

# RBF Meshless Methods for Navier-Stokes Equations

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## ABSTRACT

In this study, we consider the Navier-Stokes equations (NSE) in stream function-vorticity form and stream function only form. We present a meshless RBF collocation method [1,2] for solving NSE in these two forms. We use the generalized multiquadric RBF with constant shape parameter and varying shape parameter. The method uses the technique of fundamental solutions, where the approximations have the advantage of verifying the linear part of the PDE.

The efficiency and accuracy of this method are investigated by running several experiments to two model problems: the driven cavity flow in square and a problem with known solution. Stream function contours for different values of Reynolds numbers are displayed to see the quality of the RBF solutions. The computed velocity profiles along the vertical and horizontal centerlines are in good agreement with available data in the literature. RBF solutions using uniformly spaced interior points are compared with RBF solutions using irregularly spaced Halton points. Also, we compare the effect of placing the boundary centers directly on the boundary as opposed to placement outside the domain. Several observations are made on the errors and the condition numbers and also some interesting findings are observed.

## REFERENCES

- [1] E. Kansa. Multiquadrics A scattered data approximation scheme with applications to computation fluid dynamics I. Surface approximations and partial derivatives estimates. *Computers and Mathematics with Applications*, 19: 127–145, 1990.
- [2] G.E. Fasshauer *Meshfree Approximation Methods with MATLAB.*, World Scientific Publishers, 2007.