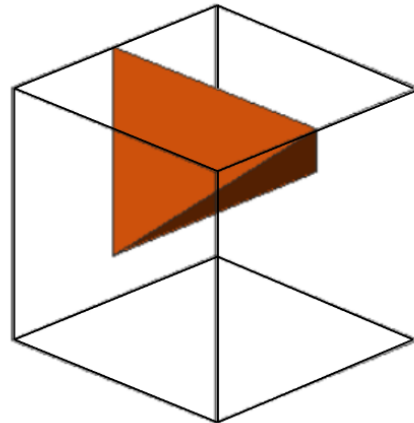


# *Lautsch Finite Elemente GmbH*

## **Bad elements and good results**



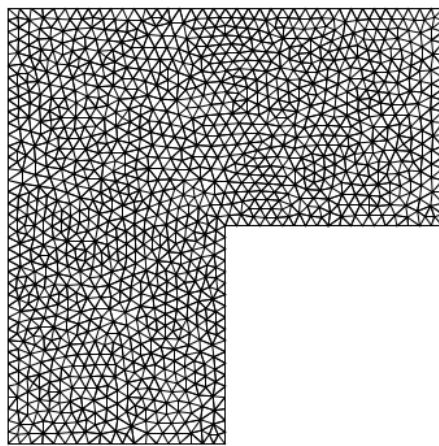
# Adaptive finite elements with anisotropic meshes\*

2012

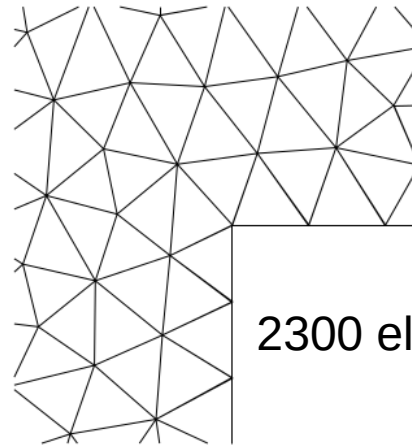
Weizhang Huang<sup>†</sup>

Lennard Kamenski<sup>‡</sup>

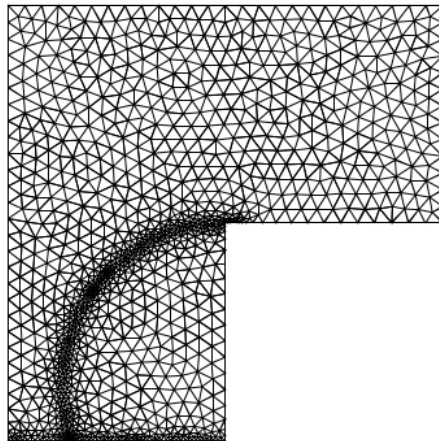
Jens Lang<sup>§</sup>



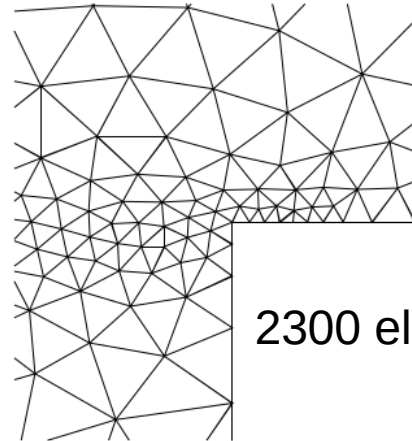
(a) Delaunay: 2326 elements; max. aspect ratio 2.8.



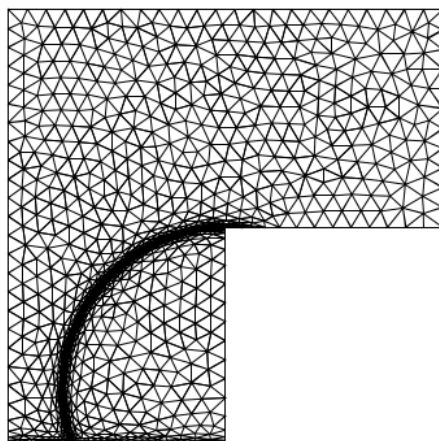
2300 elements Delaunay



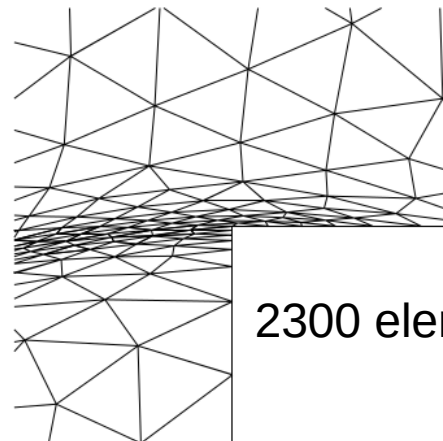
(b) Isotropic adaptive: 2321 elements; max. aspect ratio 3.0.



2300 elements isotropic + adaptive



(c) Anisotropic adaptive: 2316 elements; max. aspect ratio 24.4.



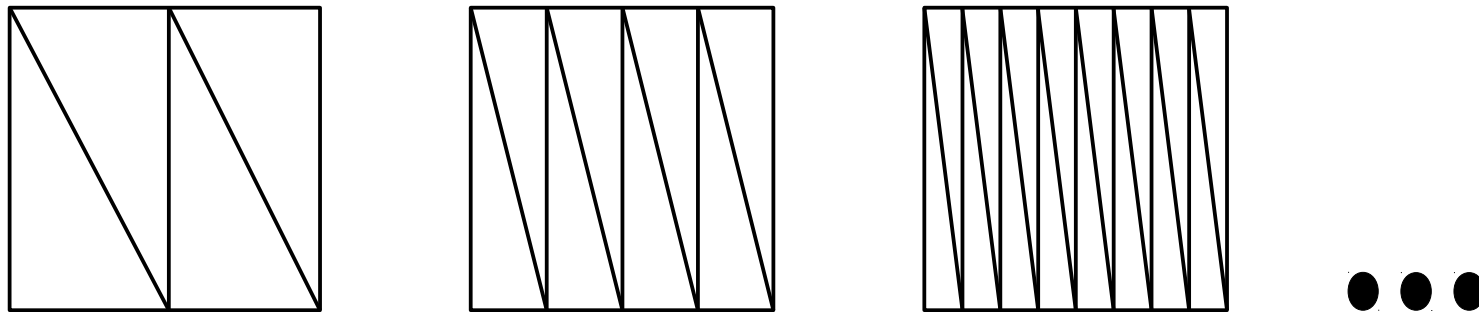
2300 elements anisotropic + adaptive

The paper presents a numerical study for the finite element method with anisotropic meshes. We compare the accuracy of the numerical solutions on quasi-uniform, isotropic, and anisotropic meshes for a test problem which combines several difficulties of a corner singularity, a peak, a boundary layer, and a wavefront. Numerical experiment clearly shows the advantage of anisotropic mesh adaptation. The conditioning of the resulting linear equation system is addressed as well. In particular, it is shown that the conditioning with adaptive anisotropic meshes is not as bad as generally assumed.

Consider  $\Delta u = u_{xx} + u_{yy} = -2$  at  $[-1, 1] \times [-1, 1]$

$u = 0$  at the vertical boundary,  $du/dy = 0$  at the horizontal boundary.

The solution is  $u(x,y) = 1.0 - x^2$



Approximation quality increases and element quality decreases.

Quadratic Elements: The solution is an element of the space to which it should be projected. ANY MESH can represent the solution without discretization errors.

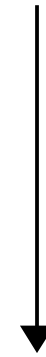
Linear static analysis  
 All edges length 1.0 D = center of A/B/C

Fixed at A1, B1, C1  
 Force at A3/B3/C3 direction B3/C3/A3

XX on D2 D3

x = Distance D2 XX

x	f(x) = torsion at D3
0.5	2.5431
0.25	2.5203
0.0625	2.4973
0.015625	2.4902
0.003906	2.4881
0.000976	2.4876



converges against ??

0.0 MESSAGE: ZERO VOLUME ELEMENT+STOP

2.4575 rigid body element  
 2.5092 bad tetra A2/B2/C2/XX deleted

