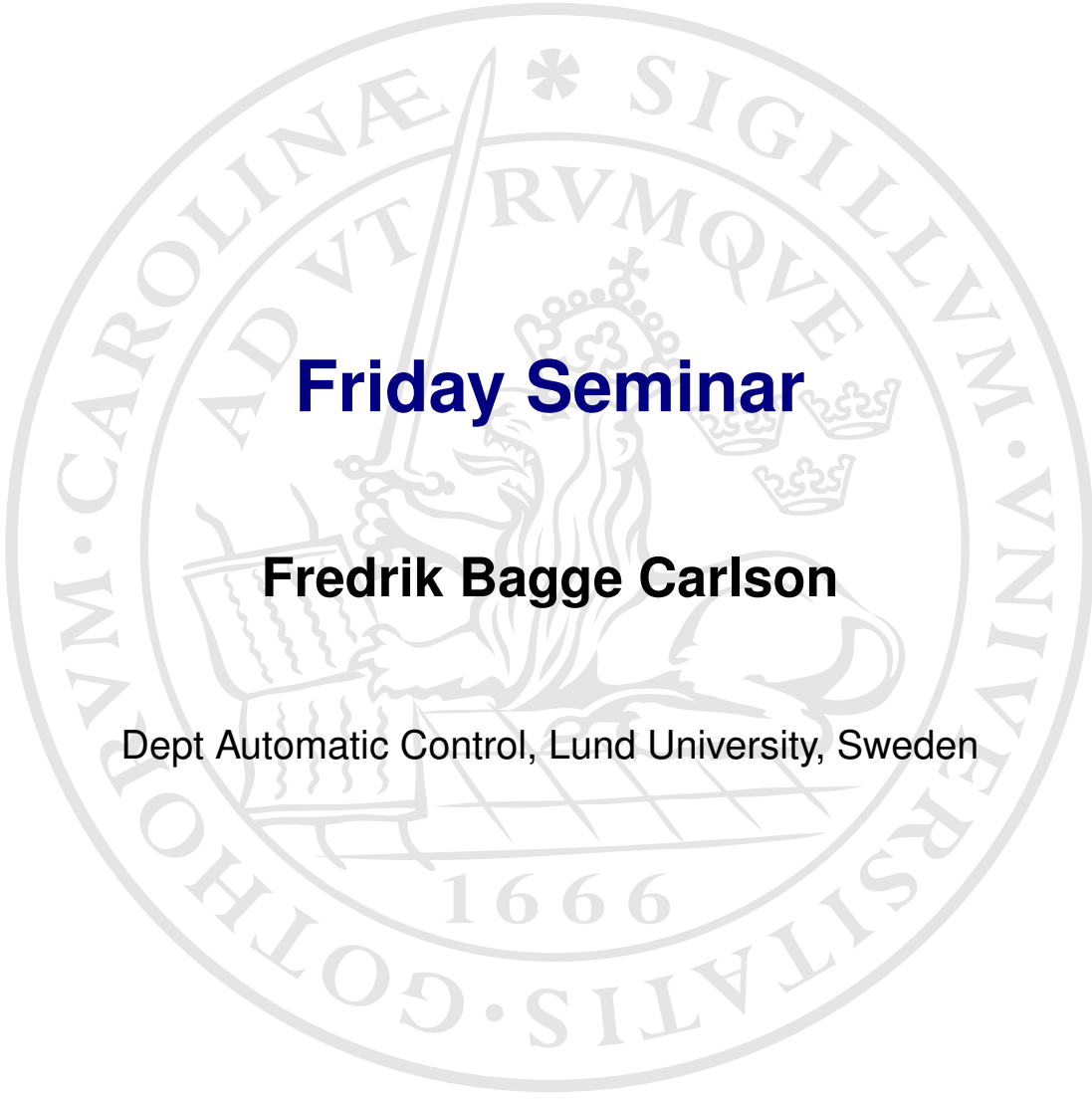


Friday Seminar

Fredrik Bagge Carlson

Dept Automatic Control, Lund University, Sweden

What do I do?

FlexiFab Friction stir welding, with robots.

ABB extRosetta Assorted research, with robots.

SARAFun Teaching assembly tasks, with robots.

FlexiFab

Flexible fabrication of lightweight aluminum structures

- Develop a closed loop control system to follow the weld path.
- Integrate sensors and robot control system.

Video

Figure: FSW at TWI in Sheffield

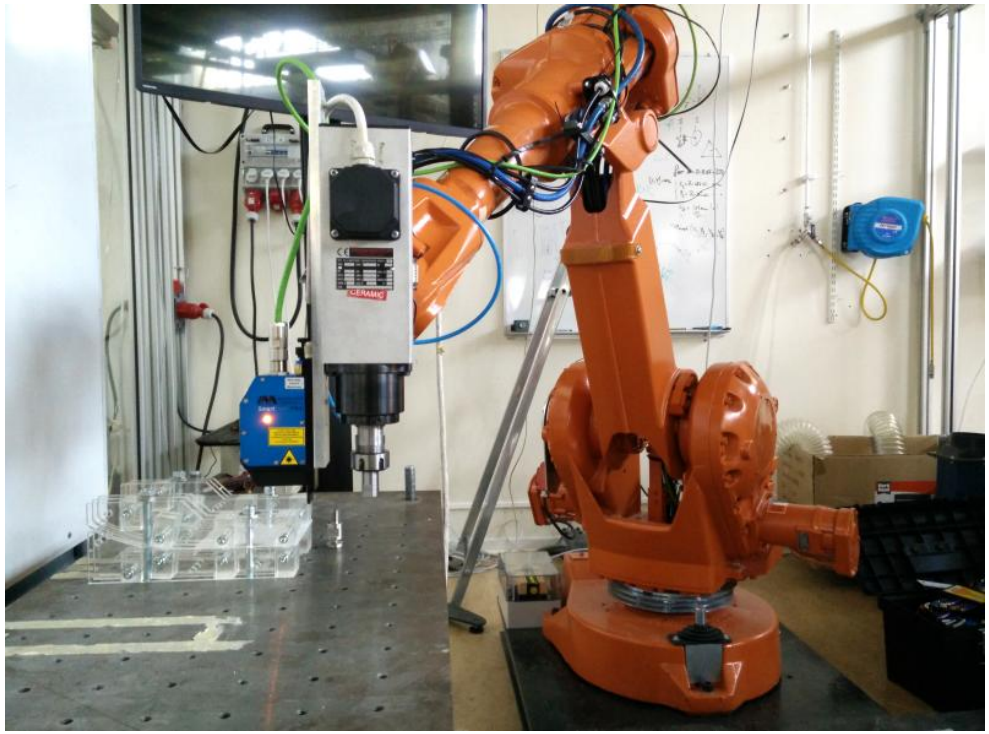


Figure: FSW at the department

Goal and challenges

Goal To accurately track the weld seam

Challenges

- Kinematic uncertainties
- Deflections due to high process force
- Inaccuracies in work cell

Feedback 2D laser sensor

Method

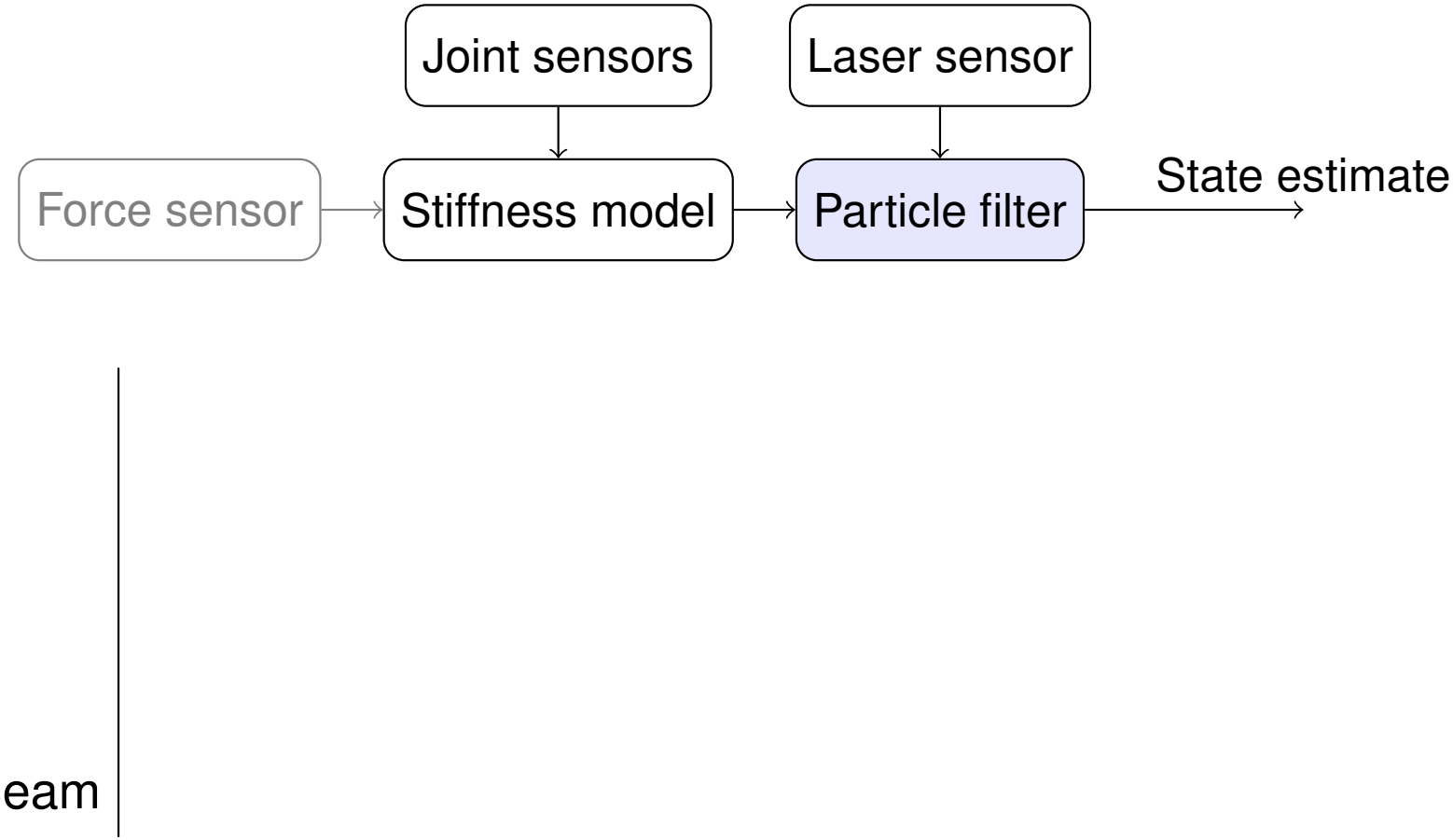
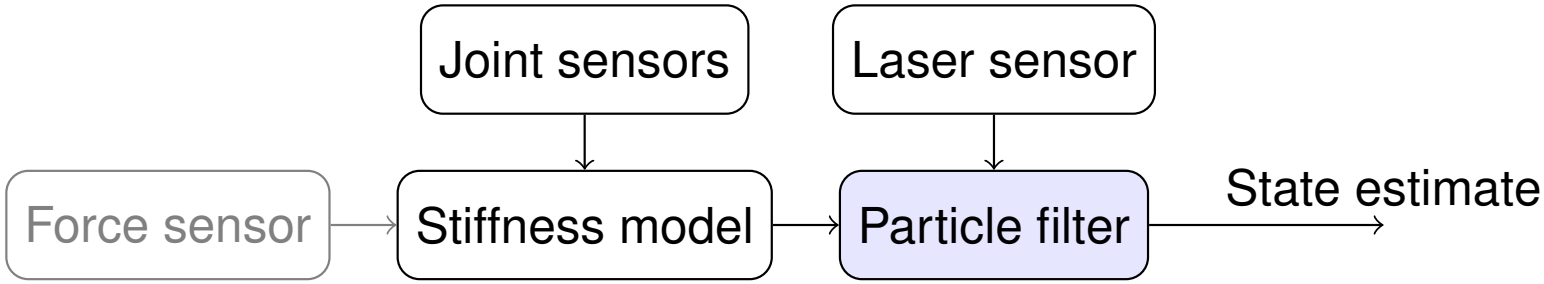


Figure: Validation of pose estimates

Method



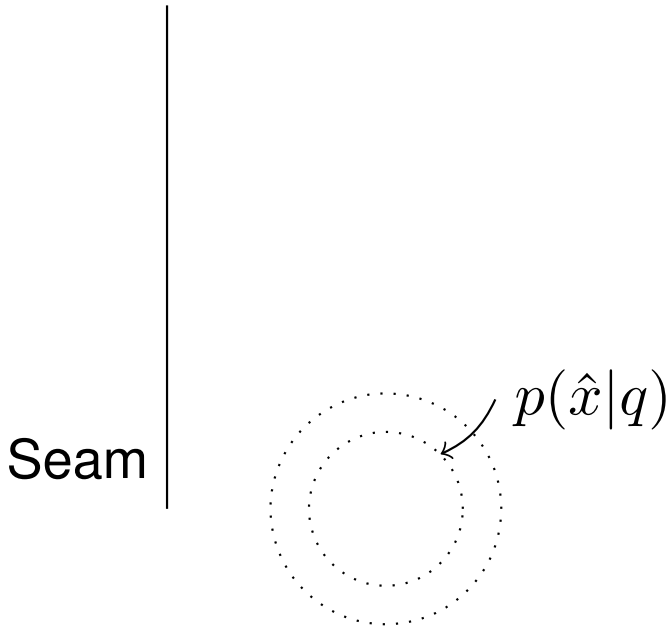
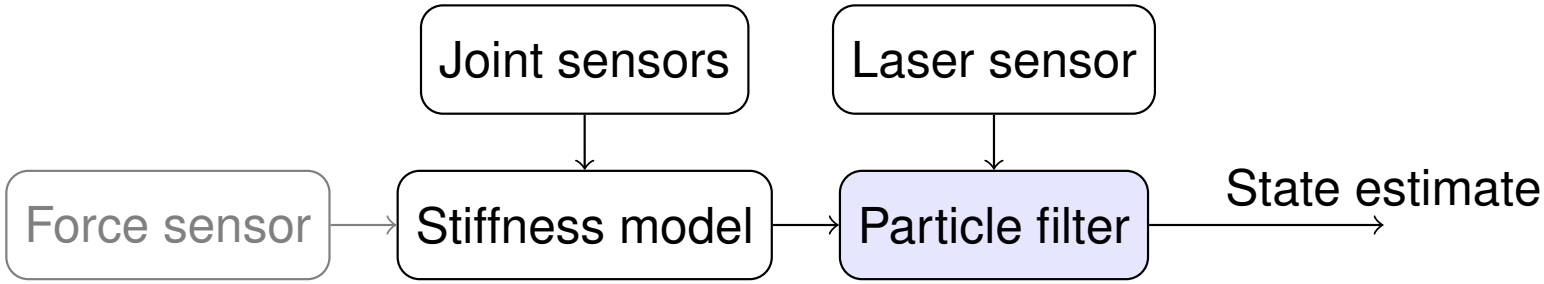


Figure: Validation of pose estimates

Method



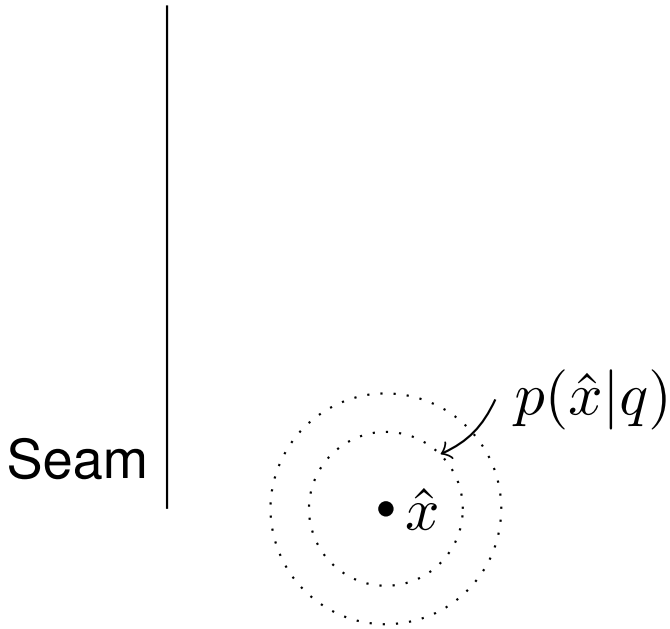
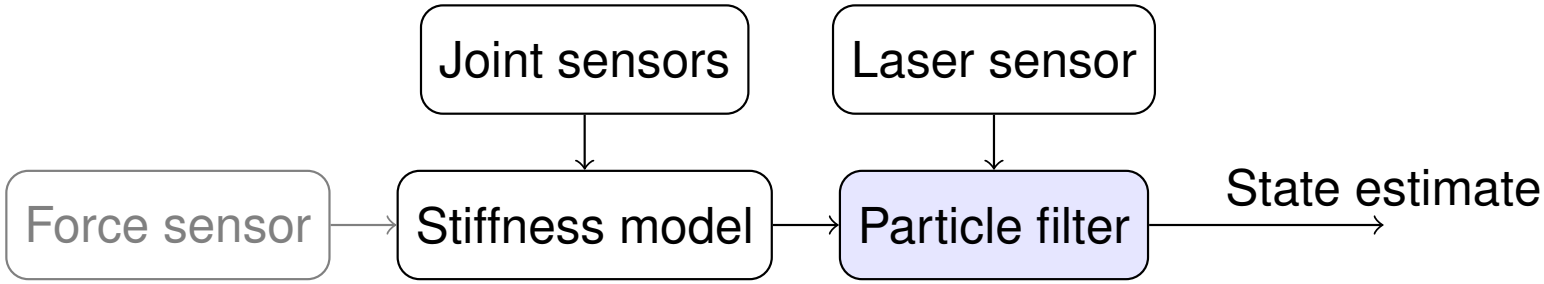


Figure: Validation of pose estimates

Method



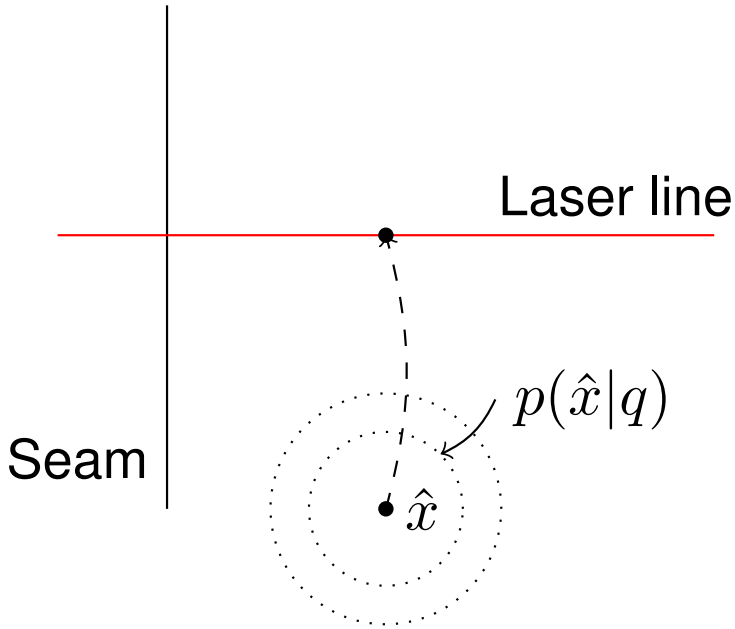
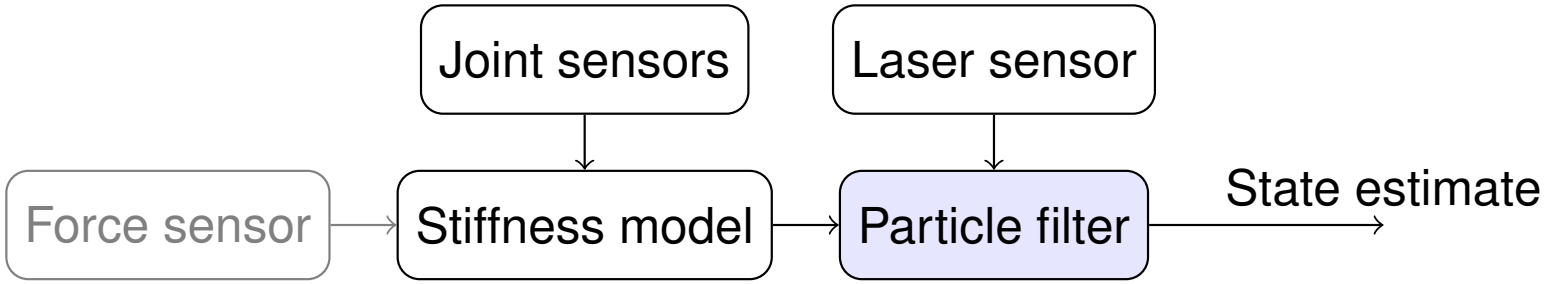


Figure: Validation of pose estimates

Method



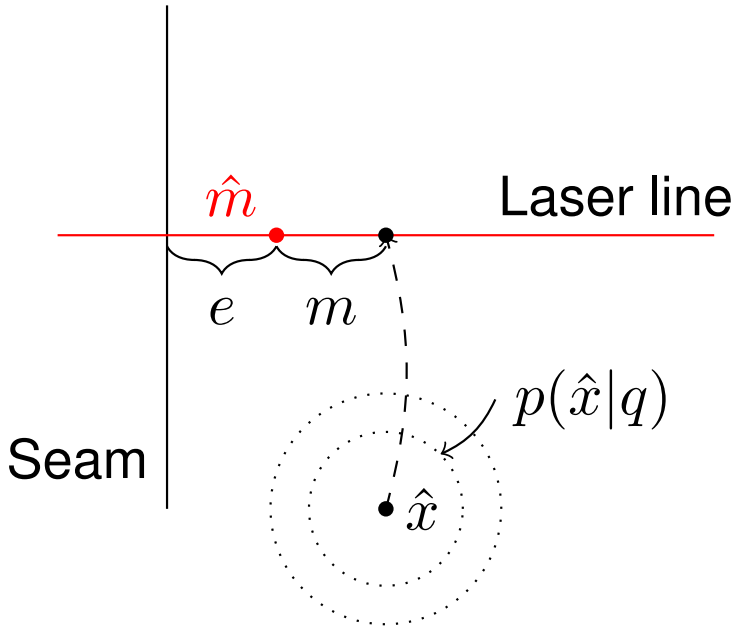
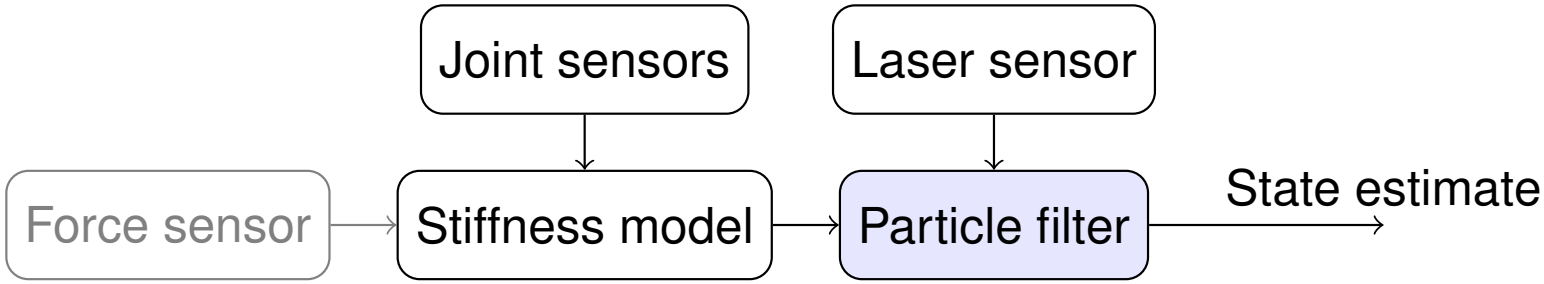


Figure: Validation of pose estimates

Method



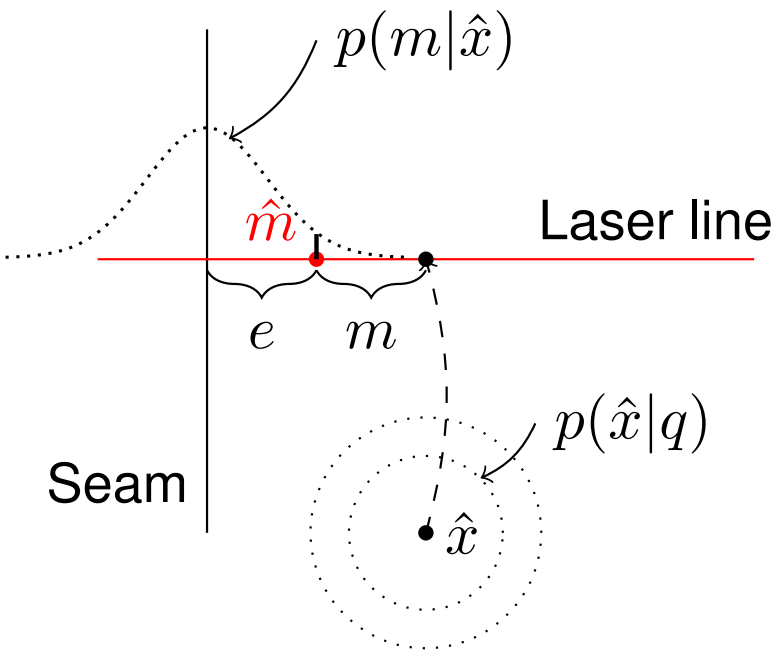
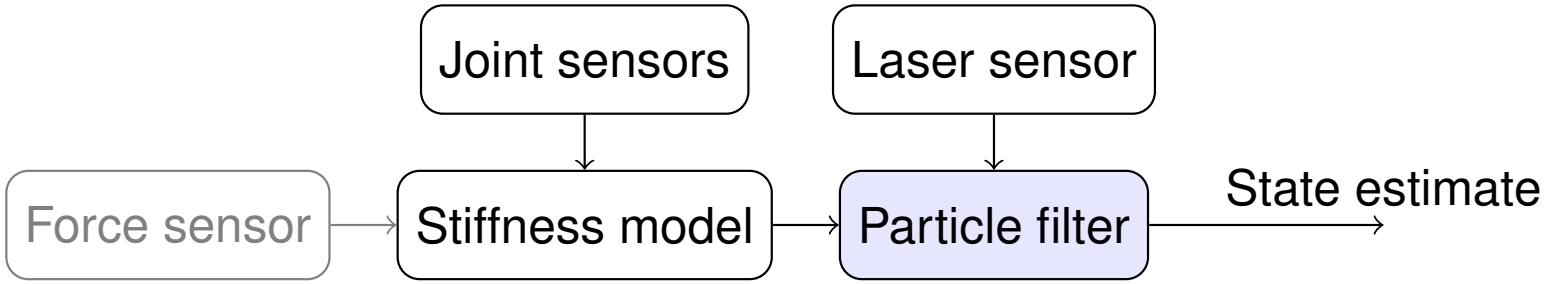


Figure: Validation of pose estimates

Method



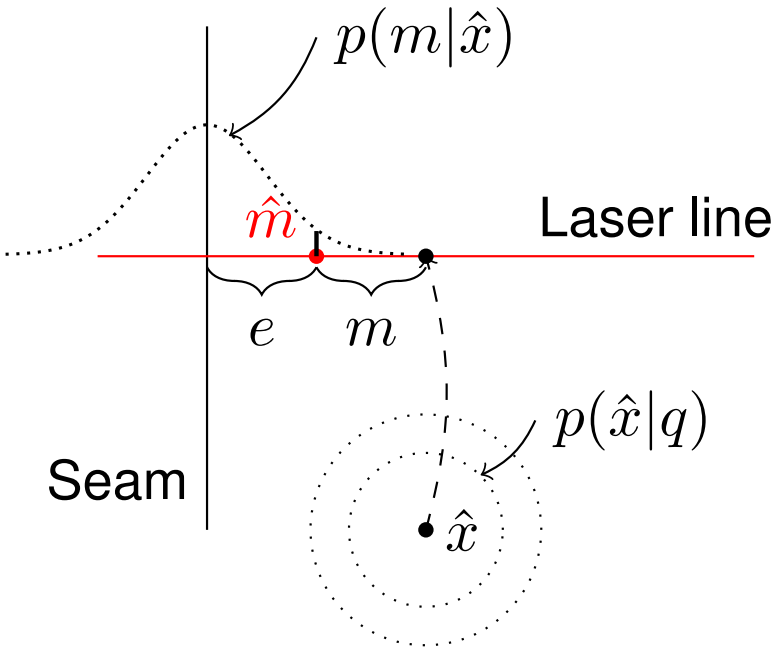


Figure: Validation of pose estimates

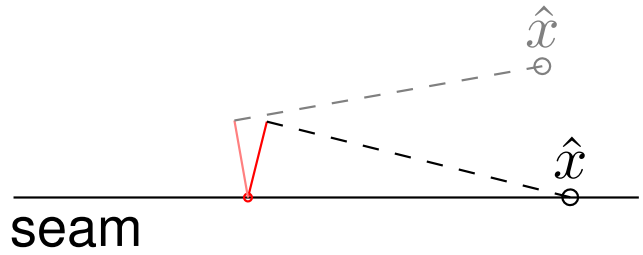
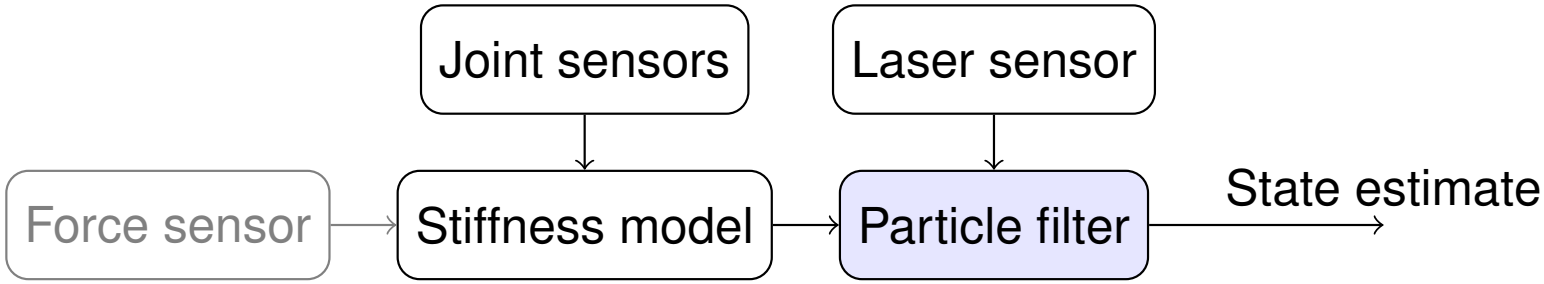


Figure: Position not fully observable (most real world seams are not exciting enough)

Method



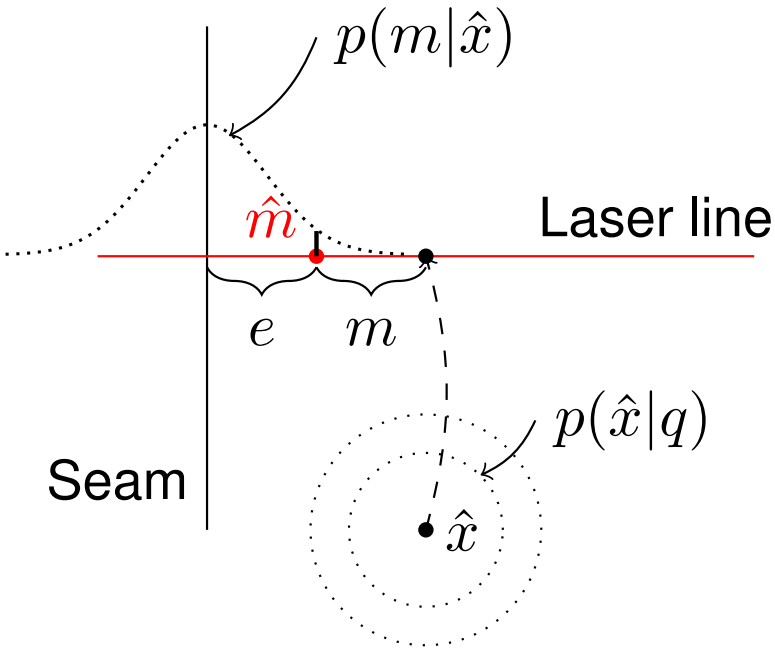


Figure: Validation of pose estimates

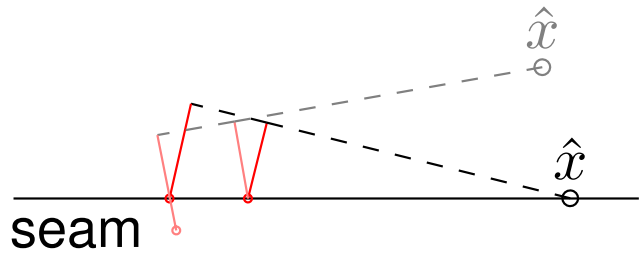
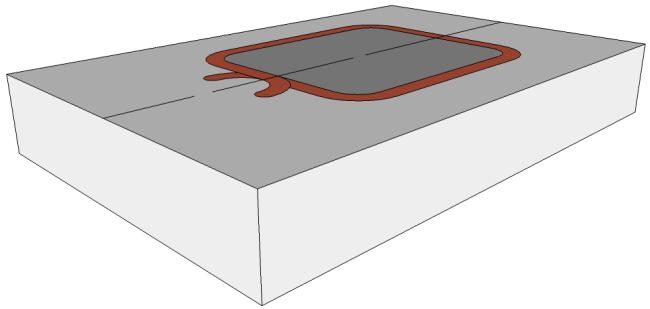
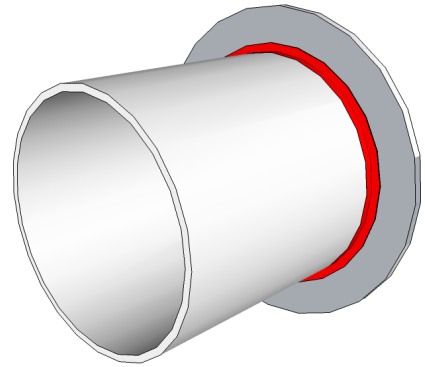
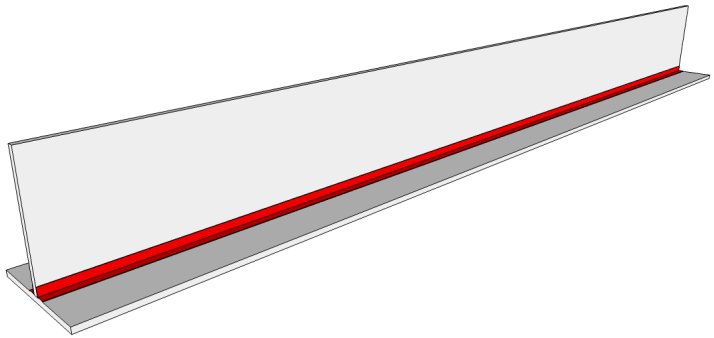


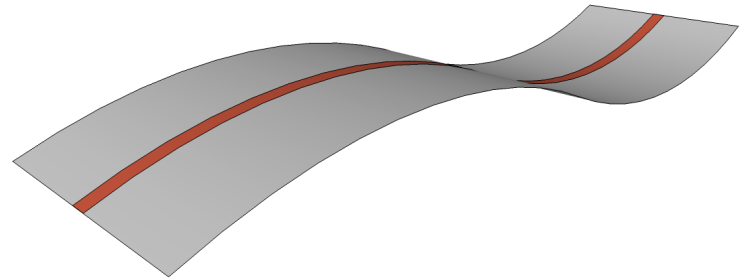
Figure: Position not fully observable (most real world seams are not exciting enough)

Joint types









EGM and Logging

Development of new logging system and integration with ABB's EGM interface is a big part of Flexifab

extRosetta

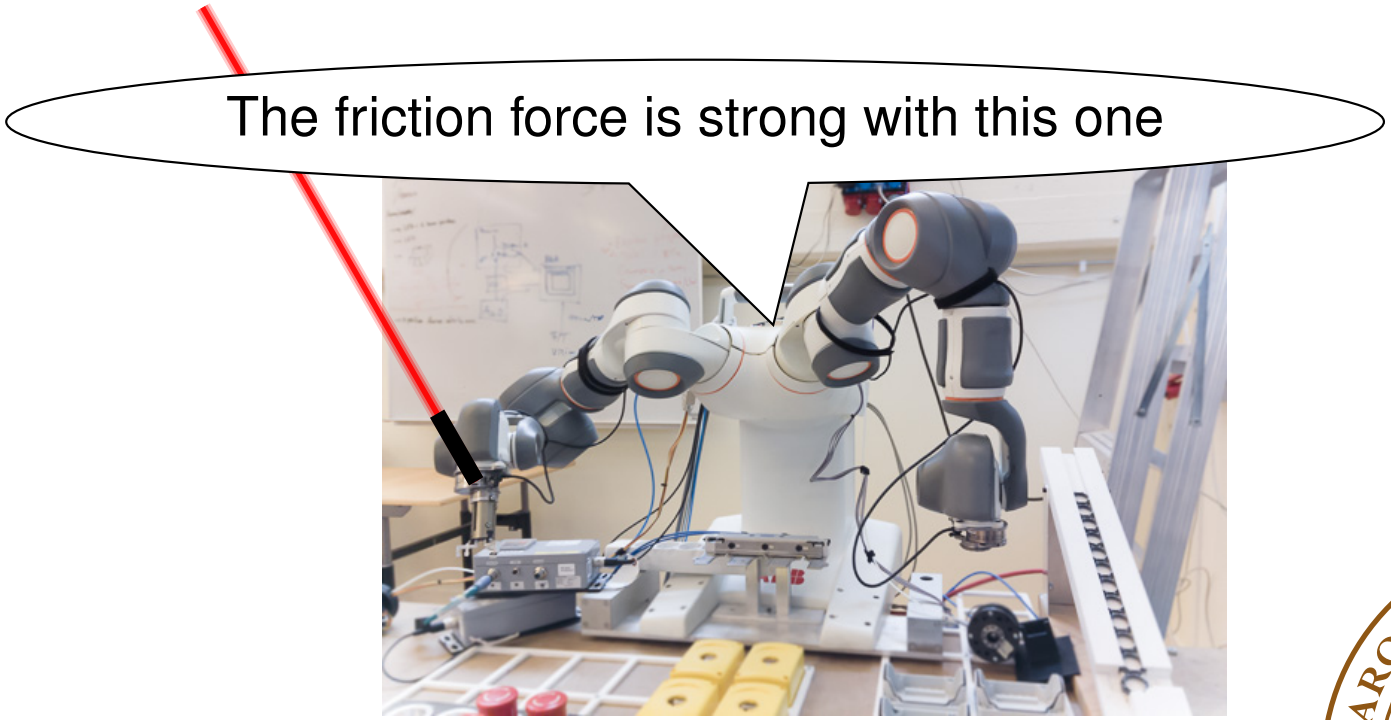
Assorted research sponsored by ABB.

Andreas Stolt Lead Through and sensor-less force estimation

Me Position and temperature dependent friction estimation

Position dependent friction estimation

- Friction in FRIDA's joints varies (a lot) with position.
- Due in large to internal cabling.



Method

How to model position dependence?

Classical model

$$F_f = k_c \operatorname{sign}(v) + k_v v$$

Method

Model the residual with an universal function approximator

RBF model

$$F_f = k_c \operatorname{sign}(v) + k_v v + k_\kappa \phi(p)$$

$$\phi : \mathbb{R} \to \mathbb{R}^n$$

Method

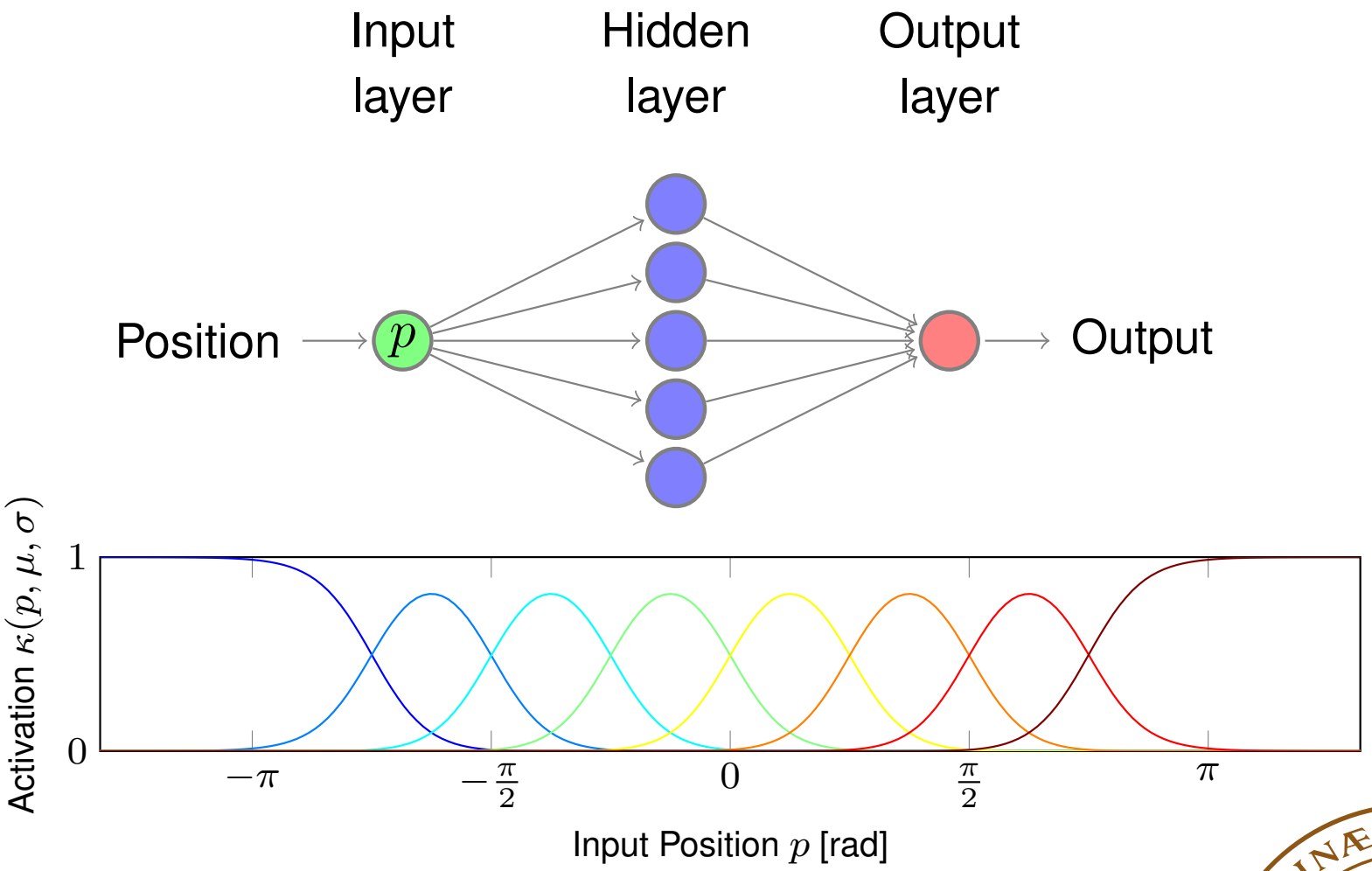


Figure: Illustration of evenly distributed RBFs

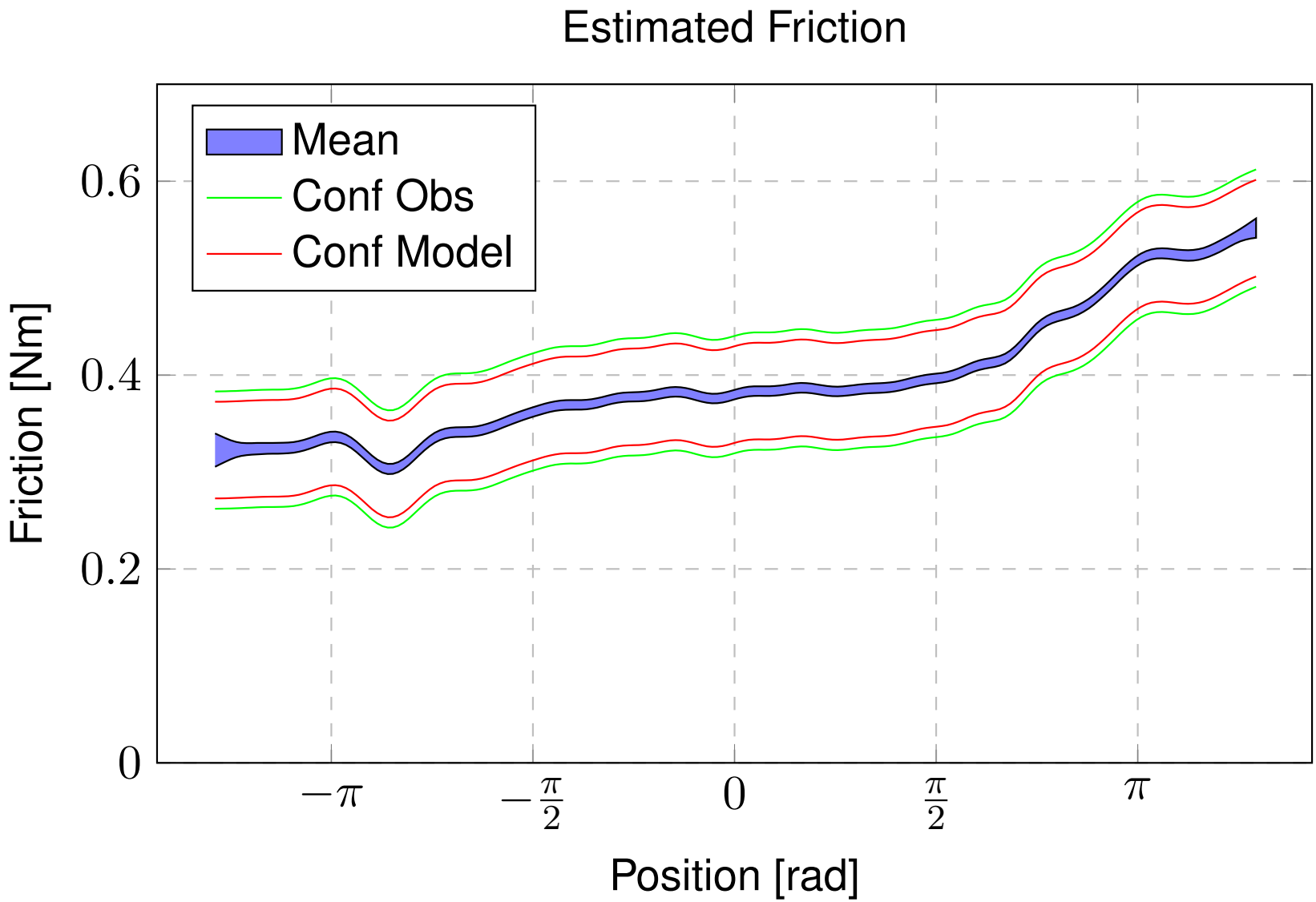


Figure: Estimated Coulomb friction level

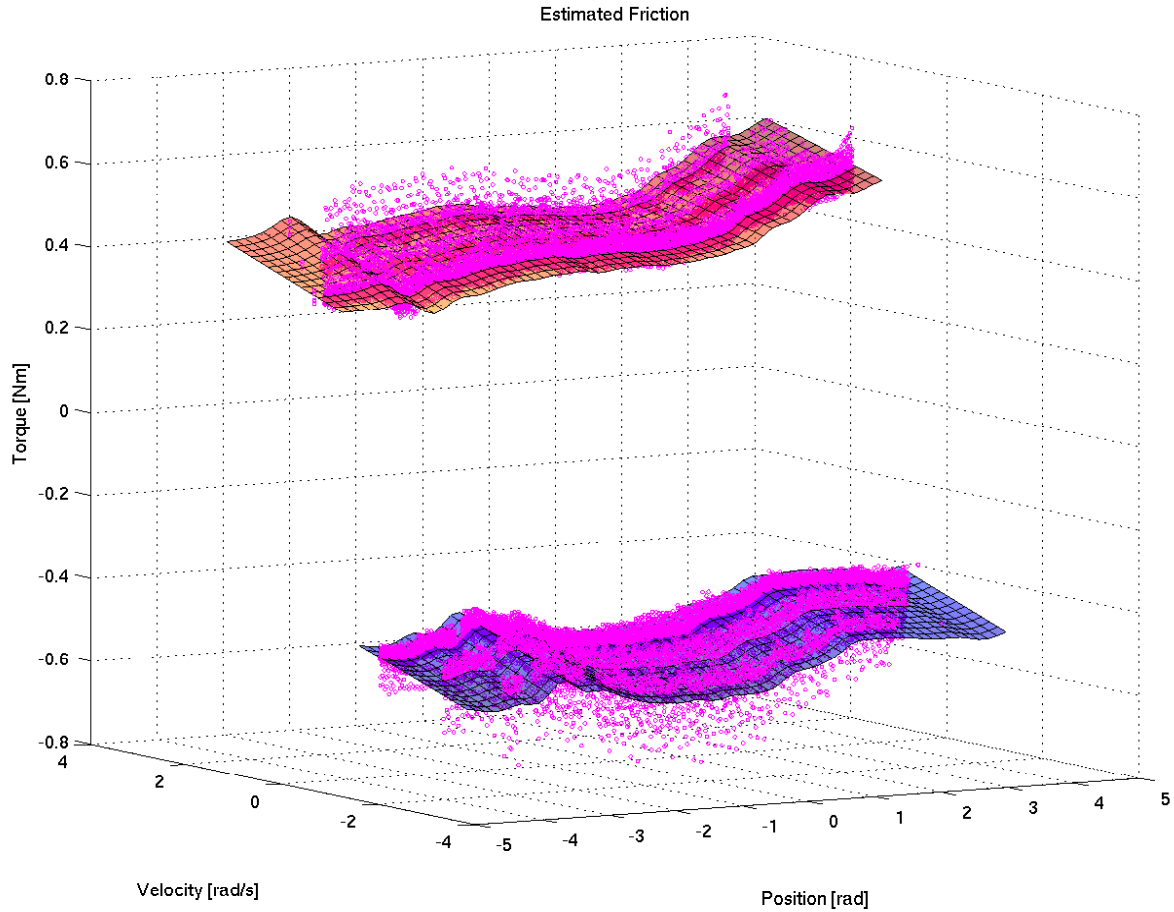


Figure: Estimated Coulomb friction level

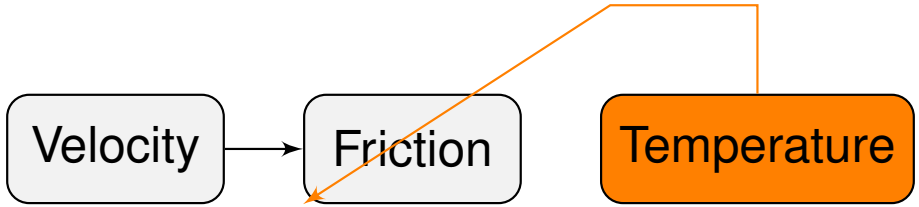
Plots

Double surface

Single surface

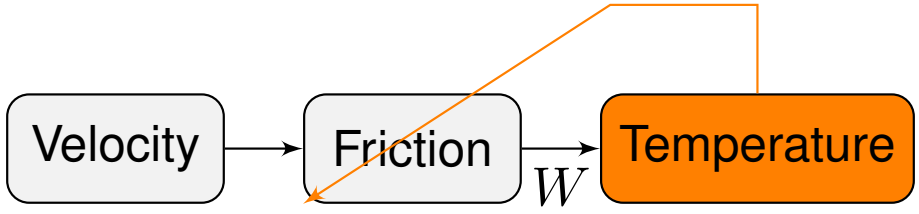
Temperature dependent friction

Temperature modifies friction, but we have no thermometer!



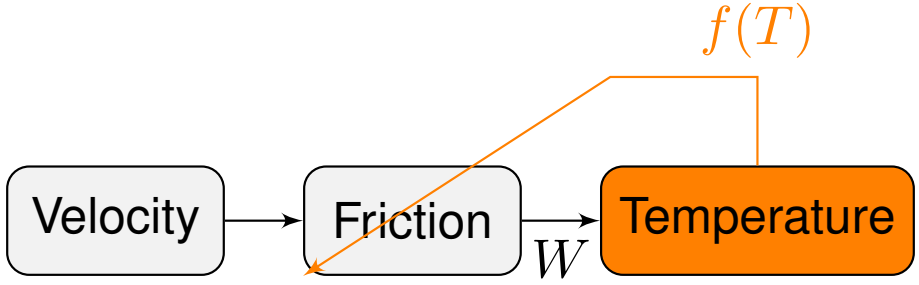
Temperature dependent friction

Temperature increase is due to friction.



Temperature dependent friction

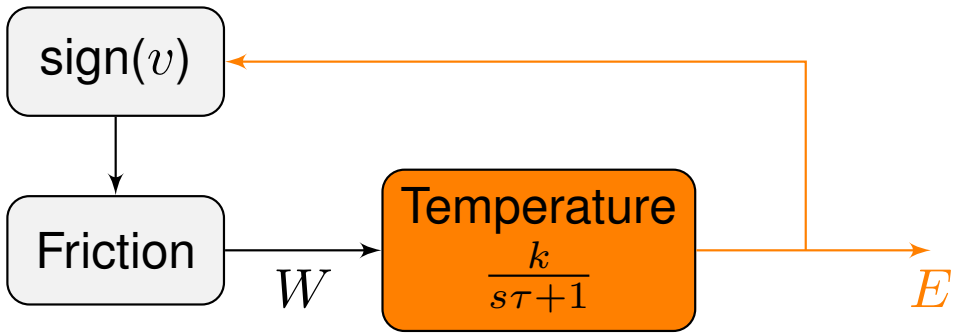
How about estimating the entire orange part together?



Temperature dependent friction

Input Power due to friction W

Output Modification of friction E



Results

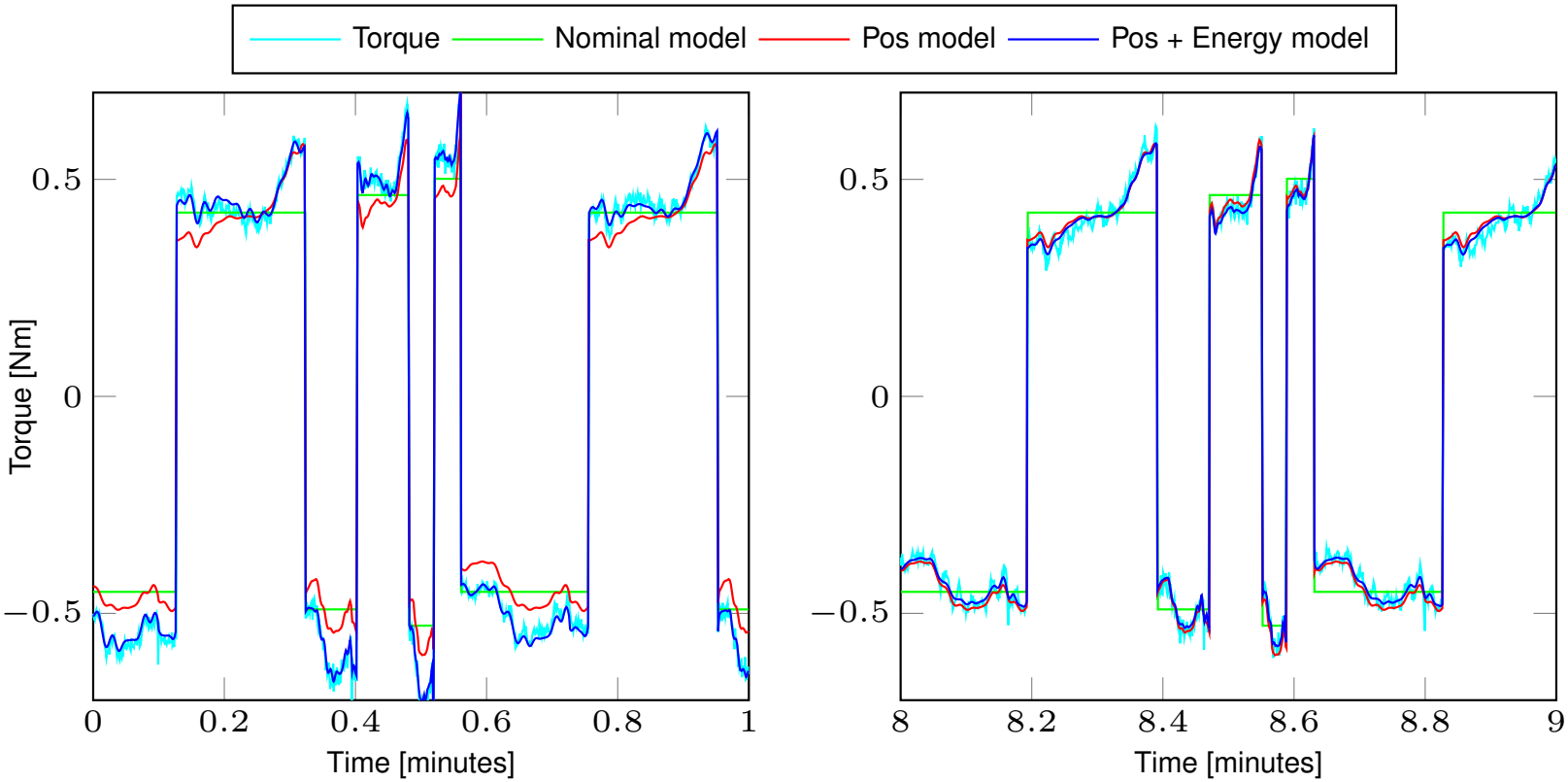


Figure: Model fit to experimental data. Left plot shows an early stage of the experiment when the joint is cold. Right plot shows a later stage, when the joint has been warmed up.

Results

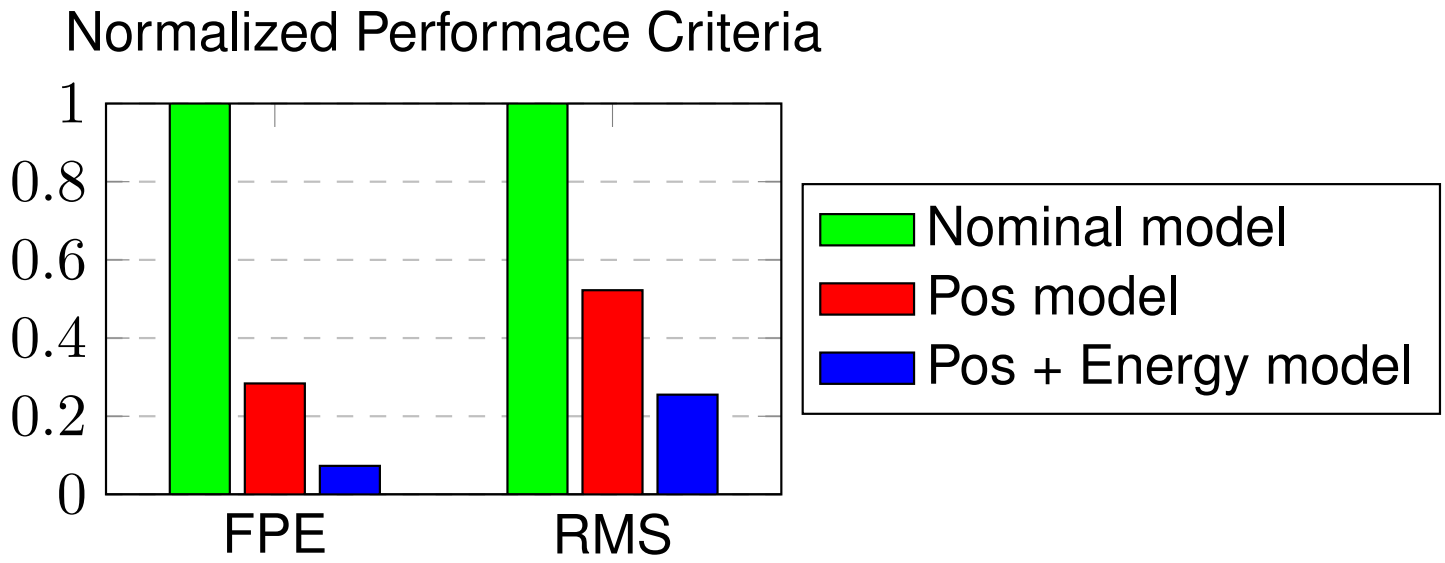


Figure: Performance indicators for the identified models, YuMi.

The future

Friction modeling Make use of model in sensorless lead-through.

SARAFun New EU project on assembly with robots.