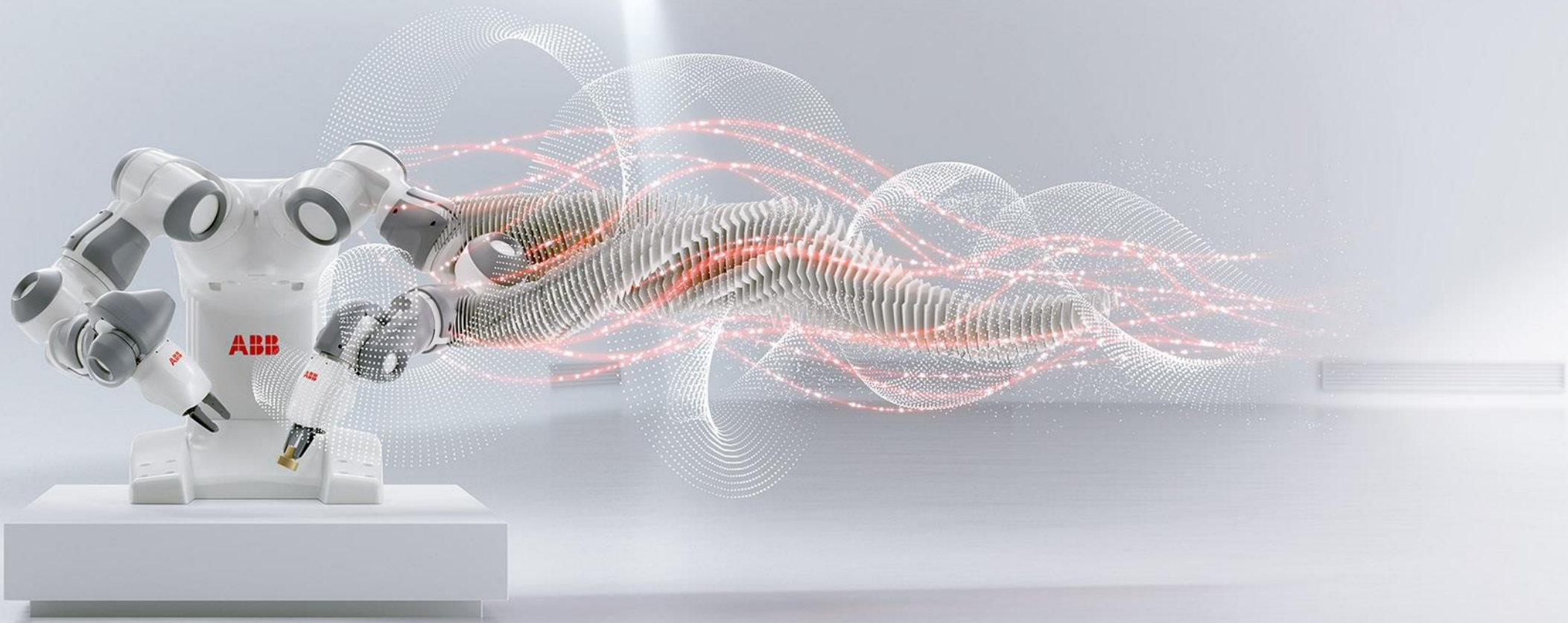

FAN DAI, ABB CORPORATE RESEARCH

# Thoughts on Robot Assembly Skills and Machine Learning

CASE 2018 Workshop “Robotic Assembly – Recent Advancements and Opportunities for Challenging R&D“

Munich, Germany, 20th August 2018

# Questions and thoughts I want to share

What are Robot Assembly Skills?

What is Machine Learning?

What should be Learned, and How?

What are the Major Obstacles?

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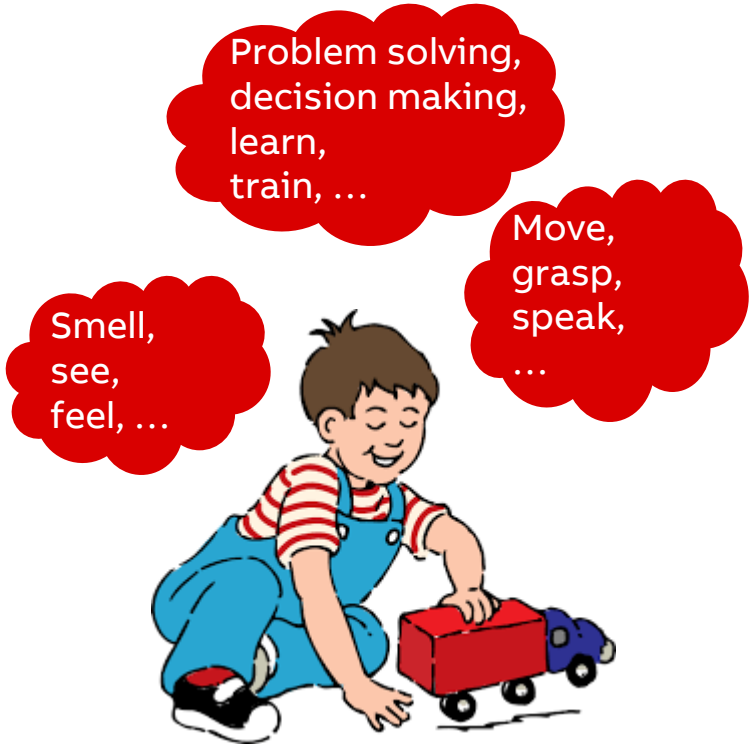
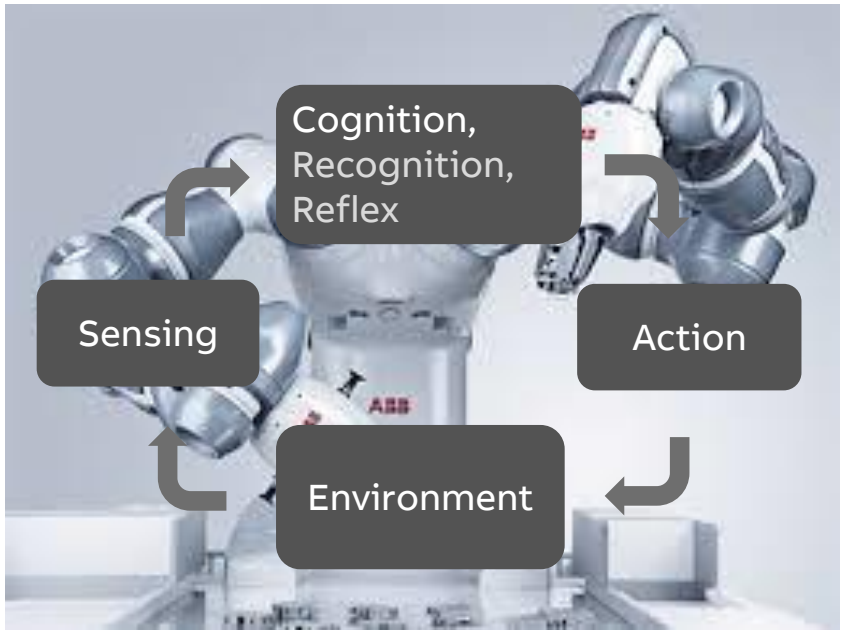
# Intelligent robots

Learn from human intelligence…




…to create skilled & easy to use robots

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# Intelligent robots

## How they should (not) be

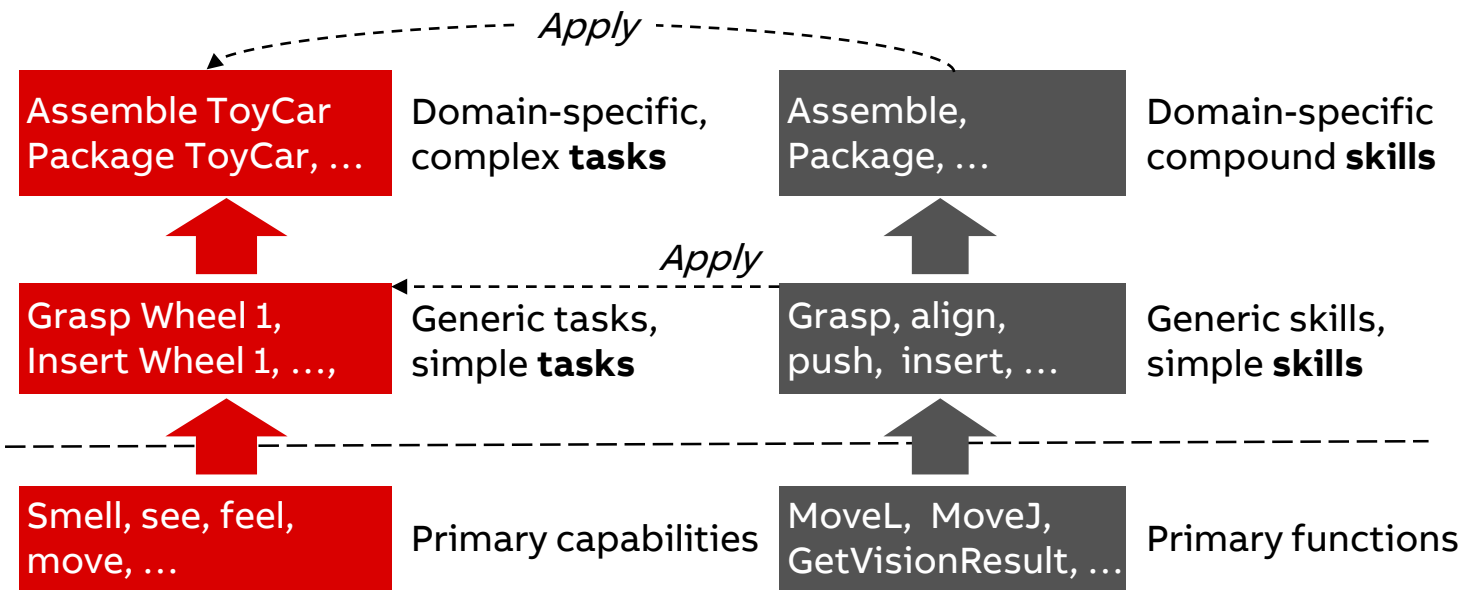
- Copy of human
- Replacement of human
- Universal machine

- Skilled to perform desired tasks (assembly, health care, …)
- Can deal with uncertainties and changing situations
- Can learn to perform tasks better (more efficient, precise, …)
- Can be intuitively instructed by human (goal-oriented, natural language or other simple input means)

# Robot Assembly Skills

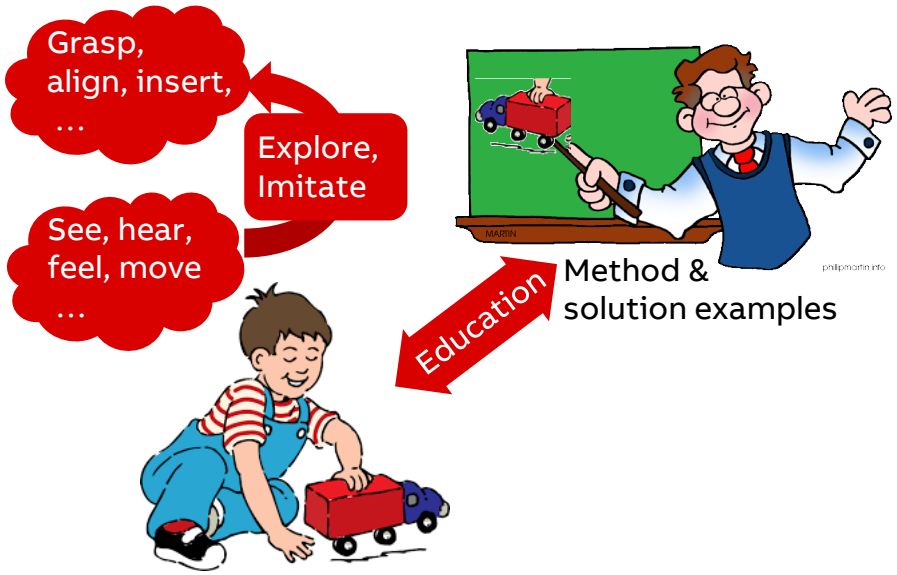
Ability to perform assembly tasks autonomous and proficiently

## Example of skills and skill levels



# How do humans gain skills

## Self-learning and/or with teacher




| | Solution Learning | Method Learning |
|---|---|---|
| By Exploration | Try out a numbers of ways and find one or several non-optimal solutions (local optima)<br>*Medium, time consuming.* | Try to summarize, analyze and structure, based on existing knowledge<br>*Weak, time consuming.* |
| By Imitation | Repeat what have been observed.<br>*Strong, relatively fast, but limited to the learned solution.* | Try to summarize, analyze and structure, based on existing knowledge<br>*Very weak.* |
| By Education | Example cases eases learning of methods<br>*Strong, fast.* | Systematic approach to enrich knowledge and enhance level of skills<br>*Strong, fast.* |

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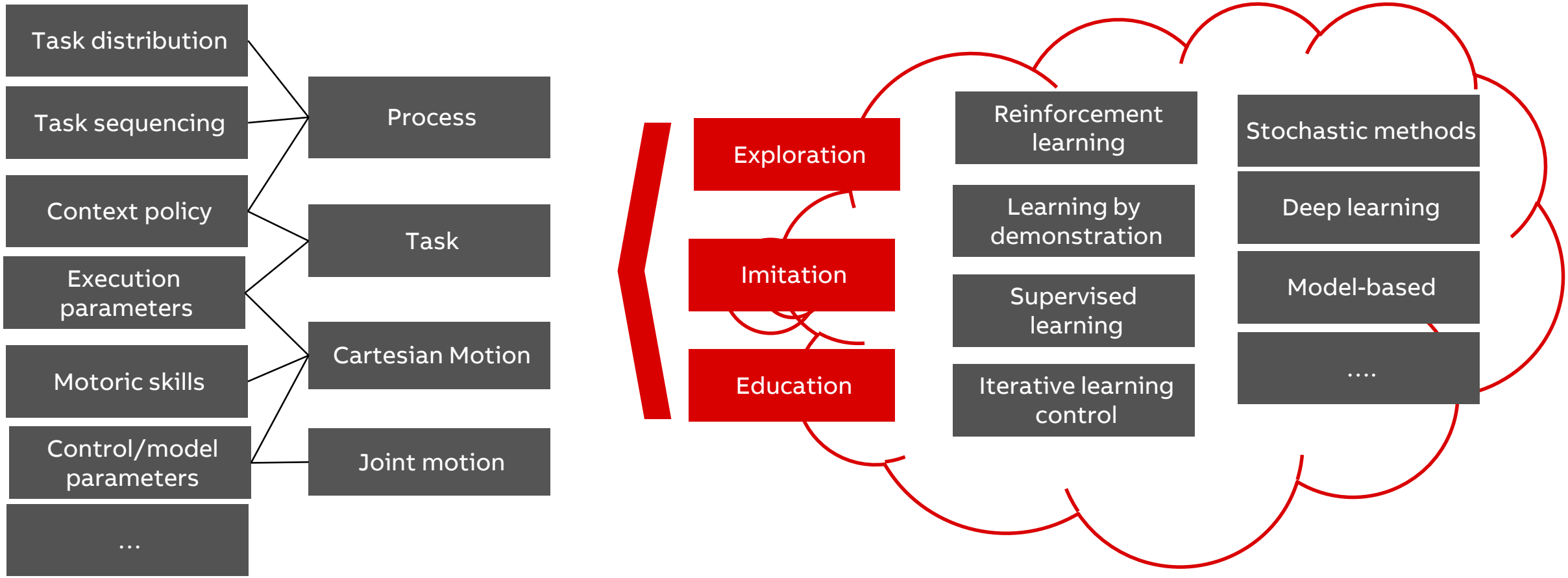
# Learning in the robotics domain

Purpose, levels, learning approaches, ….

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# Common Problems when Applying Machine Learning

Questions to be answered

- How to get the large amount of trials in a real-world scenario?
- How to deal with uncertainties during production?
- Do we have time for learning?
- Are we sure that it is the solution what we want to have?
- Are we sure that we can rely on the solution?
  - from safety perspective,
  - from quality perspective, or
  - from production reliability perspective.

Carefully define

- Purpose of learning
- Constraints
- Metrics
- Prior-knowledge

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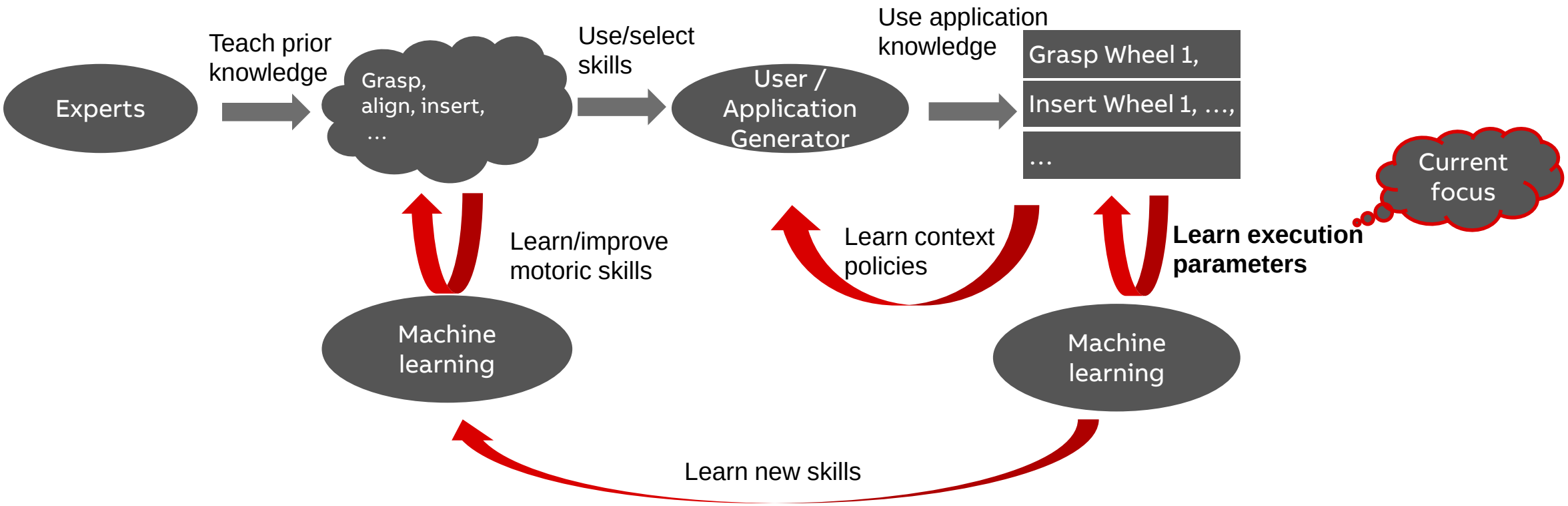
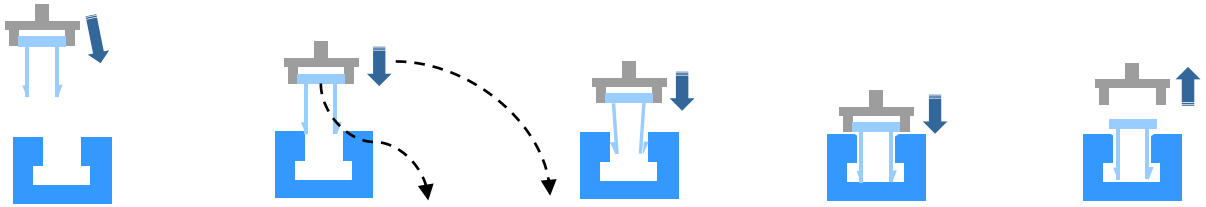
# Our approach: Skills-based application programming

## Where machine learning may help



# Robot Assembly Skills

Re-usable robot functions that are intuitive for application engineers



SnapInsert (Start_Pose, Direction, \configParams)

global var
& signals:
xxx_Status,
…

- *Approach start_pose*
- *Find right pose and alignment (Move with compliance)*
- *Move forward until snapped (Check resistant force, Optional corrective motion)*
- *Release & Move back*

global var:
SnapIn_Status

Grey-box
- Programmed by expert
- Hidden for standard application programming
- Guided calibration & configuration (automatic where possible)
- Accessible for experts

*A higher-level robot function with application-oriented parameters usable via any user interfaces*

*Appropriate UIs for different user types may further increase ease-of-use*

***Machine learning may further reduce the efforts for parameterization/configuration***

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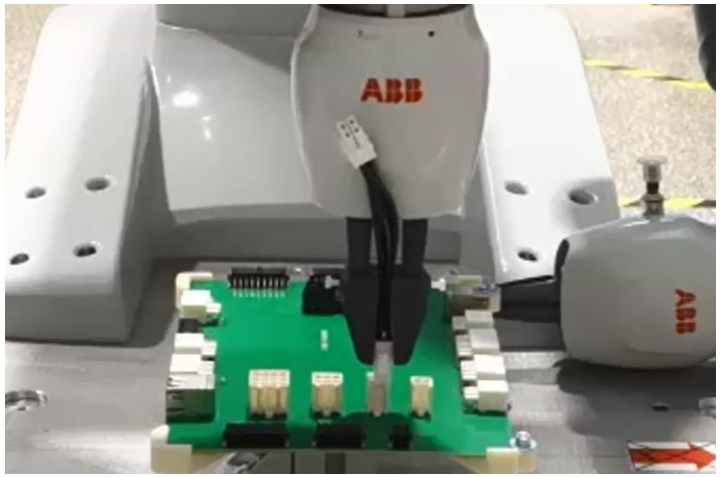
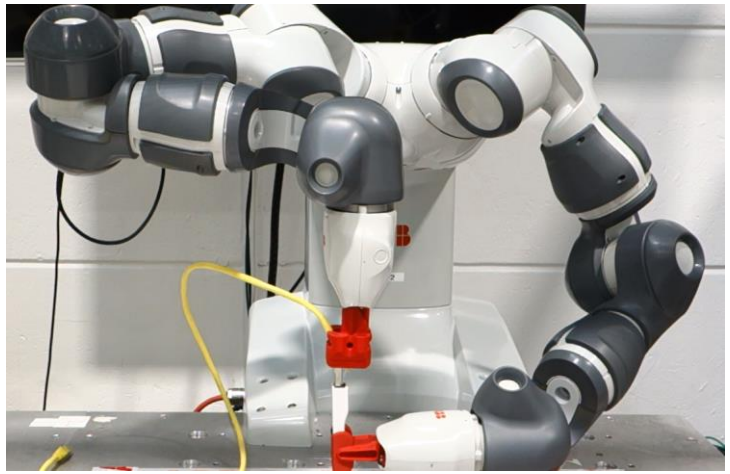
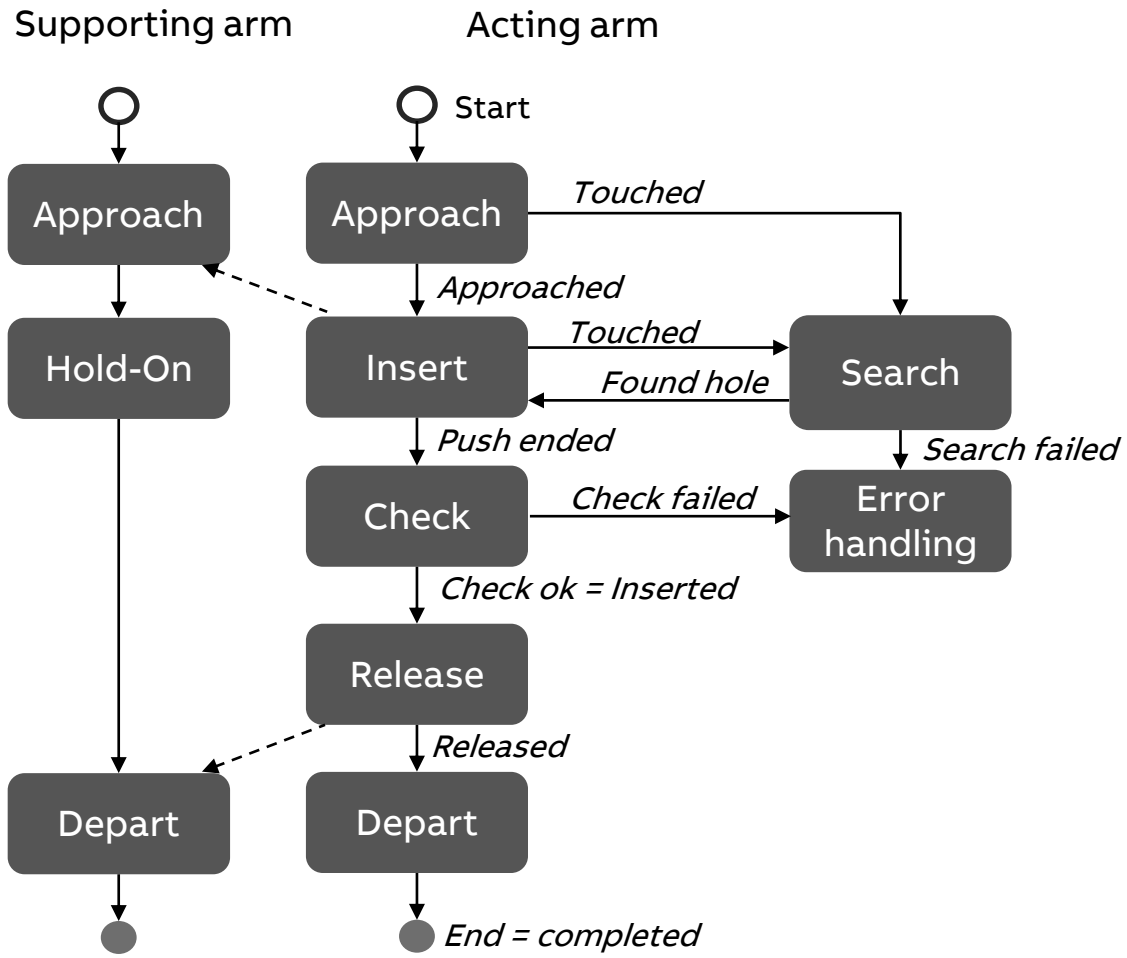
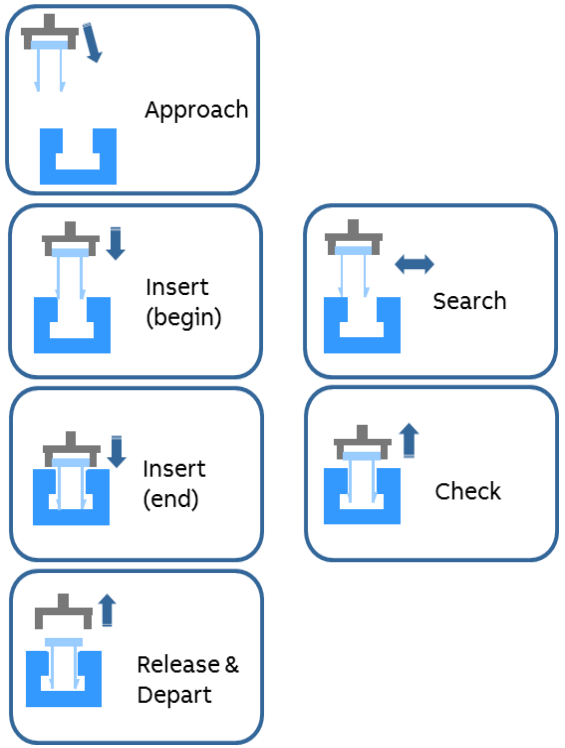
# Example of (two-handed) snap insertion



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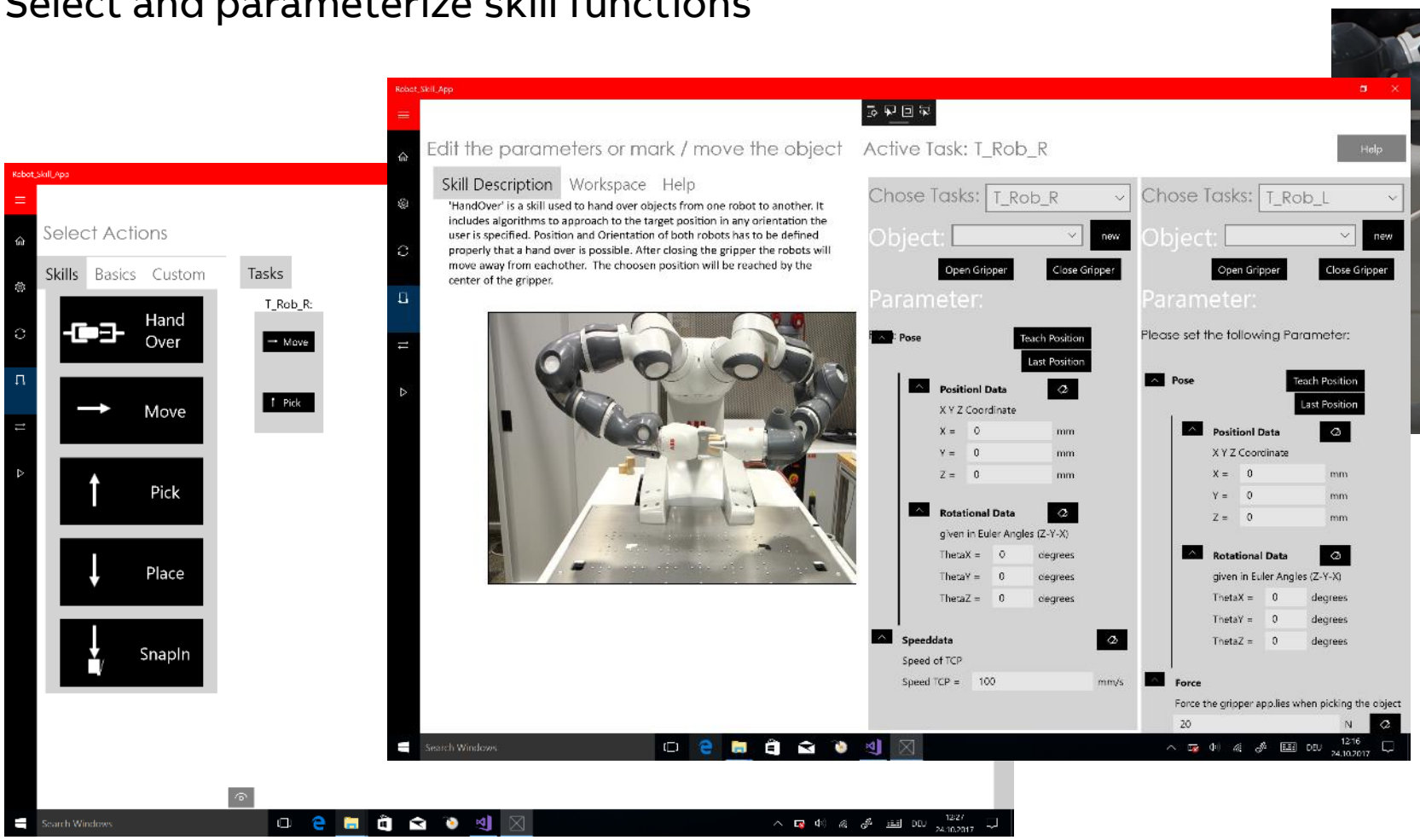
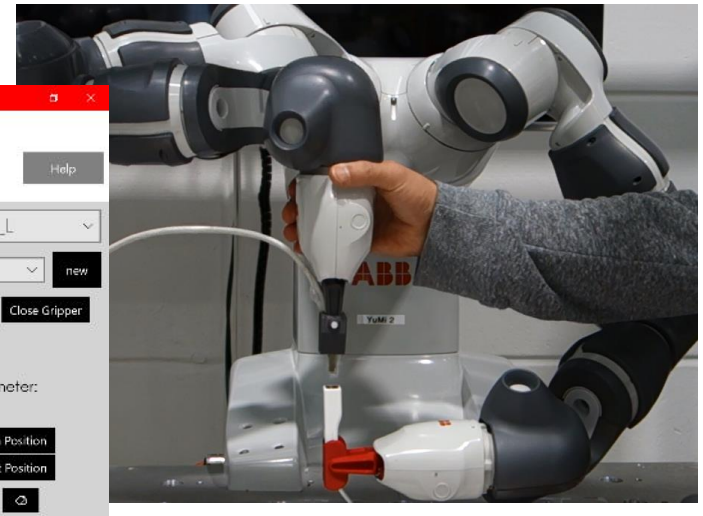
# Skill-based application programming

## Select and parameterize skill functions



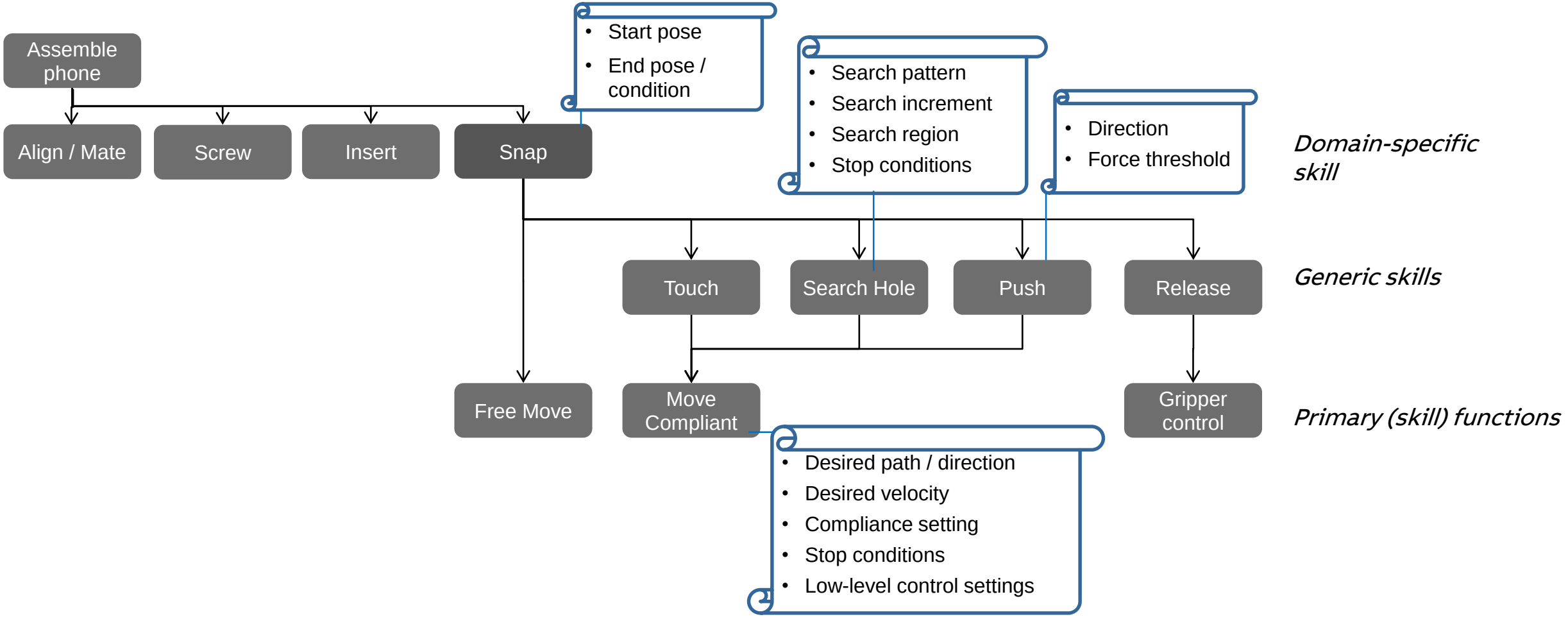



Objectives of UI design

- Reduce number of parameters for the user
- Hide/unhide lower-level parameters
- Multimodal & intuitive

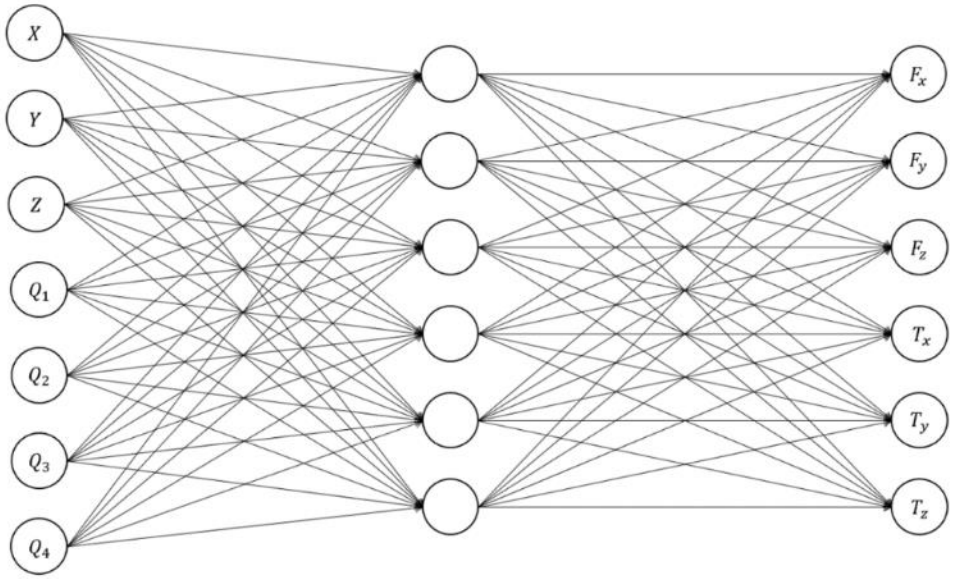
# Skills hierarchy and examples of skill parameters

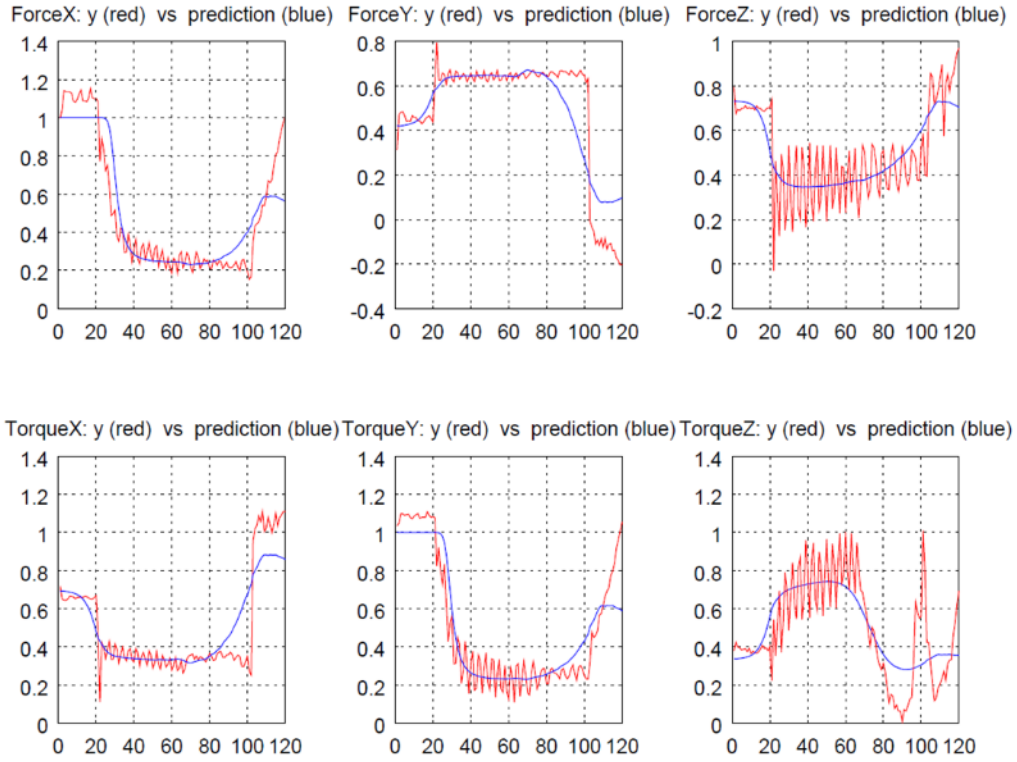
Can the parameters be learned?



# Some experiments

## Learning force threshold and starting pose for snapping

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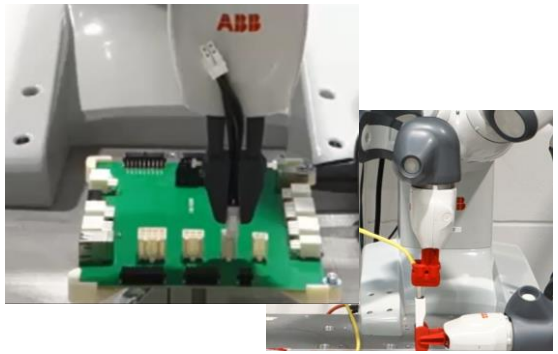
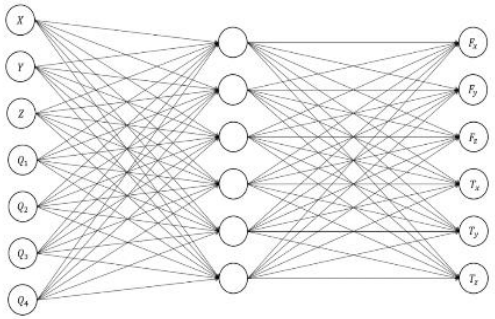
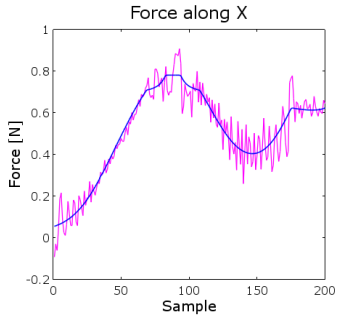
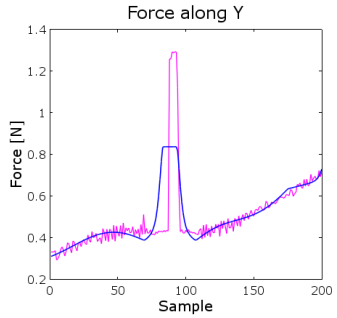
# Some experiments

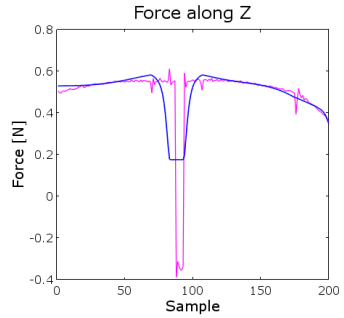
## Learning force thresholds, start pose, and search policy for snapping

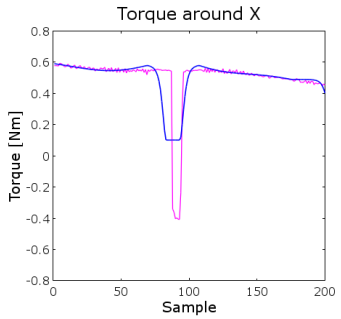


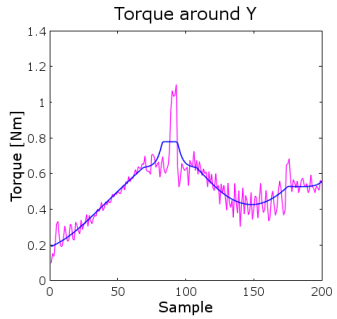



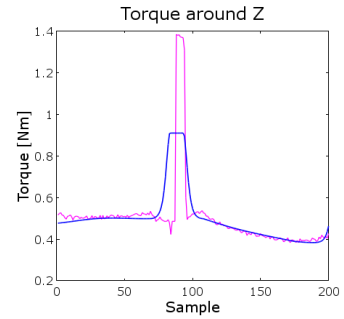


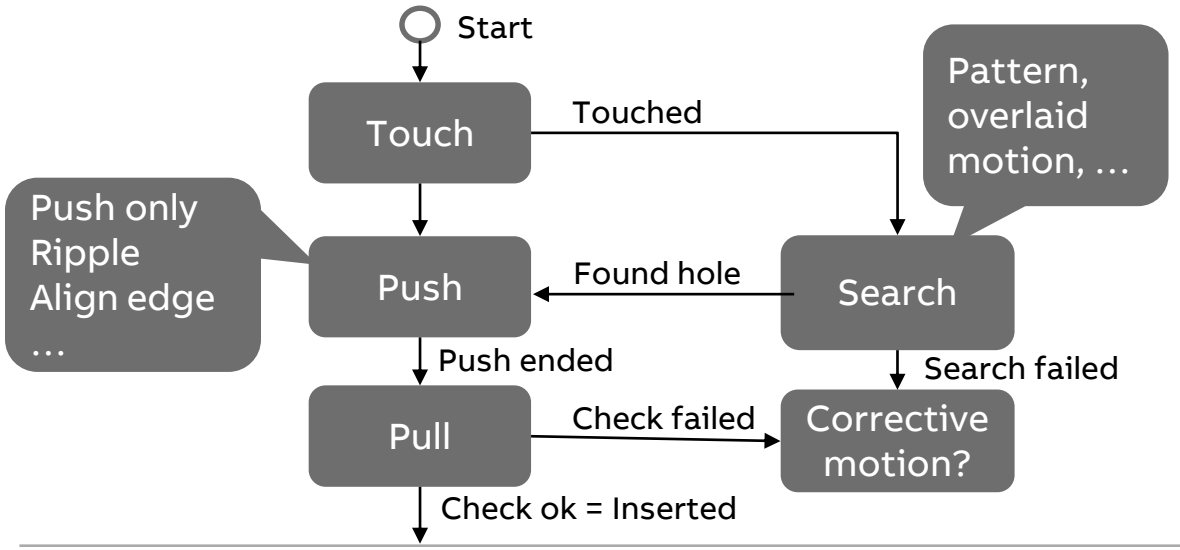



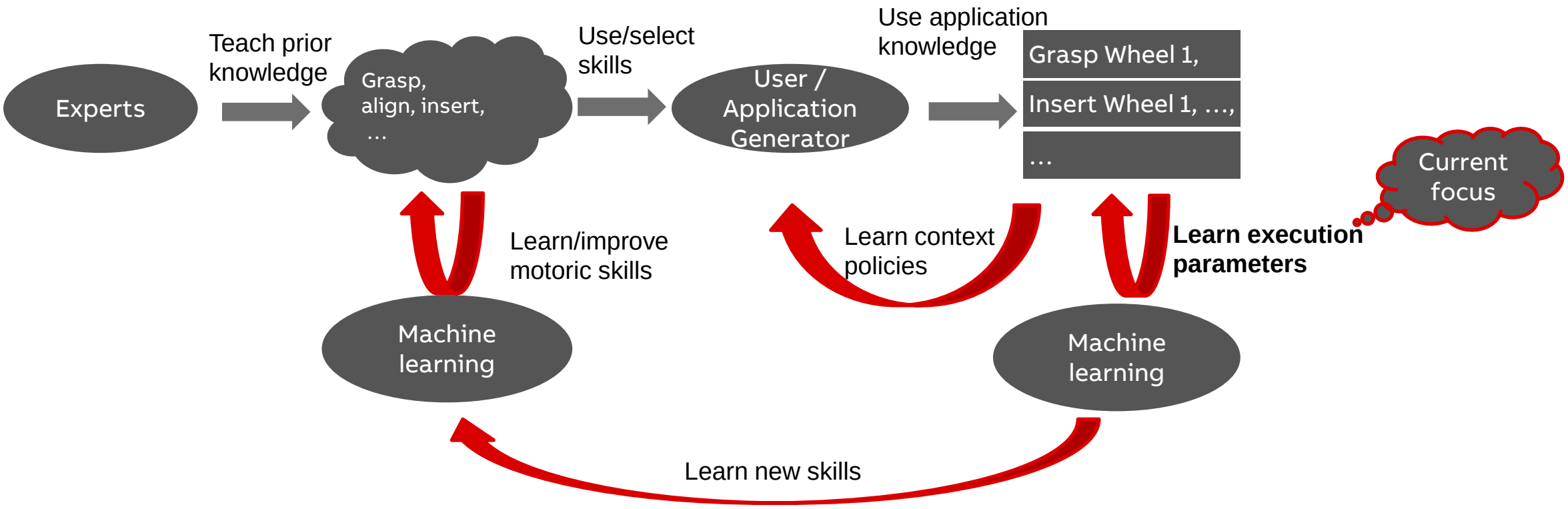



# Recall: Skills-based application programming

## Where machine learning may help



# Recall: Common Problems when Applying Machine Learning

Questions STILL to be answered

- How to get the large amount of trials in a real-world scenario?
- How to deal with uncertainties during production?
- Do we have time for learning?
- Are we sure that it is the solution what we want to have?
- Are we sure that we can rely on the solution?
  - from safety perspective,
  - from quality perspective, or
  - from production reliability perspective.

**Now investigating:**

How far combination of simulation and real-world learning can help without introducing huge additional effort of modeling / model acquisition

# Acknowledgement

This topic has been discussed within the “Productive 4.0” project team at ABB Corporate Research.

Many thanks to the project team members, especially Debora Clever, for the comments and discussions.

Productive 4.0 (https://productive40.eu/)

is a European co-funded innovation and lighthouse program, aiming at creating a user platform across value chains and industries, thus promoting the digital networking of manufacturing companies, production machines and products.

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