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AN APPROACH TO LATTICE BOLTZMANN SIMULATIONS OF FLOW IN 2D POROUS MEDIA

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MAKING THE SIMULATION APPROACH

A simulation algorithm is elaborated for liquid moving into porous media with potential moving directions (Fig. 1) as velocity of the liquid.

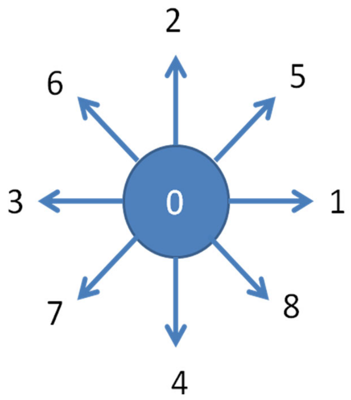

Figure 1. The 9 direction the liquid can move in the grid

The velocity of the liquid in the certain grid point is calculated using:

$$\begin{array}{l} Vx = C * (f1 + f5 + f8 - f3 - f6 - f7) * p, \\ Vy = C * (f2 + f6 + f5 - f4 - f7 - f8) * p, \end{array} \tag{1}$$

where p is pressure.

To find out local distribution of the liquid the equilibrium function should be used in the way of:

$$f_{eqi} = w * p * (1 + 3.0/C + 9.0/\left(2.0 * C^2\right) * (f_i * u) - 3.0/C^2 * u^2),$$

where p is the pressure, w is the weighting function, f_i is the liquid currently analyzed potential moving direction and u is the vector of the liquid velocity in a $[Vx, Vy]^T$ form.

The algorithm of the application is:

1. Calculate the liquid each potential directions values for all of the grid points.
2. For each grid point sum the each direction values in order to get the density of the liquid in each point of the grid.

3. Compute the velocity of the liquid in each point of the grid.
4. Calculate local equilibrium function for each direction of the each point of the grid. By this step we get how far the liquid can move in the potential direction.
5. Compute the time the liquid can move from its position to the new one in the potential direction.
6. Calculate the liquid new position after advactive moving step made from the regular grid point position for every grid point.
7. By using interpolation find out the liquid position in the regular grid by using the liquid new position after advactive moving step made from the regular grid point position for every grid point.

INTERPOLATION USED

When the liquid moved from the regular grid point to the advactive one (Fig. 2) the value on the liquid in the regular grid point the liquid moved from can be found within the area of 9 point of the analyzed grid. The central point value is unknown because the liquid moved from it, but the 8 points around the advactive point are regular with the previous time step or after interpolation got values.

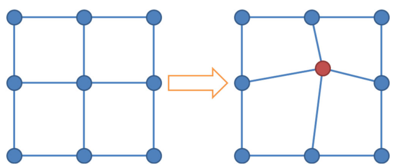

Figure 2. The central point liquid moved to advactive position

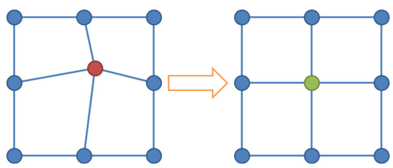

Figure 3. The advactive point is interpolated to the regular grid point

To find out the relationships between the advactive point and regular point around the advactive one we solve Ac=B matrix equation, where c is unknown vector the relationship coefficients (size=9). The matrix A each row contains the same set of freely chosen X and/or Y elements of the Taylor series, where x and y component values are the differences between the central advactive point and the current point coordinates. The each row uses coordinates of the only one point of the analyzed grid.

To calculate the liquid amount in the centre of the regular grid interpolating area it is needed to sum of multiplications of the conforming by index c vector elements and the matrix A Taylor series elements, where x and y are the differences between the central advactive point and the coordinates of the point the values should be found for.