Karlsruhe Institute of Technology

**Department of Informatics**
**Institute for Anthropomatics und Robotics (IAR)**
**Chair for Intelligent Sensor-Actuator-Systems (ISAS)**
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https://isas.iar.kit.edu

Intelligent ISAS Sensor-Actuator-Systems

Bachelor/Master Thesis

# Bayesian 3D Extended Object Tracking in Particle Measurement

We consider the problem of three-dimensional extended object tracking (EOT), where the main objective is to simultaneously estimate the target's kinematic state and its spatial extent (or shape) recursively over time, using noisy position measurements obtained from the target's surface. While EOT is well established in robotics and autonomous navigation, it also plays a pivotal role in advancing particle measurement techniques. Precise reconstruction of particulate solids' shapes is essential, as their morphology directly determines their mechanical, thermal, and chemical behavior in various industrial processing stages. When integrated with advanced tracking algorithms capable of estimating each particle's time-varying three-dimensional position and orientation, this approach can significantly enhance measurement accuracy across a broad spectrum of particulate applications.

At ISAS, we have developed a broad spectrum of shape approximations and their corresponding measurement models, ranging from basic, robust approximations to highly detailed, flexible reconstructions. The goal of this thesis is to find a closed, watertight 3D object with a flexible and continuously deformable surface. Such a deformation model provides a versatile representation that can smoothly transform an initial shape into a wide range of target shapes while maintaining closure and surface integrity, thereby enabling highly flexible 3D shape modeling. The work will roughly comprise the following tasks:

- Literature research on three-dimensional modelling methods,
- Familiarization with the Julia programming language,
- Development and design of a novel algorithm,
- Implementation and integration of the methods in Julia,
- Comparison with other state-of-the-art-methods.

**Requirements:**
Students with a background in computer science, mathematics, electrical engineering, mechatronics or other engineering majors. Strong self-motivation, reliability, and critical mind are expected.

**Emphasis:**

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| Theoretical Study | |
| Software Implementation | |
| Hardware Implementation | |

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