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Exercise 1 *DUNE grid interface (practical exercise)*

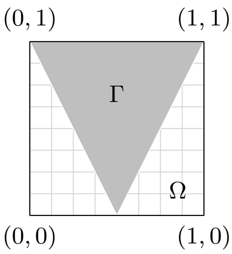
In this exercise you should become familiar DUNE grid interface. For our practical exercise we will use DUNE module *dune-npde* (see homepage).

In the directory */dune-npde/uebungen/uebung01* you will find an example programm which integrates the analytical function

$$f(x, y) = \exp^{-3.234\left((x-0.5)^2+(y-0.5)*2\right)}$$

on a structured grid. The integral is approximated by first order quadrature. The integration domain is unit cube $\Omega = \{(x, y)|0 \leq x \leq 1, 0 \leq y \leq 1\}$. The integration is done for several grid refinements (beginning with only one cell) to prove the convergence. In addition, the function f_h (approximation of f in grid vertices) will be stored as VTK file for visualization purposes.

1. Have a look at the programm, try to understand the source code, compile it and run the programm. Start *paraview* to view the VTK file. Try to use different filters (especially *warp* filter).
2. Modify the program in the way that the function f will be integrated over the triangle subdomain $\Gamma \subset \Omega$ (see picture below).



Implement following integration domains:

   i) Only cells that are completely in Γ will be considered to quadrature.

   ii) Only cells with at least one vertex in Γ will be considered to quadrature.

3. Instead of a structured grid, you should integrate over an unstructured triangle grid which covers Γ completely. The file *triangle.msh* contains the suitable grid. This file can be read with the following commands:

```
typedef Dune::UGGrid<2> GridType;
GridType grid;
// read gmsh file
Dune::GridFactory<GridType> factory(&grid);
Dune::GmshReader<GridType>::read(factory,"triangle.msh",true,true);
factory.createGrid();
```

   Compare the convergence orders of structured and unstructured grid. Try different integration orders. Does it make any difference? Why?

4. Modify the class *FunctorVTKFunction* such that the output will be zero for all cells which are not completely in Γ.

(20 Points)