

Subodh Joshi

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About Me

I am a researcher working in the broad area of scientific computing and numerical methods for conservation laws. I recently obtained my Ph.D. from the Department of Aerospace Engineering, Indian Institute of Technology Bombay. (<https://www.aero.iitb.ac.in/home/>).

Research Interests

Computational Fluid Dynamics (CFD),
Higher-order accurate numerical schemes,
Numerical methods for hyperbolic problems,
Scientific computing

Education

- 2011-2018 **Integrated M.Tech. + Ph.D. (CPI: 9.64/10)**
Department of Aerospace Engineering, IIT Bombay
M.Tech specialization: Aerospace Propulsion (*Department rank 1*)
Ph.D. Thesis title: Application of Multilevel Methods to Higher-Order Numerical Schemes for Linear Hyperbolic Problems
Ph.D. Advisor: Prof. Avijit Chatterjee
<https://www.aero.iitb.ac.in/home/people/faculty/avijit>
- 2007-2011 **Bachelors in Engineering**, Mechanical stream, Pimpri Chinchwad College of Engineering, Pune University (*First class with distinction*)
- 2006 **Higher Secondary Certificate** examination (HSC), Maharashtra state board. (*83.33%*)
- 2004 **Secondary School Certificate** examination (SSC), Maharashtra state board. (*86.93%*)

Other Training

- 2017 ACAI Summer School on Reinforcement Learning, a week long summer school organized by European Association for Artificial Intelligence (EurAI) and Vrije Universiteit Brussel (VUB), Nieuwpoort, Belgium.

2014 Workshop on Computational Fluid Dynamics using OpenFOAM, Organized by FOSSEE, IIT Bombay, India.

2013 Advanced Workshop on Theoretical and Computational Aspects of Nonlinear Waves (TCANW-2013) under National Program on Differential Equations: Theory, Computation & Applications (NPDE-TCA), Organized by Department of Mathematics, IIT Bombay, India.

Research

May 2018 **Development of a Nodal Discontinuous Galerkin Framework for Fluid Dynamics Simulations**
-Present

I am currently working as a project research scientist on an industry funded project at IIT Bombay. The work involves development of a Discontinuous Galerkin (DG) framework for simulation of Euler and Navier-Stokes equations. The framework is targeted at solving internal and external fluid flow problems using DG schemes on 3D mixed-element computational grids.

2012-2018 **Development of a Multilevel Method for Linear Hyperbolic Problems**

As the main contribution of my Ph.D. thesis, I developed a multilevel (ML) algorithm for efficient simulation of linear propagating waves using higher-order accurate schemes. The ML method is targeted at reducing the computational cost of higher-order accurate methods while retaining numerical accuracy. We developed the ML method for application to the spectral volume method (SVM) and the ADER space-time coupled finite volume schemes. In the Ph.D. thesis, we have shown through analytical treatment as well as numerical tests that the ML method retains the higher-order accuracy while significantly reducing computing cost. The accuracy and the efficiency of the ML method were also demonstrated on benchmark problems in computational aeroacoustics (CAA).

2017 **A-Posteriori Diffusion Analysis of Numerical Schemes in Wavenumber Domain**

I developed a simple technique for diffusion error analysis of numerical schemes while working on my Ph.D. thesis. A-posteriori diffusion analysis of linear as well as nonlinear numerical schemes is carried out in wavenumber domain. The analysis yields information about diffusion errors, wave-resolution properties and stability of a candidate numerical scheme based on the modal and total energy of a broadband signal used as initial conditions for numerical solution of scalar linear advection equation. This analysis is very simple and inexpensive to perform.

2013-Present **Traffic Modeling and Numerical Simulation of Traffic Flows**

I am also engaged in a collaborative project on traffic modeling and numerical simulation of traffic flows. The work includes predicting accurate traffic behavior for the Indian roads. I am responsible for numerical implementation of the macroscopic traffic models using higher-order accurate WENO scheme and TVD-Runge Kutta timestepping. In addition to this, I also contributed to model development for prediction of the two-wheeler vehicles' behavior in the highway traffic. The model has been validated using data obtained through an on-site observation of the traffic. The traffic model developed during this project is found to accurately simulate highway traffic on Indian roads.

Work Experience

May-October 2018 **Project Research Scientist, IIT Bombay.**

Development of a CFD software using Discontinuous Galerkin (DG) numerical schemes on mixed-element meshes. Funded by Siemens Technologies, Bangalore. (PI: Prof. Shivasubramanian Gopalakrishnan, Mechanical Engineering, IIT Bombay)

2011-2018 **Teaching Assistant (TA)**, for following courses at IIT Bombay-

1. Aerodynamics of Aerospace Vehicles (AE707)
2. Numerical Methods for Conservation Laws (AE617)
3. Aircraft Design (AE332)
4. Propulsion Lab, Department of Aerospace Engineering, IIT Bombay.

Publications

Journal

- 1 Joshi S. M., Chatterjee A., Higher-order multilevel framework for ADER scheme in computational aeroacoustics, *Journal of Computational Physics*, Vol.338, pp.388-404, 2017
- 2 Chatterjee A. and Joshi S. M., A p-variable higher-order finite volume time domain method for electromagnetic scattering, *Progress In Electromagnetics Research M*, Vol.64, pp.147-156, 2018.
- 3 Sreekumar M., Joshi S. M., Chatterjee A., Mathew T., Analyses and implications of higher order finite volume methods on first order macroscopic traffic flow models, *Transportation Letters- The International Journal of Transportation Research*, 2018.

Conference

- 1 Chatterjee A., Joshi S. M., Multilevel Higher Order Method for Simulation of Linear Wave Propagation, *8th International Conference of Computational Fluid Dynamics*, Chengdu - China, 14 - 18 July, 2014.
- 2 Joshi S. M., Chatterjee A., Multilevel Spectral Finite Volume Method for Linear Systems, *17th AeSI CFD Symposium*, NAL, Bangalore , 11-12 August, 2015.
- 3 Joshi S. M., Chatterjee A., Multilevel ADER Scheme for Computational Aeroacoustics, *9th International Conference of Computational Fluid Dynamics*, Istanbul-Turkey, 11-15 July, 2016.
- 4 Joshi S. M., Chatterjee A., Spectral Analysis of Higher-Order Multilevel Method, *18th AeSI CFD Symposium*, NAL, Bangalore , 10-11 August, 2016.
- 5 S. M. Joshi and A. Chatterjee, A-posteriori Diffusion Analysis of Numerical Schemes in Wavenumber Domain, *20th AeSI CFD Symposium*, NAL, Bangalore, 2018.

Under Preparation

- 1 S. M. Joshi and A. Chatterjee, A-posteriori diffusion analysis of higher-order numerical schemes for propagating linear waves, (*arXiv link* <https://arxiv.org/abs/1707.05026>).
- 2 M. Sreekumar, S. M. Joshi, A. Chatterjee and Tom Mathew, A stochastic multi-class first order model to explain disordered nature of vehicles in mixed traffic flow.

Skills

Programming	C, C++, Python, \LaTeX
Softwares and Libraries	OpenFOAM, Deal II, ParaView, Gmsh, Triangle
Environments and Tools	Linux, Git, Vim, SCons
HPC	OpenMP, MPI

Awards/ Achievements

- 2018 Best paper award (third place), 20th AeSI CFD Symposium, NAL, Bangalore.
- 2017 Received a travel grant from the European Association for Artificial Intelligence (EurAI), for attending a summer school on Reinforcement Learning in Nieuwpoort, Belgium.
- 2013 Department rank 1 in M.Tech. program, Department of Aerospace Engineering, IIT Bombay.
- 2011 Qualified Graduate Aptitude Test in Engineering (GATE) (All-India Rank 139, out of 81175 participants). Received MHRD fellowship for pursuing higher education in IIT Bombay based on the GATE score.
- 2010 Selected for IMTMA-JAGRITI Youth program, a national level program organized by Indian Machine Tools Manufacturing Association (IMTMA), received a travel grant for attending IMTEX machine tool exhibition at BIEC, Bangalore.
- 2002 Selected for School Students' Summer Programme (SSSP), Inter University Center for Astronomy and Astrophysics (IUCAA), Pune.

Other Interests

- Fitness I enjoy outdoor activities like trekking, cycling and running.
- Music I play the Indian bamboo flute and acoustic guitar.
- Reading I like reading Marathi and English literature. I also enjoy reading some of the online blogs (as well as watching YouTube videos) on science and technology.
- Art I enjoy pencil sketching and photography in my spare time.

References

- Prof. Avijit Chatterjee, IIT Bombay
<https://www.aero.iitb.ac.in/home/people/faculty/avijit>
- Prof. Shivasubramanian Gopalakrishnan, IIT Bombay
http://www.me.iitb.ac.in/~sgopalak/SGK_temporary/About_Me.html
- Prof. Prabhu Ramachandran, IIT Bombay
<https://www.aero.iitb.ac.in/~prabhu/index.html>
- Prof. G. R. Shevare, IIT Bombay
<https://www.aero.iitb.ac.in/home/people/faculty/shevare>