MESH GENERATION OF TWO-DIMENSIONAL COMPLEX DOMAINS

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1 Objectives

Indonesia is a tsunami prone area since it is an active seismic region [3]. The Krakatau eruption that generated great tsunami in 1883, the 2004 Indian ocean tsunami with over one hundred and fifty thousand fatalities in Indonesia or several other tsunami events in Pangandaran and Palu are examples that showed the coastal areas of Indonesia are potential to be hit by a tsunami.

One way to study this complexity is to use a water wave model to simulate a tsunami in a particular area. To do this, we need to select (or derive) the appropriate water wave model. Since tsunami can be considered as shallow water waves [2], we choose the shallow water equations (SWE), which will be solved numerically by the Finite Element Method (FEM).

In order to implement FEM for SWE, we need to divide the domain into a finite number of triangular elements and defines a polynomial basis function for each element. In this work, we employ a mesh generator in FreeFem++ [1] to create a triangulation.

2 Mesh generated using an image

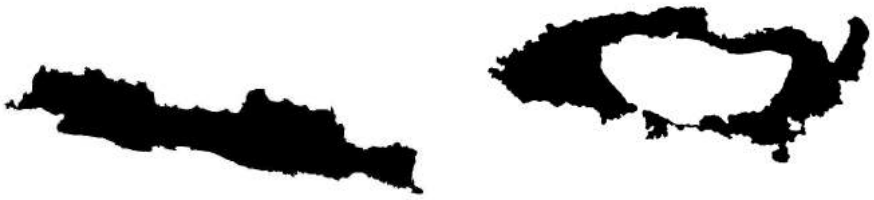
We present here the method to build a mesh from an image using FreeFem++. We took images of Java Island and Toba Lake from Google Earth to get a good resolution.

(a) (b)

Figure 1: Initial images of (a) Java Island and (b) Toba Lake

Using Photoshop, we put black and white color on the images. On the island of Java, we give black color for the island and white color for the ocean, the opposite is for Lake Toba. The results of the black and white images can be seen in Figure 2. Then we convert the jpg image to a pgm image which can be read by FreeFem++ using terminal command:

```
convert java.jpg java.pgm.
```



(a) (b)

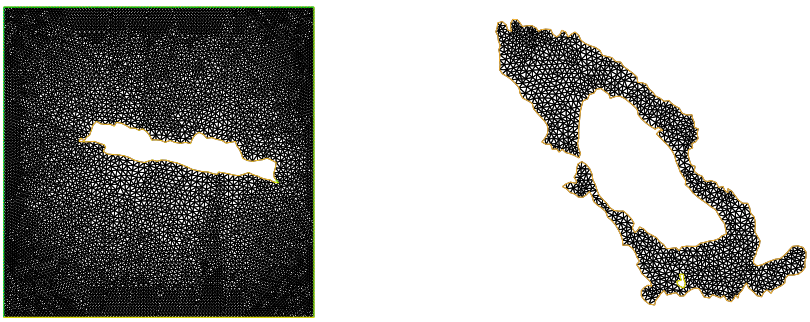
Figure 2: Black and White images of (a) Java Island and (b) Toba Lake

In order to generate meshes of Java Island and Toba Lake domain, we read the pgm file as follows:

```
load "isoline"
load "ppm2rnm"

string name="java.pgm";
real[int,int] xy(3,1); //to store the isoline points
int[int] be(1); //to store the begin, end couple of lines
int nc;// nb of curve
{
real[int,int] ff1(name); // read  image and set to an rect. array
//  remark (0,0) is the upper, left corner.
int nx = ff1.n, ny=ff1.m;
// build a cartesain mesh such that the origne is at the right place.
mesh Th=square(nx-1,ny-1,[(nx-1)*(x),(ny-1)*(1-y)]);
// warning  the numbering is of the vertices (x,y) is
// given by $  i = x/nx + nx* y/ny $
fespace Vh(Th,P1);
Vh f1; f1[]=ff1; //transform array in finite element functions
nc=isoline(Th,f1,xy,iso=0.25,close=0,beginend=be,
smoothing=.005,ratio=0.1);
}

macro GG(c)
border G#c(t=0,1)
{
  P=Curve(xy,be(c*2),be(c*2+1)-1,t);
  label=c+1;
}
real lg#c=xy(2,be(c*2+1)-1);  // END OF MACRO

// number of closed curves
GG(0)
real hh=-3;
// How many closed curves are there in the image
func bord = G0(lg0/hh);
plot(bord,wait=0);
```

```
real  x0=-250.0, y0=-400.0, Lx=1200.0, Ly=1200.0; //"L" length
border  a1(t=0,1){x=x0+Lx*t; y=y0;} //lower
border  a2(t=0,1){x=x0+Lx; y=y0+Ly*t;} //right
border  a3(t=1,0){x=x0+Lx*t; y=y0+Ly;} //top
border  a4(t=1,0){x=x0; y=y0+Ly*t;} //left
real nnp=50;
mesh Th=buildmesh(a1(nnp)+a2(nnp)+a3(nnp)+a4(nnp)+(bord));

plot(Th,wait=0);
plot(Th,wait=0, ps="java.eps");
```

Then we can create the mesh of our domains. For Java island, we have to add an outer boundary in the form of a rectangular boundary. This is because the ocean is the domain. In the Figure 3 meshes of our domains are shown. The mesh will be used in the simulated tsunami.



(a) (b)

Figure 3: Meshes of (a) Java Island and (b) Toba Lake

References

[1] *FreeFEM++*. URL `http://www3.freefem.org/`.

[2] Hiroshi Kanayama and Hiroshi Dan. A tsunami simulation of hakata bay using the viscous shallow-water equations. volume 30, 2013. doi: 10.1007/s13160-013-0111-7.

[3] Finn Løvholt, Daniela Kühn, Hilmar Bungum, Carl B. Harbitz, and Sylfest Glimsdal. Historical tsunamis and present tsunami hazard in eastern indonesia and the southern philippines. *Journal of Geophysical Research: Solid Earth*, 117, 2012. ISSN 21699356. doi: 10.1029/2012JB009425.