A (more) human approach to localization tasks
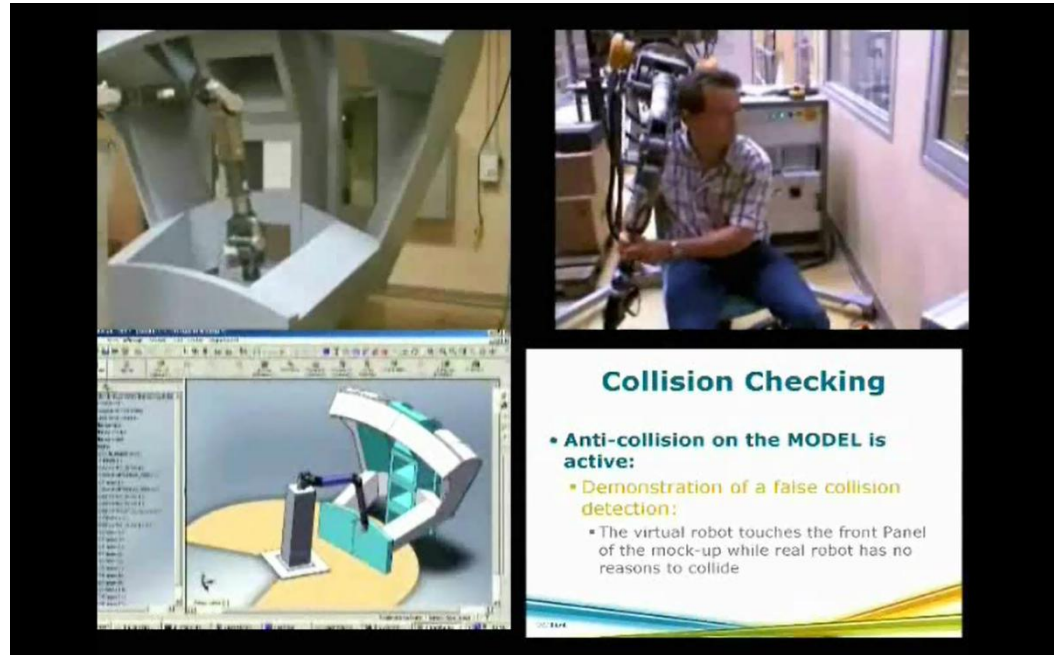
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Motivation

FACT: A reliable scene model is fundamental for contact avoidance and operator assistance

NEED: Enhance the ability to calibrate 3D scene models coping with:

- control errors
- uncertainties on objects' pose
- camera obstructions

Collision Checking

- **Anti-collision on the MODEL is active:**
  - Demonstration of a false collision detection:
    - The virtual robot touches the front Panel of the mock-up while real robot has no reasons to collide

Force sensing proved useful, especially in harsh environments

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Human Blind Localization Experiment

Objective: to observe human beings facing a calibration and localization task in a structured environment

- 30 adult subjects
- 30 seconds to look at the scene, then cover eyes and spin once
- Sensor shut down: eye-cover, thick glove, headset

TEST 1: v-block on the table
TEST 2: v-block on the right edge

**task**: localize the v-block and release the stick on top of it

Experiment: Results

Self-orientation

Table pose

V-block pose

DOF	Description
γ_P	tester orientation around the z axis
x_T	table x coordinate
y_T	table y coordinate
γ_T	table orientation around the z axis
x_{VB}	V-block x coordinates
y_{VB}	V-block y coordinates
γ_{VB}	V-block orientation around the z axis

Same Sequence of actions chosen

Step	Chosen Action	DOF(s)	Test 1	Test 2
1	touch p1 or p2	γ_P	6/30	5/30
2	touch AC	γ_T x_T	26/30	25/30
3	touch AB or CD	y_T	16/30	21/30
4	table-compliant	z_{VB}	21/30	22/30
5	T exploration	x_{VB} y_{VB}	30/30	30/30
6	V exploration	γ_{VB}	30/30	30/30

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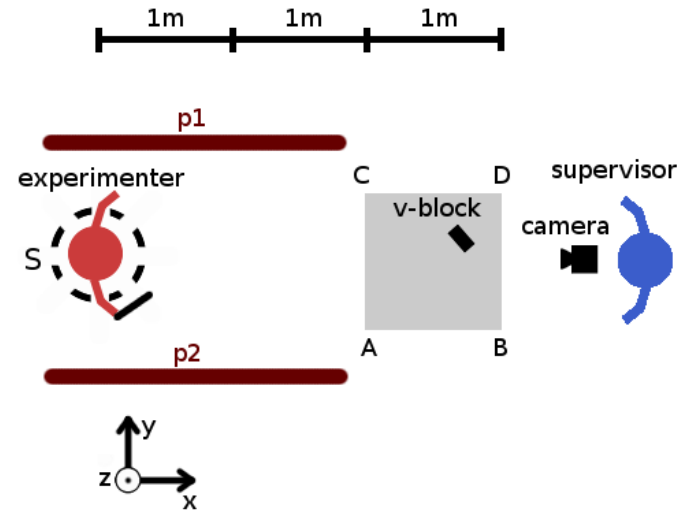
Experiment: Analysis

- Subjects chose the same sequence of actions
- Direct link between action and DOFs
- Resolution increased on control and estimation as uncertainty was reduced
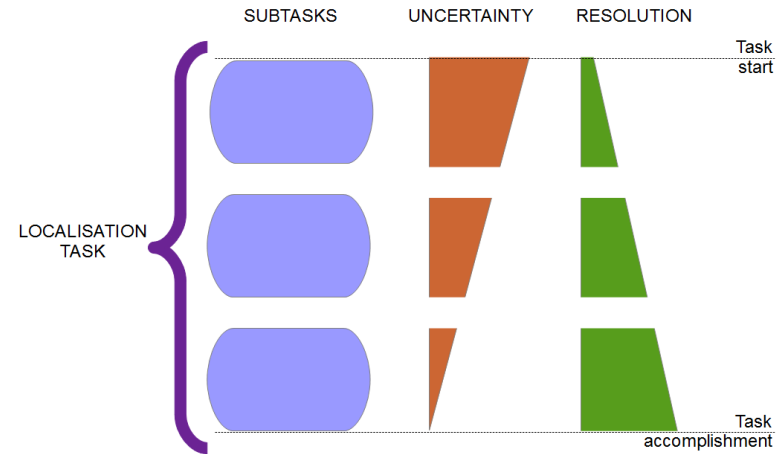
DOF-Decoupled Active Sensing

- Task divided into subtasks, each of them focused on a DOFs subset
- Decision-making about what to sense next formulated as a constrained optimization within each subtask

$$\operatorname*{argmax}_{a} r(b,a) = w_I I(b,a) - w_m C_m(b,a) - w_c C_c(b,a)$$

r = reward
b = belief
a = action
$\{w_I, w_m, w_c\}$ = weights
I = info gain (KL distance or Entropy difference)
C_m = motion cost
C_c = computational cost

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DOF-Decoupled Active Sensing: first example

Task: localization of a rectangle on the table

Simplifying assumptions:
1. Pre-defined sub-task sequence (taken as-is from the experiment)
2. Decision making solved with a pre-programmed sequence of actions within each subtask

Implementation:
- Matlab simulation
- Staubli RX90 (under development)

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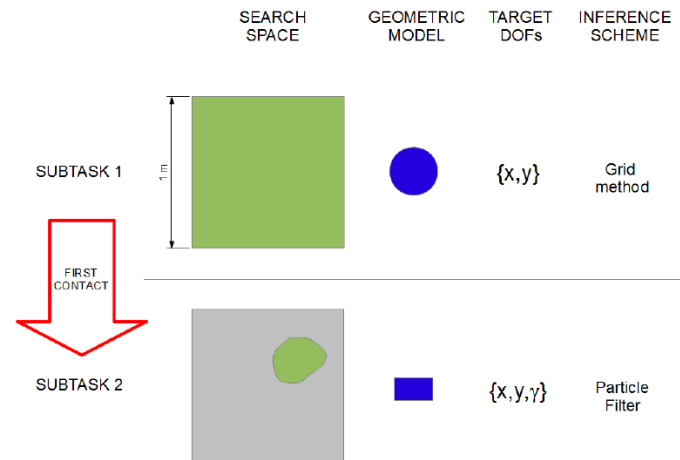
Rectangle localization: subtask 1
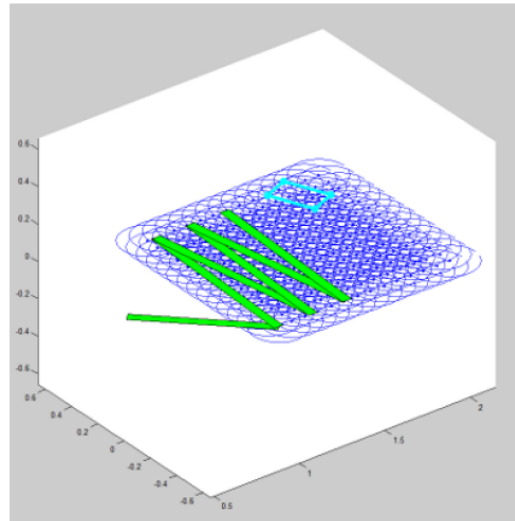
Target DOFs: {x, y}
Geometric model: bounding circle
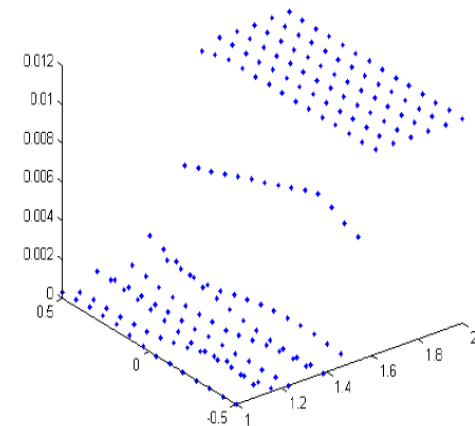**Inference scheme**: 2D grid
Initial uncertainty: {1m, 1m ,180deg}
Sensing: sweeps with contact detection

Further to the experiment, the sequence of sweeps is pre-programmed to cover the table surface.

Sensing

Posterior distribution

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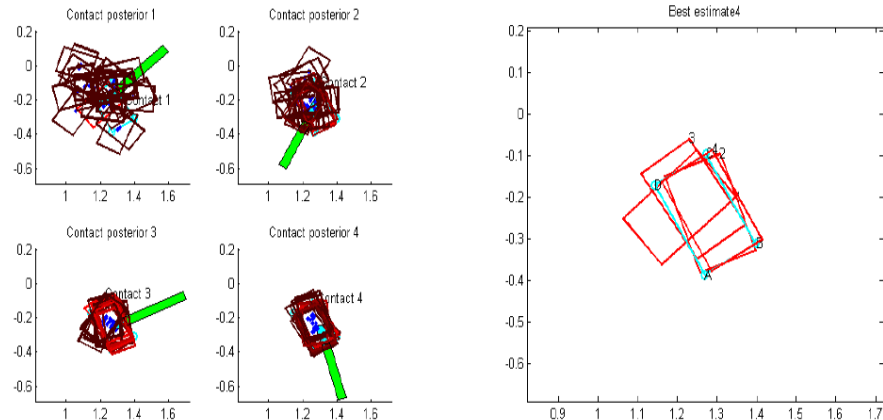# Rectangle localization: subtask 2

Target DOFs: $\{x, y, \gamma\}$
Geometric model: rectangle
Inference scheme: 3D particle filter
Initial uncertainty: $\{0.3m, 0.3m, 180deg\}$
**Sensing:** sweeps with contact detection

Four sweeps are defined with respect to the best-estimate.

Rectangle localization: results

- Localization performed with high initial uncertainty (1m in translation and 180deg uin rotation)
- Feasible solutions for on-line applications
- Negligible overhead when doubling the initial uncertainty

- Decision making improvable: best-estimate approach does not guarantee a touch on each sweep

(??? benchmark to estimate the computational cost
 of using rectangles and 3D particle filter????)
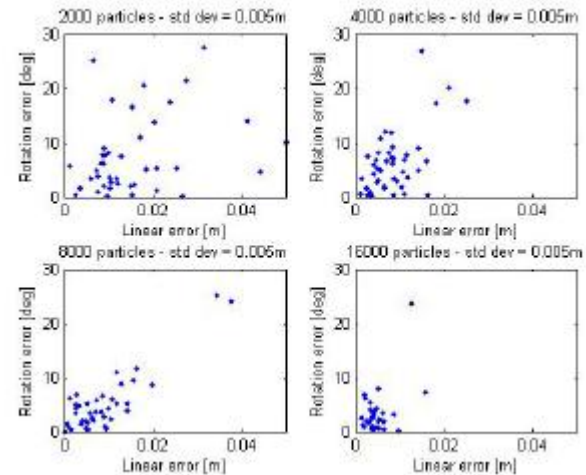
Next steps

- Robot implementation of the rectangle localization
- Decision making for both subtasks as constrained optimization
- Application of DOF-Decoupled Active Force Sensing to more-complex geometries
- 6DOF localization

Contacts

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