Interactive Tuning of Robot Program Parameters via Expected Divergence Maximization

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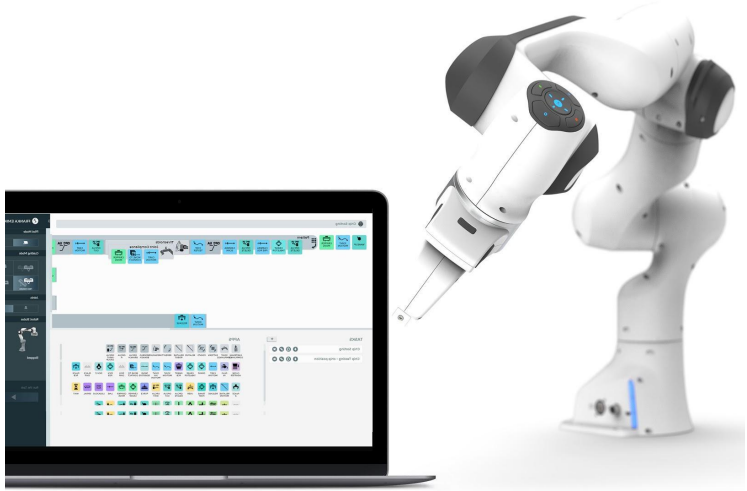
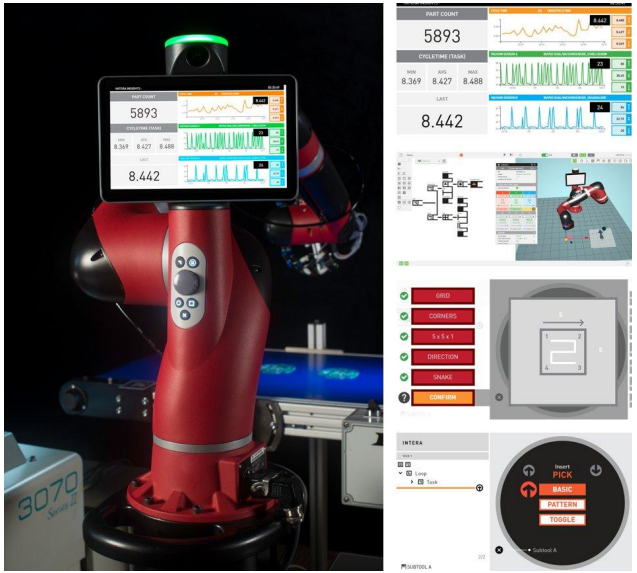
ROBOT END-USER PROGRAMMING

Main motivation: **End-User Programming makes robots accessible to novice users**



Desk Environment for FRANKA EMIKA Panda robot



Intera Environment for Rethink Robotics Sawyer

AIDING END-USER PROGRAMMING

Robot actions are the building blocks for EUP programs, with each varying number and complexity of parameters

PARAMETERS

- Goal Pose
- Translational Speed
- Collision Threshold (move until you sense a contact)

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Challenges faced by end-users

- What robot actions to use to achieve the goal?
- **How to set the action parameters?**
- How to evaluate the program (debug and fix)?

PARAMETER TUNING FOR ROBOT ACTIONS

How are parameter values usually specified?

PARAMETERS

- Goal Pose → Kinesthetic Teaching
- Translational Speed
- Collision Threshold (move until you sense a certain amount of force)

→ GUI elements (e.g. 1-D sliders)

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Trial-and-error tuning strategy (**tedious** and **time consuming**):

- often effects of changes to parameter values are not immediate
- sometimes specifying a single value is not enough

AIDING 1-D PARAMETER TUNING

Idea: **what if the robot proposes the parameter values to try? instead of the user selecting them with sliders**

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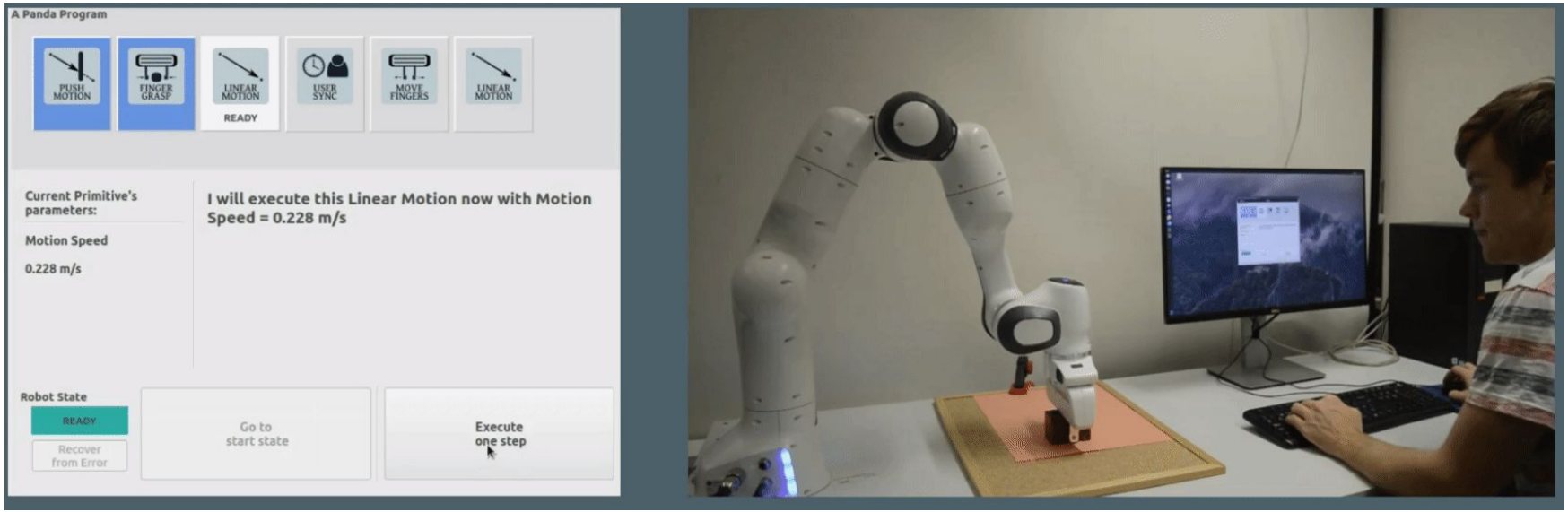
Formulation: **we formulate this as an Active Learning (AL) problem.**

AL agent iteratively:

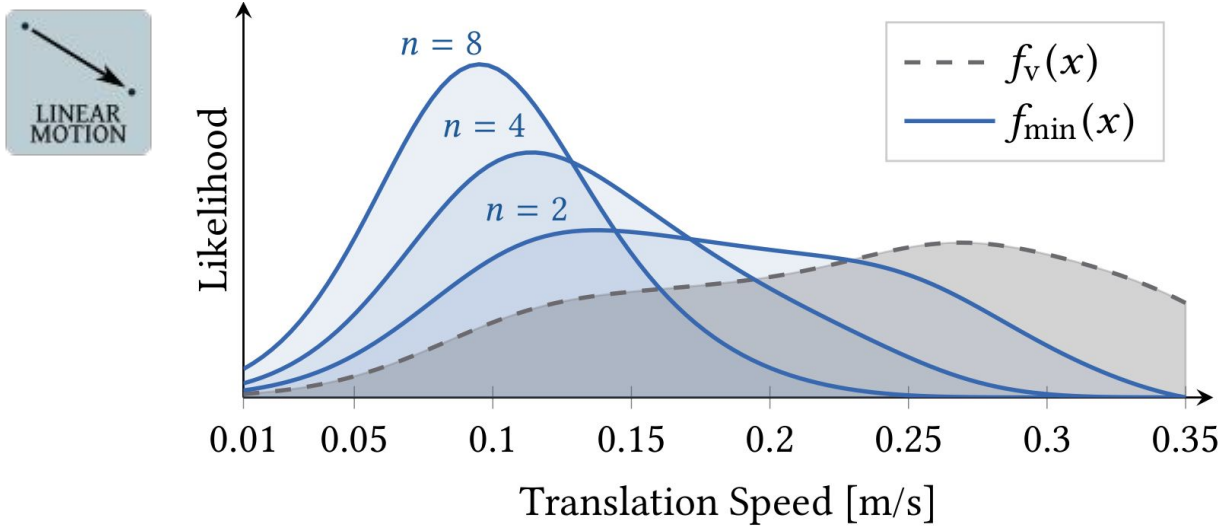
1. **selects informative parameter values to try** (*query selection*)
2. **action is reproduced with selected parameter** (*actual querying*)
3. **user gives feedback** (*answering*)
4. **parameter range estimation is updated** (*model update*)

TUNING PIPELINE IN ACTION



BAYESIAN PARAMETER ESTIMATION

Bayesian approach: **priors over parameter values** (e.g. from expert programs)



FEEDBACK AFTER THE ACTION

Directional answers: given the 1-D nature of the estimated parameters**, the user's feedback can be directional (higher, lower, fine)**

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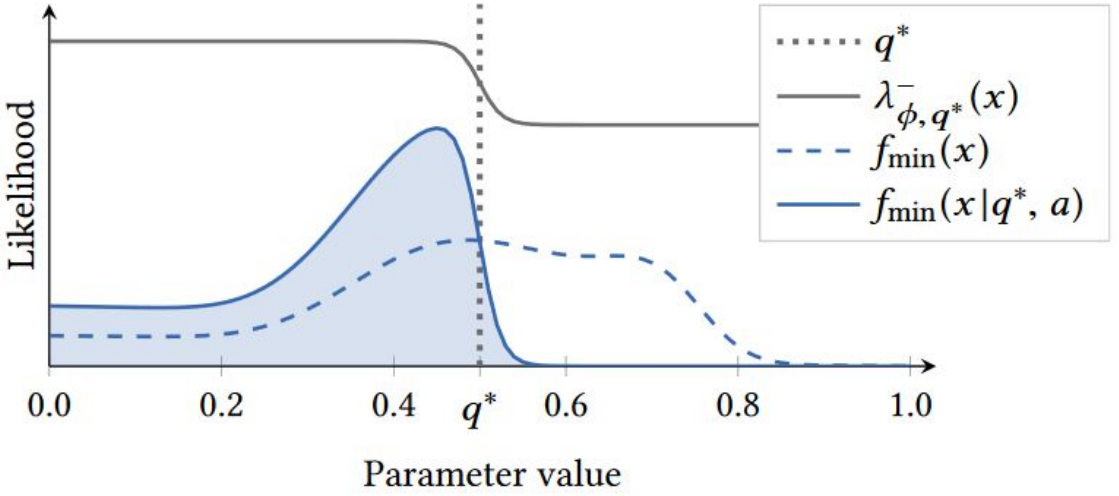
"The motion was too fast! I want it slower"



SELECTING THE VALUE TO PROPOSE

How to select the **parameter value**?

- **At random** (complexity O(1))
- **Uncertainty sampling** (O(k)) ~ basically a weighted binary search on the prior
- **Expected Divergence Maximization** ($O(k^2)$)

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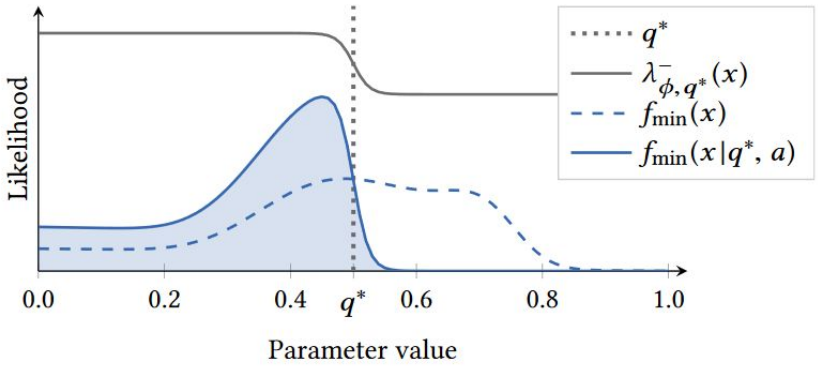
$$S_v^{\cdot} = \mathop{\mathbb{E}}_{a}[\mathbb{JS}(\overbrace{f_{\cdot}(x|v,a)}^{\text{post query}}, \overbrace{f_{\cdot}(x)}^{\text{pre query}})]$$
$$= \sum_{a} p(a|v, f_{\cdot}(x))\mathbb{JS}(f_{\cdot}(x|v,a), f_{\cdot}(x))$$



EXPERIMENTS

1. synthetic priors and simulated oracle users
2. priors from expert programs (8 experts) and simulated oracle users
3. **usability study: 8 novice users, using expert priors**

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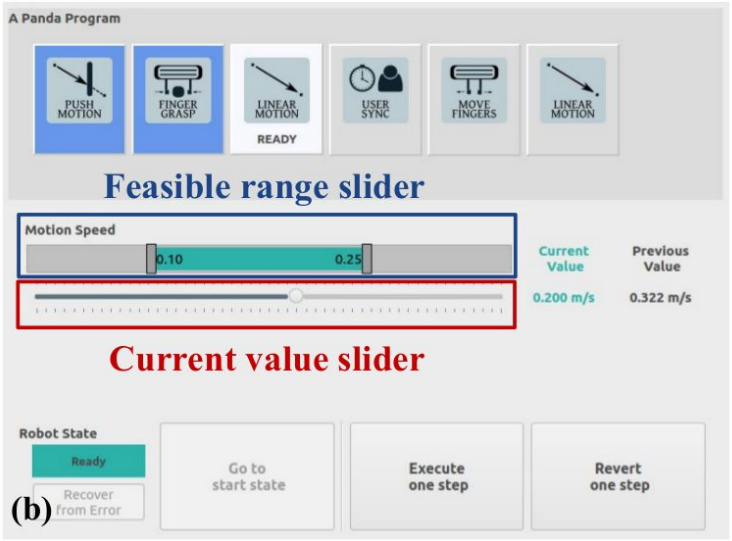
Domain Specific Language (DSL) -- 5 actions each with 1 or 2 parameters

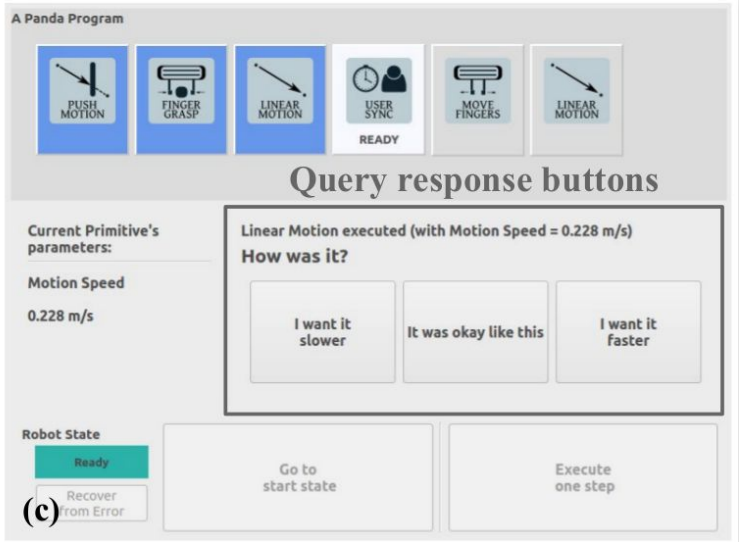
Tasks for priors: handover, 2 pushing tasks, and a pick and place

EVALUATION WITH NOVICE USERS

Task: **tune the parameters of a provided handover program**

Conditions: **Baseline (GUI sliders)** *vs* **Active tuning**





RESULTS and OBSERVATIONS

- **SUS score: baseline 73.7** *vs* **Active tuning 73.1 (good usability)**
- **With Active tuning**, novice users produced parameter ranges **closer** to the expert ones
- **With Active tuning**, **faster tuning** (**8 min** *vs* **13 min**)

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From participants' feedback:

- **Active tuning** helped at the beginning **but had strict control over the process**
- Participants reduced tuning attempts over time with the baseline
  Active tuning did not → perceived as slower and less efficient!

INTERESTING FUTURE DIRECTIONS

Interaction side:

- **Control issue: more discreet ways of suggesting parameter values to try out**
  e.g. overlaying information on the GUI sliders or Active tuning only on demand
- **Time consuming: can (some) executions be handled in simulation/visualization tools?** can users still express feedback?

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Learning side:

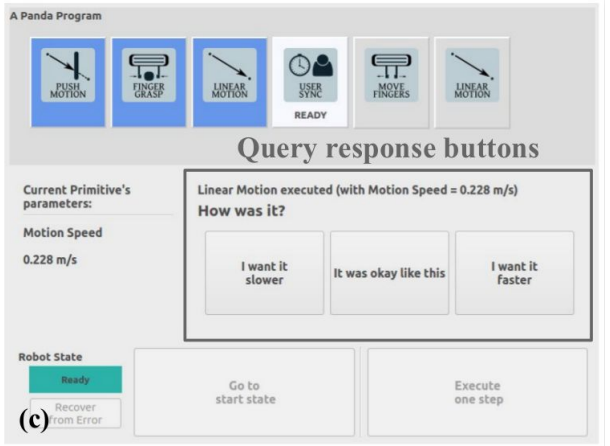
- **Different querying schemes**: if action has 2 or more parameter, let AL agent **pick which parameter to tune**
- **Tune single or multiple parameters at a time?** can users still express feedback?

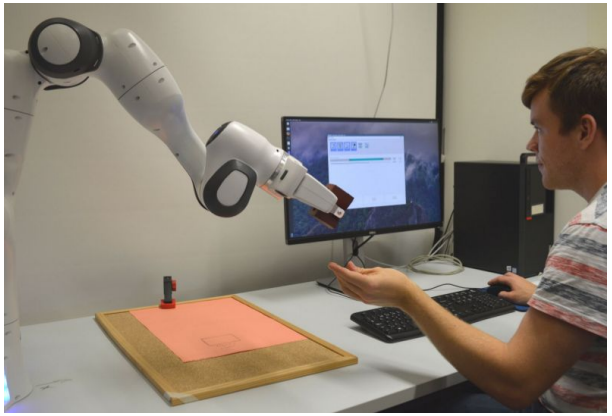
CONCLUSIONS

We framed the tuning of parameters of robot actions as an Active Learning problem and proposed a novel interactive tuning method.

We validated the tuning approach both in simulation and in a real robot scenario.

Experiments showed the usability of the method with novice users, and allowed us to identify several promising future directions.





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Code available at github.com/mattiaracca/eupanda
Showcase video at vimeo.com/mattiaracca/hri20
Paper available on ACM Digital Library!

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