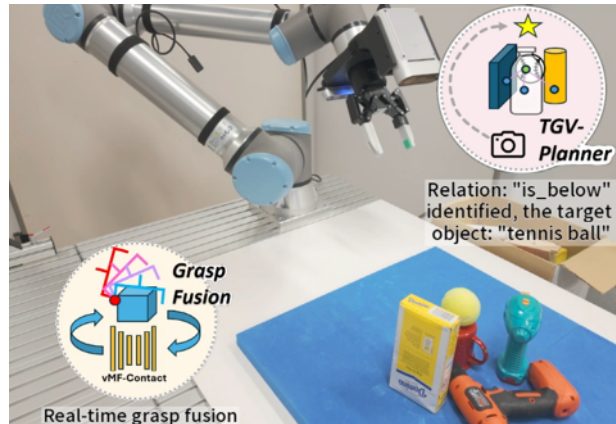


Hauptseminar

Multi-Modal Active Perception for Robotic Manipulation

Background and Motivation

Active perception describes perception in which sensing and action are coupled: instead of only processing observations that are passively available, a robot deliberately performs actions that are expected to improve task-relevant information. Examples include changing the camera viewpoint to reduce occlusions, moving or reorienting an object to reveal hidden geometry, or establishing contact to estimate properties that are difficult to infer visually. The aim is typically to reduce uncertainty and improve subsequent planning or manipulation decisions.



Existing methods using active perception for robotics include active vision and next-best-view methods as well as active tactile or haptic exploration through probing, sliding, or contact changes. There is also prior work combining vision and touch. However, these lines of research are still comparatively fragmented: many systems actively exploit one dominant modality, while multimodal methods often focus on sensor fusion rather than on deciding what particular sensor modality to use next. A relevant research direction is therefore active perception across multiple modalities such as RGB, depth/point clouds, tactile sensing, and force/torque sensing, including the selection of informative sensing or manipulation actions.

Hauptseminar Task

The goal of this Hauptseminar is to review literature on multi-modal active perception for robot manipulation. The work is a literature study only; no implementation or experimental system is required. The seminar should establish the state of the art and distinguish between passive multi-sensor fusion, single-modality active perception, and approaches in which several modalities contribute to an information-gathering strategy.

Representative approaches should be compared with respect to the sensing modalities used, the actions selected by the robot (e.g., viewpoint changes, contacts, probing motions, re-grasps), the role of uncertainty or information gain, the manipulation problem being addressed, and how the systems are evaluated. Particular attention should be given to whether sensing modalities are merely fused or whether the system actively chooses when, where, and how to acquire additional information. The final seminar should identify the strongest current approaches and recurring limitations and derive open research questions.

Suggested Starting Literature

The following papers provide a useful entry point, ranging from foundational concepts to directly relevant visuo-haptic active perception in manipulation:

- Bajcsy, R., Aloimonos, Y., & Tsotsos, J. K. (2018). Revisiting active perception. *Autonomous Robots*, 42, 177–196. [doi:10.1007/s10514-017-9615-3](https://doi.org/10.1007/s10514-017-9615-3)
- Bohg, J., Hausman, K., Sankaran, B., Brock, O., Kragic, D., Schaal, S., & Sukhatme, G. (2017). Interactive Perception: Leveraging Action in Perception and Perception in Action. *IEEE Transactions on Robotics*, 33(6), 1273–1291. [doi:10.1109/TRO.2017.2721939](https://doi.org/10.1109/TRO.2017.2721939)
- Navarro-Guerrero, N., Toprak, S., Josifovski, J., & Jamone, L. (2023). Visuo-haptic object perception for robots: an overview. *Autonomous Robots*, 47, 377–403. [doi:10.1007/s10514-023-10091-y](https://doi.org/10.1007/s10514-023-10091-y)

- Siddiqui, M. S., Coppola, C., Solak, G., & Jamone, L. (2021). Grasp Stability Prediction for a Dexterous Robotic Hand Combining Depth Vision and Haptic Bayesian Exploration. *Frontiers in Robotics and AI*, 8, 703869. [doi:10.3389/frobt.2021.703869](https://doi.org/10.3389/frobt.2021.703869)
- Murali, P. K., Dutta, A., Gentner, M., Burdet, E., Dahiya, R., & Kaboli, M. (2022). Active Visuo-Tactile Interactive Robotic Perception for Accurate Object Pose Estimation in Dense Clutter. *IEEE Robotics and Automation Letters*, 7(2), 4686–4693. [doi:10.1109/LRA.2022.3150045](https://doi.org/10.1109/LRA.2022.3150045)

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Startdatum: ab März.2027