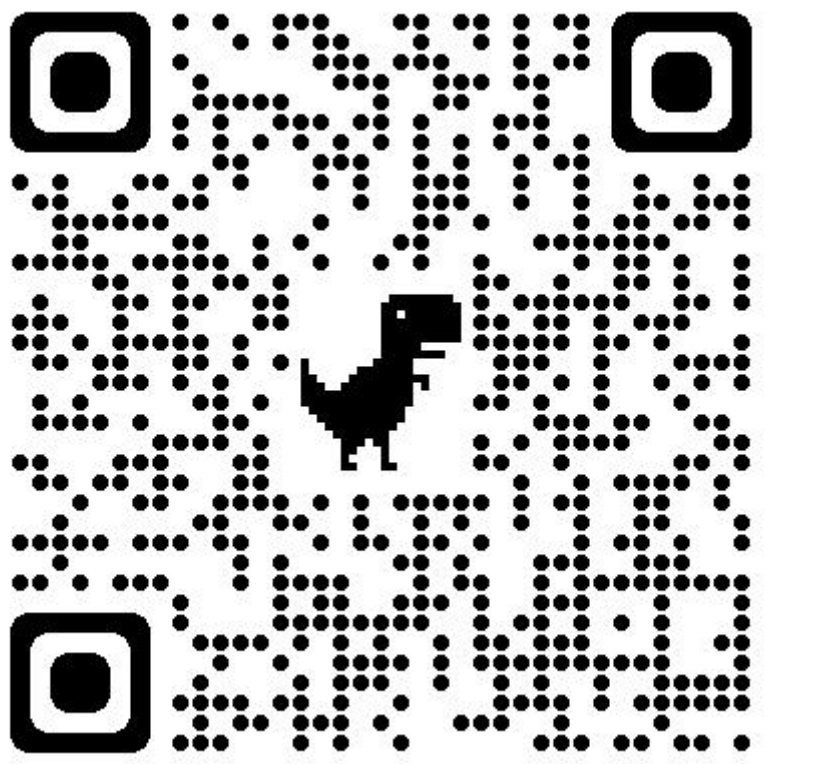


A Robust and Safe Strategy for Robotic Assembly

Yi Liu, Andreas Verleysen, Francis wyffels (IDLab-AIRO, elis, Ghent University - imec)



Code/Video is available

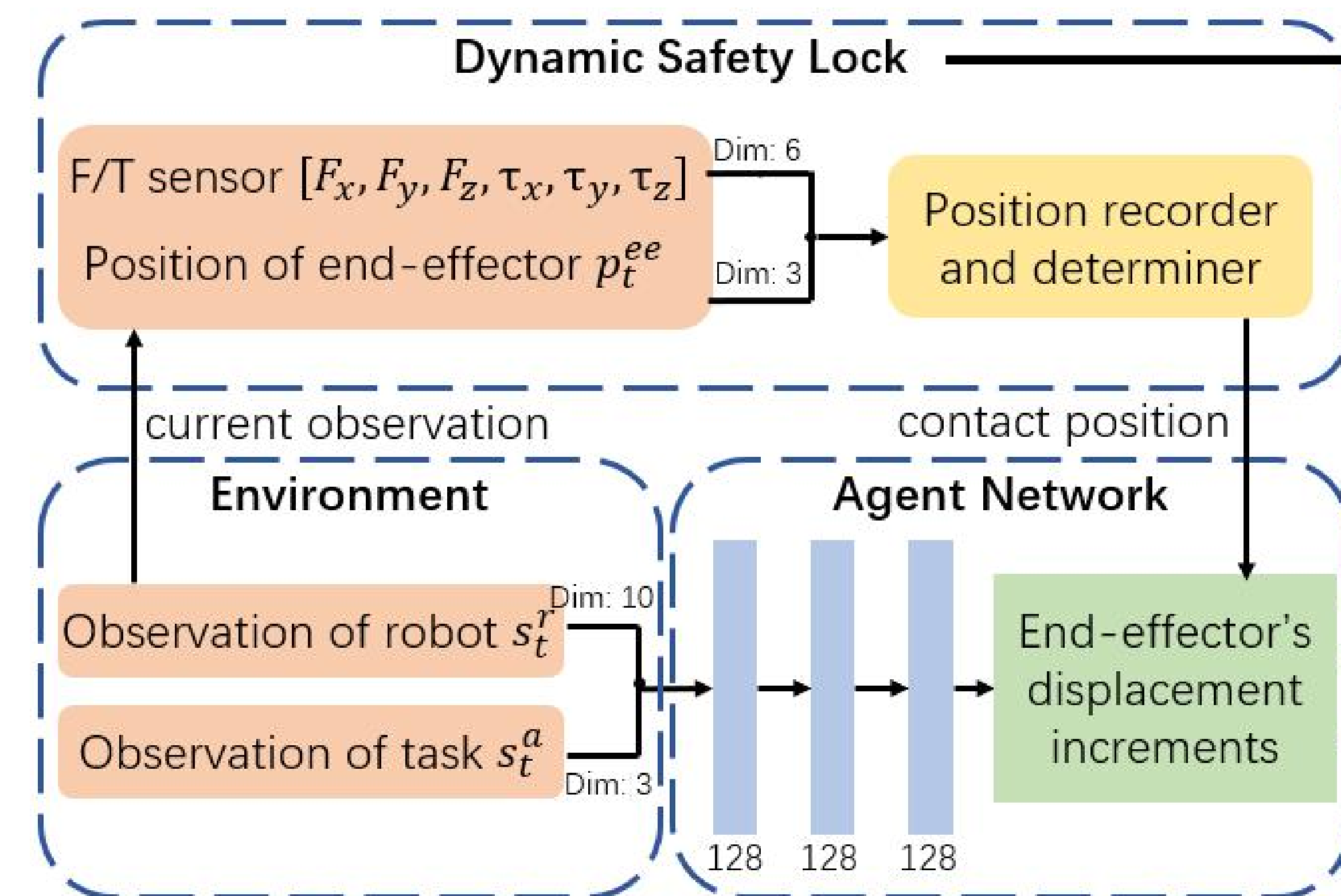
What the work is trying to solve

This work proposes a reinforcement learning-based (PPO) approach to safely perform assembly-type tasks for robots. We introduce a **force-based dynamic safety lock (DSL)** to limit the pressing force of the robot and to prevent emergency stops from being triggered due to excessive force output.

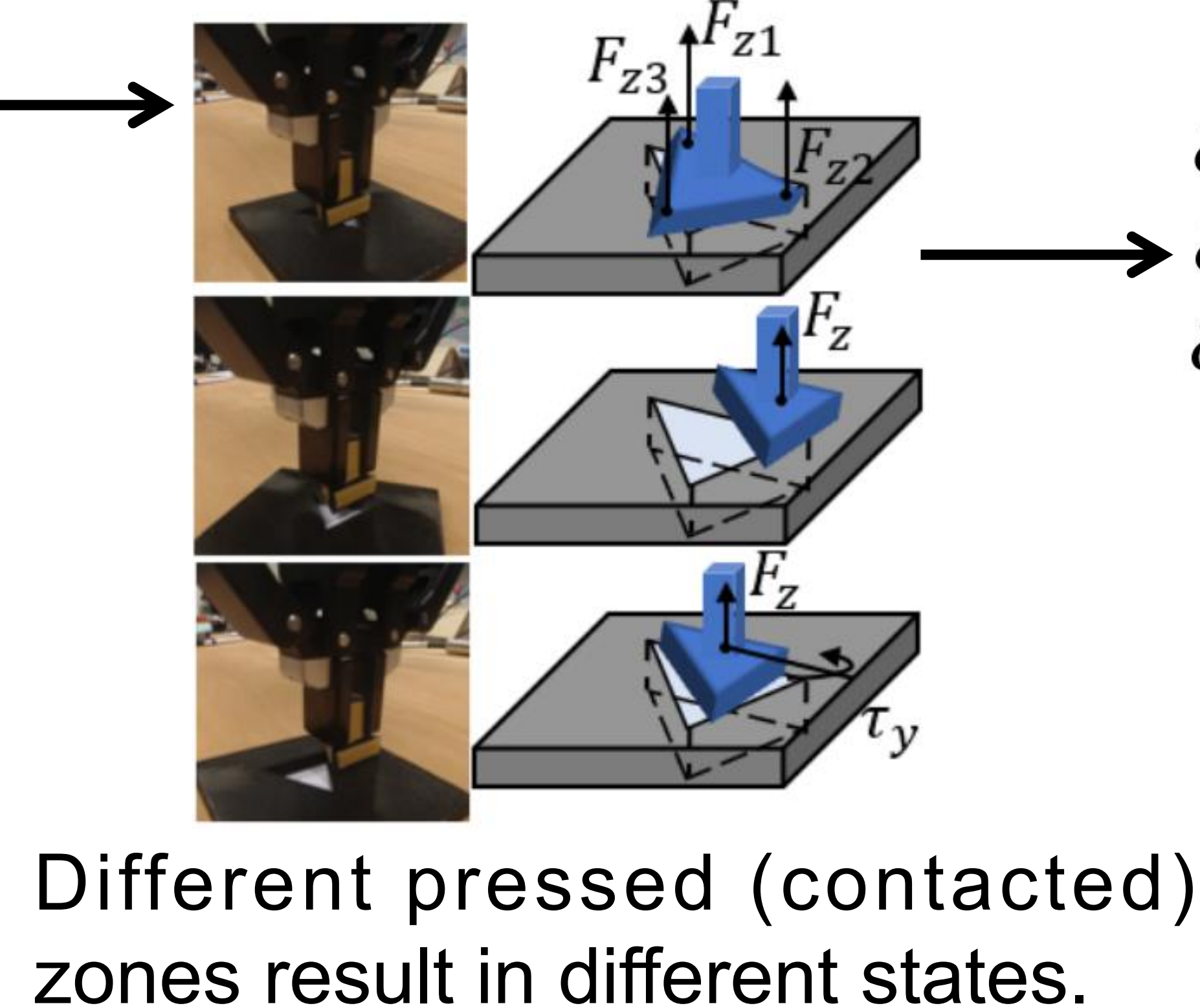
Contribution

- **The DSL is set for the robot's motion trajectory** to ensure safe interaction during the insertion process.
- **Simplifying the vision function** by using F/T sensors to determine the precise position and direction of the hole instead of the camera.
- **Demonstrating how to effectively** use F/T sensors and visual feedback for hole searching, alignment and insertion on real robot.

DSL-embedded system



DSL-determiner



$$\begin{aligned}\delta x_t^{ee} &= \beta_{11} \cdot (F_x(t) - F_x(t-1) + \tau_x(t) - \tau_x(t-1)) \\ \delta y_t^{ee} &= \beta_{12} \cdot (F_y(t) - F_y(t-1) + \tau_y(t) - \tau_y(t-1)) \\ \delta z_t^{ee} &= \beta_{13} \cdot (F_z(t) - F_z(t-1) + \tau_z(t) - \tau_z(t-1)),\end{aligned}$$

$$z_t^c = z_t^{ee} + \delta x_t^{ee} + \delta y_t^{ee} + \delta z_t^{ee}$$

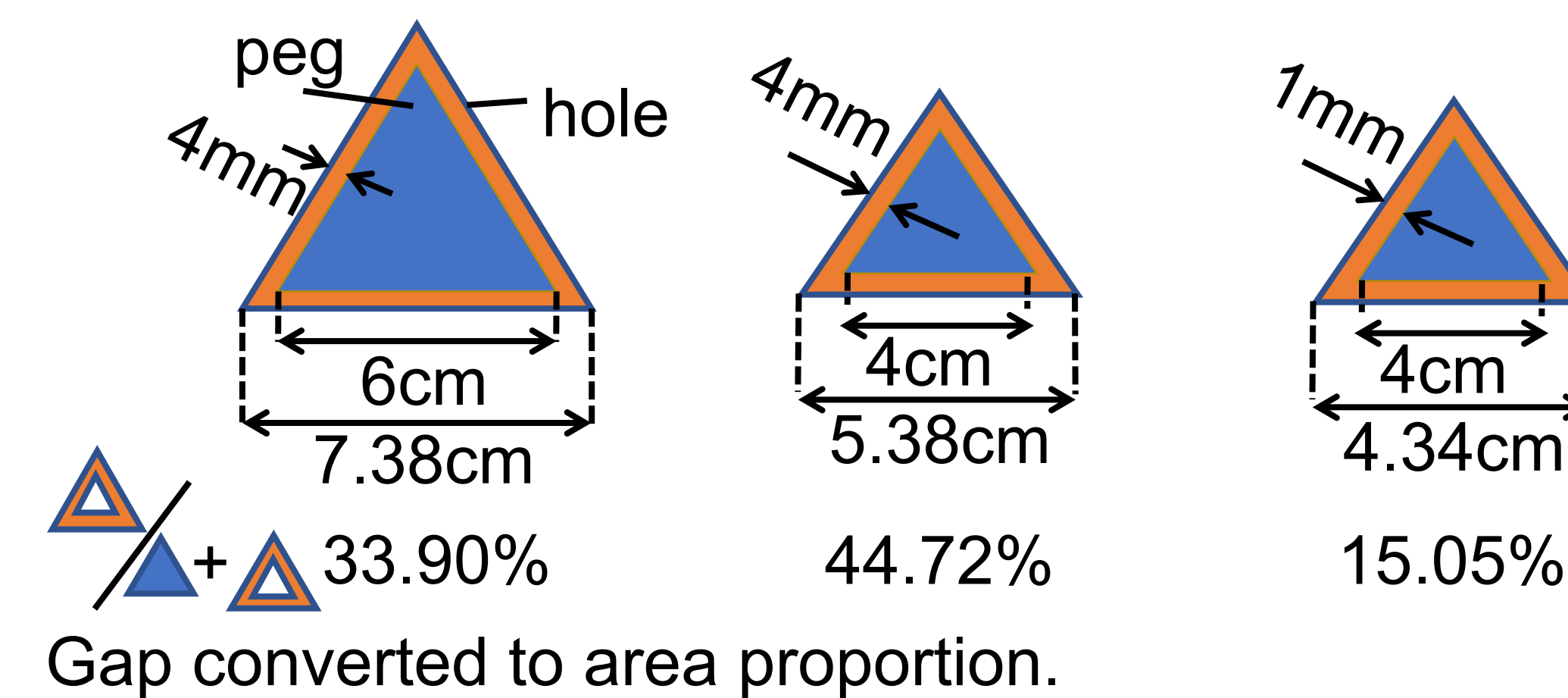
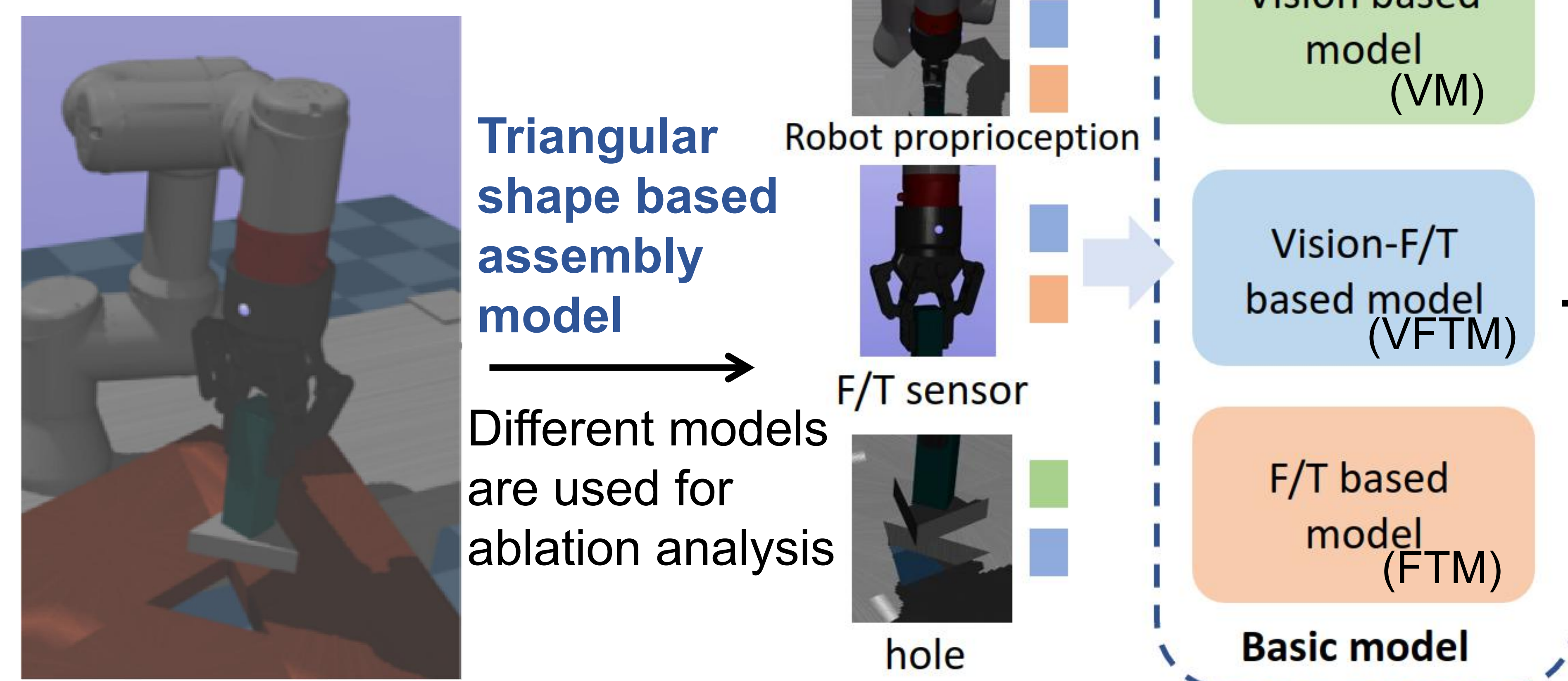
Set the offset amount in the Z direction (insertion direction) according to the strength of the pressing.

Next

- Can this model be adapted for soft body (peg and hole)?
- Will the DSL still work if the path inside the hole is not straight?
- What does sim2real need to consider?
- Whether the policy can be transferred to other robots?
- Could the sense of touch at the robotic fingertip improve the effectiveness of the policy?
- Define the gap with distance or proportion?

Experiment-sim

Training in simulation



		4mm	1mm
VFTM-DSL	r	5.73±0.51	-0.32±0.44
	sr	88.57%	41.95%
VFTM-Sliding	r	-4.29±0.03	-4.29±0.48
	sr	25.03%	0.64%

DSL vs. Sliding, testing 500 times in mujoco.

	tr	rtr	trm	cir	b-trm	b-rtr
proportion	26.3%	7.8%	24.7%	30.65%	9.33%	13.78%
success rate	79.63%	18.64%	68.52%	83.67%	15.43%	20.00%

proportion: proportion of gap area (hole vs. objects), testing 50 times.

Experiment-real

Differentiated shapes assembly testing



using the trained model (triangular based) to test

