Institut für Numerische Simulation
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Practical Lab
Variational Methods and Inverse Problems in Imaging

Summer term 2014

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Problem sheet 1 **April 25th, 2014**

Problem 1 (First example)

In this exercise we will study the following elliptic partial differential equation that was already mentioned in the introduction.

$$\begin{aligned} u - \alpha\Delta u &= u_0 \quad \text{in } \Omega \\ \partial_\nu u &= 0 \quad \text{on } \partial\Omega \end{aligned}$$

where $\partial_\nu := < \nabla u, n >$ with a normal n on $\partial\Omega$ and $\alpha := 2\pi$.

(i) Make yourself familiar with the technical setup. Follow the instructions provided to obtain and compile the source code.

(ii) Execute the first example `projects/introduction/exercise01` and have a look at the results.

(iii) Make yourself familiar with the Quocmesh library by looking through the source code carefully.

(iv) Use the documentation to look up the used operators aol :: MassOp and aol :: StiffOp. Study the class hierarchy and find out where the assembly routine described in the introduction has been implemented. Also search for prepareLocalMatrix and try to understand how the mass and stiffness matrices are actually implemented.

(v) Based on the way aol :: StiffOp is implemented, write your own Finite Element operator for the following modified equation:

$$\begin{aligned} u - \operatorname{div}\{\alpha(x)\nabla u\} &= u_0 \quad \text{in } \Omega \\ \partial_\nu u &= 0 \quad \text{on } \partial\Omega \end{aligned}$$

where $\alpha(x) = 1$ everywhere except a small stripe around $x = 0.5$ where $\alpha(x) = 10^{-3}$. **Hint:** use the `getGlobalCoords` method of the configurator to obtain global coordinates.

Problem 2 (Demonstration: Switching to 3D)

In this exercise we will try to solve the same problem as above but now in dimension 3.