Abhishek Singh

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Education

2022–Present **Purdue University**, *Ph.D. Candidate, Mechanical Engineering*, West Lafayette, IN, USA.
GPA: 3.92/4.00 (Affiliations: Vlachos Research Group; Predictive Science Laboratory).

2018–2022 **Indian Institute of Technology Mandi**, *B.Tech., Mechanical Engineering*, Himachal Pradesh, India.
GPA: 9.11/10

Research Interests

Flow Diagnostics: PIV/PTV	Medical Image Analysis	Bayesian Inverse Problems
4D Flow MRI	Physics-Informed Learning	Uncertainty Quantification

Research Experience

Aug 2024–Present **Graduate Research Assistant**, Predictive Science Laboratory (PSL), Purdue University.

- **Bayesian aneurysm growth detection (uncertainty-aware longitudinal surveillance).** Developed a probabilistic growth classifier from paired baseline/follow-up vascular surface meshes using aneurysm-vs.-healthy-vessel displacement mean-shift as an internal control, propagating measurement uncertainty to deliver calibrated growth probabilities robust to segmentation/meshing/registration bias.
- **End-to-end 3D PIV from particle images (Gaussian-splatting + motion consistency).** Developed an end-to-end method that reconstructs a continuous 3D particle-density field directly from multi-camera images and estimates the 3D flow field by enforcing short-time motion consistency between frames—removing the need for voxel-based tomographic reconstruction, particle tracking, and separate track-to-grid interpolation; currently integrating an automated camera calibration module.

Aug 2022–Present **Graduate Research Assistant**, Vlachos Research Group, Purdue University.

- Designed and implemented automated image import and processing tools for handling raw 4D Flow MRI acquisitions from multiple MRI systems (GE, Philips, Siemens), including DICOM conversion, preview visualization, and cross-dataset compatibility checks.
- Developed an end-to-end 4D Flow MRI workflow integrating unsupervised/physics-informed segmentation, velocity corrections, and hemodynamic quantification (e.g., pressure estimation and wall shear stress) for intracranial, cerebrospinal, and cardiovascular applications.
- Engineered a 3D PTV reconstruction framework leveraging RBF interpolation and physics-informed constraints (e.g., divergence minimization; momentum-consistency losses) for super-resolved velocity fields and derived quantities (vorticity, stresses), with comparisons to 4D Flow MRI.
- Integrated Lagrangian Coherent Structures (LCS) tools for enhanced transport and mixing diagnostics in both 4D Flow MRI and PIV/PTV workflows.
- Supported multiple experimental fluid mechanics studies including in vitro PTV of CSF flow through nerve-root geometries, snake tongue flicking in quiescent environments, and falling spheres in density-stratified media, analyzing fluid–structure interactions via Eulerian and Lagrangian diagnostics.

Journal Publications

1 **Singh, A.** and Kumar, P., "Droplet impact dynamics onto a deep liquid pool of wavy free surface," *Physics of Fluids* 34, 022107 (2022). doi:10.1063/5.0084530

2 Dasaro, S.R., **Singh, A.**, Vlachos, P., and Ristroph, K.D., "Mechanistic insights into how mixing factors govern polyelectrolyte-surfactant complexation in RNA lipid nanoparticle formulation," *Journal of Colloid and Interface Science* 678(Part A), 98–107 (2025). doi:10.1016/j.jcis.2024.08.150

Journal Manuscripts (Submitted / In Preparation)

1 **Singh, A.**, Rayz, V.L., and Vlachos, P.P., "VAST-MRI: Vascular Flow Analysis and Segmentation Toolkit for 4D Flow MRI" (manuscript in preparation).

2 Roa-Castro, J.A., **Singh, A.**, Hans, A., Kondratiuk, K., Saloner, D., Rayz, V.L., Bilionis, I., and Vlachos, P.P., "Bayesian Soft-Threshold Model for Detecting Aneurysm Growth," *Medical Image Analysis* (manuscript in preparation).

3 **Singh, A.**, Hans, A., Bilionis, I., and Vlachos, P.P., "Coupled Particle Density and Velocity Estimation for Volumetric PIV via Gaussian Splatting and Photometric Warping" (manuscript in preparation).

4 Hans, A., **Singh, A.**, Vlachos, P., and Bilionis, I., "SMURF: Scalable Method for Unsupervised Reconstruction of Flow in 4D Flow MRI," *arXiv preprint* arXiv:2505.12494 (2025).

5 Anand, P., **Singh, A.**, Socha, J. J., and Vlachos, P. P., "Dynamics of airborne odorant entrainment by a snake tongue: a three-dimensional in vitro flow study" (manuscript in preparation).

6 Babakhani Galangashi, R., Rahimi, E., **Singh, A.**, Delp, E., and Vlachos, P. P., "In-Vitro Tomographic Particle Tracking Velocimetry (PTV) Analysis of the Impact of Spinal Cord and Nerve Roots on Cerebrospinal Fluid (CSF) Flow Dynamics" (manuscript in preparation).

Conference Proceedings

1 **Singh, A.** and Kumar, P., "Dynamics of the Drop Impact Phenomenon onto a Deep Liquid Pool with Initial Axisymmetric Wavy Interface," 8th International and 47th National Conference on Fluid Mechanics and Fluid Power (FMFP), Dec 9–11, 2020, IIT Guwahati, India.

2 **Singh, A.** and Kumar, P., "Drop impact dynamics onto a deep liquid pool: Influence of free surface topology," Droplets 2021, Aug 16–18, 2021, TU Darmstadt, Germany.

3 **Singh, A.** and Kumar, P., "Impact of droplet on a superhydrophobic curved surface," 26th National and 4th International ISHMT-ASTFE Heat and Mass Transfer Conference, Dec 17–20, 2021, IIT Madras, India.

4 **Singh, A.**, Anand, P., Eshraghi, J., Meyers, B.A., Bhattacharya, S., and Vlachos, P.P., "Wakes of Three Cylinders in a Falling Soap Film: Linking Lagrangian Coherent Structures from PIV to Interferograms," *Bulletin of the American Physical Society*.

5 **Singh, A.**, Meyers, B.A., Loke, Y.H., and Vlachos, P.P., "Computationally Enhanced Processing of 4D Flow MRI for Intracardiac Diagnostics," ECCOMAS 2024, Lisbon, Portugal.

6 Anand, P., **Singh, A.**, Yang, H., Meyers, B.A., Socha, J.J., and Vlachos, P.P., "Snake tongue flicking: A fluid mechanics approach," *Bulletin of the American Physical Society*.

7 **Singh, A.**, Anand, P., Yang, H., Meyers, B.A., and Vlachos, P.P., "A Physics-Informed and Uncertainty-Informed Radial Basis Function Meshless Proper Orthogonal Decomposition for 3D Particle Tracking Velocimetry (PTV)," *Bulletin of the American Physical Society*.

8 **Singh, A.**, Hans, A., Meyers, B.A., Loke, Y.H., Bilionis, I., and Vlachos, P.P., "Dynamic analysis of cardiac flow using 4D Flow MRI," 28th Annual Scientific Sessions of the Society for Cardiovascular Magnetic Resonance (SCMR).

9 **Singh, A.**, Hans, A., Yang, H., Meyers, B.A., Rayz, V., Bilionis, I., and Vlachos, P.P., "Automated segmentation reconstruction and analysis of cerebral vasculature flow using 4D Flow MRI," 28th Annual Scientific Sessions of the Society for Cardiovascular Magnetic Resonance (SCMR).

10 **Singh, A.**, Hans, A., Bilionis, I., and Vlachos, P. P., "A New Twist on 3D PIV: Particle-Field Representation with Gaussian Splats Coupled with Photometric Warp–Based Velocity Estimation,". APS Division of Fluid Dynamics Annual Meeting 2025.

References

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