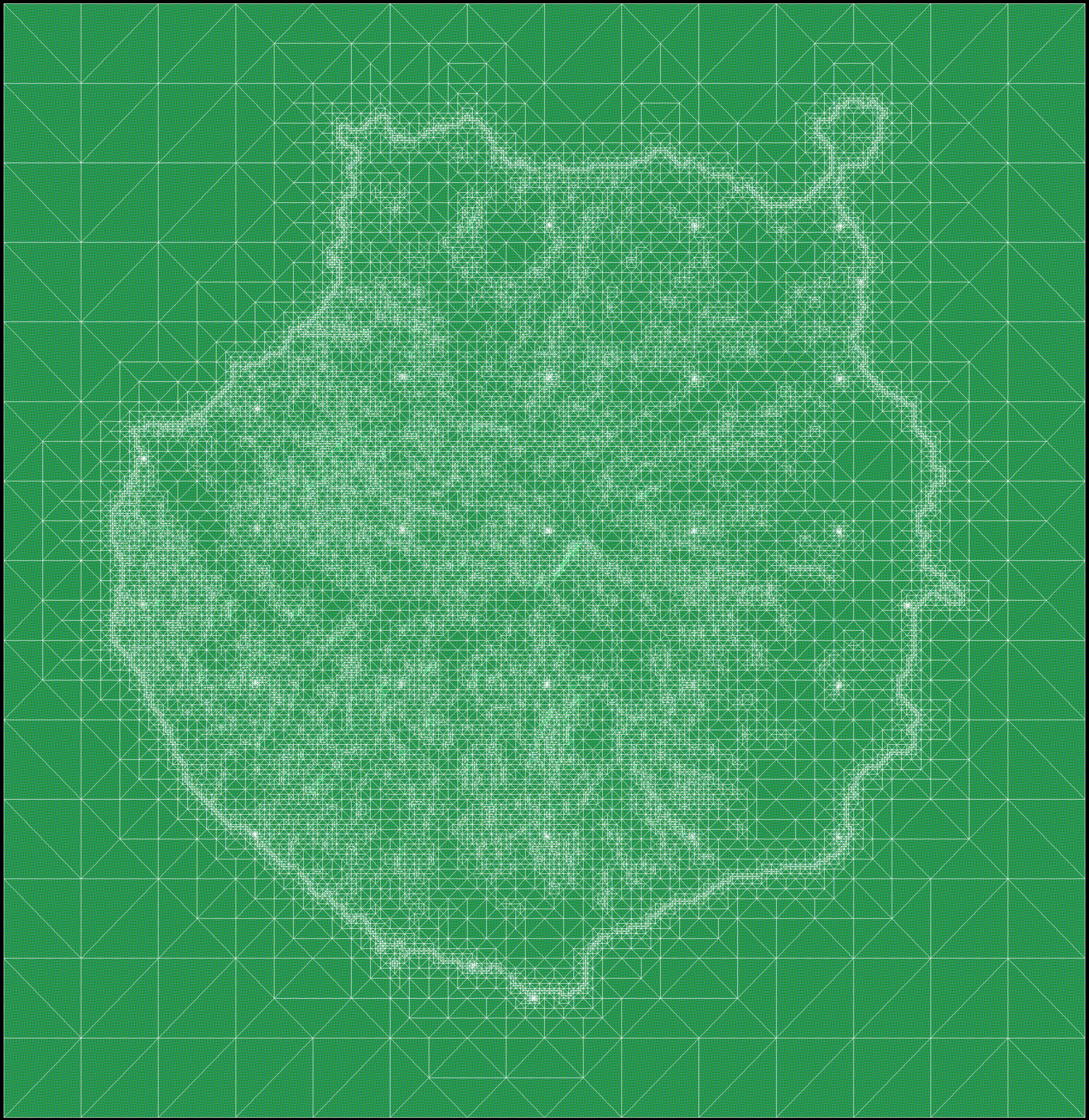
Rough approximation

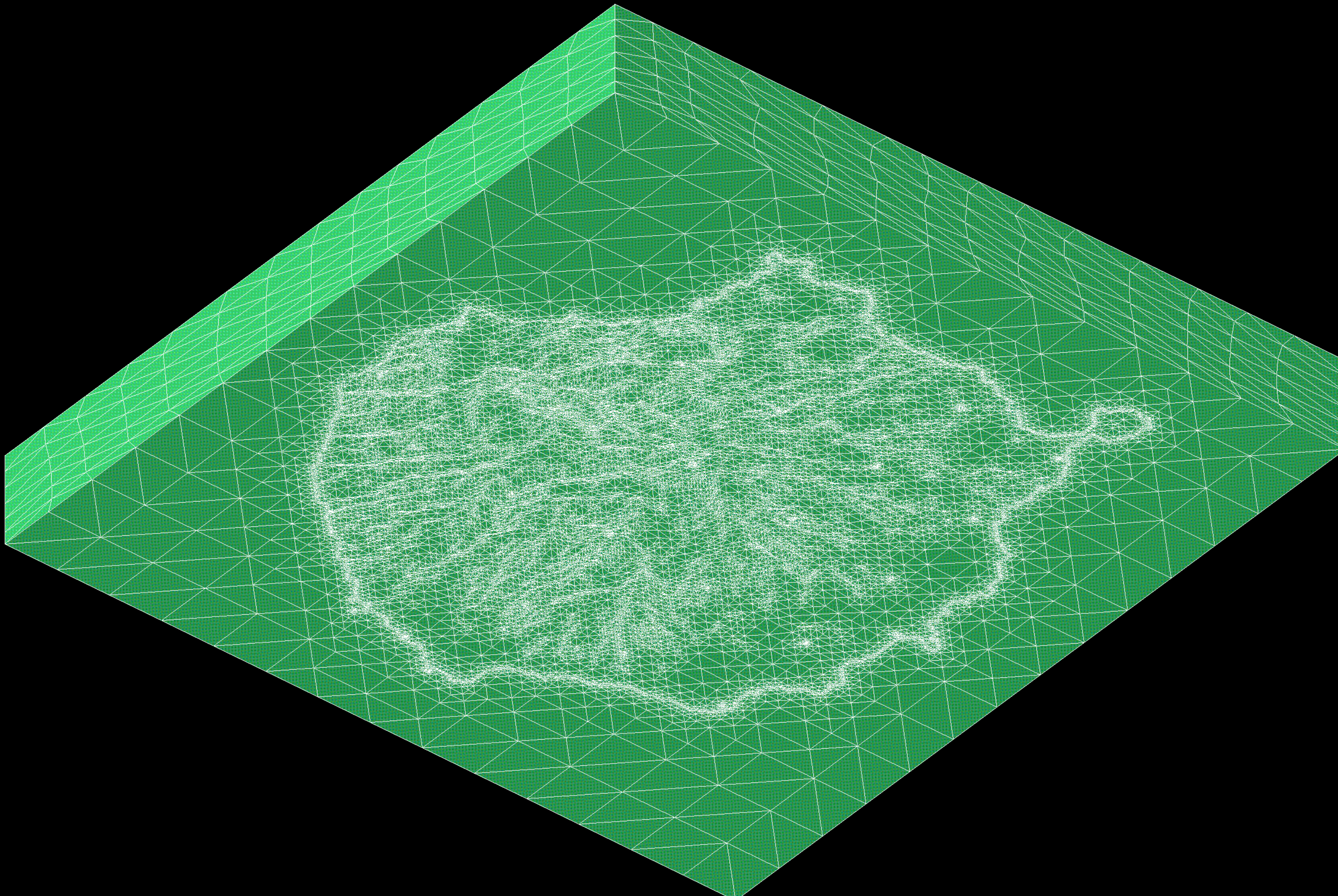


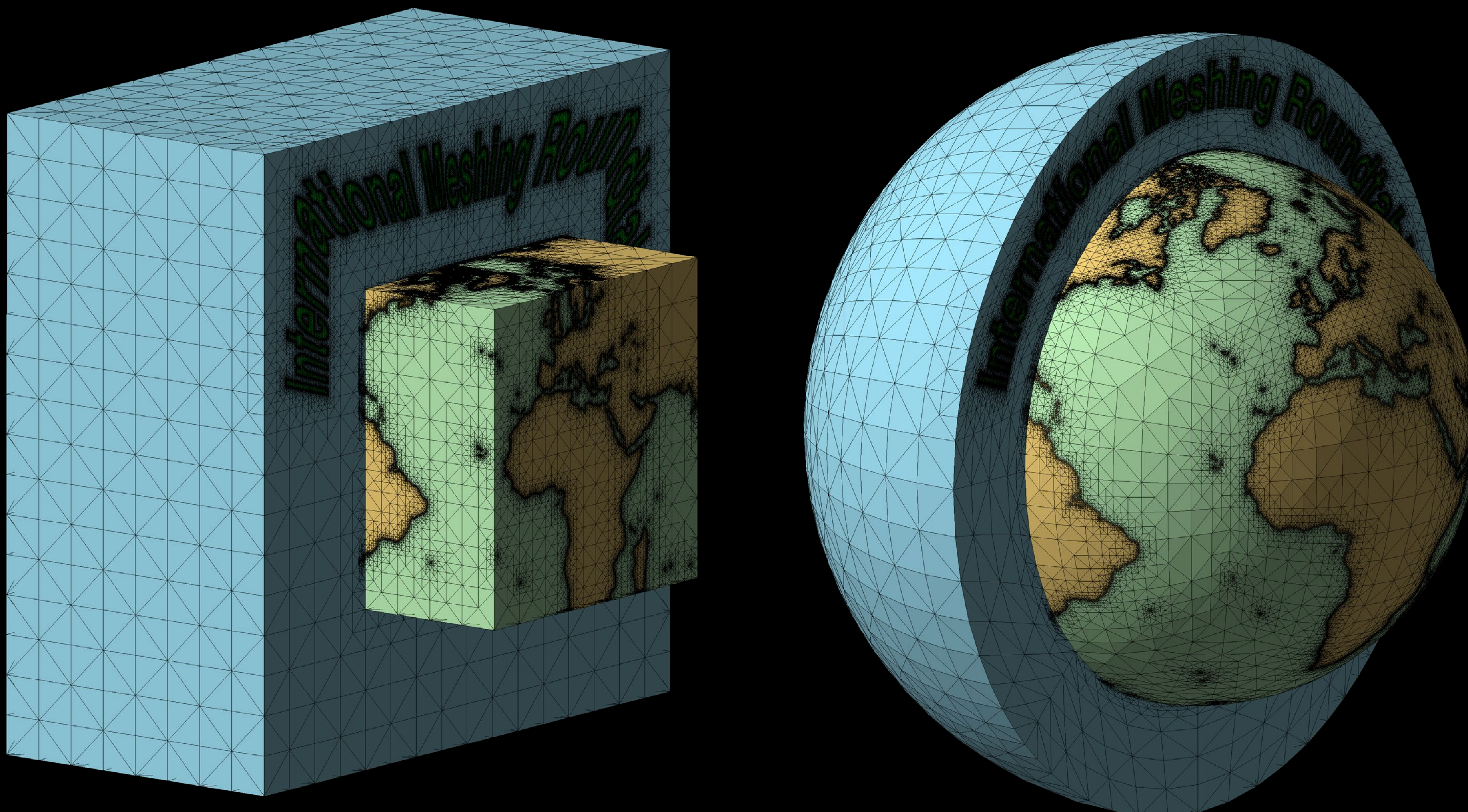
Smooth approximation

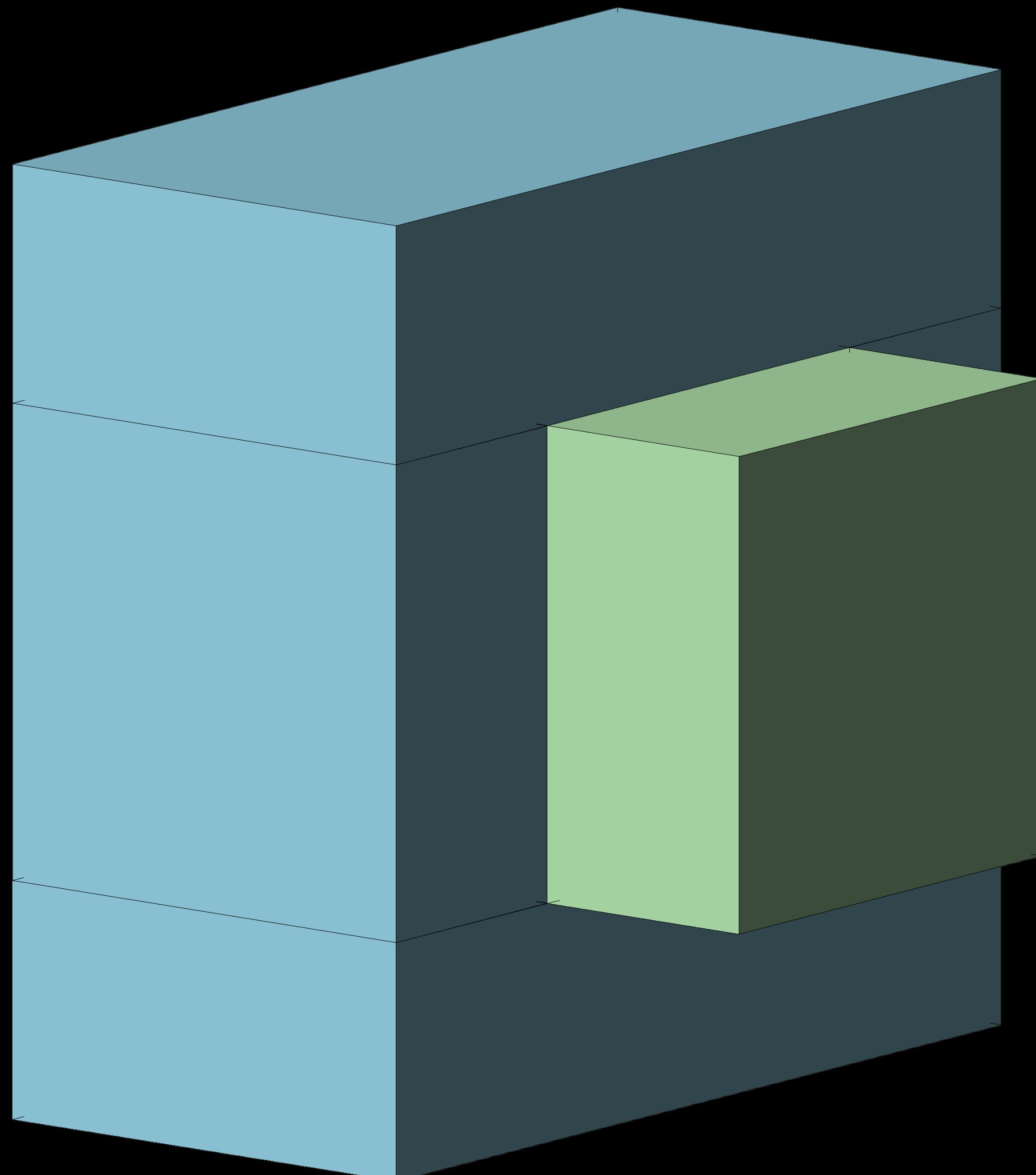

Las Palmas de Gran Canaria

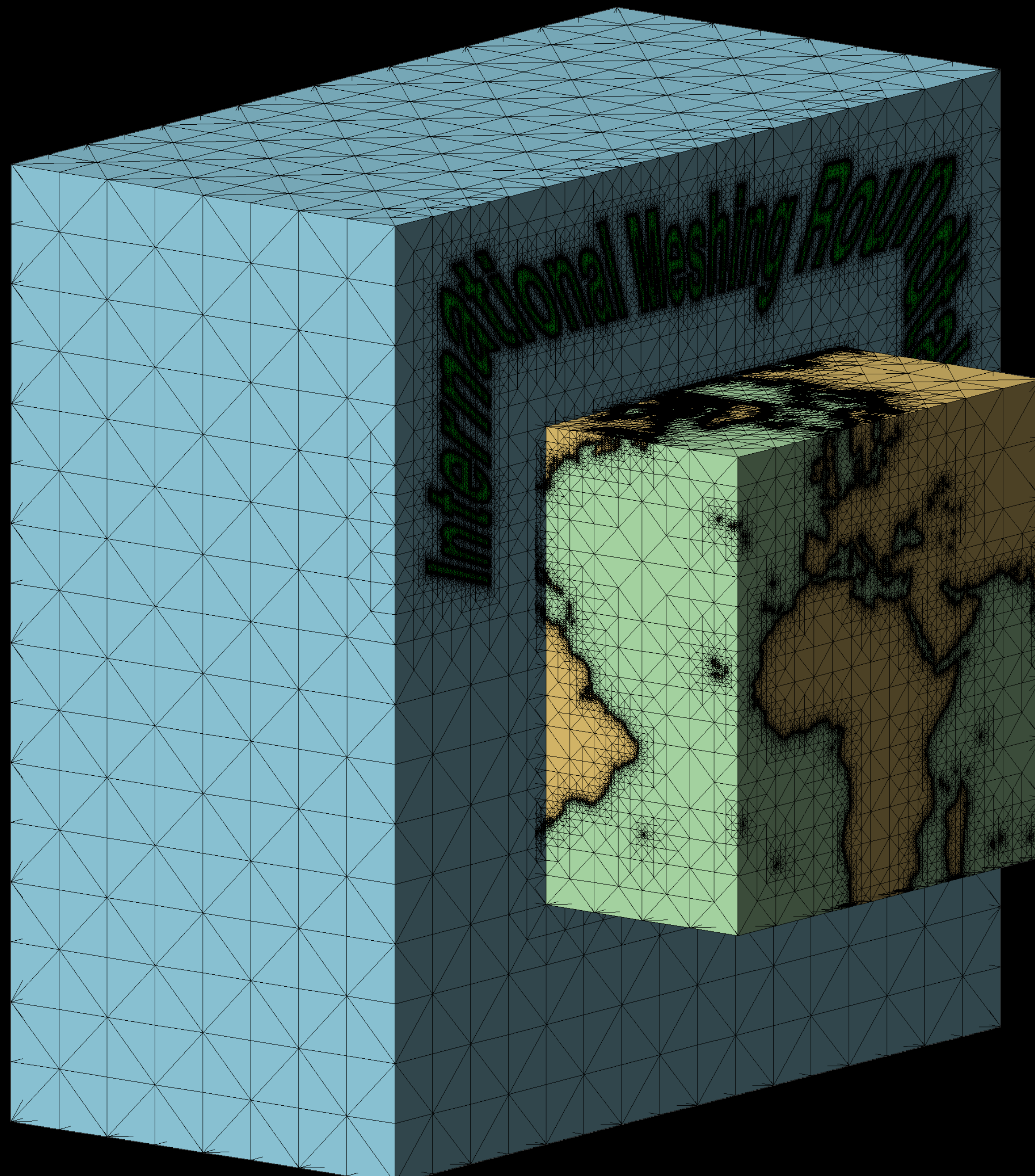


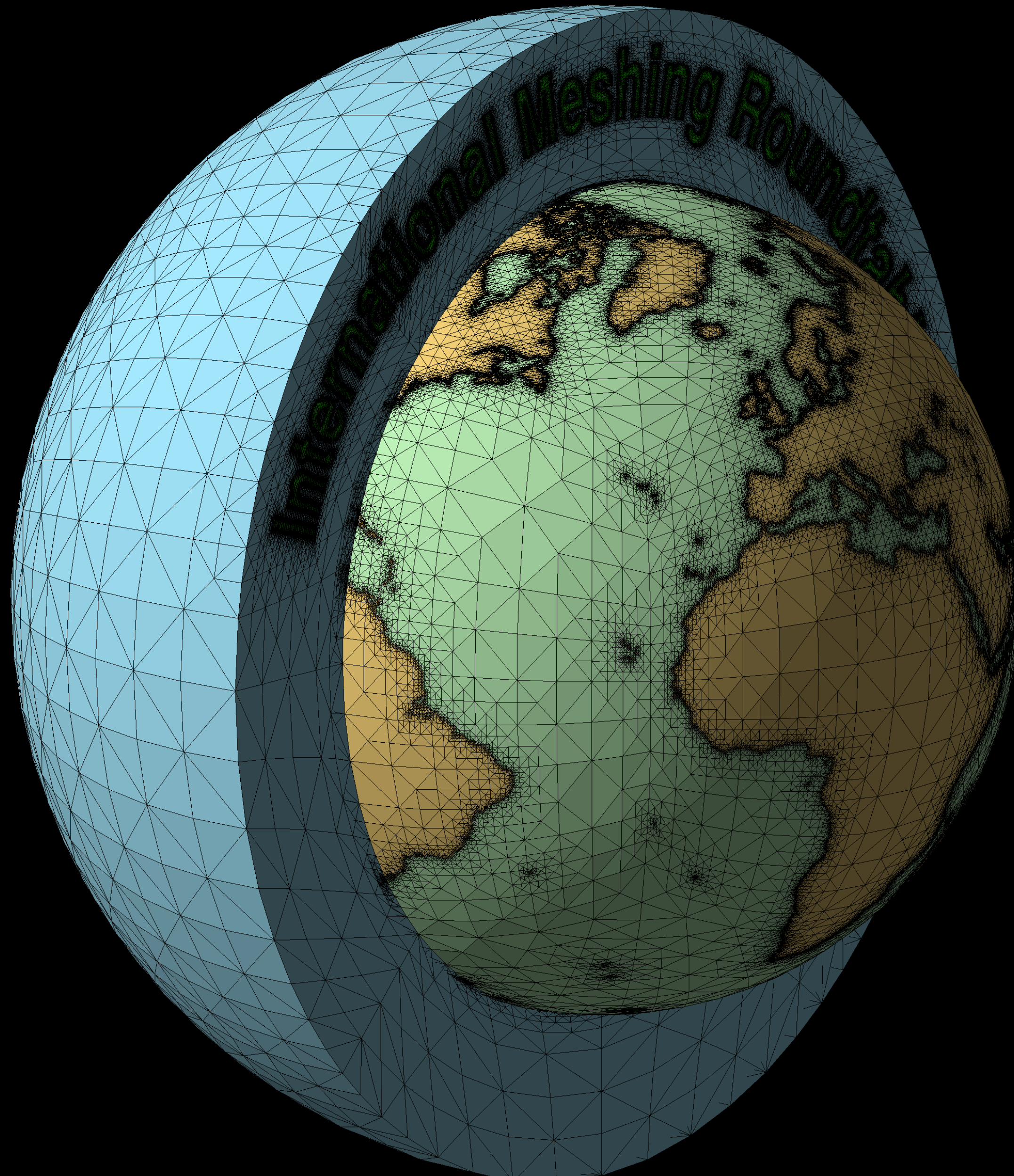


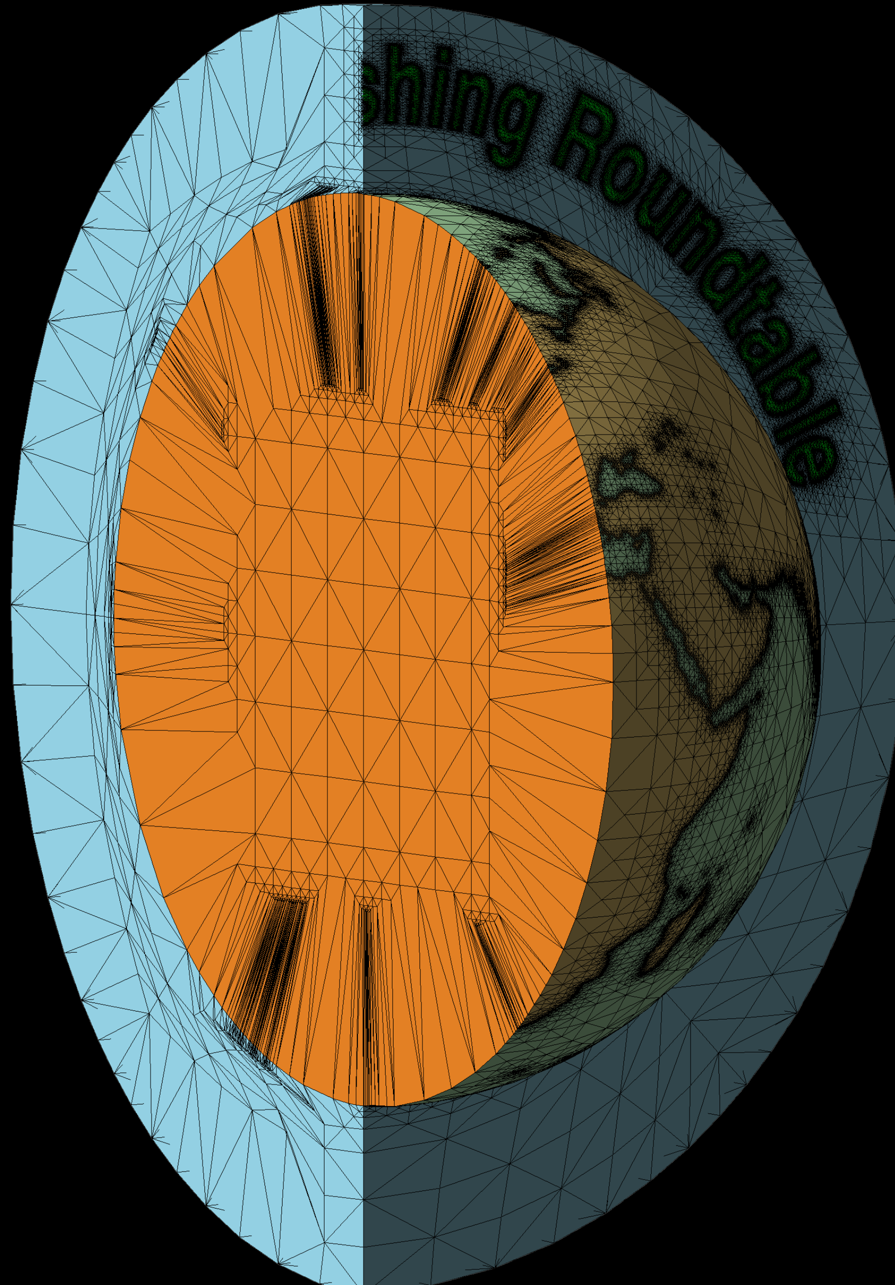


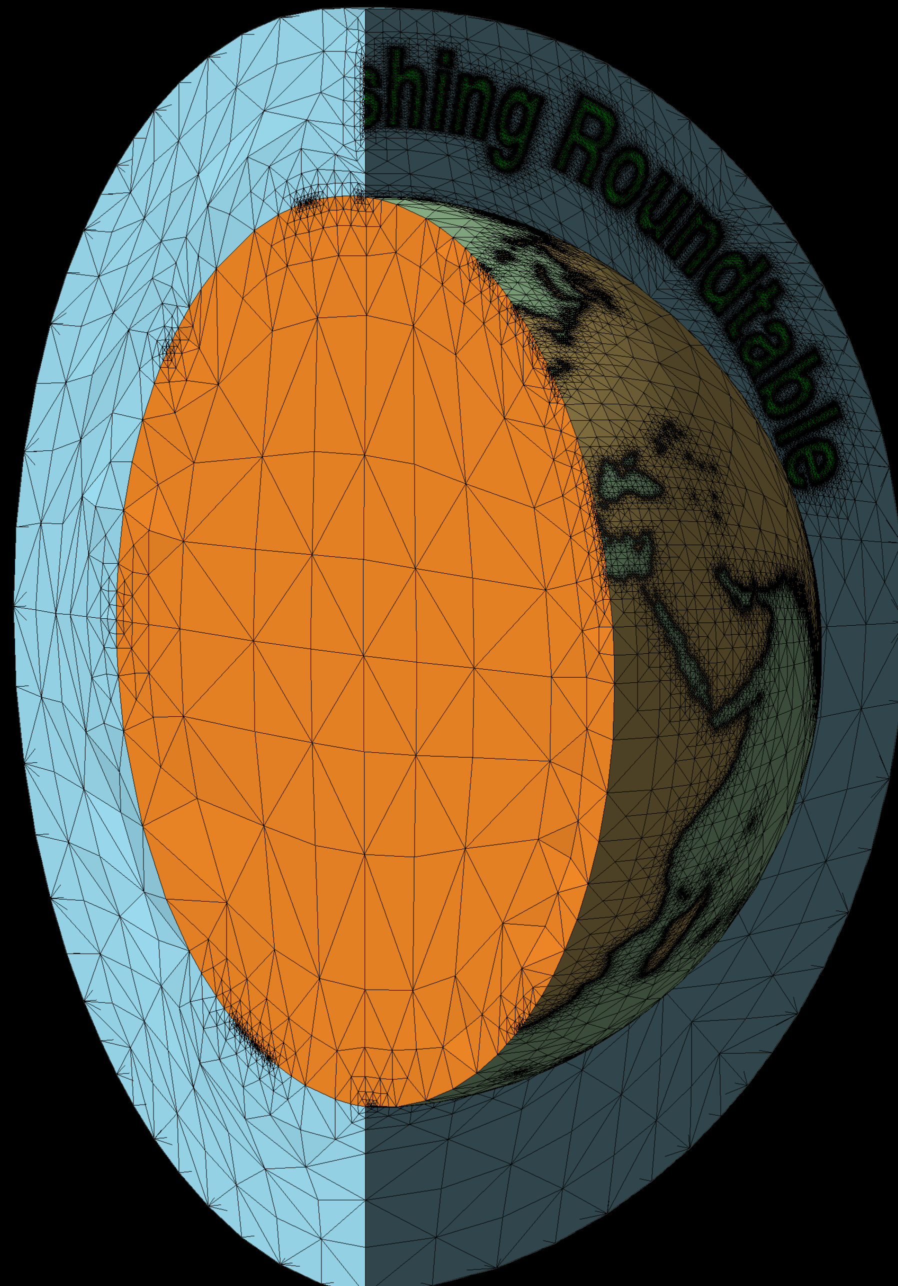

International Meshing
International Meshing

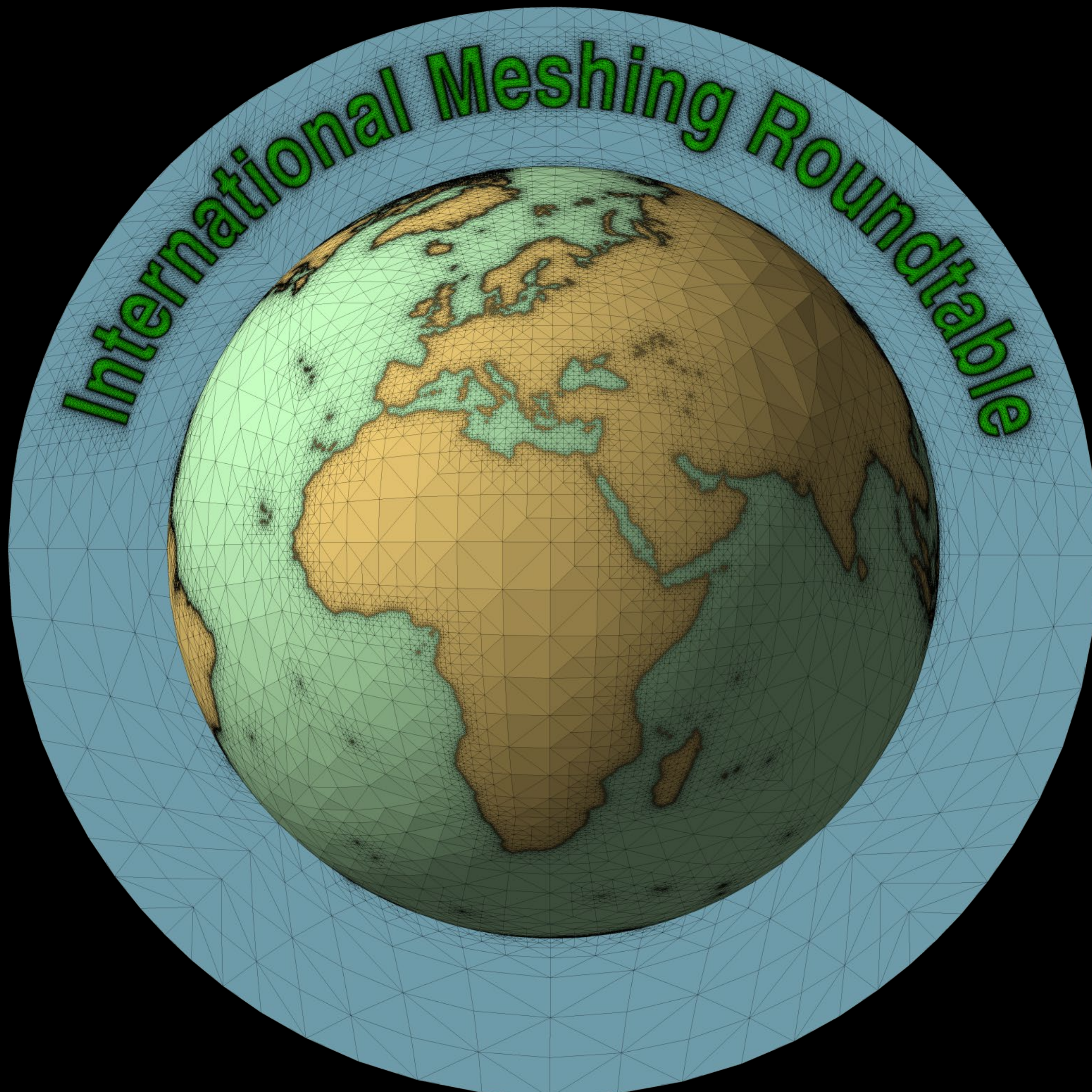



International Meshing


International Meshing Roundta

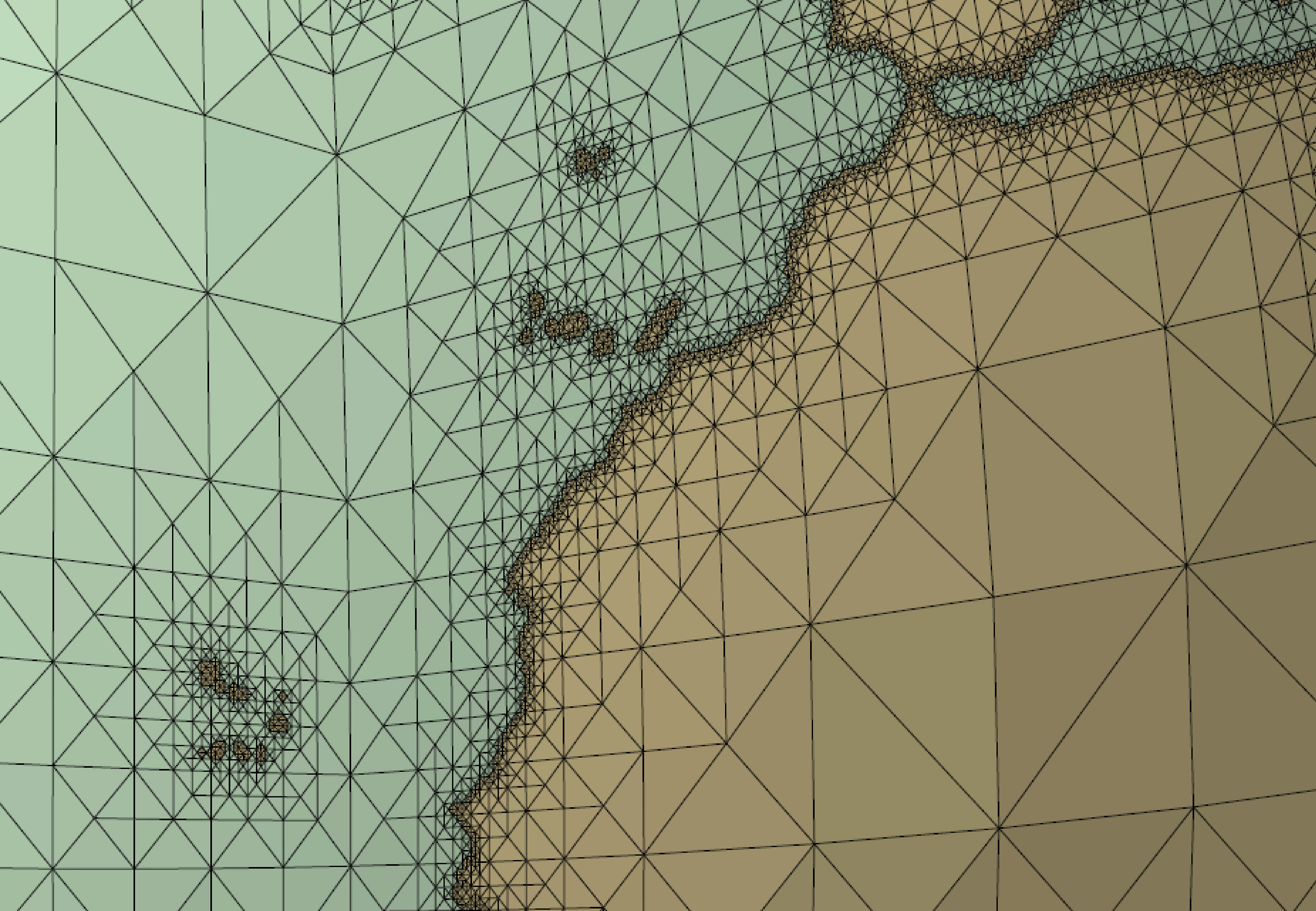

shing Roundtable


shing Roundtable


International Meshing Roundtable

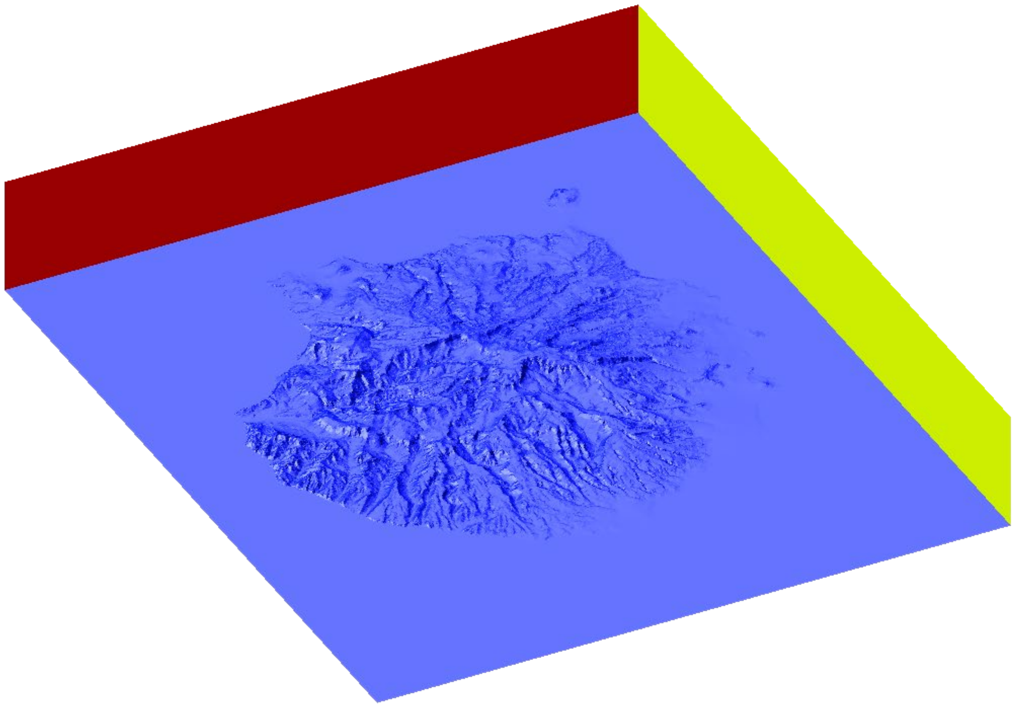
Universidad de Las Palmas de Gran Canaria

www.ulpgc.es

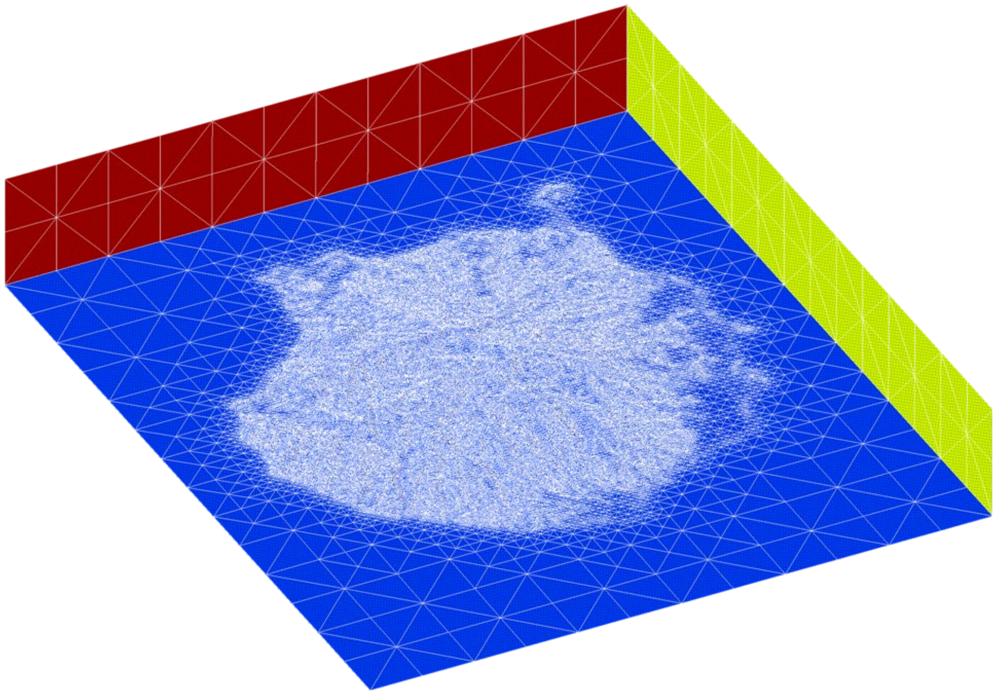


Automatic Meccano Method over Complex Terrain

Gran Canaria Island



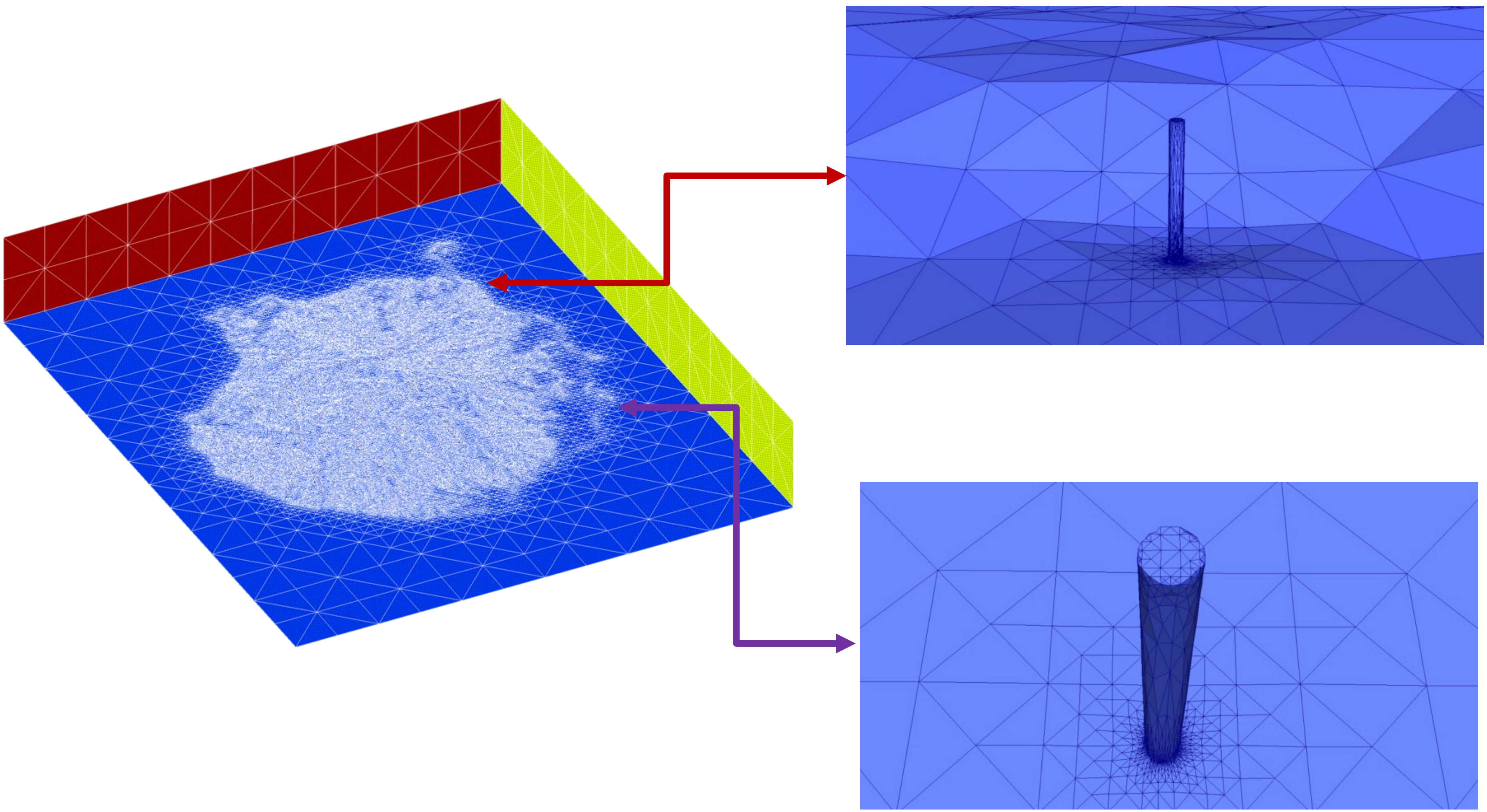
Orography



Tetrahedral mesh

Automatic Meccano Method over Complex Terrain

Gran Canaria Island



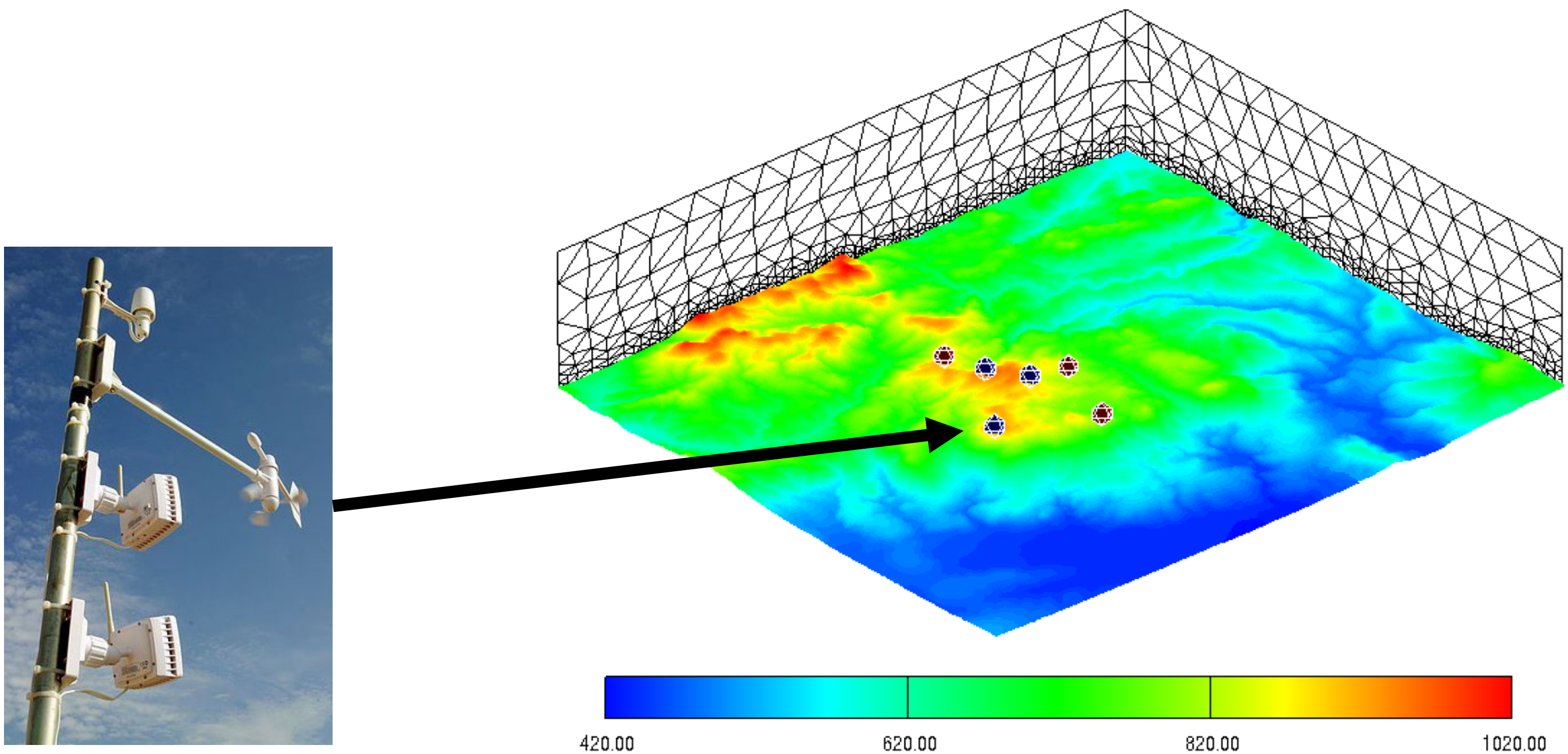

Campos de Viento

Mass Consistent Wind Model

Mathematical aspects

Let $\Omega \subset R^3$ be a domain with boundary $\Gamma = \Gamma_a \cup \Gamma_b$

$\mathbf{u}_0 = (u_0, v_0, w_0)$: observed wind, which is obtained with horizontal interpolation and vertical extrapolation of experimental or forecasted data.



Mass Consistent Wind Model

Mathematical aspects

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Let $\Omega \subset R^3$ be a domain with boundary $\Gamma = \Gamma_a \cup \Gamma_b$

$\mathbf{u}_0 = (u_0, v_0, w_0)$: observed wind, which is obtained with horizontal interpolation and vertical extrapolation of experimental or forecasted data.

Objective: find the velocity field $\mathbf{u}$ that it adjusts to $\mathbf{u}_0$ verifying

- Incompressibility condition in the domain: $\nabla \cdot \mathbf{u} = 0 \quad \text{in } \Omega$
- Impermeability condition on the terrain: $\mathbf{n} \cdot \mathbf{u} = 0 \quad \text{on } \Gamma_a$

- Then, $\mathbf{u}$ is the solution of the least-square problem: Find $\mathbf{u} \in K$ verifying

$$\begin{cases} E(\mathbf{u}) = \min\limits_{\mathbf{v} \in K} E(\mathbf{v}) \\ K = \left\{ \mathbf{v};\ \nabla \cdot \mathbf{v} = 0,\ \mathbf{n} \cdot \mathbf{v}\big|_{\Gamma_a} = 0 \right\} \end{cases}$$

where $E(\mathbf{v}) = \dfrac{1}{2} \displaystyle\int_\Omega (\mathbf{v} - \mathbf{u}_0)^t \, \mathbf{P} \, (\mathbf{v} - \mathbf{u}_0) \, d\Omega$

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- Lagrange multiplier technique is used to solve this problem. So, if we introduce

$$L(\mathbf{v}, \lambda) = E(\mathbf{v}) + \int_{\Omega} \lambda \nabla \cdot \mathbf{v} \, d\Omega$$

its saddle point $(\mathbf{u}, \phi)$ verifies the Euler-Lagrange equations:

$$-\nabla \cdot \left(\mathbf{P}^{-1} \nabla \phi\right) = \nabla \cdot \mathbf{u}_0 \qquad \text{in } \Omega$$

$$-\mathbf{n} \cdot \mathbf{P}^{-1} \nabla \phi = \mathbf{n} \cdot \mathbf{u}_0 \qquad \text{on } \Gamma_a$$

$$\phi = 0 \qquad \text{on } \Gamma_b$$

and, finally, the adjusted velocity field is obtained by: $\mathbf{u} = \mathbf{u_0} + \mathbf{P}^{-1} \nabla \phi$

Discontinuous in classic FEM

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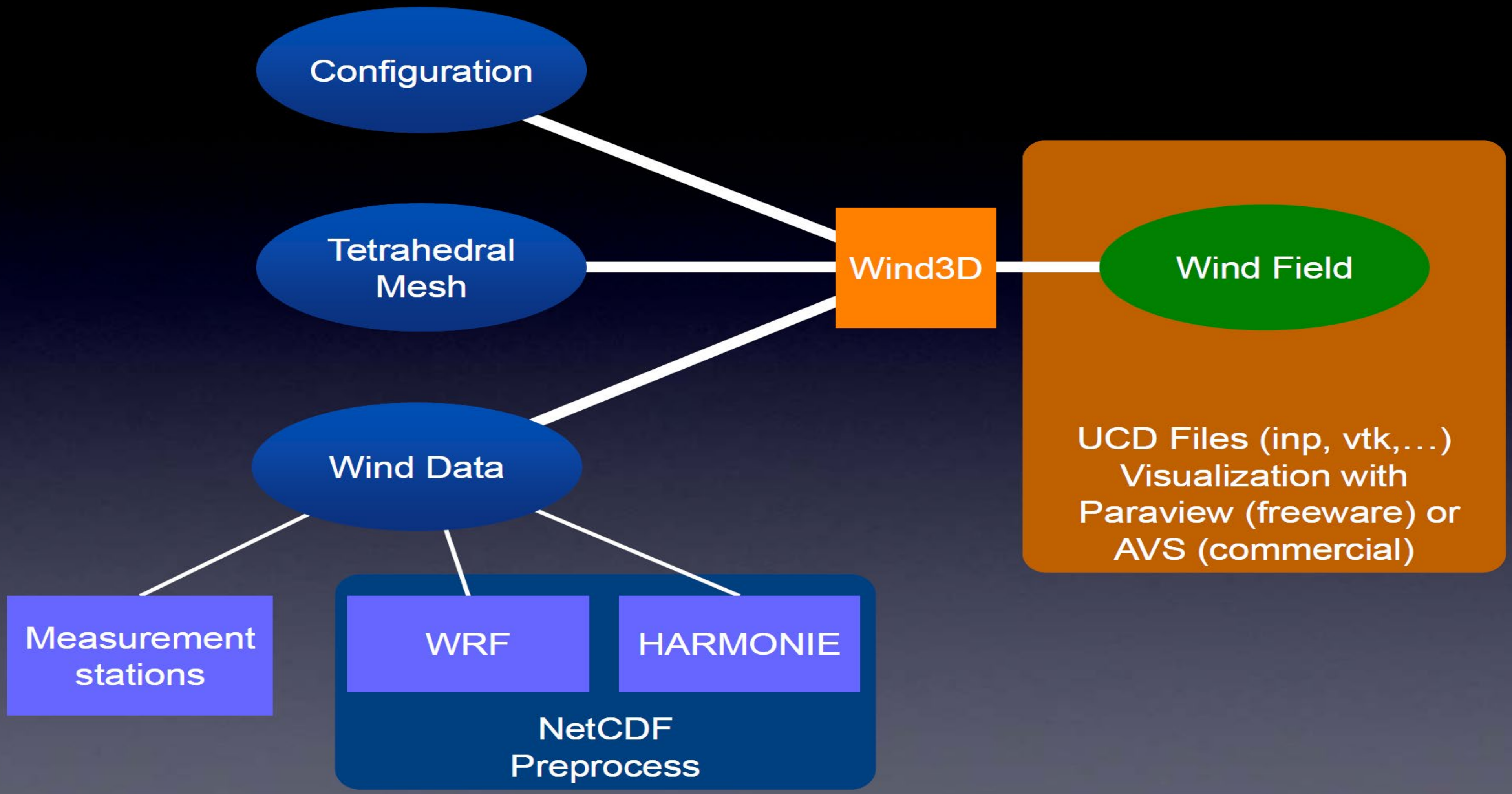
- Objetivo:
  - Construir un modelo de elementos finitos (MEF) adaptativo 3-D para mejorar las predicciones de los modelos meteorológicos
- Metodología:
  - Predicción con modelos meteorológicos (WRF, HIRLAM, HARMONIE,…) (escala de kilómetros)
  - Interpolación de los resultados en el dominio real (malla de tetraedros).
  - Ajuste del viento al campo interpolado con el modelo de masa consistente (escala de metros)

Predicción de Viento sobre Orografía Irregular

Wind3D Code (software libre)

http://www.dca.iusiani.ulpgc.es/Wind3D/



Wind3D: Wind3D - Mozilla Firefox

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www.dca.iusiani.ulpgc.es/Wind3D/en/

modelo meteorológico mesoscala

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Español

Wind3D 1.0

Mass consistent wind field computation

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- Wind3D
  - Data Structures
  - Files
    - File List
    - Globals
      - All
      - Functions
      - Variables
      - Typedefs
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      - Macros

Wind3D

Introduction

Wind3D is a software that simulates a 3D wind field over complex terrains using an adaptive mass consistent model. The software can use as forecast weather models results, station measured wind data or an interpolated wind field.

Information

Title: Wind3D
Registration application number: GC-96-2012.
Registration entry: 00 / 2012 / 2506
Date: February 23rd, 2012.
Owner organization: Universidad de Las Palmas de Gran Canaria.

Authors

Eduardo Rodríguez Barrera, Gustavo Montero García, José María Escobar Sánchez, Rafael Montenegro Armas, Albert Oliver Serra

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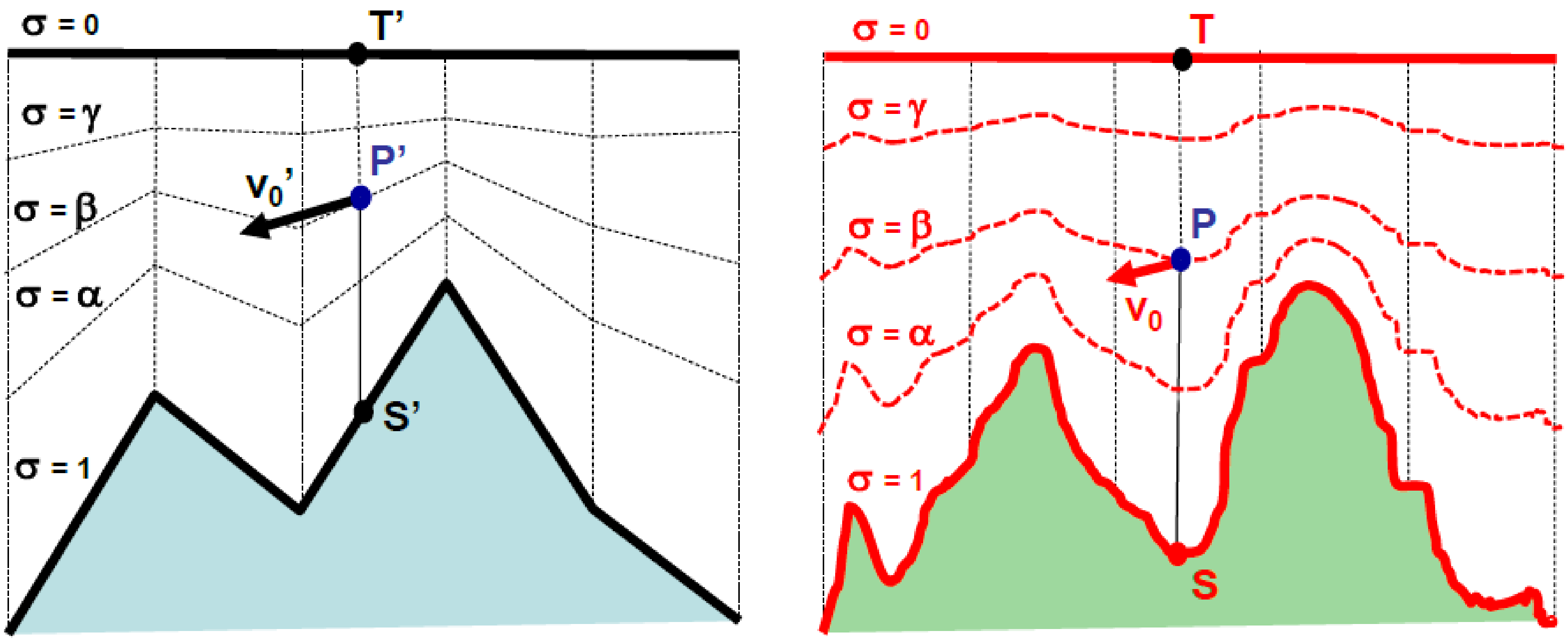
http://www.dca.iusiani.ulpgc.es/Wind3D/

HARMONIE Meteorological Model

Data interpolation in FE domain: Problems with terrain discretization



HARMONIE FD domain

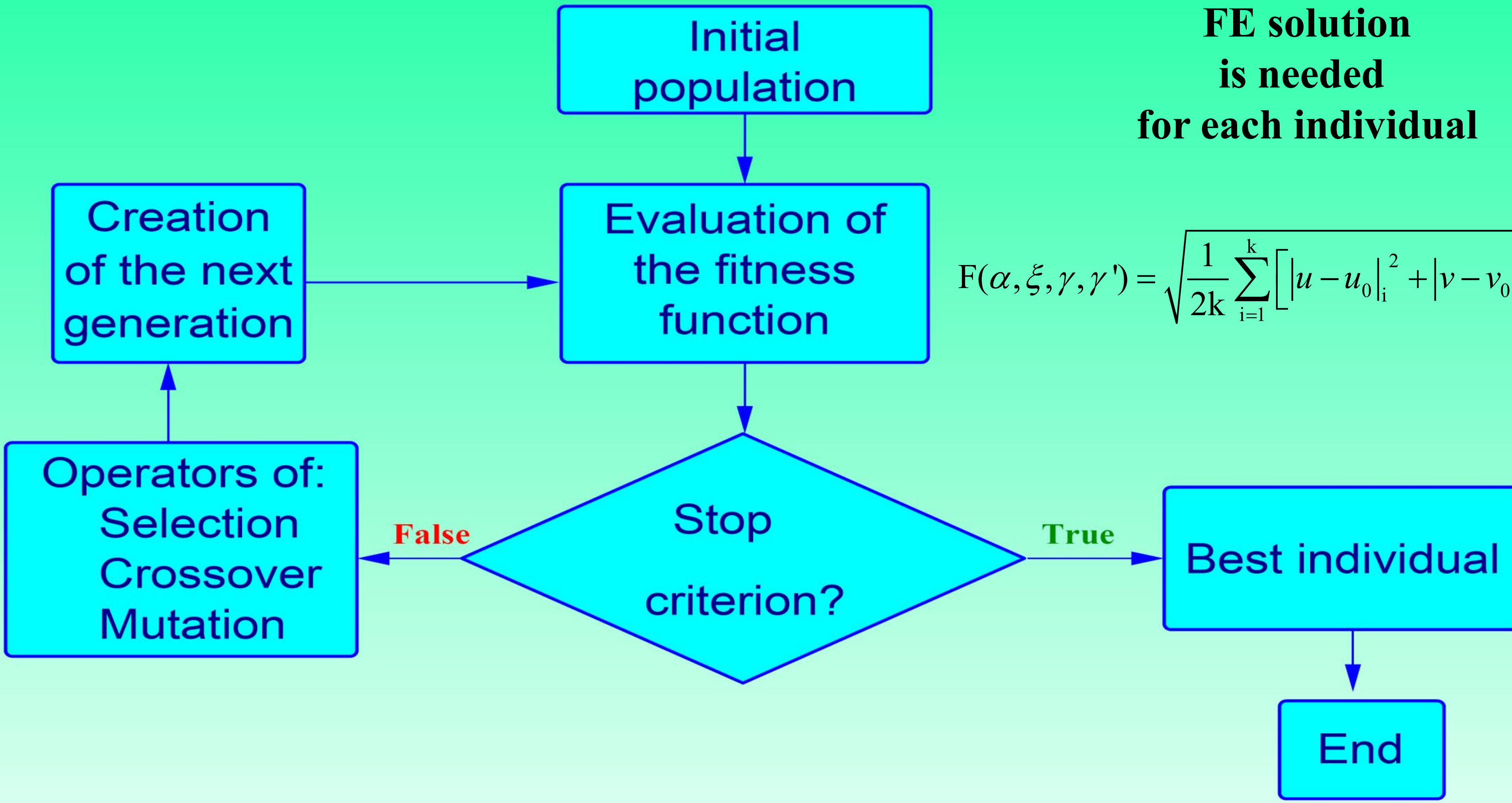
FE domain

Possible solutions for a suitable data interpolation in the FE domain:

- Use U10 and V10 supposing it is 10m over the FE terrain (used in this talk)
- Given a point of FE domain, find the closest one in HARMONIE domain grid
- Other possibilities can be considered

Estimation of Model Parameters

Genetic Algorithm

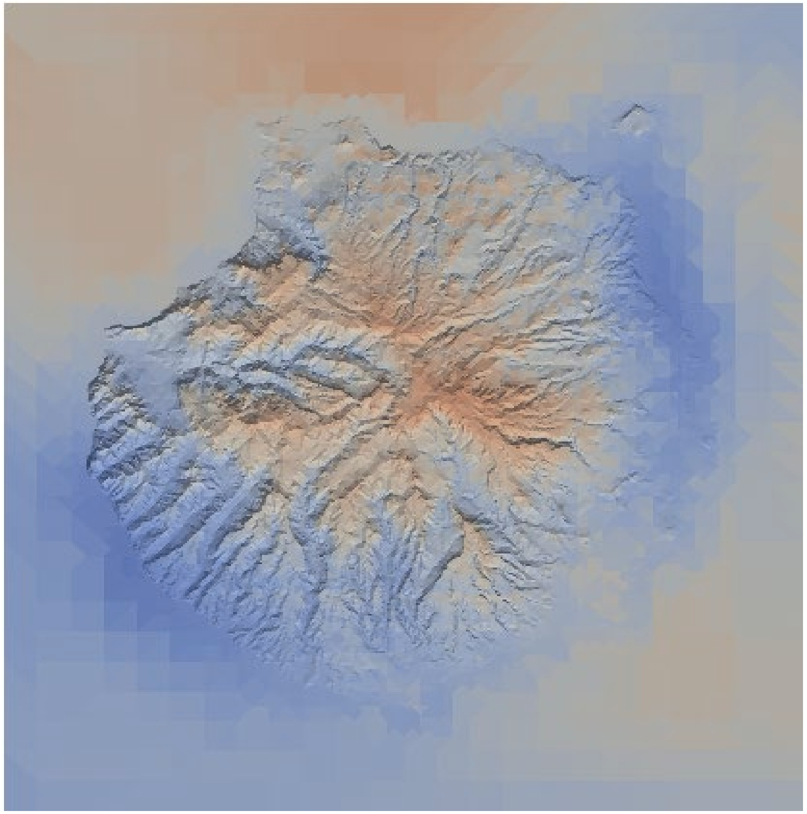


FE solution is needed for each individual

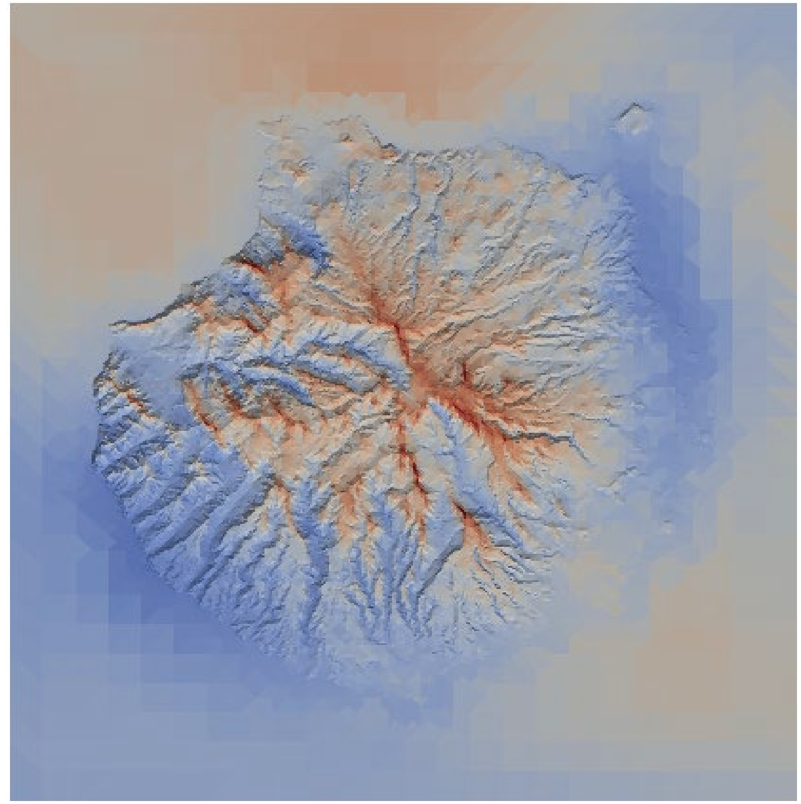
$$F(\alpha,\xi,\gamma,\gamma') = \sqrt{\frac{1}{2k}\sum_{i=1}^{k}\left[\left|u-u_0\right|_i^2 + \left|v-v_0\right|_i^2\right]}$$

Velocity Module - 23/12/2009 - 18:00 h

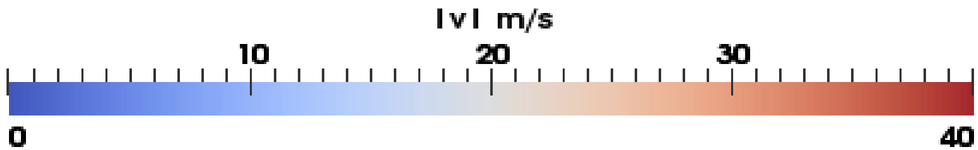
Wind on the terrain surface



Interpolated field from HARMONIE



Resulting field with the mass consistent model



Predicción de Viento sobre Orografía Irregular

Líneas de corriente del campo interpolado en Gran Canaria

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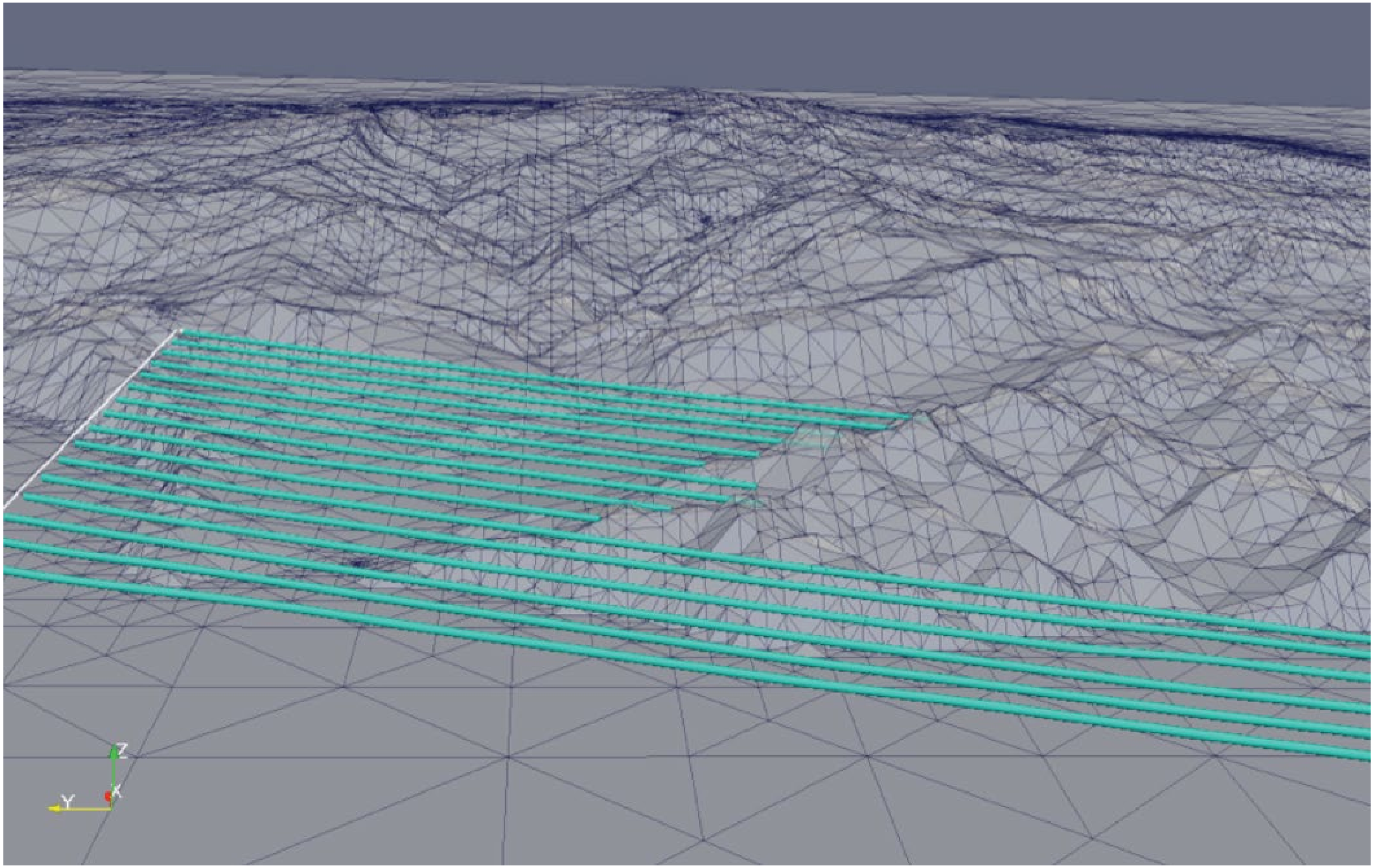

Predicción de Viento sobre Orografía Irregular

Influencia de la orografía sobre las líneas de corriente en Gran Canaria

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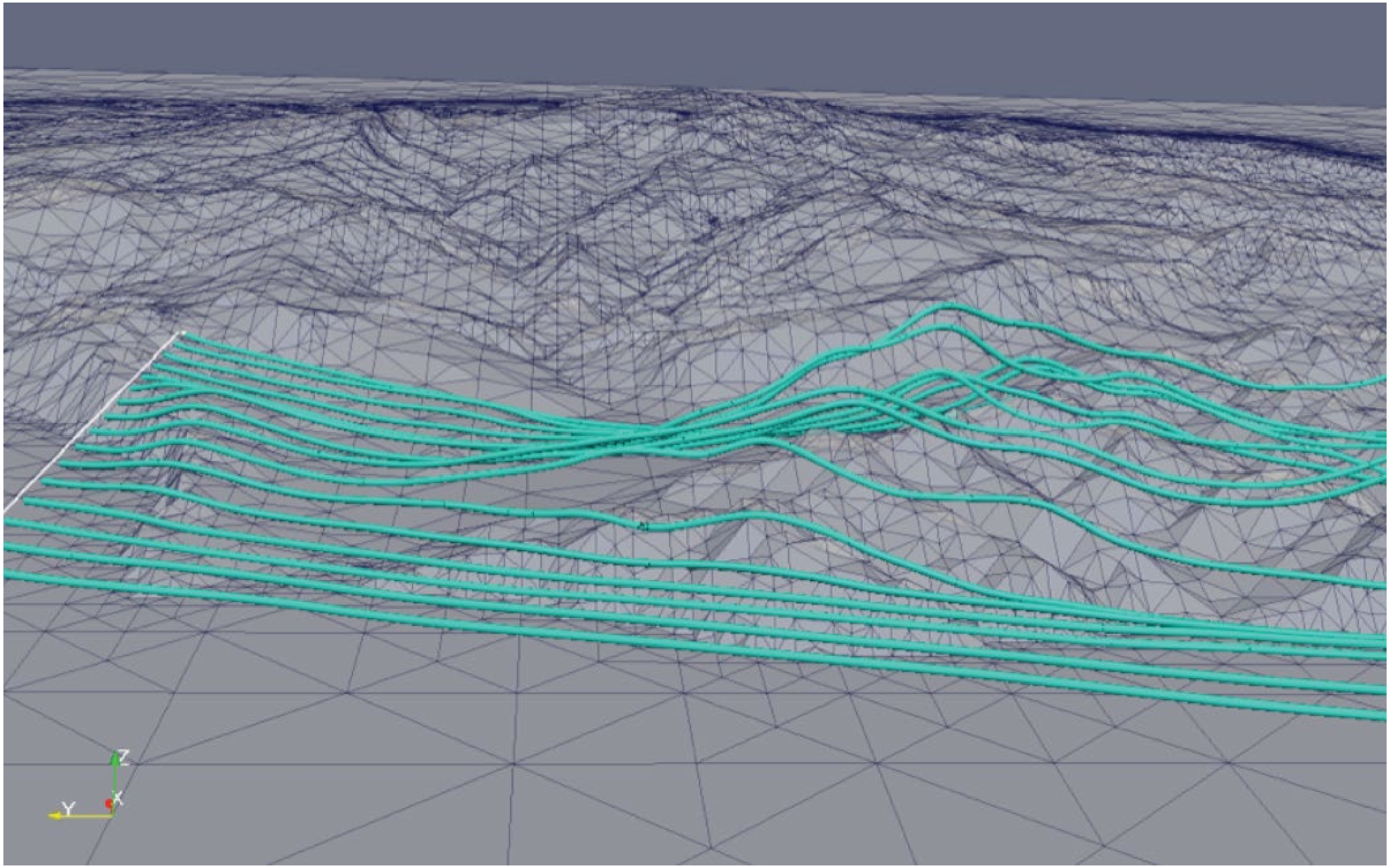
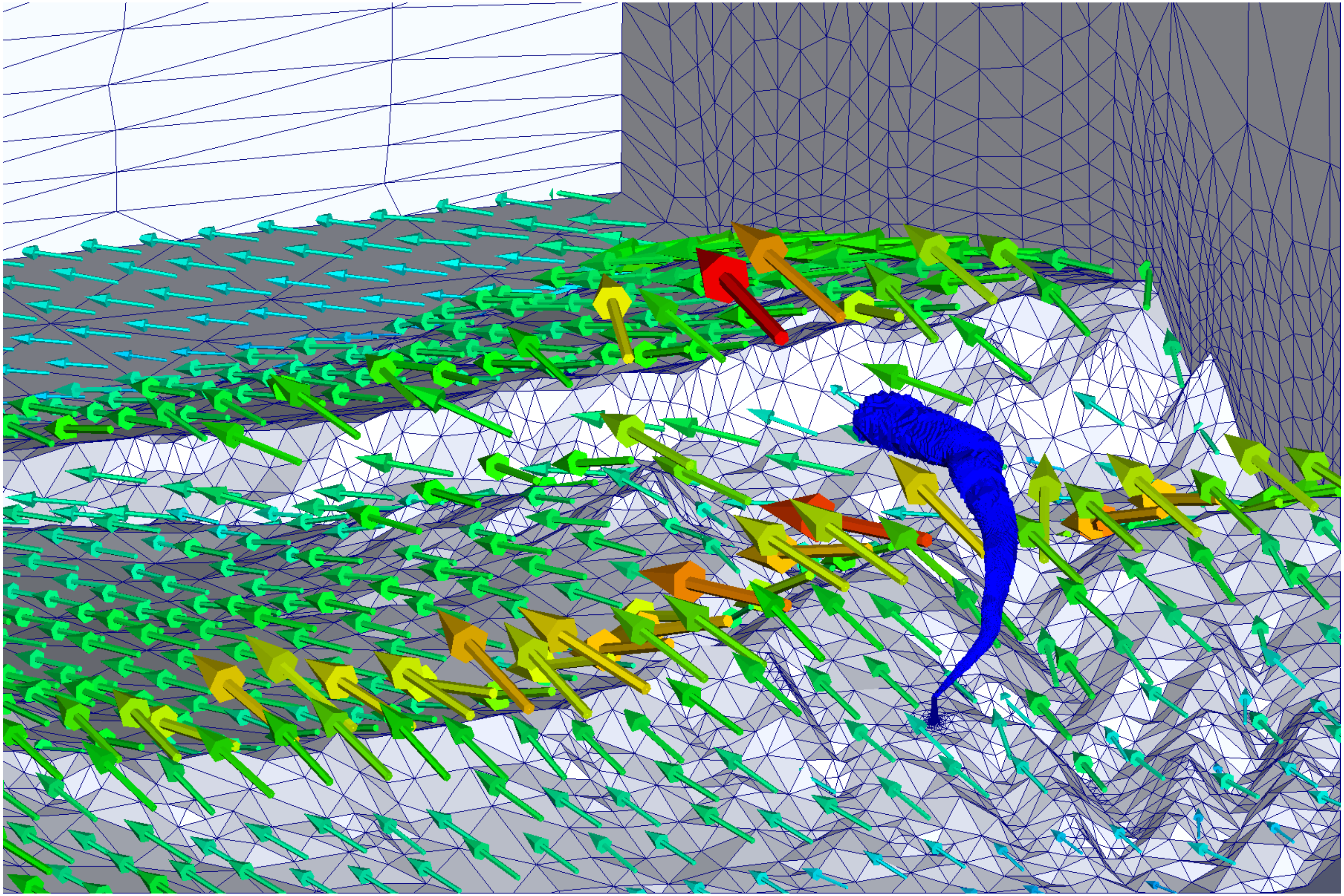


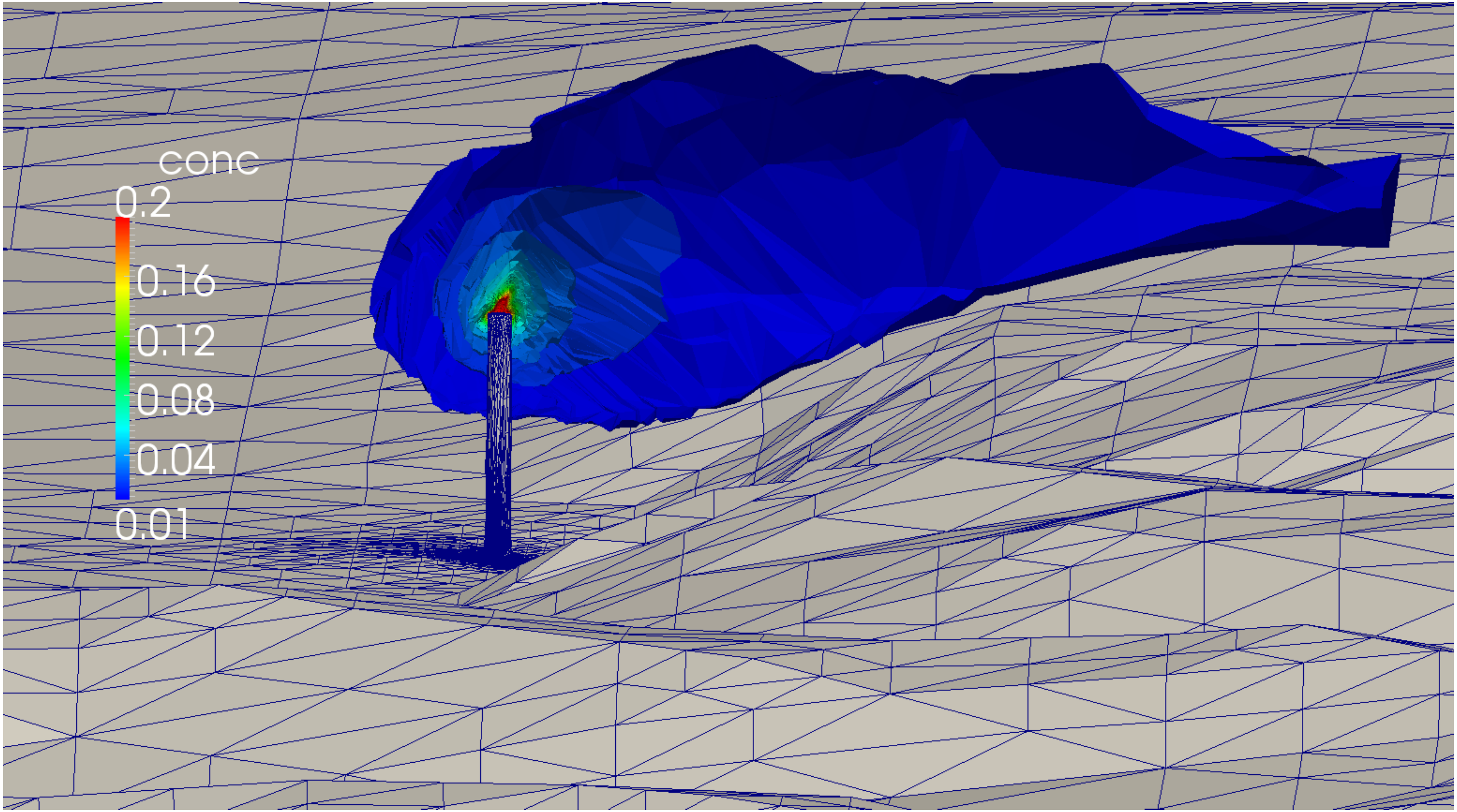
Campos de Viento para Simulación de Contaminantes

Adaptación de la Malla a la Orografía y a la Pluma Contaminante



Campos de Viento para Simulación de Contaminantes

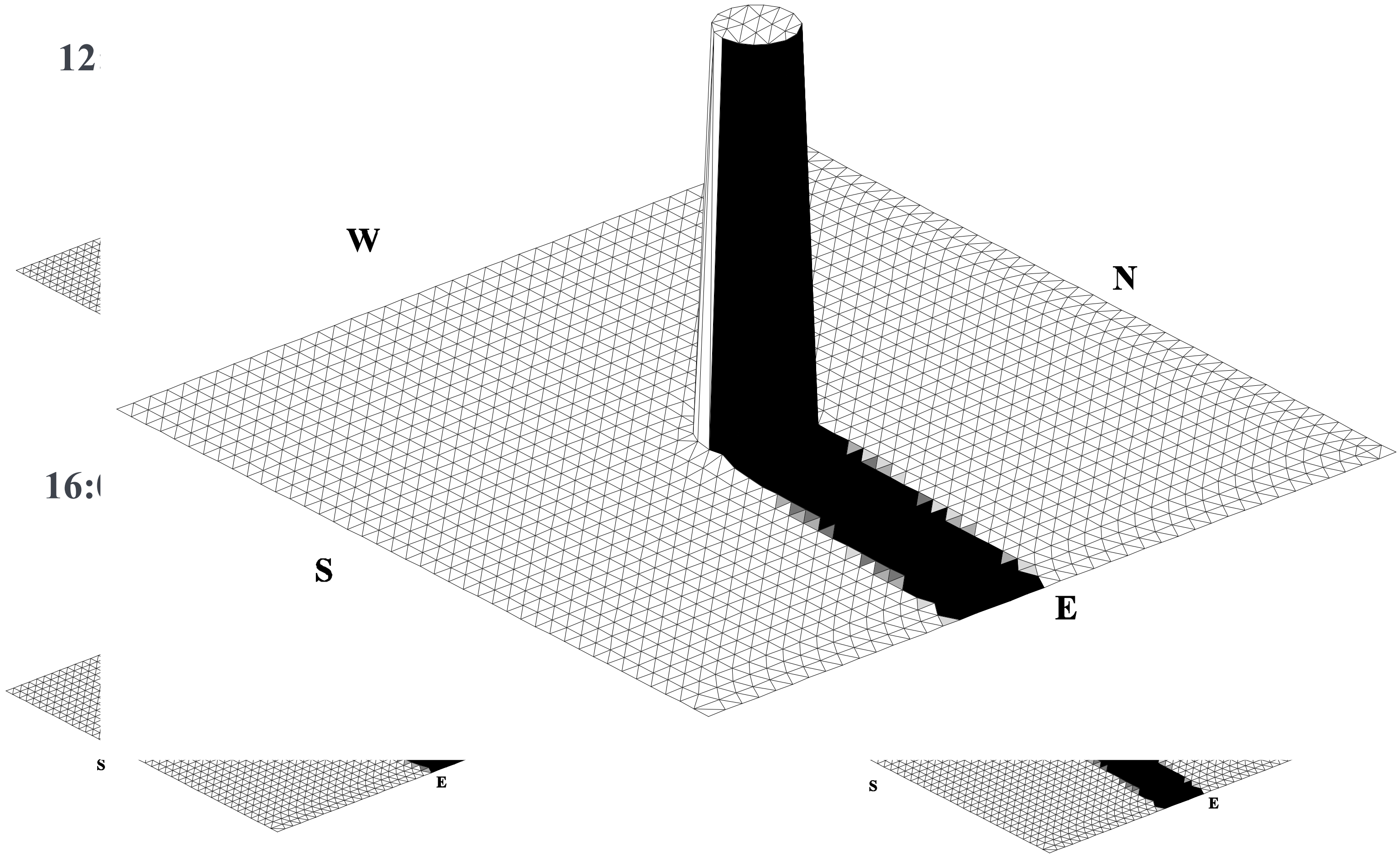
Concentración de Contaminante Emitido por una Chimenea



Radiación Solar

Simulación de Radiación Solar

Detección de sombras sobre una triangulación de la superficie del terreno



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- Objetivo:
  - Construir un modelo de radiación solar sobre una malla adaptativa de la superficie del terreno, basado en la detección de sombras sobre cada triángulo y mejorar las predicciones de los modelos meteorológicos

- Metodología:
  - Calcular la radiación solar (directa, difusa y reflejada) sobre cada triángulo de la malla considerando cielo limpio
  - Evaluar un año meteorológico típico para todas las estaciones de medida
  - Corregir los valores de radiación a cielo limpio para obtener la radiación con cielo real, usando los valores del año meteorológico típico

Simulación de Radiación Solar

Ejemplo de Mapa de Radiación Solar Mensual en Gran Canaria en J/m²

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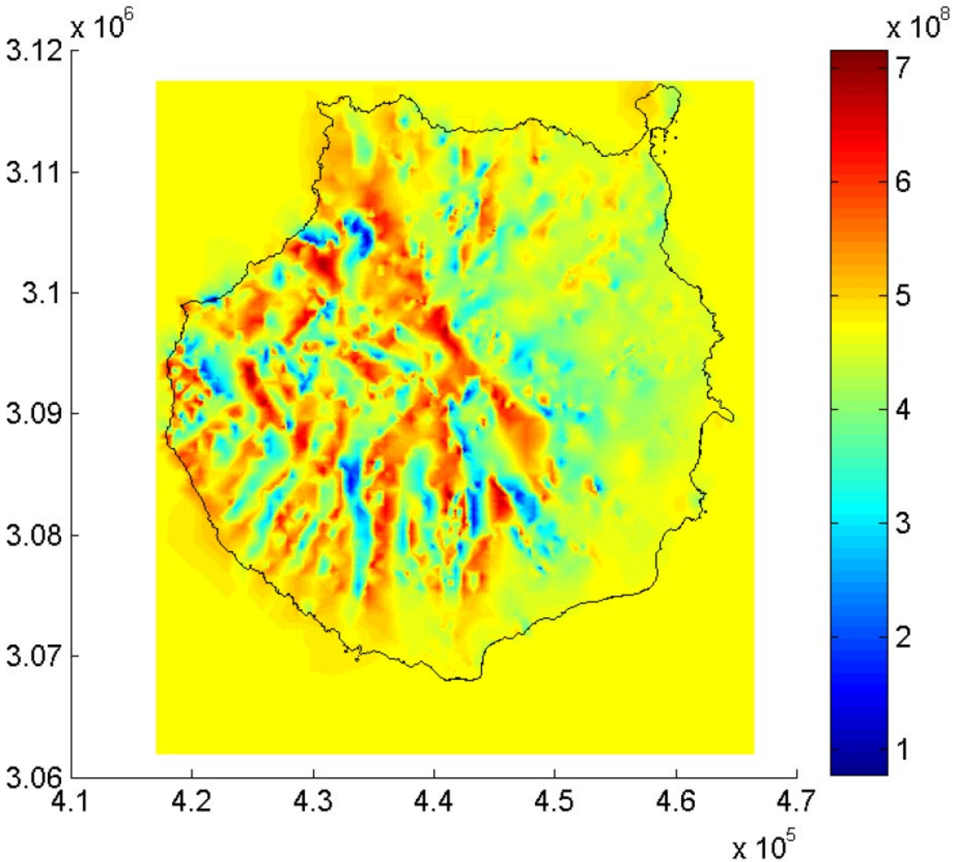
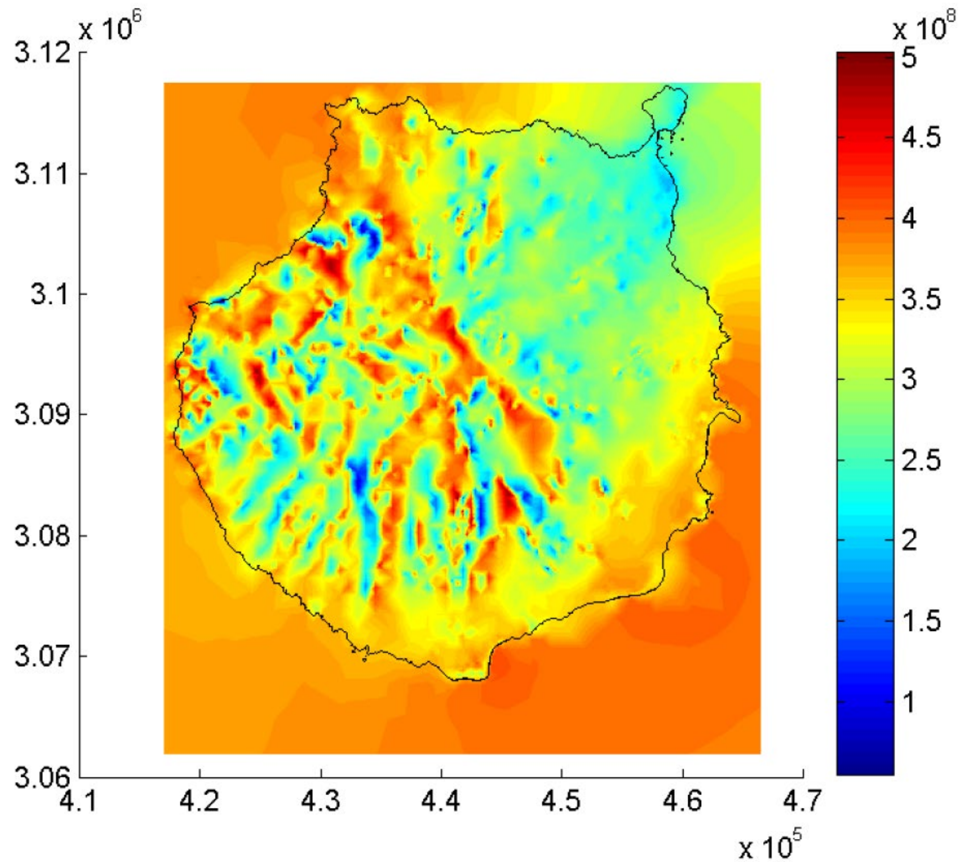


Radiación global a cielo limpio (J/m²)
Diciembre 2006



Radiación global con cielo real (J/m²)
Diciembre 2006

Isogeometric Analysis (IGA) vs Finite Elements (FEM)

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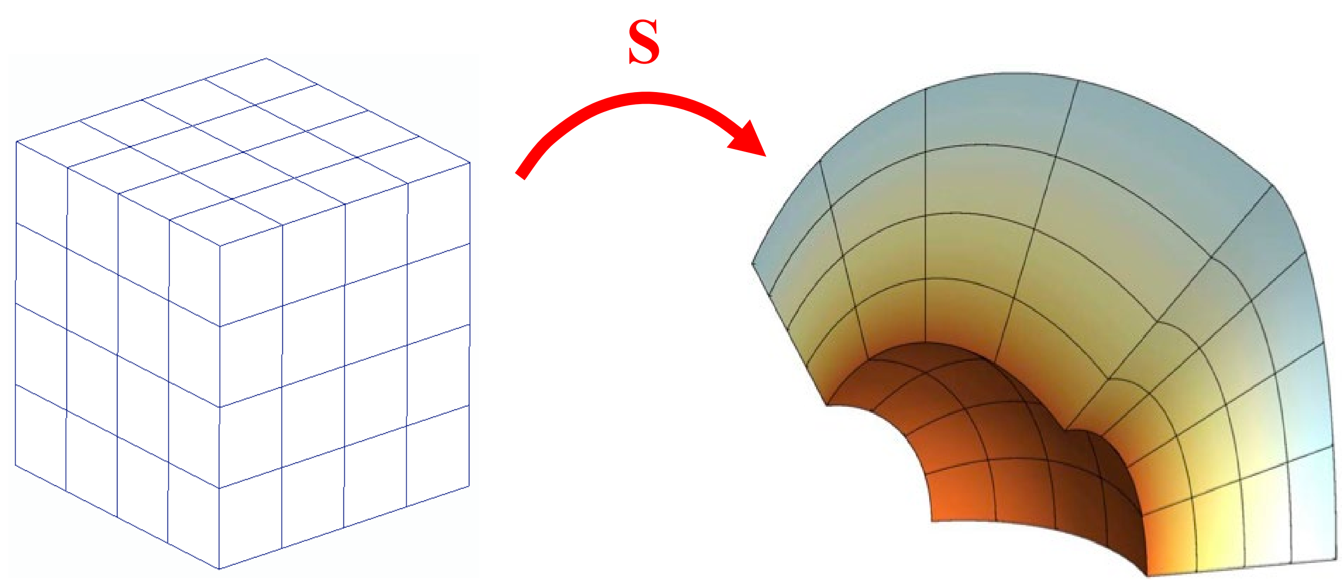
IGA:

- Global mapping
- Exact geometry
- C^K continuity

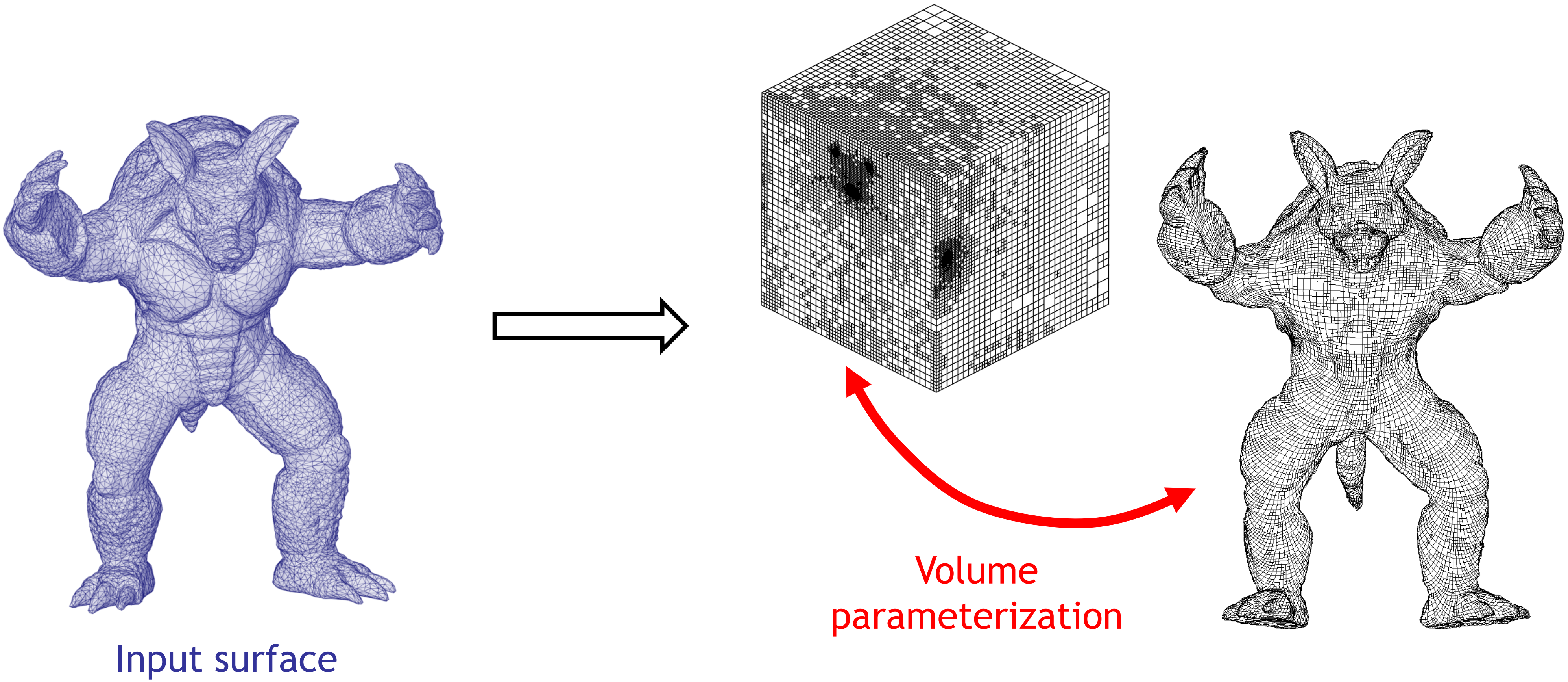
FEM:

- Element by element mapping
- Approximated geometry
- C^0 continuity



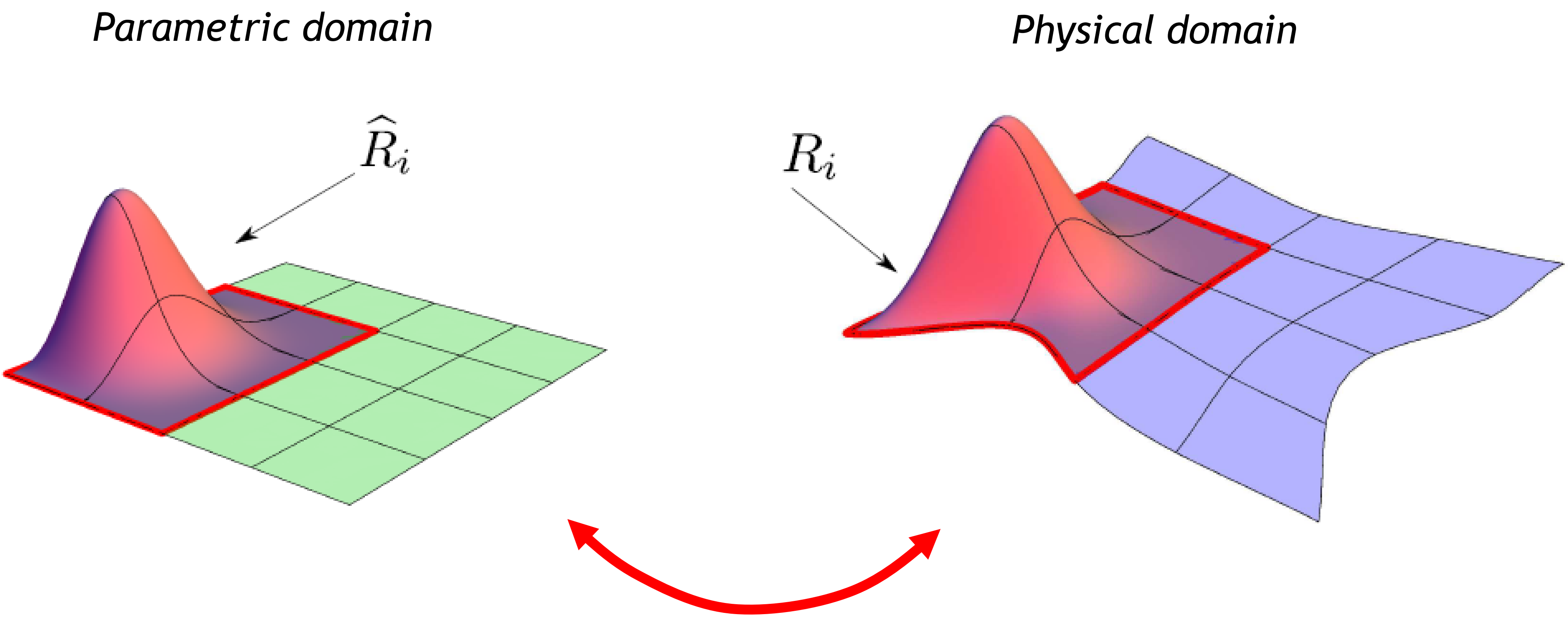
Open problems of Isogeometric Analysis (our work)

- Domain parameterization from its B-rep based on the Meccano Method
- Construction of a set of cubic spline basis functions on T-meshes



Isogeometric Analysis

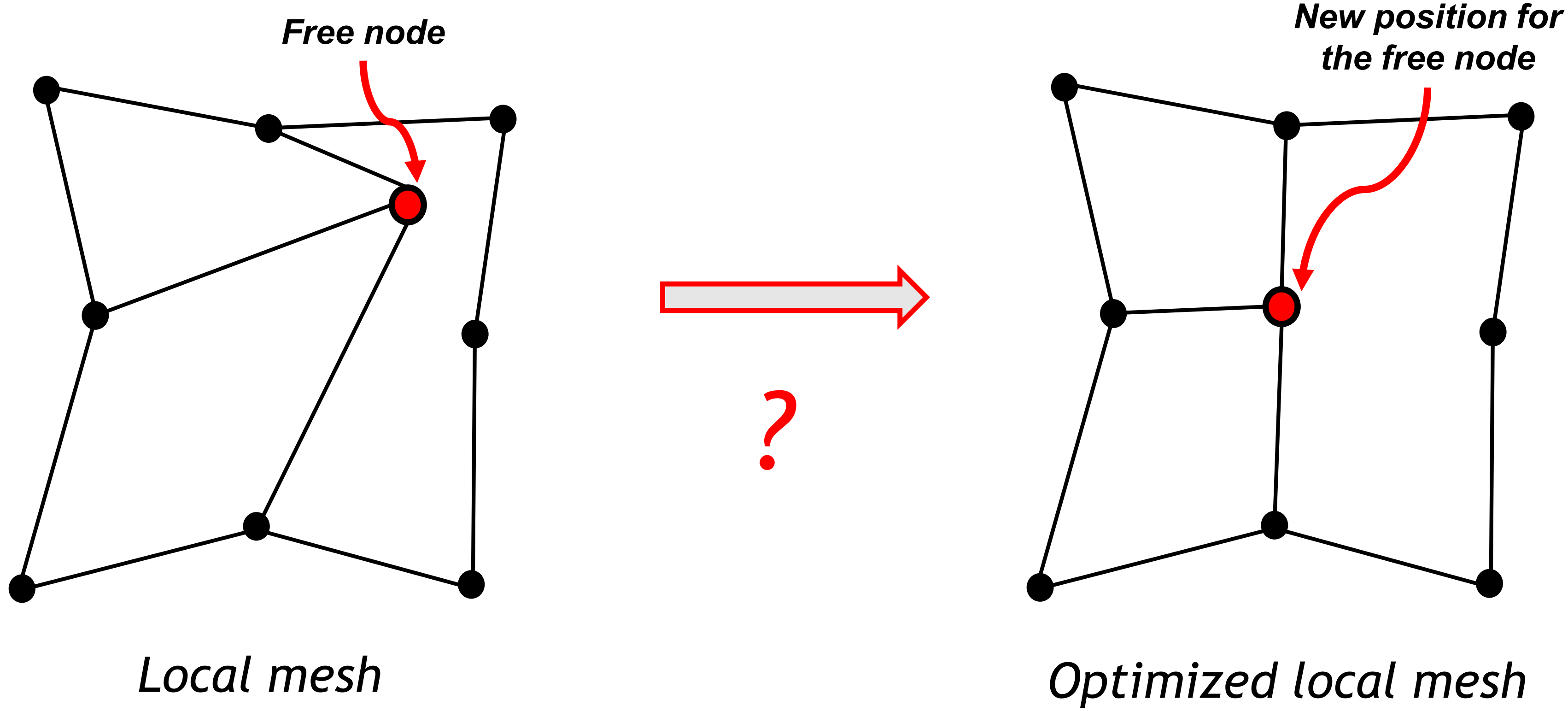
Basis functions defined by knot vectors



$$\mathbf{S}(\xi,\eta) = \sum_j \mathbf{P}_j \, \widehat{R}_j(\xi,\eta),$$

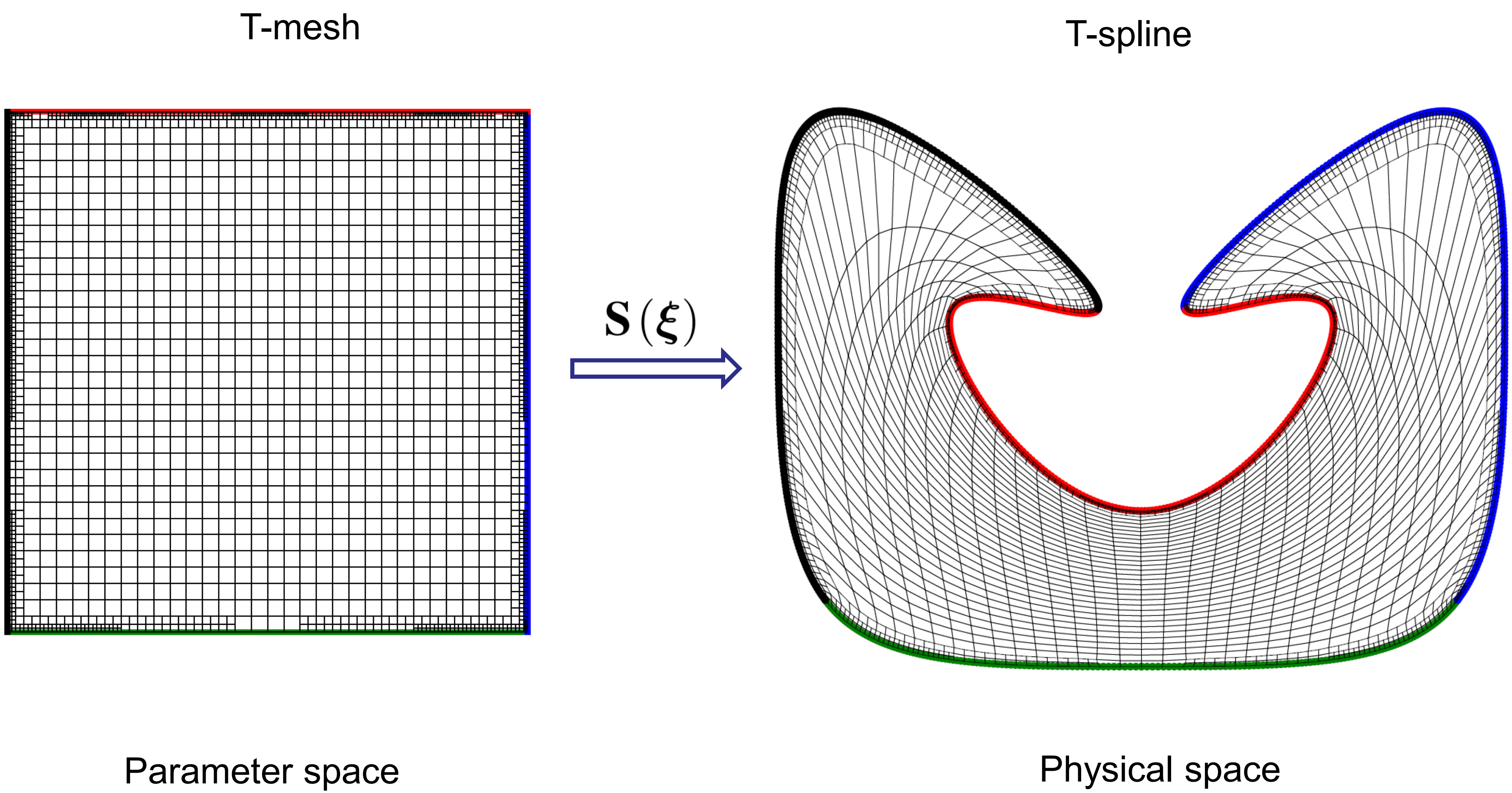
Local optimization

***Objective:* Improve the quality of the local mesh by minimizing an objective function**



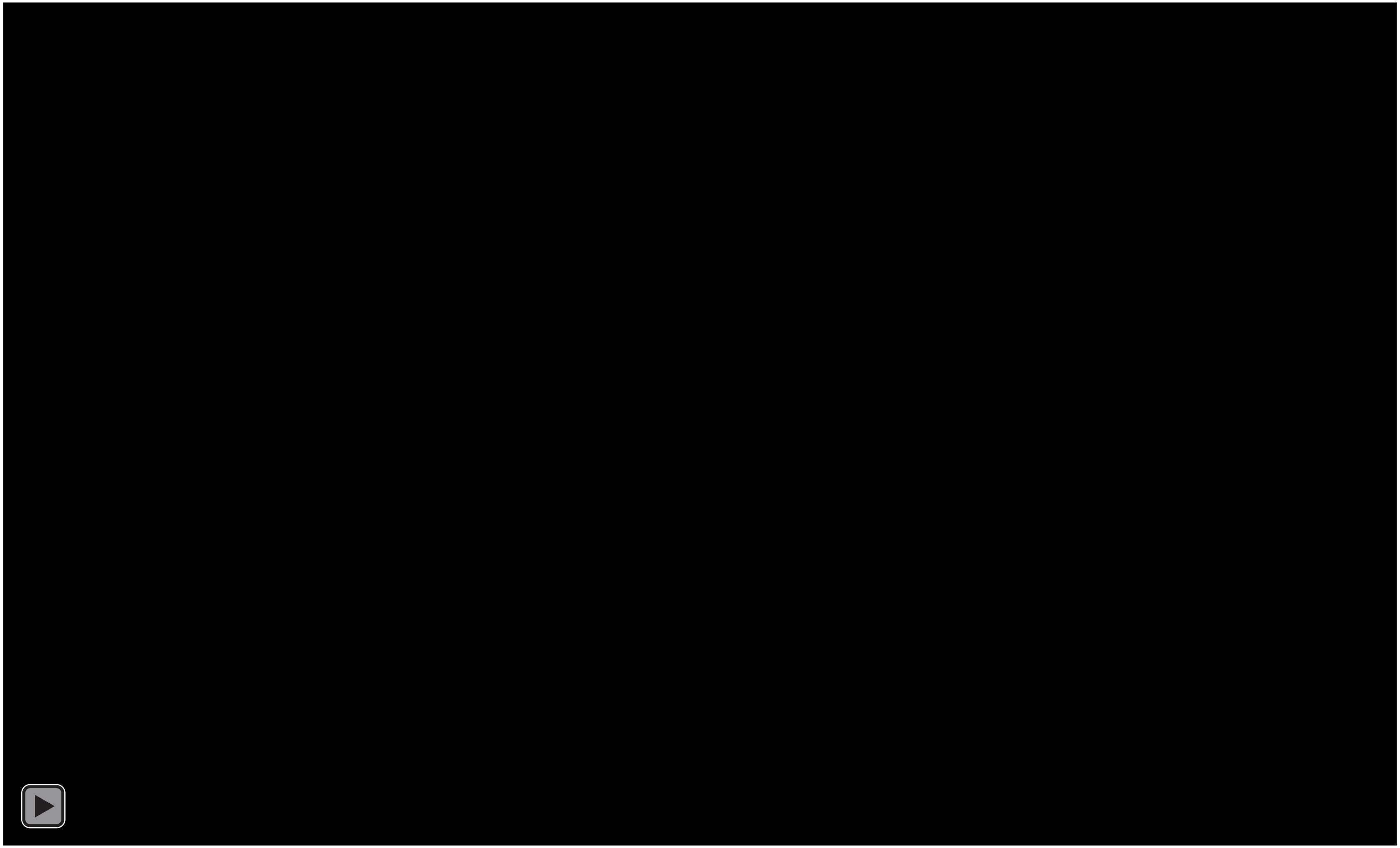
Simultaneous Untangling and Smoothing of T-meshes

T-mesh transformation along the SUS process: Example



Spline parameterization method

T-mesh transformation along the SUS process: Video



J

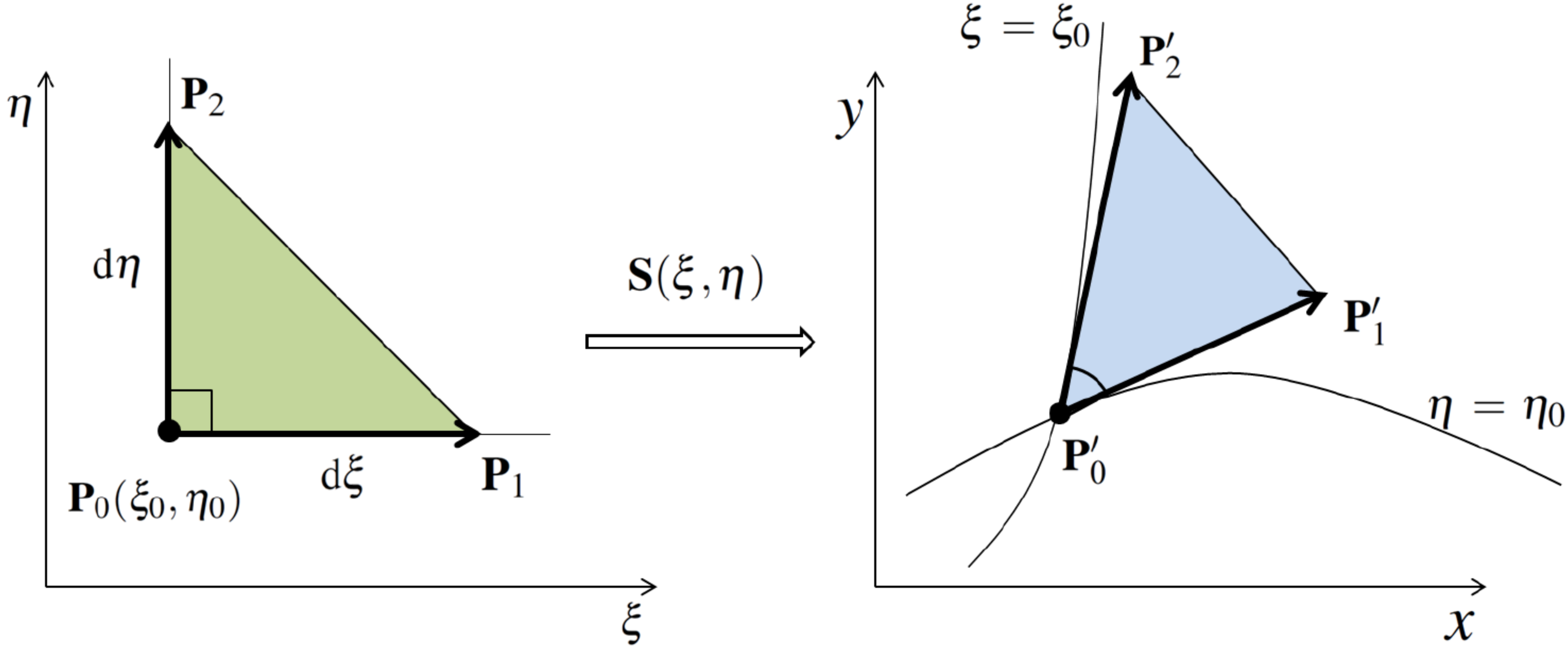
Mean Ratio Jacobian $J_r(\xi)$ of parametric transformation

A quality metric of the mapping at any point P_0 (…as conformal as possible)

Valid mapping condition

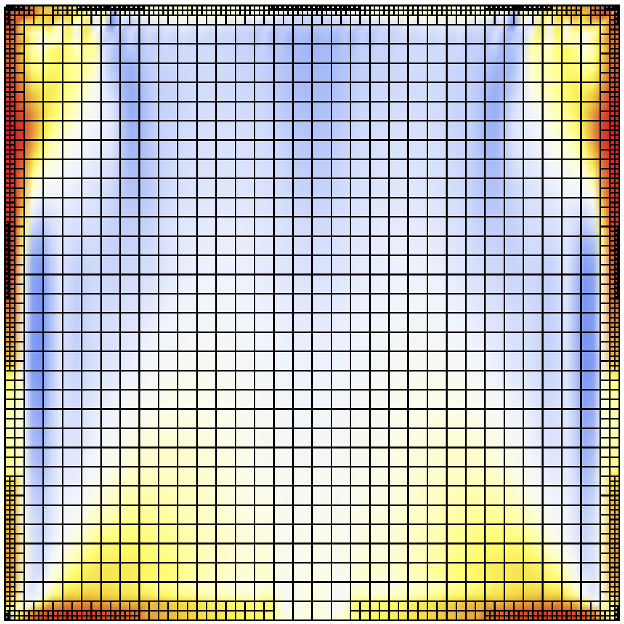
$$0 < J_r(\xi) = \frac{2\det(J)}{\|J\|^2} \leq 1$$

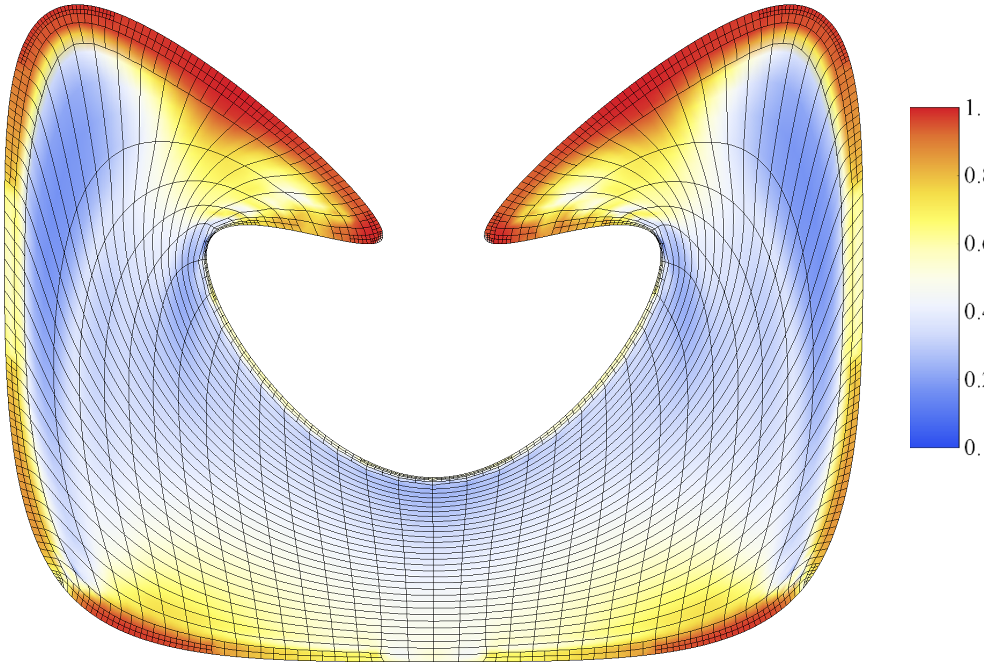
where J is the Jacobian matrix of the spline mapping $\mathbf{S}$



Spline parameterization method

T-mesh transformation along the SUS process: Mean ratio Jacobian

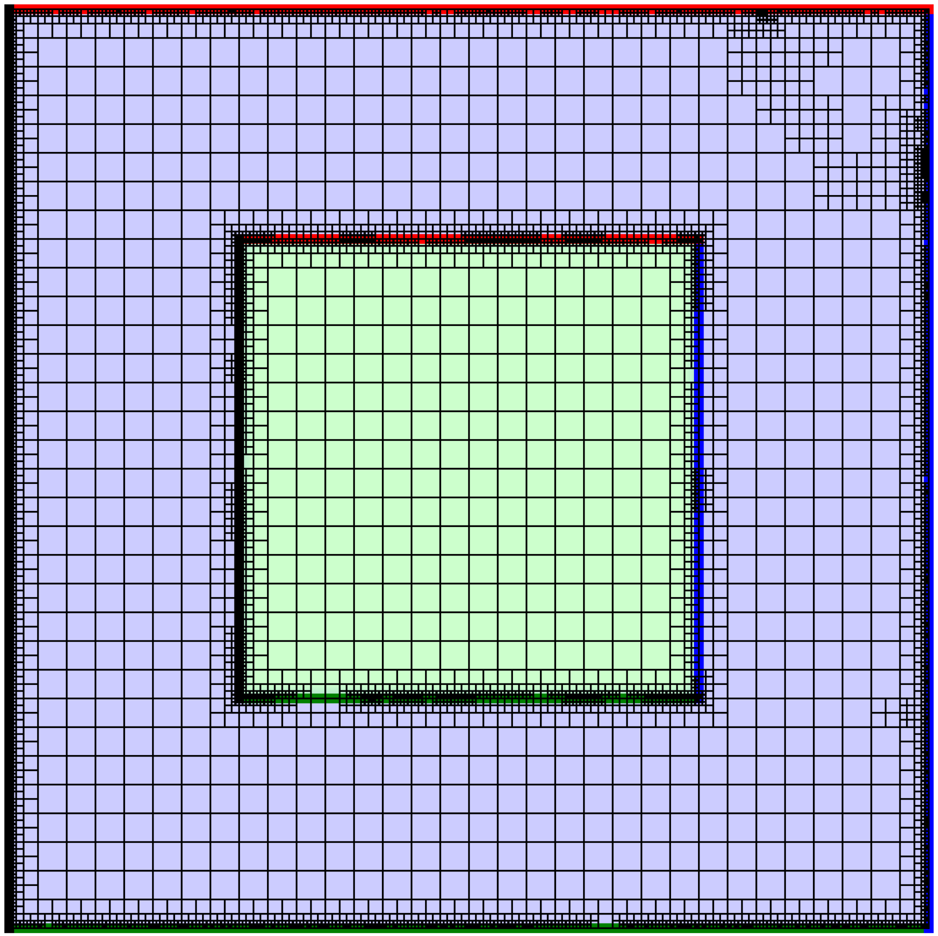


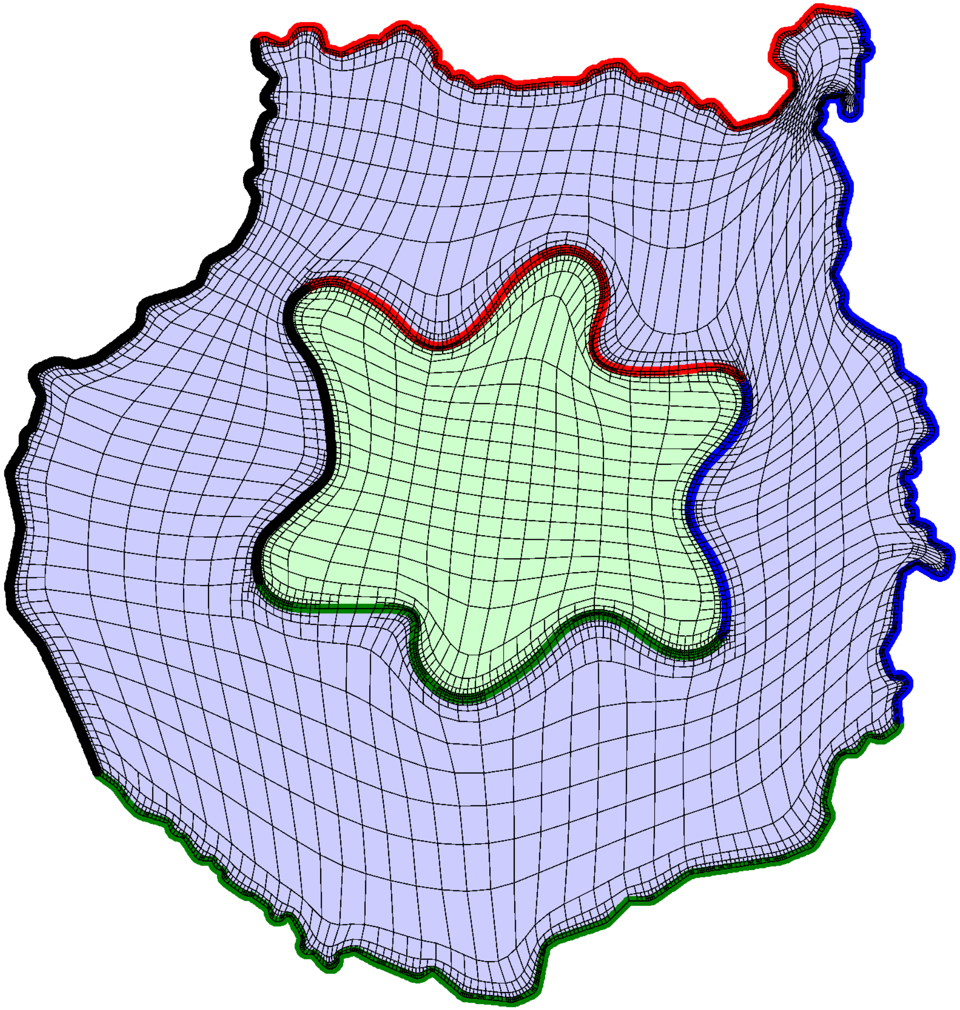


Min value of mean ratio Jacobian is 0.16

Applications: Isogeometric Modeling

Geometries with several materials





Isogeometric analysis on 2D domain

Poisson problem with Dirichlet boundary condition

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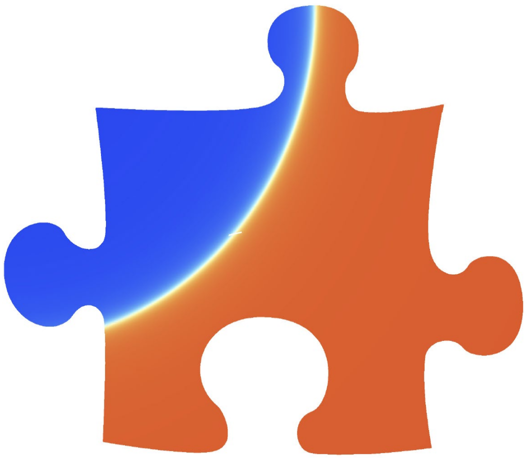
$$
\begin{aligned}
-\triangle u &= f \qquad \text{in } \Omega, \\
u &= g \qquad \text{on } \partial\Omega.
\end{aligned}
$$



- Analytical solution: Steep wave front given by

$$u(r) = \arctan(\alpha(r - r_0)), \qquad \text{where } r = \sqrt{(x - x_c)^2 + (y - y_c)^2}\ ,$$

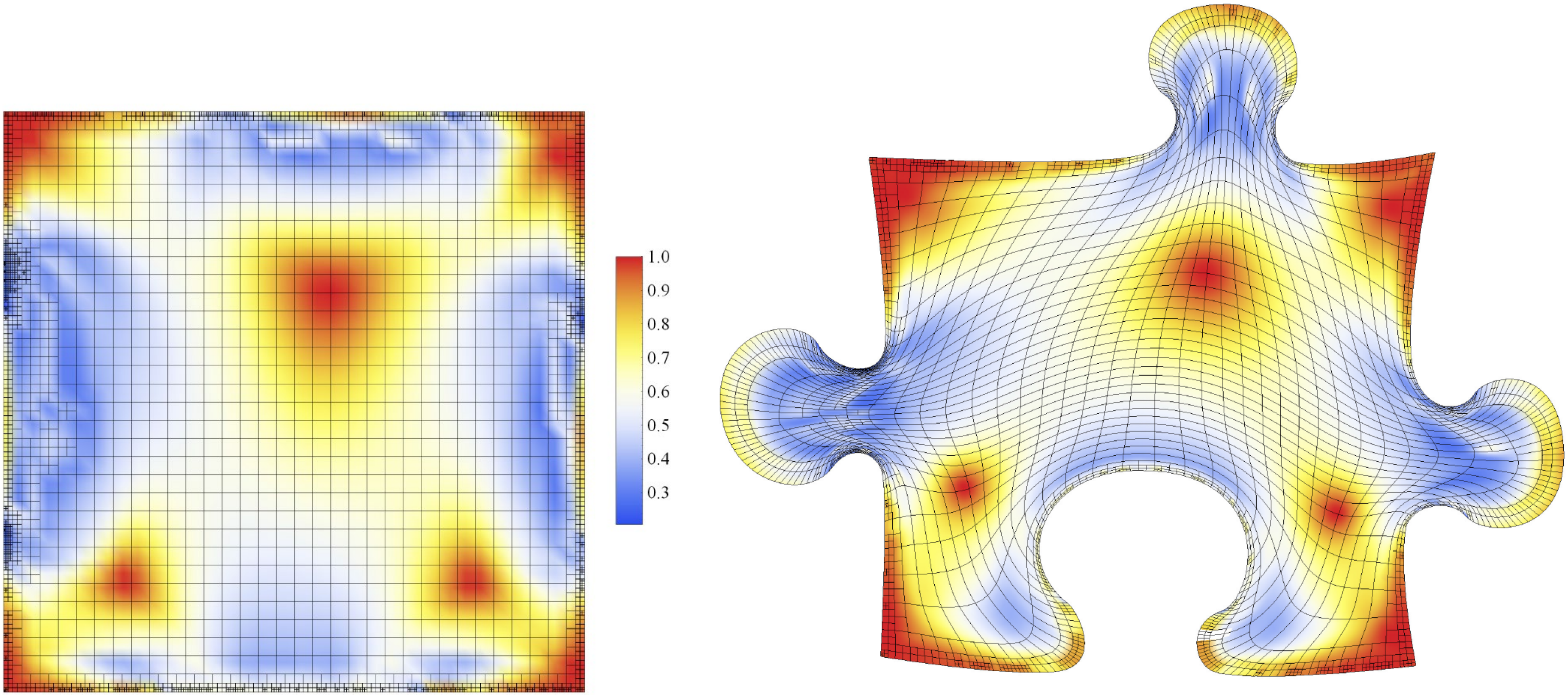
$$(x_c, y_c) = (0, 0),\ \alpha = 200 \text{ and } r_0 = 0.6$$

- Adaptive strategy: Residual-type error indicator:

$$\eta(\Omega_e)^2 = \int_{\Omega_e} h^2 \left(f + \Delta u_h\right)^2 \, d\Omega$$

Isogeometric analysis for 2D Poisson problem

Domain parameterization. Mean ratio Jacobian



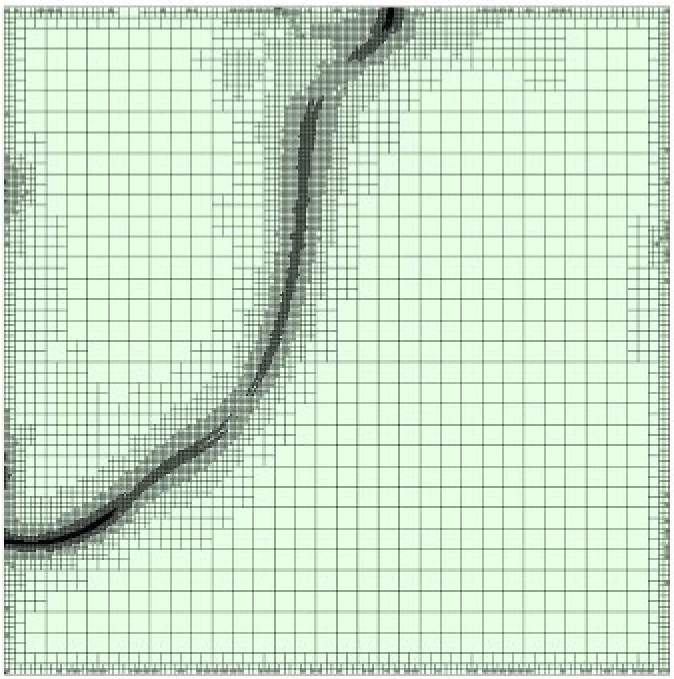
parametric domain *physical domain*

Min value of mean ratio Jacobian is 0.23

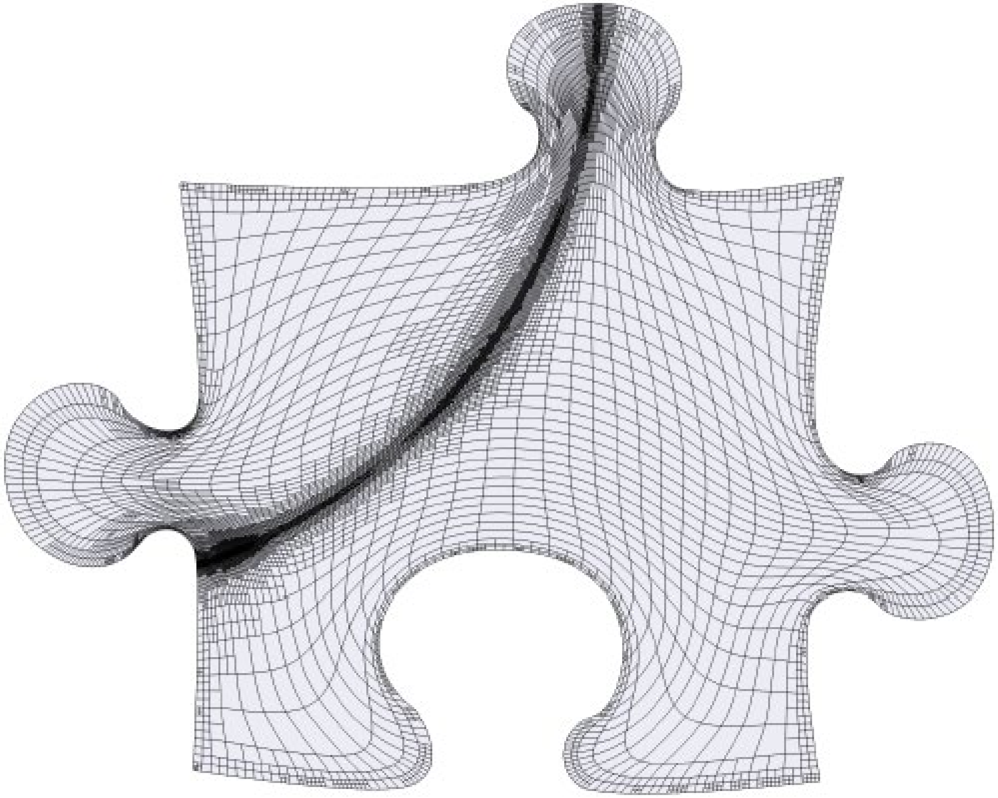
Isogeometric analysis for 2D Poisson problem

Poisson problem on puzzle piece domain

Final refinement:



parametric domain

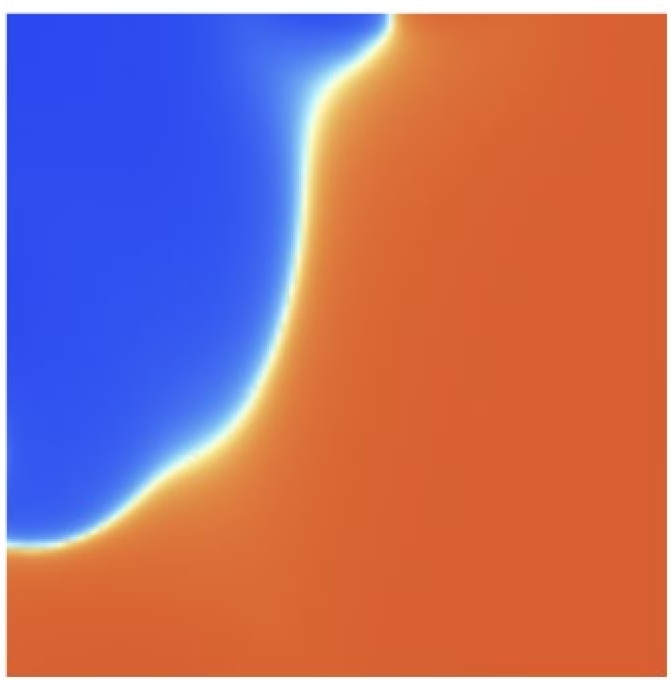


physical domain

Isogeometric analysis for 2D Poisson problem

Poisson problem on puzzle piece domain

Numerical solution:



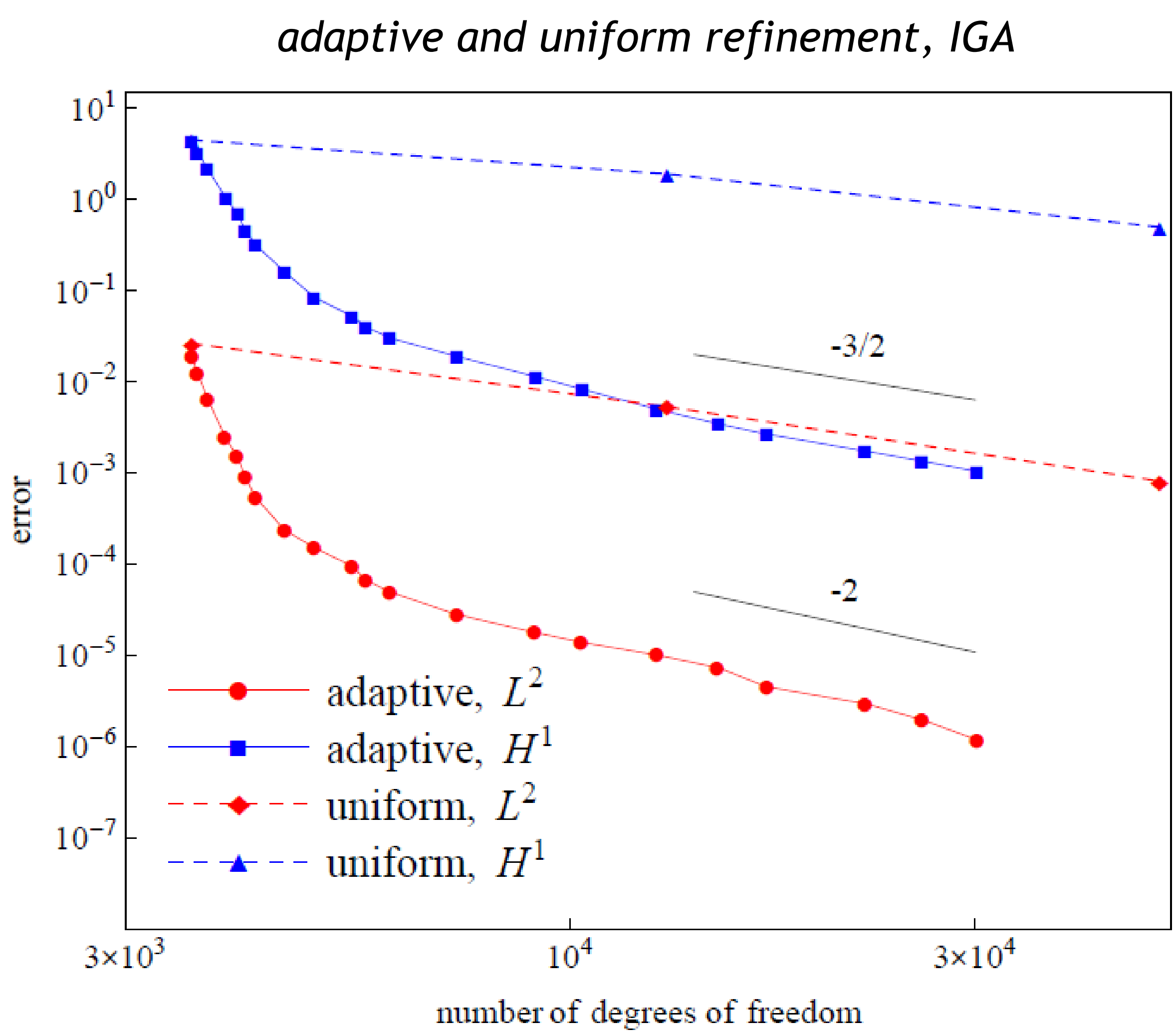
parametric domain

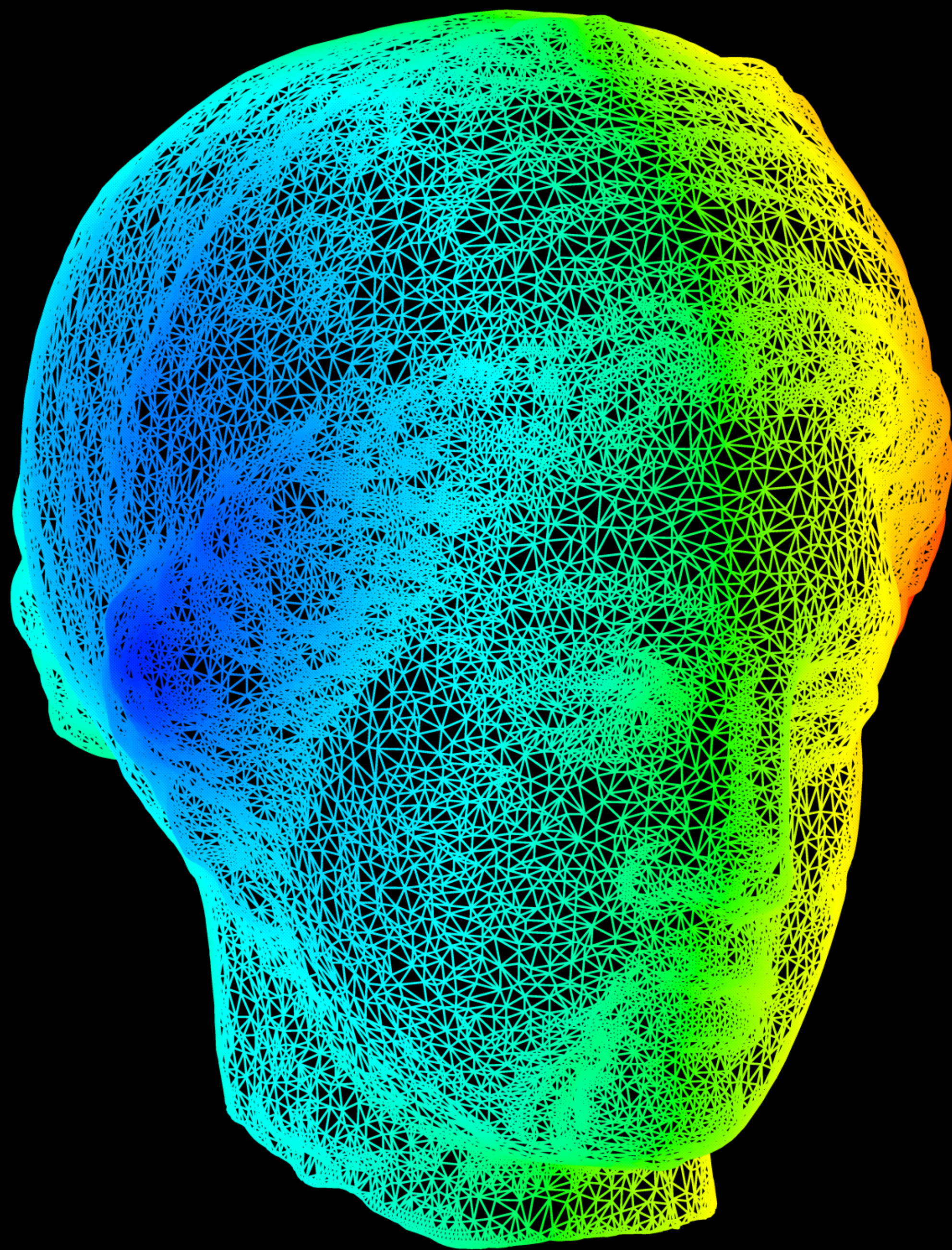
physical domain

Isogeometric analysis for 2D Poisson problem

Poisson problem on puzzle piece domain

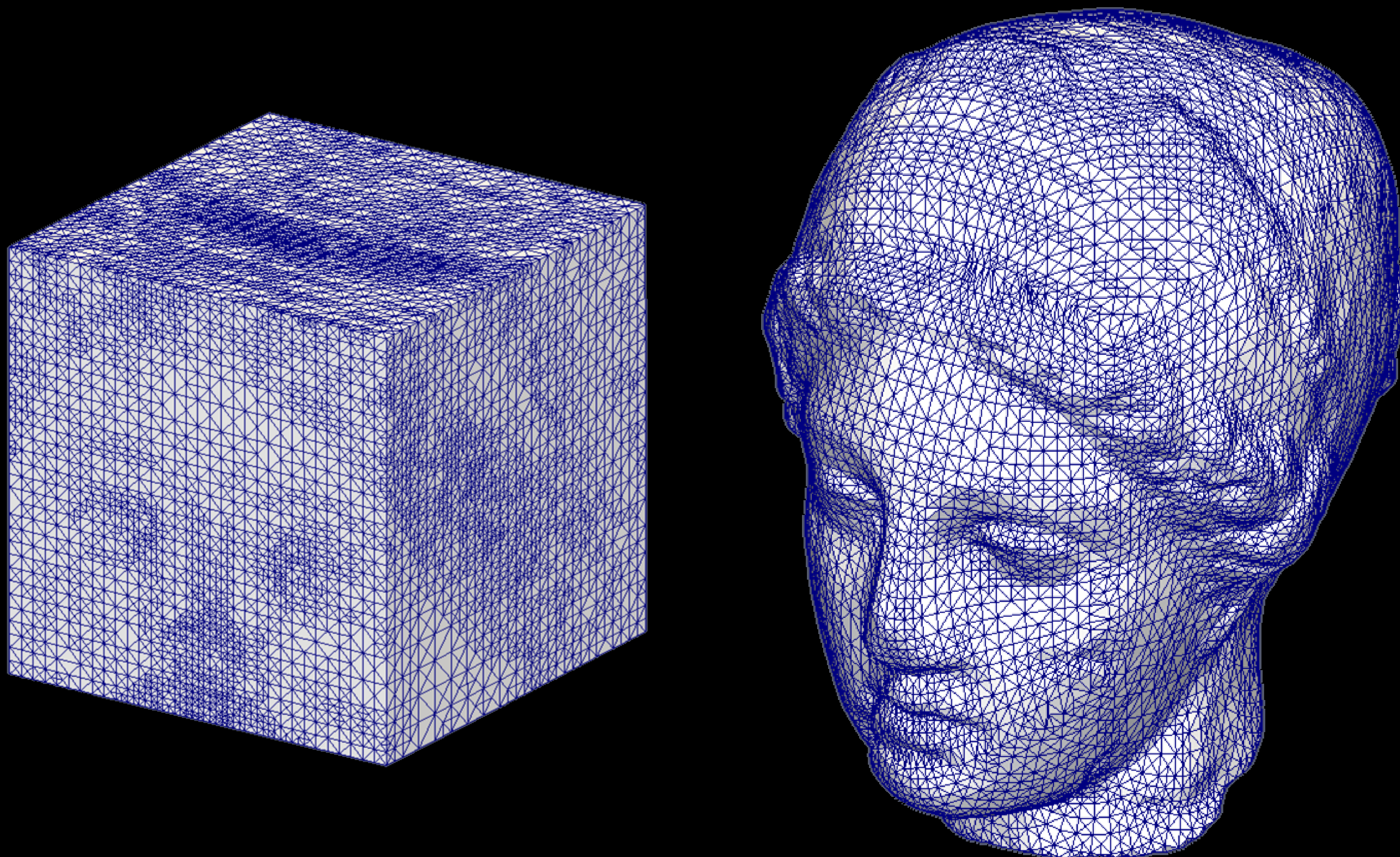
Error convergence:

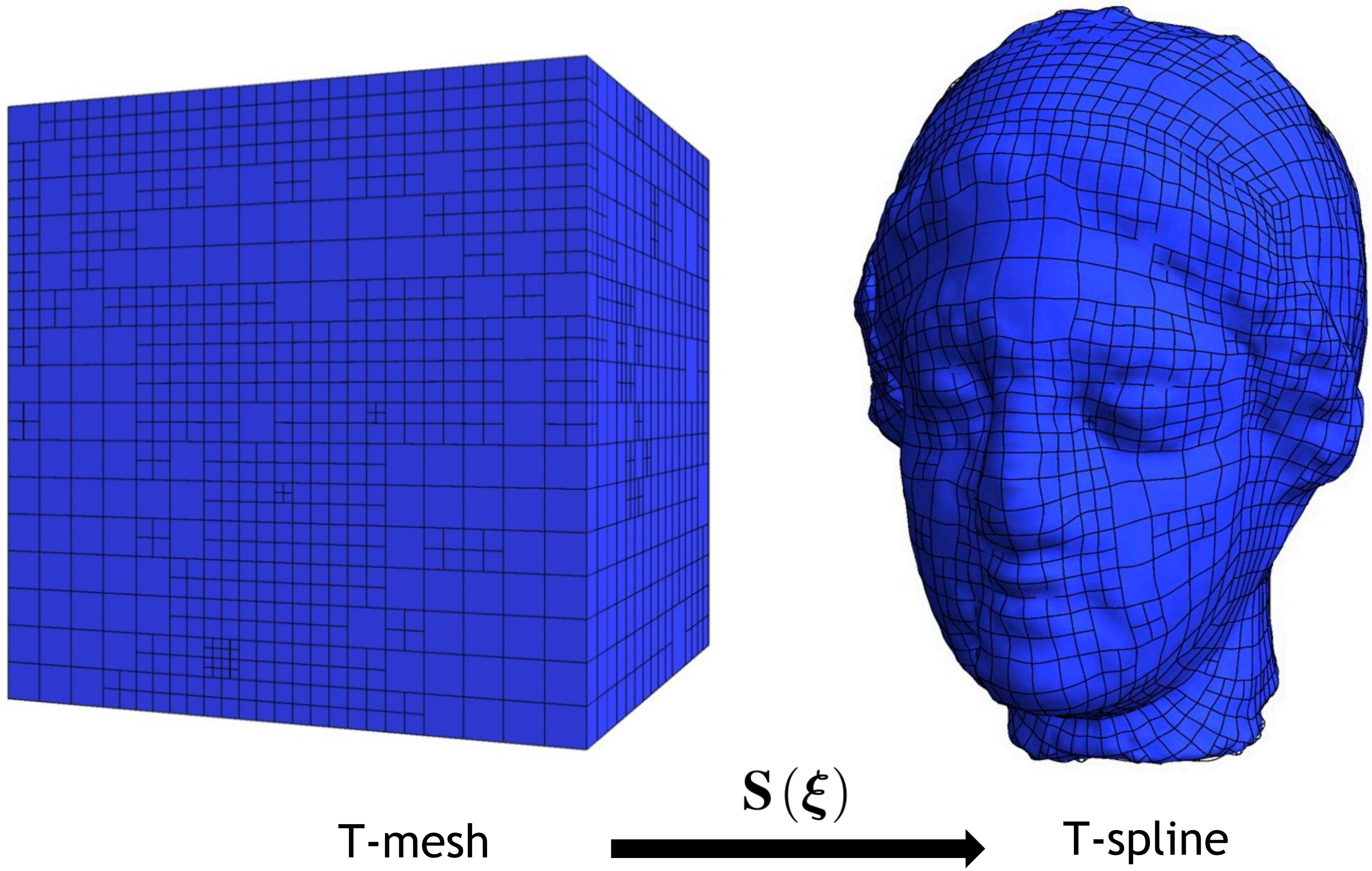




INPUT DATA: Surface Triangulation

http://www.cyberware.com/

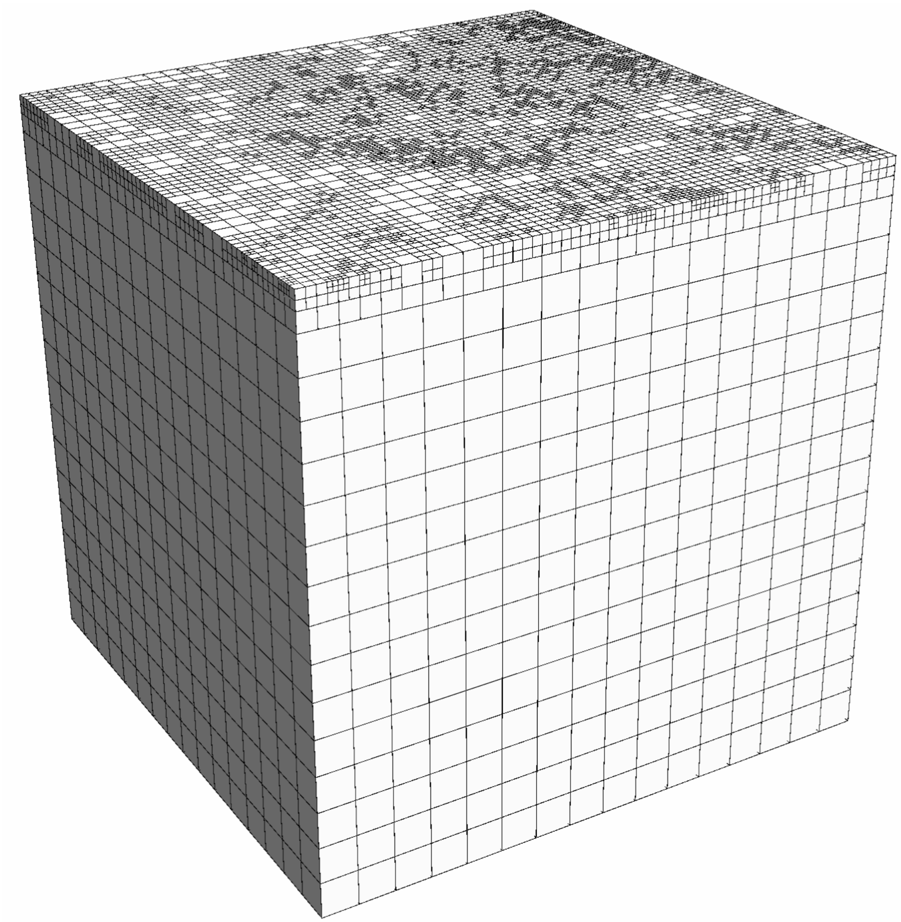


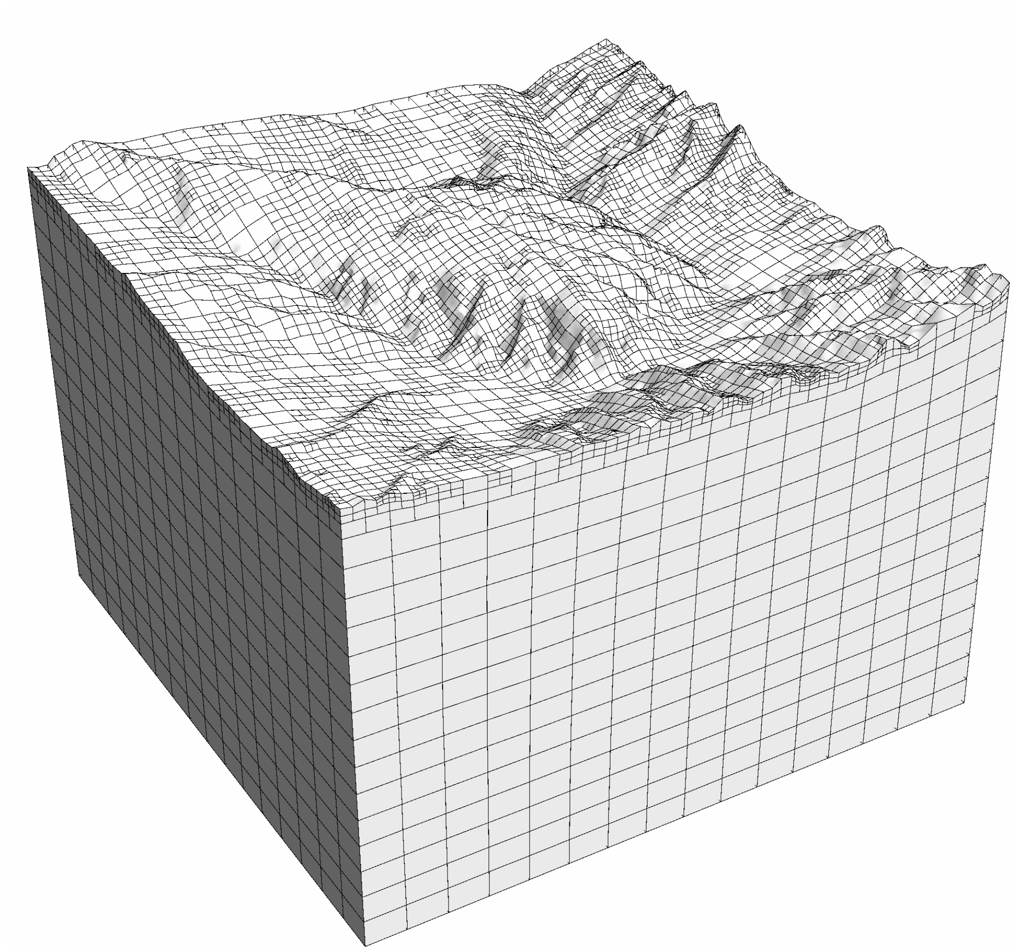


$\mathbf{S}(\boldsymbol{\xi})$
T-mesh
T-spline

Wind field simulation in La Palma Island

Parametric and physical domains





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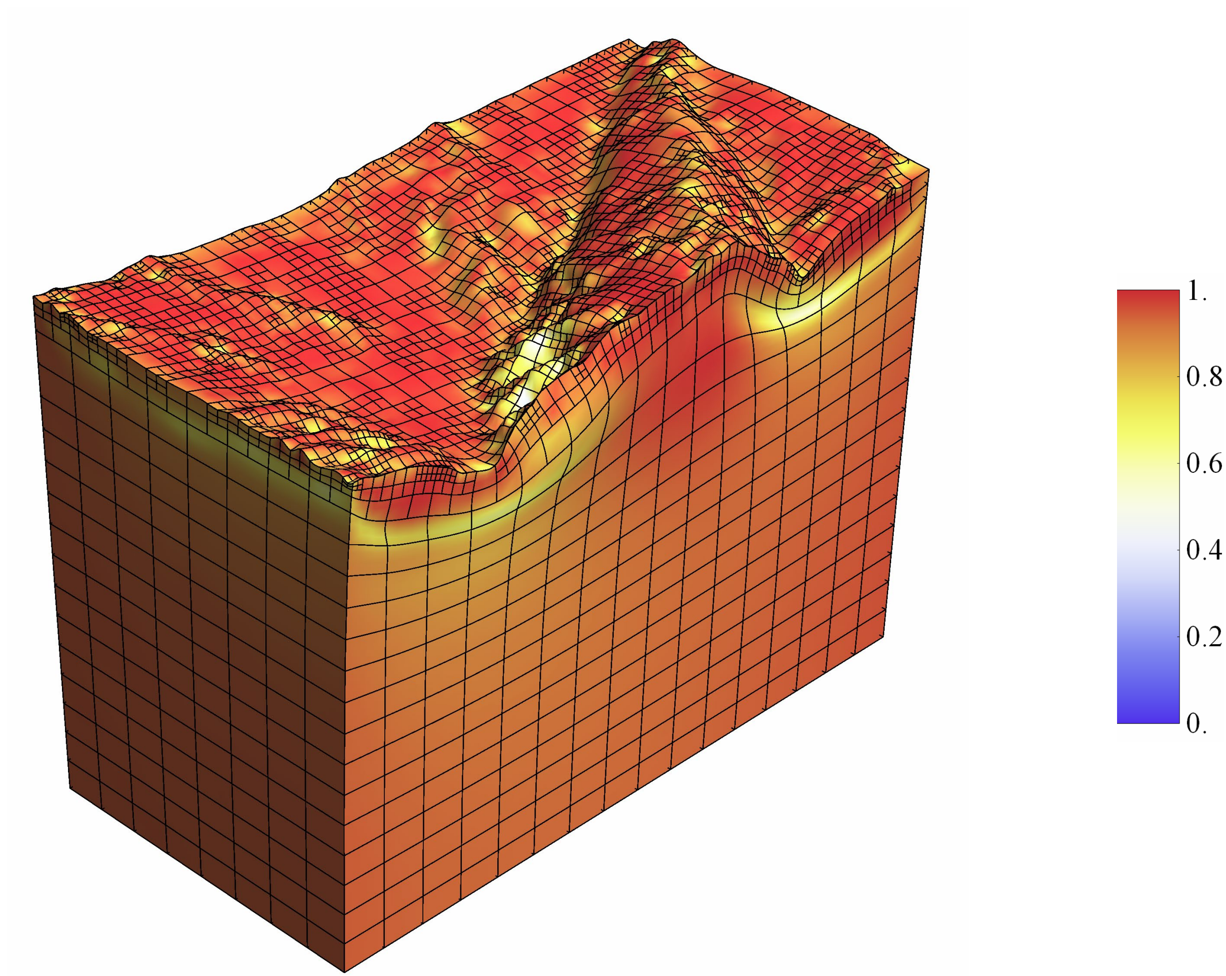
Wind field simulation in La Palma Island

Mean ratio Jacobian



Min value of mean ratio Jacobian is 0.35

Applications: Isogeometric Analysis

Wind Simulation: La Palma Island

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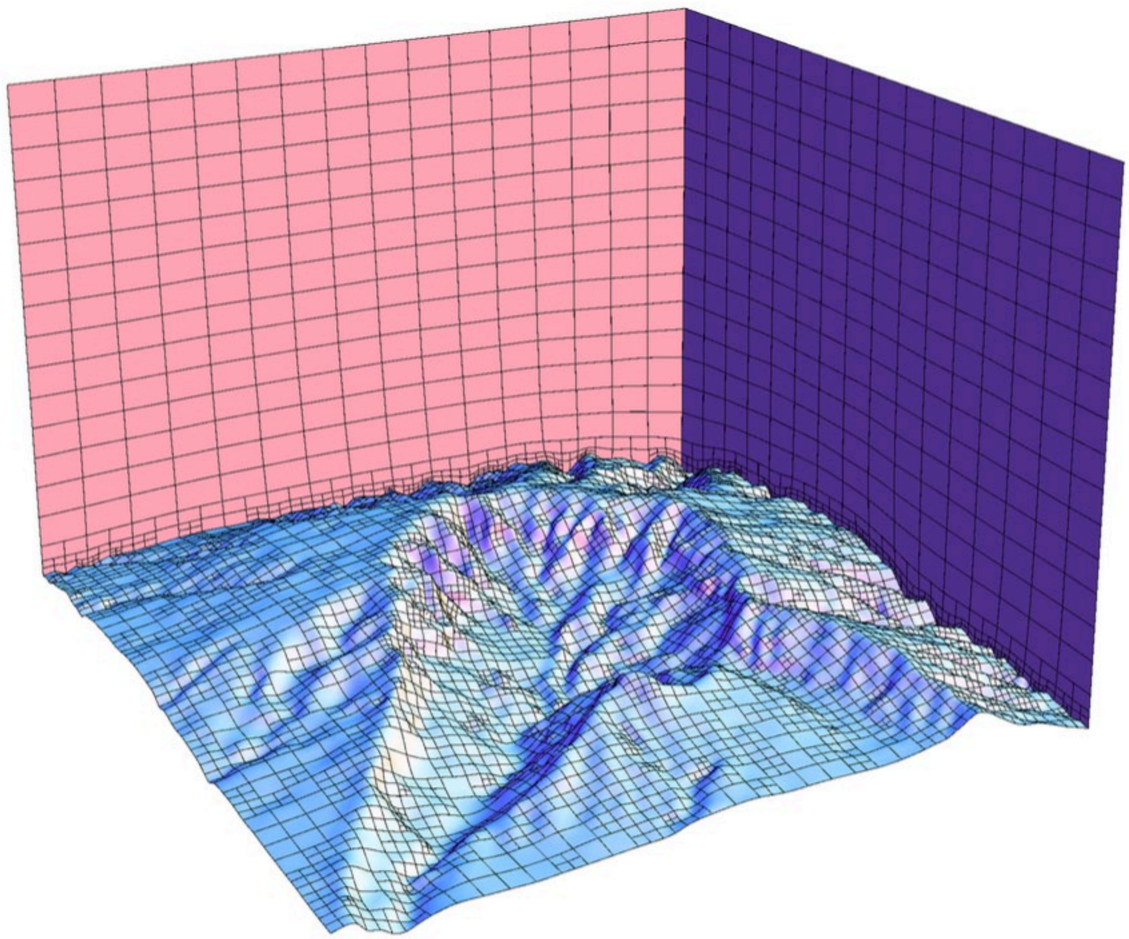

Applications: Isogeometric Analysis

Wind Simulation: La Palma Island

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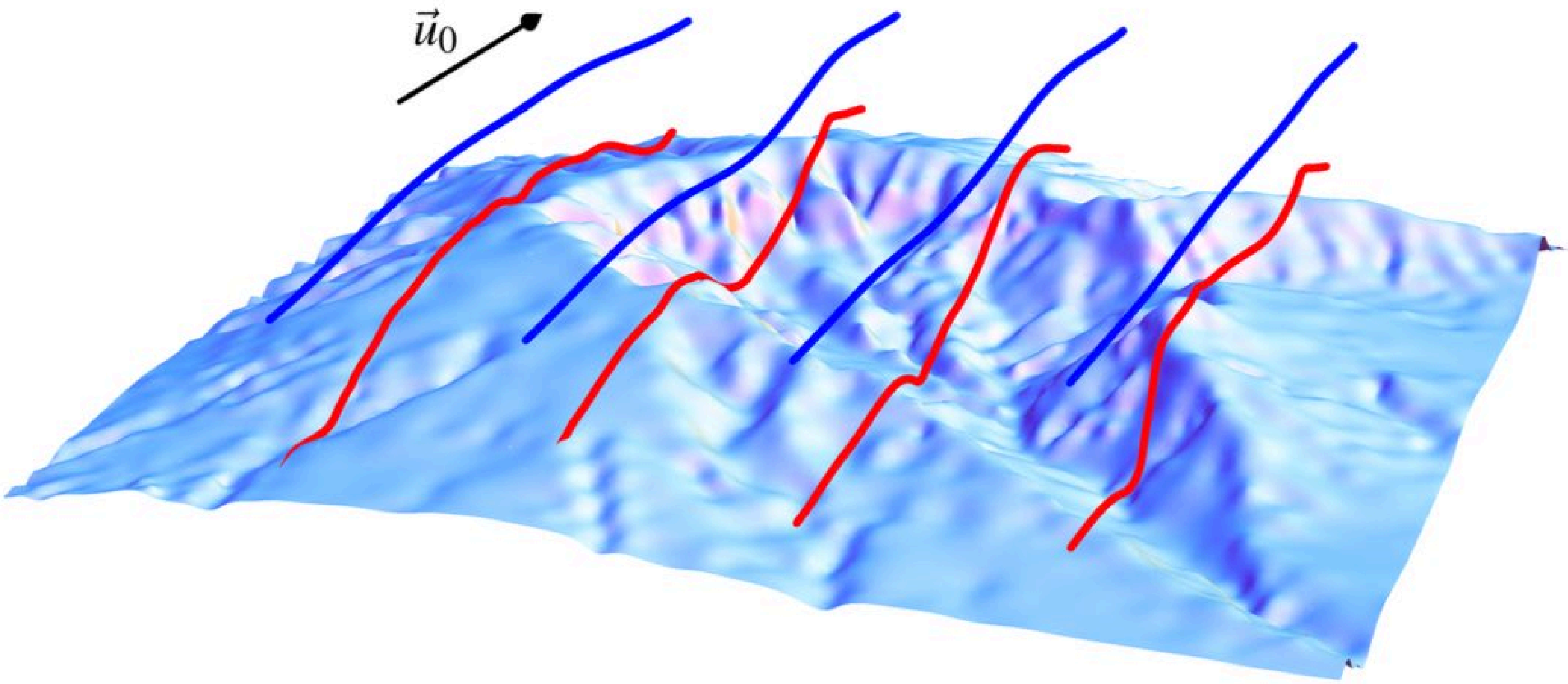
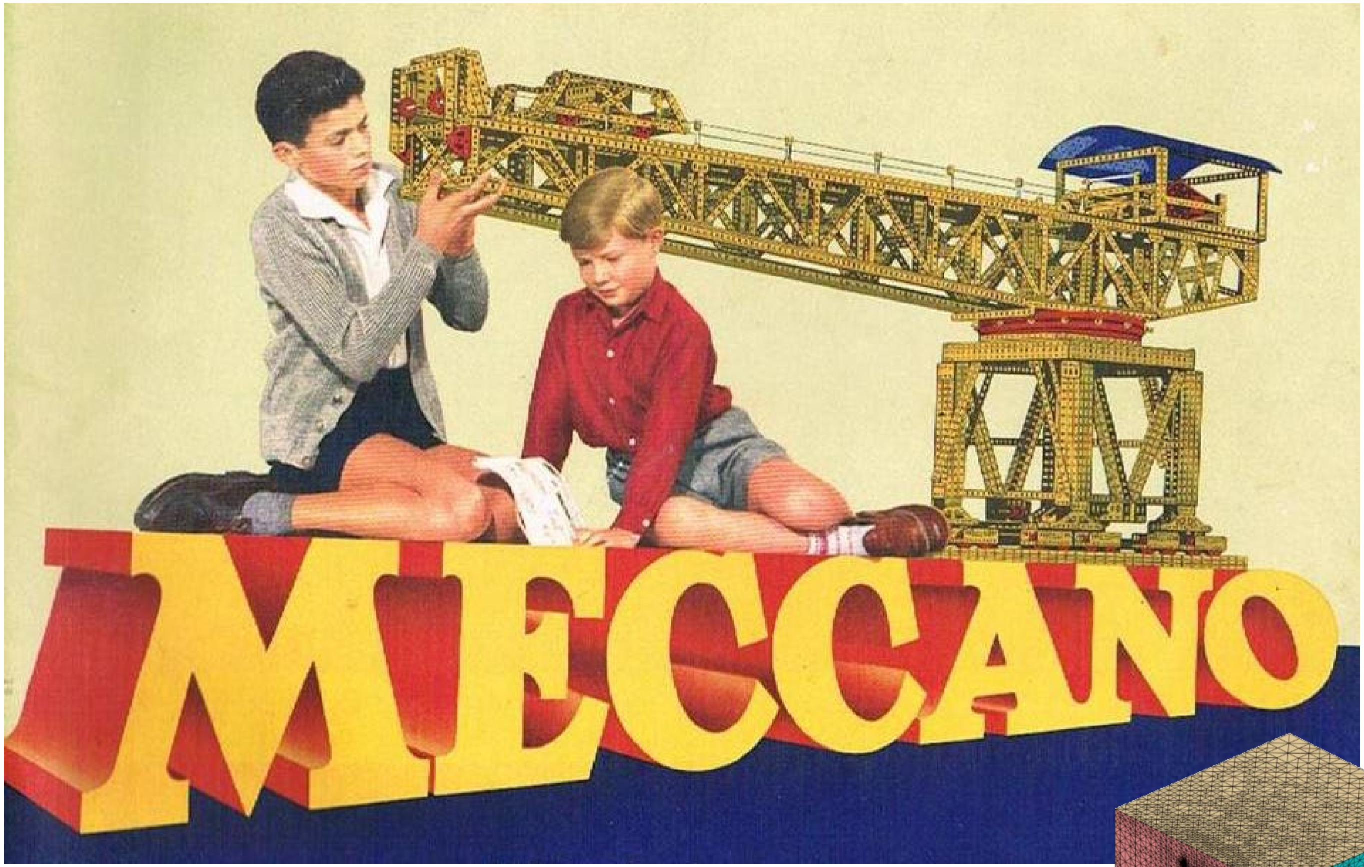


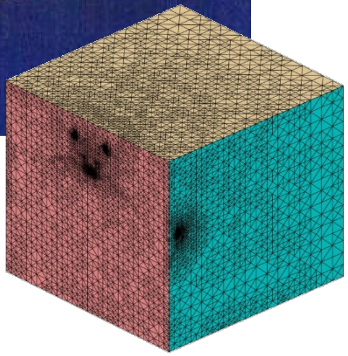
Comentarios Finales

… El método del mecano podría ser un camino
para
la generación automática de mallas adaptativas
y
la parametrización volumétrica de sólidos …

Key of the Method: Simultaneous Untangling and Smoothing

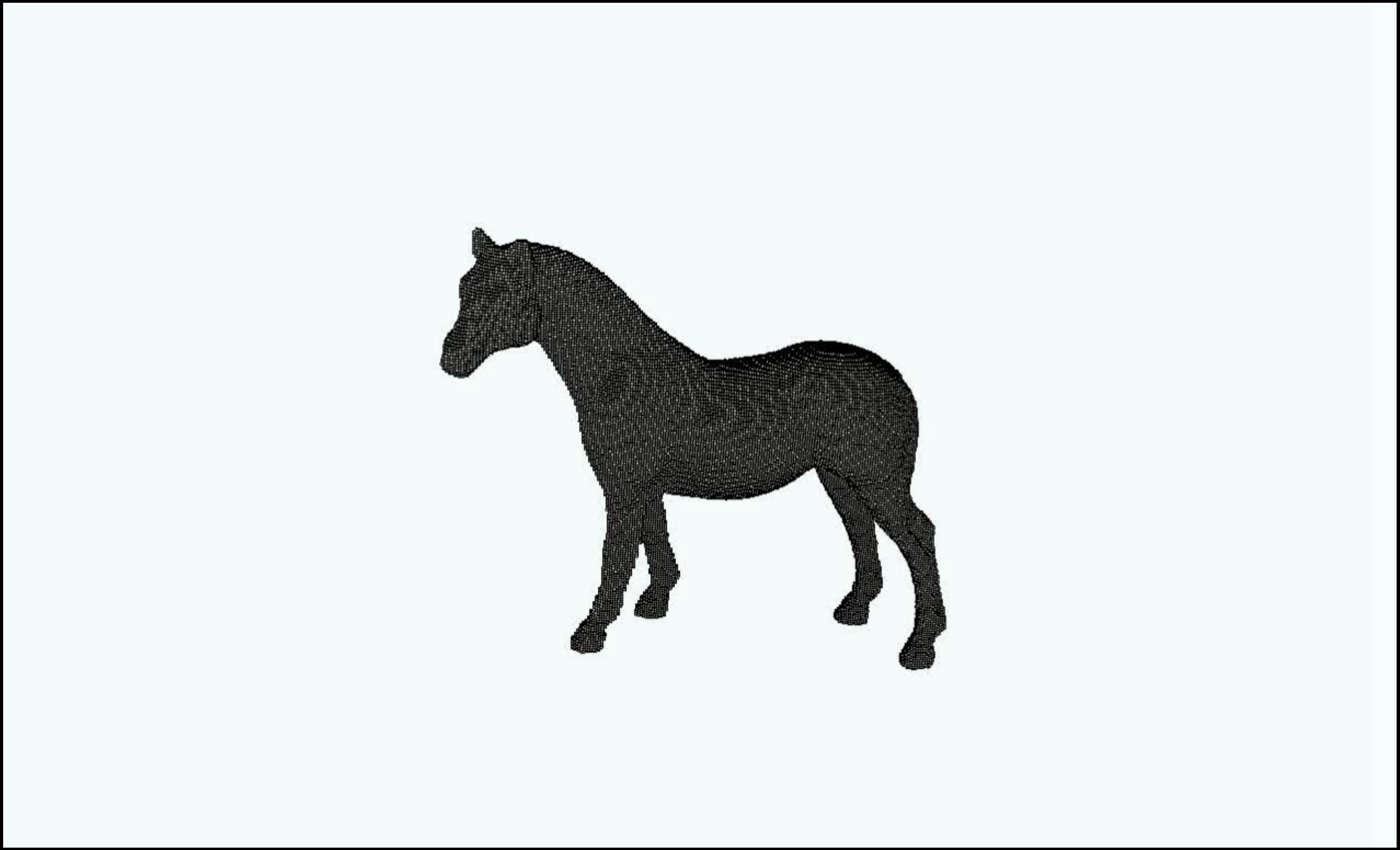
Automatic Construction of the Meccano





Future Works

Automatic Construction of the Meccano



Integración de Nuevas Metodologías en Simulación de Campos de Viento, Radiación Solar y Calidad del Aire

SIANI INSTITUTO UNIVERSITARIO INGENIERÍA COMPUTACIONAL

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD · FEDER · ULPGC

Proyecto
- Descripción
- Objetivos
- Investigadores
- Resultados
- Links de interés

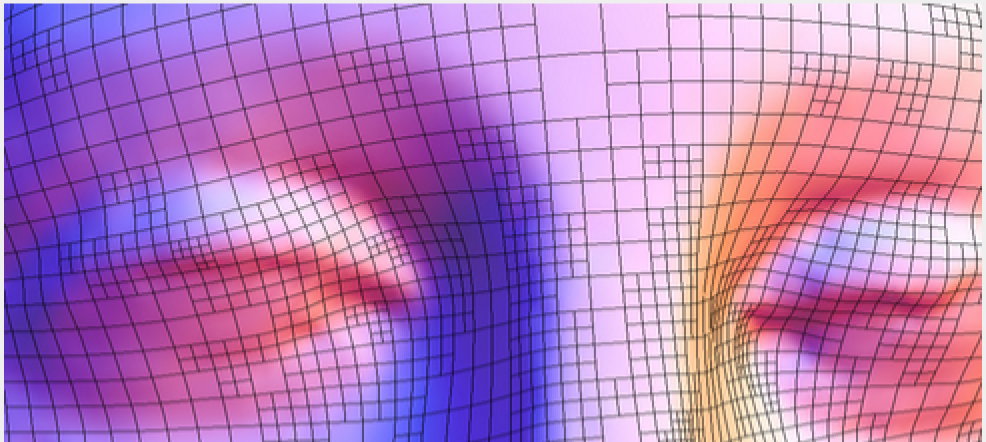
Publicaciones
- Artículos
- Congresos
- Libros y capítulos
- Otras publicaciones

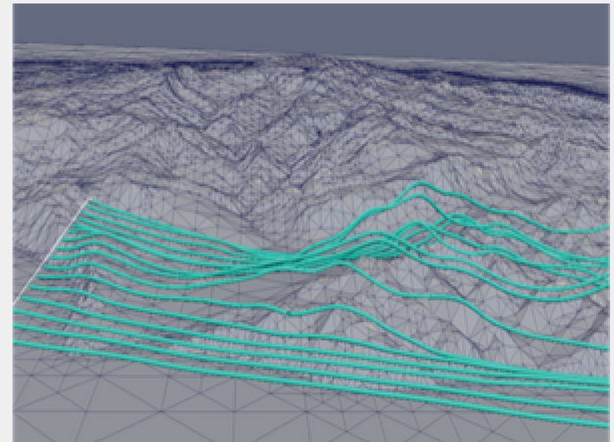
Otras actividades
- Vall de Nuria
- Workshops en la AEMET
- Proyecto Consolider
- Cursos y Conferencias
- Congresos Organizados

Ministerio de Economía y Competitividad y FEDER
Referencia: CTM2014-55014-C3-3R
Plazo de Ejecución: 01/01/2015 - 31/12/2017

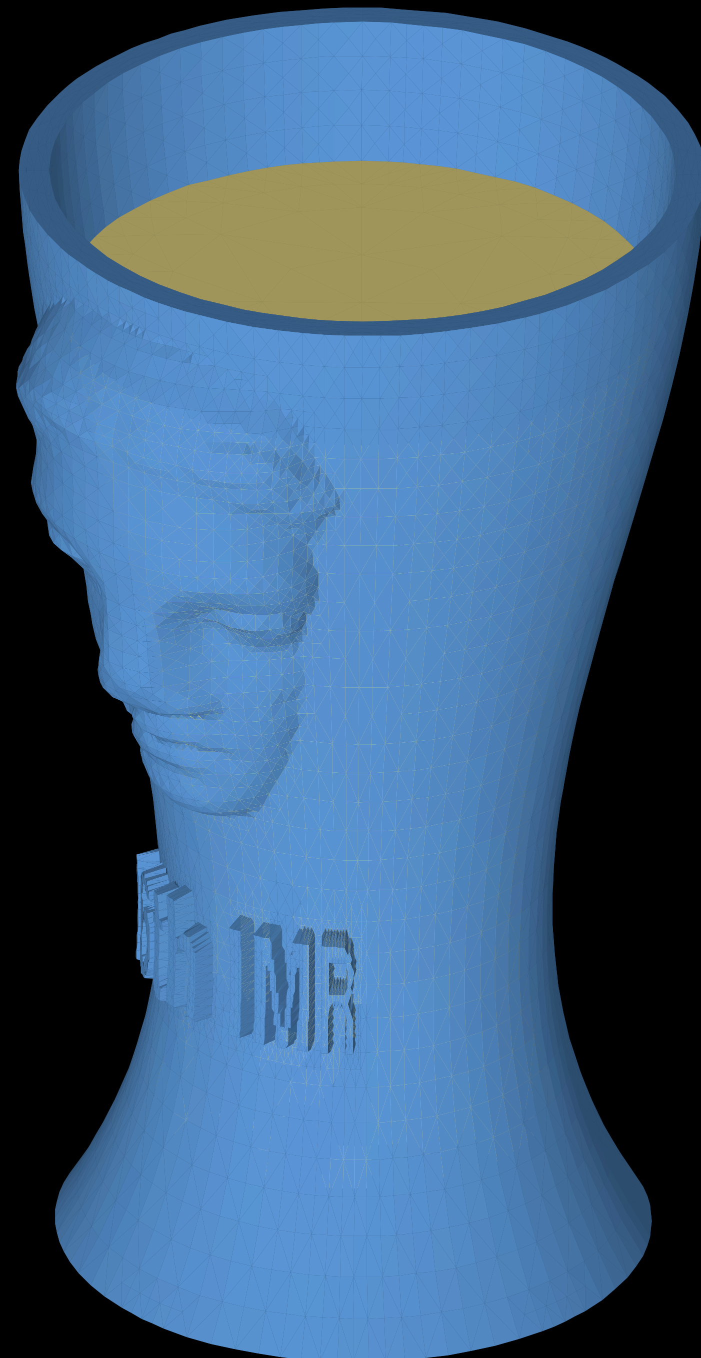
Descripción del proyecto

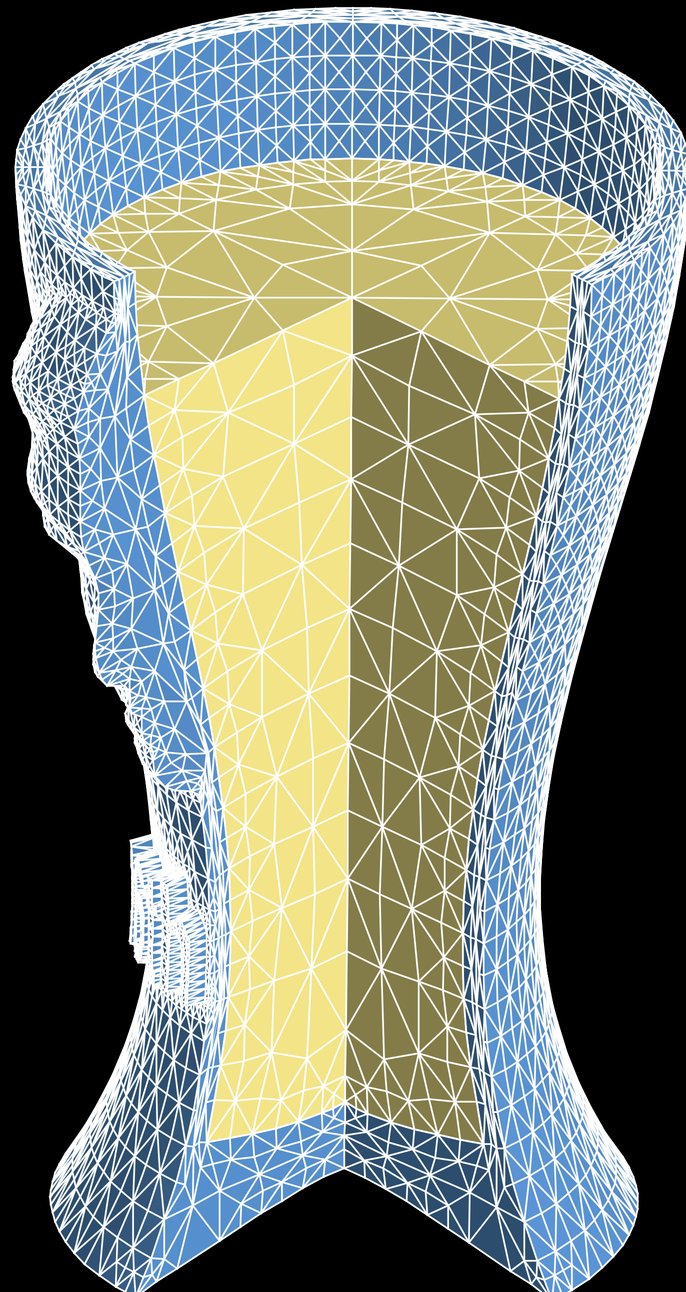
Este Subproyecto de Investigación de la Universidad de Las Palmas de Gran Canaria, titulado "Integración de nuevas metodologías en simulación de campos de viento, radiación solar y calidad del aire", con referencia 604155032-55032-45-514, se enmarca dentro del Proyecto Coordinado: "Integración de nuevas metodologías para gestión medioambiental", con referencia CTM2014-55014-C3-1-R, financiado por el Ministerio de Economía y Competitividad y FEDER a través de la convocatoria 2014 de proyectos I+D+i del programa estatal de Investigación, desarrollo e innovación orientada a los retos de de la sociedad. Adjudicado para el periodo 2015-2017.

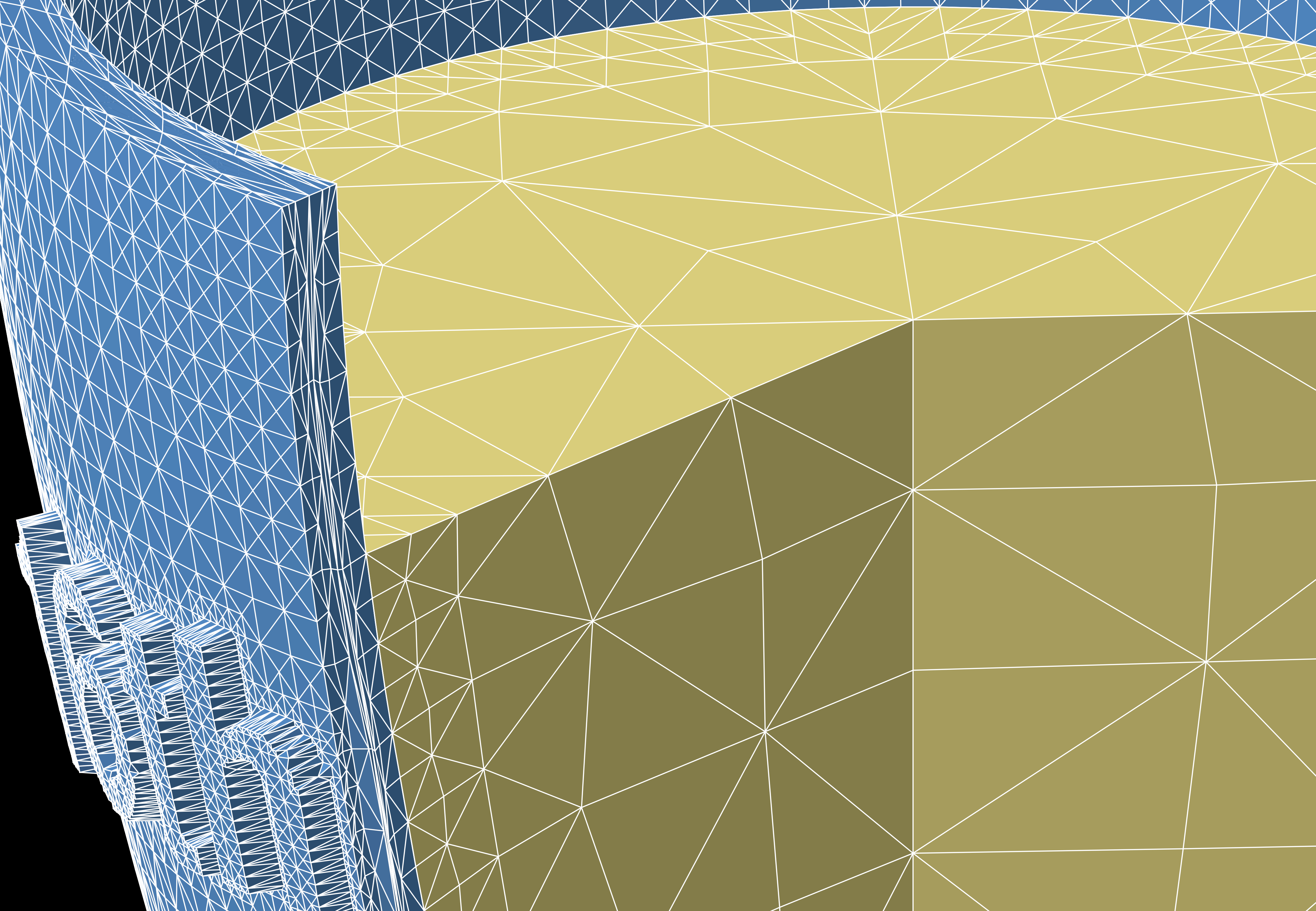




http://www.dca.iusiani.ulpgc.es/proyecto2015-2017


MR





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