

## Network extraction code – pnextract

pnextract extracts a conventional pore network from a microCT image. The algorithm is a rewrite of the Dong and Blunt (2009) code. There are major differences though. First, the pore and throat detection algorithm is revised; see Stages 1 and 2 described in Raeini et al. (2017) <https://doi.org/10.1103/PhysRevE.96.013312>. Raeini et al. (2017) is an extension of this code. The shape of pores in this code are deduced from shape factors, the shape-factor equation is changed compared to the old definition, see Bultrys et al (2018, currently under-review).

### 1 Input file

The input file for the network extraction code is a mhd header file compatible with paraview and Fiji (ImageJ with plugins) with additional optional keywords specific to network extraction algorithm. See the file Image.mhd for a sample input.

#### 1.1 Format specifications:

1. The order of the first 6 keywords should not be changed for compatibility with third-party software (ImageJ and Paraview)
2. Use “#” for comments
3. All keyword and its data should be given in a single line

#### Important keywords:

1 to 3rd keywords (should not be changed):

1. `ObjectType = Image`
2. `NDims = 3`
3. `ElementType = MET_UCHAR`
4. keyword: `DimSize` – used to assign the dimensions of the image:  $N_x$ ,  $N_y$  and  $N_z$
5. keyword: `ElementSpacing` – used for assigning voxel size:  $\delta x$ ,  $\delta y$  and  $\delta z$  should be equal
6. keyword: `ElementDataFile` – specifies the name of binary 8bit data file (.raw), ascii (.dat), .raw.gz, and .tif files are supported too.

```

ObjectType = Image
NDims =      3
ElementType = MET_UCHAR

DimSize =      400    400    400
ElementSpacing = 5.345 5.345 5.345
Offset =        0      0      0

ElementDataFile = Berea.raw

```

Fig. 1: Sample input header file

**Medial-surface settings:**

The `medialSurfaceSettings` is an optional technical keyword which can be used for sensitivity analysis, for instance.

```
medialSurfaceSettings 0.1 0.9 0.7 0.5 1.5 1.21 7 0.25 1.6;
```

where the keyword arguments are `clipROutx` `clipROutyz` `midRFrac` `RMedSurfNoise` `lenNf` `vmvRadRelNf` `nRSmoothing` `RCorsf` `RCors`, respectively.

The `pnextract` code produces few lines showing the settings being used. something like:

```

medialSurfaceSettings: 0.05 0.98 0.7 2.75 0.6 1.1 3 0.15 1.75
medialSurfaceSettings:
clipROutx      : 0.05
clipROutyz     : 0.98
midRFrac       : 0.7
RMedSurfNoise  : 2.75
lenNf          : 0.6
vmvRadRelNf    : 1.1
nRSmoothing    : 3
RCorsf         : 0.15
RCors          : 1.75

```

The first line is the keyword and its parameters and the rest are short names for each of the parameters and their values. In case you want to do a quick evaluation, you can copy the first line into the `pnextract` input, the `.mhd` file, and change the parameters and re-run the code. Here is a short explanation for these parameters:

`clipROutx` is used to limit the size of maximal-spheres extending outside the rock image in the x direction.

`clipROutyz` is used to limit the size of maximal-spheres extending outside the rock image in the y and z directions.

`midRFrac` is the relative size of the distance-map of the voxel between two maximal-spheres, for the spheres to be considered part of the same pore.

`RMedSurfNoise` is a measure of noise amplitude. Decreasing this will likely increase the number of pores, but it also affects the number of corners per throat.

`lenNf` is a relative distance for merging adjacent pores which are too close to each other.

`vmvRadRelNf` is the relative size of the throat between the two pore considered for merging, the contraction should be less than this to merge the nearby pores (that are less than `lenNf` apart), otherwise the pore will not be merged. Decreasing these two will increase the number of pores.

`nRSmoothing` applies a small amount of Gaussian-like smoothing on the computed distance map, which in turn affect the rest of the computations. Decreasing this will probably increases the number of pores.

`RCorsf` controls the distance between the maximal spheres. This is a sensitive parameter, changing it may need changing other parameters to get good results.

`RCors` controls the minimum distance between (small) maximal-spheres. This is a sensitive parameter, changing it may need changing other parameters to get good results.

## Contact:

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## References:

See <http://www.imperial.ac.uk/earth-science/research/research-groups/perm/research/pore-scale-modelling/publications/>