

Special Session

Accuracy Beyond Specs: Strategies for High-Accuracy Positioning in Industrial Robots

Organizers

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Prof. Dr.-Ing. Frank Schrödel is Professor of Automation and Robotics at Schmalkalden University of applied sciences, specializing in autonomous systems. He earned his doctorate at RWTH Aachen University in control engineering. Before his academic tenure, he led development for intelligent driving systems at IAV GmbH. Currently, he leads a research group of six doctoral students, He is joined by **Venkata Prashanth Uppalapati**, a Research Assistant and M.Eng. graduate specializing in ROS-based control systems for mobile robots and industrial robots. Together, they represent a research group overseeing 11 laboratories dedicated to mobile robotics, industrial automation and human-centric technologies.

Motivation and Timeliness

Strategies for High-Accuracy Positioning in Industrial Robots is a very relevant topic not only in research, but above all in industrial applications. High-precision Robotic manipulators are increasingly deployed in applications where sub-millimetre or even sub-micrometre accuracy is critical. Unlike traditional industrial uses such as welding or bulk material handling, modern precision Robotics addresses tasks in semiconductor manufacturing [1], photonics assembly [2], metrology [3], and robot-assisted surgery [4, 13], where positioning errors directly impact yield, quality, and safety.

Most 6-axis industrial Robots and collaborative Robots (cobots) offer good unidirectional position repeatability (0.1mm–0.5mm [8]) but, their multidirectional repeatability and volumetric accuracy, rarely specified in datasheets (typically >1mm [8]) remain limiting factors for precision applications. These systems, although not inherently high-precision instruments, can serve as potential candidates for precision tasks when properly calibrated.

Various strategies for high-accuracy positioning in industrial robots will be presented in the special session. All the concepts presented have already been prototypically implemented and validated in an industrial environment.

Scope and Topics

- Systematic quantification of the accuracy of modern handling systems
- Real-time acquisition of the positioning accuracy of modern handling systems
- Modelling the motion dynamics and positioning errors of modern handling systems
- Concepts for optimal motion planning and error correction of modern handling systems
- Efficient control concepts for optimal tracking behaviour of modern handling systems
- Critical discussion of industrial use cases

Format Plan

- 5 invited talks + panel/Q&A)

Diversity and Balance Plan

- The section will consist out of an optimal mixture of ideas and inputs from academia and industry

Tentative Speaker List

- Design and Development of a Cost-Effective High-Precision Tactile Probe End Effector for an Industrial Robot Arm, Niranjana Kannali Ramesha, Research assistant M.Eng Mechatronics and Robotics, Schmalkalden University – Contributed paper
- Sub-Millimetre Accurate Image-Based Visual Servoing Using Occupancy Margins and Minimum-Motion Interaction Matrice, Jayabadrinath Krushnan Research assistant M.Eng Mechatronics and Robotics, Schmalkalden University - Contributed paper
- Closed-Loop Accuracy Enhancement of a 6-DOF Manipulator Using Dual-Stage Laser and Vision-Based Offset Compensation for laser engraving, Dr. Daniel Garten, Head of Testing Technology and AI Division, GFE GmbH - Contributed paper
- Advanced Assembly: High-Accuracy Robotic Pick-and-Place Industrial Use Cases, Dr. David Sommer, Head of R&D, SCS Robotik GmbH - Presentation
- NEURA Robotics (TBA) – Presentation

Expected Audience and Impact

- Due to very high relevance of the topic- several participants from research and industry will be attracted
- We would love to use the special session in order to build a active community for High-Accuracy Positioning in Industrial Robots, in order to transfer the current results to more industrial players and to initiate new research initiatives

Relevance to ICFT 2026 Tracks

- Robotics and Autonomous Systems
- Ideas from the AI and Embedded Systems Track will also be involved in these section

There exist already a variety of solutions and best practises in this area: Reducing cycle speed may marginally improve accuracy, but this compromises cycle time, whereas custom high-precision Robots significantly increase product cost. Compact manipulators such as the Meca500 (from Mecademic [9]) achieve high repeatability (0.005 mm), but with reduced reach and payload. To overcome these limitations, recent research has explored error correction strategies [8]. One promising direction is data-driven, machine-learning-based correction [5, 6, 7, 10], where a model predicts the adjusted Cartesian positions before execution, improving placement accuracy by commanding randomised or predefined robot motions and recording discrepancies between commanded and actual end-effector positions. Neural networks have shown strong performance in predicting correction vectors, which can then be integrated into the control system [10]. This software-based approach preserves cycle time, requires no hardware changes, and can be transferred across platforms. Its accuracy, however, depends heavily on the training dataset, requires exceptional computational energy, and performance may degrade in poorly sampled regions of the workspace. To further enhance precision and accuracy in dynamic environments, sensor-based feedback systems are explored. Vision-based robot servoing or visual feedback control offers a closed-loop solution by continuously estimating the end-effectors pose and adjusting motions in real time [11]. Implementation typically employs a camera, either in eye-in-hand or eye-to-hand configuration, to detect and track objects, compute relative poses, and refine trajectories. This approach is sensitive to lighting variations that degrade feature detection [12]. Real-time processing of image data also imposes high computational demands, particularly with high-resolution inputs or deep learning-based perception. Furthermore, even small camera-to-Robot calibration errors can propagate into significant spatial inaccuracies, thereby limiting the achievable precision.

However, we see a very strong need to develop innovative solutions to increase performance and industrial relevance!

Session Logistics

- Estimated Duration: Classical conference section duration
- No special equipment needs
- Hybrid is needed (for sharing live demos from Lab as well as to involve some industrial experts) for example
Industrial partners will be present online for discussion and presentation

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- [3] Bernard C. Jiang, Ramesh Duraisamy, Gloria Wiens, et al. ” Robot metrology using two kinds of measurement equipment” , Journal of Intelligent Manufacturing Vol. 8, 1997.
- [4] Yeisson Rivero-Moreno, Sophia Echevarria, Carlos Vidal-Valderrama, Luigi Pianetti, Jesus Cordova-Guilarte, Jhon Navarro-Gonzalez, Jessica Acevedo-Rodríguez, Gabriella Dorado-Avila, Luisa Osorio-Romero, Carmen Chavez-Campos, Katheryn Acero-Alvarracín, ” Robotic Surgery: A Comprehensive Review of the Literature and Current Trends” , Cureus, 2023.
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