Vikrant Kumar Singh

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Profile

Systems and mechatronics researcher specializing in precision motion control, scanning probe microscopy, and micro/nanoscale instrumentation. Currently Assistant Professor at IIT Kharagpur, developing advanced mechatronic systems such as six-axis self-stabilizing levitation platforms, micro-robotic actuators, and miniaturized high-throughput MEMS-based Atomic Force Microscopes and Force sensors. These innovations address challenges in advanced manufacturing, metrology, and mechano-electrophysiology.

Research Interests

Mechatronic system design; Precision Actuators and Sensors; Hybrid-levitation based positioners; Micro-robotic systems for mechano-electrophysiology; Control systems.

Education

- Ph.D. in Instrumentation and Applied Physics, Indian Institute of Science (IISc), Bangalore, 2022.
- M.S. (Engineering) in Instrumentation and Applied Physics, Indian Institute of Science, Bangalore, 2022.
- B.E. in Electronics and Instrumentation, Institute of Technology and Management, Gwalior, 2014.

Awards and Recognition

- University of Texas at Dallas Provost's Office Postdoctoral Appreciation Award (2025): For outstanding achievements and contributions to UT Dallas.
- Editor's Highlight Selection, *Nature Communications* (2022): For the paper titled "Diamagnetically Levitated Nanopositioners with Large-range and Multiple Degrees of Freedom."
- Best Ph.D. Thesis Award, Dept. of Instrumentation and Applied Physics, IISc Bangalore (2022).
- Best Paper Award, 5th Intl. *Conference on Machines and Mechanisms* (iNaCoMM 2021), India.

Postdoctoral Research Experience

Postdoctoral Research Scientist, Laboratory for Dynamics and Control of Nanosystems (LDCN), Dept. of Systems Engineering, UT Dallas **June 2022 – January 2026**

- **Hybrid Near-Field Acoustic Levitation (NFAL) and Electromagnetic Positioning System:** Invented a hybrid positioning system combining near-field acoustic levitation and electromagnetic actuation to achieve nanometer-scale resolution, bandwidth above 100 Hz, and 3-DOF motion control, overcoming trade-offs in existing levitation techniques. In this self-stabilizing design, the NFAL module provides high vertical stiffness and damping, while a co-planar electromagnetic coil offers lateral stabilization, eddy-current damping, and multi-axis control.
- Demonstrated that the hybrid levitation approach improves horizontal positioning resolution by $10^3\times$ and bandwidth by $100\times$ compared to prior NFAL-based systems. It also increases payload capacity and vertical positioning bandwidth by up to $10^3\times$ over other self-levitation platforms, enabling robust, high-precision positioning for advanced robotics and manufacturing applications.
- Combined the hybrid positioning system with a modular optical microscope based machine vision multi-axis position measurement and control system for automated optical and Atomic Force Microscopy, and manipulation tasks.

- **Electromagnetic Micro-Robots with Ultra-High Actuation Force and Bandwidth:** Conventional untethered micro-robots (magnetic platforms levitated and driven by planar coils) offer large motion range and nanometer precision but are limited to tens of hertz in-plane bandwidth due to low electromagnetic stiffness. We introduced a new planar electromagnetic micro-robot design and derived scaling laws indicating that in-plane trapping stiffness scales as $1/l^3$ where l represents the pitch of the coil generating a spatially periodic force field .
- Achieved an actuation bandwidth two to three orders of magnitude higher than the state-of-the-art (on the order of kilohertz vs. $\sim$10 Hz). Designed modular arrays of micro-scale magnets to increase load capacity and system size without sacrificing bandwidth. These high-bandwidth micro-robots can integrate with diamagnetic, acoustic, or hydrodynamic levitation platforms to enable untethered micro-robotic swarms with large range, high precision, and ultra-fast response.

- **Miniaturized Atomic Force Microscope for High-Throughput Parallel Imaging:** Co-developed a miniaturized AFM featuring an array of three active microcantilevers to overcome the throughput limitations of single-probe AFMs. Each microcantilever integrates on-chip piezoelectric (high-frequency) and electrothermal (large-range) actuators for Z-axis motion control.
- Implemented on-chip differential piezoelectric sensors for real-time deflection feedback, enabling parallel probe operation. The prototype achieves a 10× smaller footprint and 3× higher imaging throughput than a conventional AFM, supporting high-speed nanoscale metrology for advanced manufacturing and materials inspection.

- **MEMS precision force transducer and voltage-based patch clamp for studying pain hypersensitivity**
  Collaboration: Prof. Theodore Price (Dept. of Neuroscience)
- Employed a feedback-controlled MEMS force transducer capable of applying and sensing nanonewton-scale forces to determine the stiffness of human Dorsal Root Ganglion (hDRG) neurons. Integrated the MEMS force transducer with patch-clamp to quantify picoampere-scale mechanosensitive currents in hDRG neurons.
- Proposed a novel diamagnetic-hydrodynamic micro-robotic platform which can measure the stiffness and Young's modulus of the cells inside aqueous medium.
- Examined pain hypersensitivity and mapped it to variation in cell stiffness and the corresponding increase in mechanosensitive currents in hDRG neurons.

Doctoral Research Experience

Graduate Researcher, Nanometrology Lab, Dept. of Instrumentation and Applied Physics, IISc Bangalore **2015 – 2022**

- **Ultra-Compact Six-DOF Nanopositioner via Diamagnetic Levitation:** Invented a palm-sized six-degree-of-freedom (6-DOF) nanopositioner (20 cm^3 volume) using diamagnetic levitation and electromagnetic actuation. Achieved millimeter-range translational motion with nanometer resolution, and radian-range rotational motion with micro-radian resolution.
- This levitated mechatronic stage provides multi-DOF motion with piezoelectric-stage precision and piezo-motor range, all in a tenfold smaller footprint and without hysteresis. It addresses the traditional trade-off between degrees of freedom, range, and resolution in precision positioning, benefiting micro-robotics and advanced manufacturing applications.

- **Automated In-Situ AFM Tip Replacement System:** Invented a modular mechanism for in-situ replacement of Atomic Force Microscope tips, allowing the AFM probe to remain intact while swapping only the worn pyramidal tip. Developed a vision-guided (machine vision) micro-assembly technique that performs automated tip exchange within seconds with nanometer-scale accuracy, thus ensuring low maintenance downtime and increased throughput of the instrument.
- Designed the system to be retrofittable into existing AFM platforms, transforming the AFM probe from a consumable into an accessory. This innovation extends probe lifespan and facilitates broader use of specialized microcantilevers and advanced probe designs in AFM-based research and industrial inspection.

Publications

Journal Articles:

1. H. M. Nasrabadi, **K. S. Vikrant**, and S. O. R. Moheimani, "Parallel Active Microcantilevers for High-Throughput Atomic Force Microscopy," *IEEE/ASME Transactions on Mechatronics* (Accepted May 2026).
2. **K. S. Vikrant**, Prosanto Biswas, and S. O. R. Moheimani, "A Three-axis Nanopositioner based on Near-Field Acoustic Levitation and Electromagnetic Actuation," *Sensors and Actuators A: Physical*, July 2025.
3. **K. S. Vikrant**, D. Dadkhah, and S. O. R. Moheimani, "Optimization of Design Parameters to Improve Performance of a Planar Electromagnetic Actuator," *IEEE Transactions on Magnetics*, vol. 60, 2024.
4. H. M. Nasrabadi, N. Nikooienejad, **K. S. Vikrant**, and S. O. R. Moheimani, "Integration of Piezoelectric and Electrothermal Actuators for High-Resolution Atomic Force Microscopy," *Mechatronics*, vol. 99, 2024.
5. **K. S. Vikrant** and G. R. Jayanth, "Diamagnetically Levitated Nanopositioners with Large-Range and Multiple Degrees of Freedom," *Nature Communications*, vol. 13, no. 1, 2022. [Featured in Editors' Highlights]
6. **K. S. Vikrant**, K. Hithiksha, and G. R. Jayanth, "An Automated AFM Tip-Replacement System for In Situ Tip Replacement," *IEEE/ASME Transactions on Mechatronics*, vol. 26, 2020.
7. **K. S. Vikrant** and G. R. Jayanth, "An AFM Tip Replacement System Compatible with All Ambient Media and Operation Modalities," *Ultramicroscopy*, vol. 196, 2019.

Conference Proceedings:

1. Prosanto Biswas*,**K. S. Vikrant***, and S. O. R. Moheimani, "Modeling and Control of Z-Dynamics of a Hybrid NFAL-Electromagnetic Platform," *Accepted in IEEE/ASME International Conference on Advanced Intelligent Mechatronics*

(AIM 2026) (Accepted May 2026).

2. **K. S. Vikrant**, D. Dadkhah, and S. O. R. Moheimani, "Measurement of Electromagnetic Force using a Feedback-Controlled MEMS Force Sensor," *Proc. of the Australian & New Zealand Control Conference (ANZCC)*, Gold Coast, Australia, 2024.
3. **K. S. Vikrant**, H. M. Nasrabadi, and S. O. R. Moheimani, "A Novel Actuator based on Near-Field Acoustic Levitation and Electromagnetic Actuation," *Proc. of the Intl. Conf. on Manipulation, Automation and Robotics at Small Scales (MARSS)*, Abu Dhabi, UAE, 2023.
4. H. M. Nasrabadi, N. Nikooienejad, **K. S. Vikrant**, and S. O. R. Moheimani, "AFM Microcantilever with On-Chip Electrothermal and Piezoelectric Transducers: Z-axis Control and Standalone Operation," *Proc. of IEEE/ASME Intl. Conf. on Advanced Intelligent Mechatronics (AIM)*, Seattle, WA, pp. 94–98, 2023.
5. **K. S. Vikrant** and G. R. Jayanth, "A Diamagnetically Levitated Actuator Capable of Independent In-Plane and Out-of-Plane Positioning," *Proc. of the 5th International & 20th National Conference on Machines and Mechanisms (iNaCoMM)*, Jabalpur, India, 2021. [Best Paper Award]

Patents

1. G. R. Jayanth and **K. S. Vikrant**, "Positioning of Payloads," Indian Patent, Patent No. 538904.
2. G. R. Jayanth, R. S. M. Mrinalini, and **K. S. Vikrant**, "Micro-Scale Ball and Socket Joint," Indian Patent, Patent No. 039295.

Research Proposal Submissions

- Co-Principal Investigator, "Control-Enabled Hybrid Levitation for High-Throughput Nanopositioning and Swarm Micro-Robotics," proposal submitted to NSF CMMI (Dynamics and Control program) – under review.
- Co-Principal Investigator, "Near-Field Acoustic Levitation and Electromagnetic Stabilization based High-Sensitivity Inertial Sensors," proposal submitted to DARPA (Levitas Program).

Teaching Experience and Interest

- **Teaching Assistant**, IN227 – Control Systems Design (IISc Bangalore), 2017–2020
  Prepared design based questions and graded assignments for a graduate-level course on classical control systems design.
- **Teaching Assistant**, Control Systems Design (NPTEL online course), 2018
  Moderated discussion forums and assisted in content preparation for a national online course on control systems.
- **Teaching Assistant**, IN221 – Sensors and Transducers (IISc Bangalore), 2019
  Supervised laboratory experiments and evaluated student work for an upper-level course on sensor instrumentation.
- **Teaching Interests**: Systems and Control, Linear Systems, Embedded Systems, and Precision Actuators and Sensors.

Technical Skills

1. Programming: C, C++, Java, Embedded C/C++, Assembly
2. Software/Tools: MATLAB/Simulink, LabVIEW, COMSOL Multiphysics, ANSYS, OpenCV
3. Controllers: STM32 (ARM Cortex-M), TI MSP430, dSPACE DS1104, NI PXIe-8821
4. Characterization: Scanning Electron Microscope (SEM), Focused Ion Beam (FIB), Atomic Force Microscope (AFM)
5. Microfabrication: Photolithography, Thin-film Deposition, Etching (wet & plasma)

Professional Service

Journals and Conferences: Reviewer for *IEEE/ASME Trans. on Mechatronics*; *Mechatronics*; *Ultramicroscopy*; *Microsystem Technologies*; *IEEE Sensors Journal*; *Sadhana*, Reviewer for American Control Conference (ACC); IEEE Conference on Decision and Control (CDC).

Institutional Service

1. One of the three hiring committee members responsible for shortlisting Program Director - Institute of Data Analytics at UT Dallas in October 2025.
2. Represented UT Dallas at University of Texas System Postdoctoral Symposium held at UT Arlington in September 2025.
3. Department Program co-ordinator for Open Day at the Indian Institute of Science, Bangalore, 2019.