

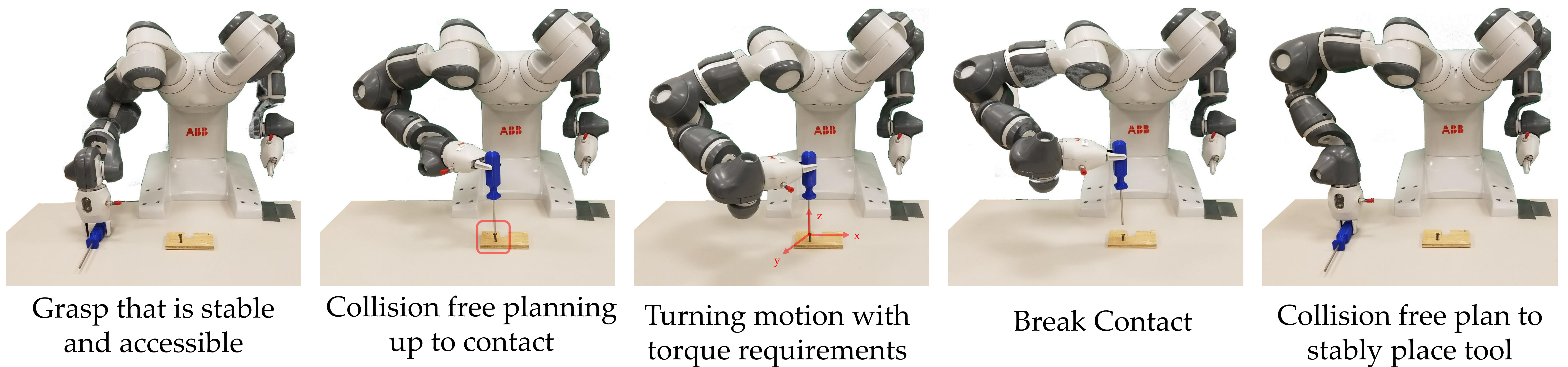
Robotic Tool Use via Constrained Manipulation Planning



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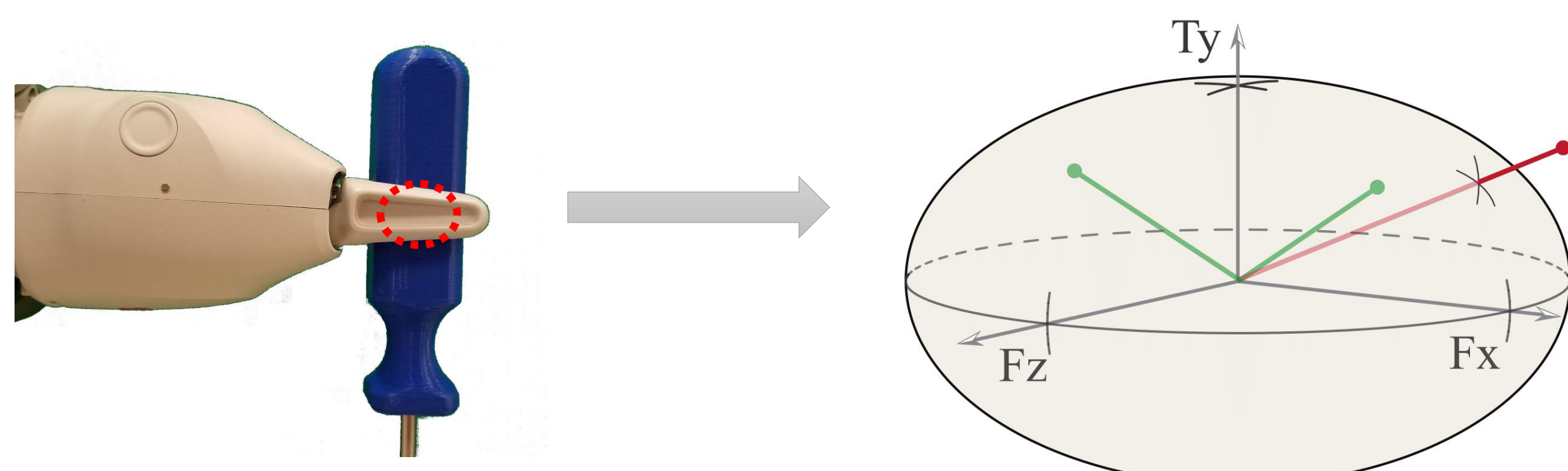
Example Multi-stage Constrained Task: Screw driving



Grasp Stability under Task Forces

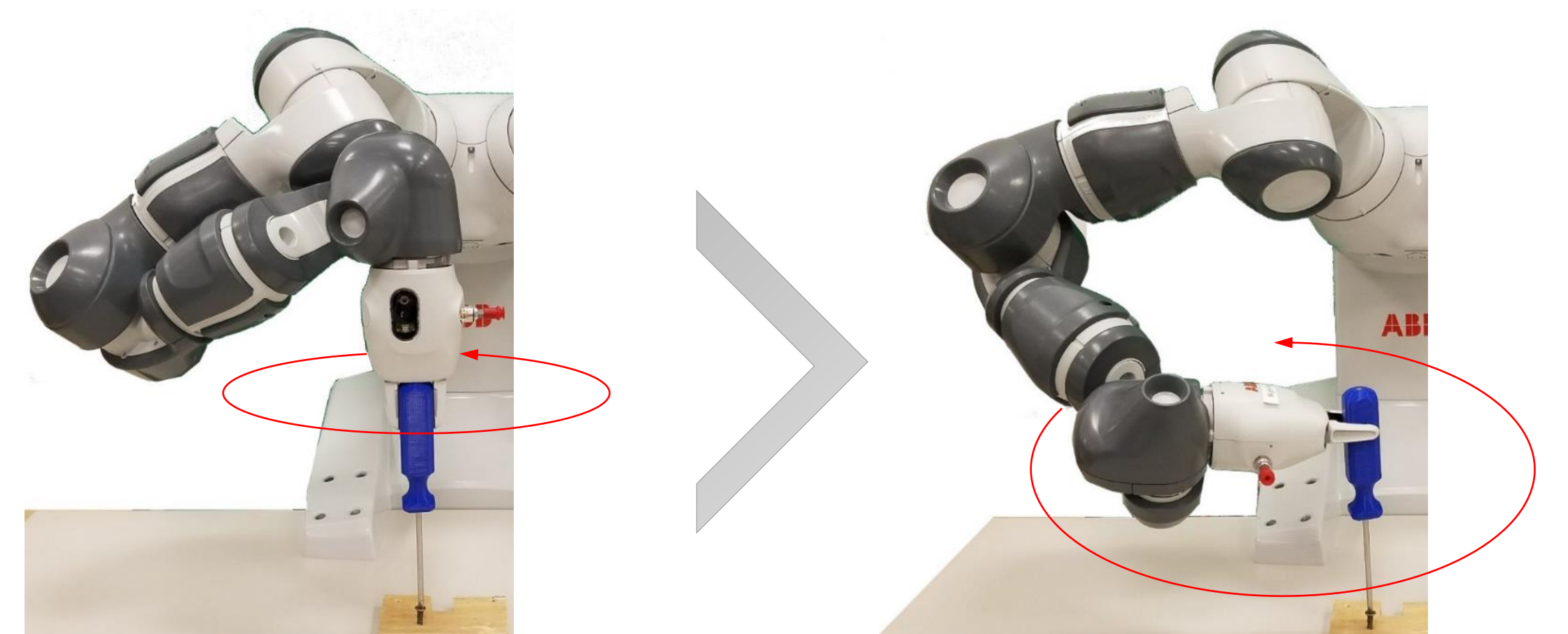
Model grasp with planar patch contacts

Model finger friction with ellipsoidal approximation to limit surface.



$$\frac{f_x^c}{(N\mu)^2} + \frac{f_z^c}{(N\mu)^2} + \frac{t_y^c}{(N\mu)^2(rc)^2} < 1$$

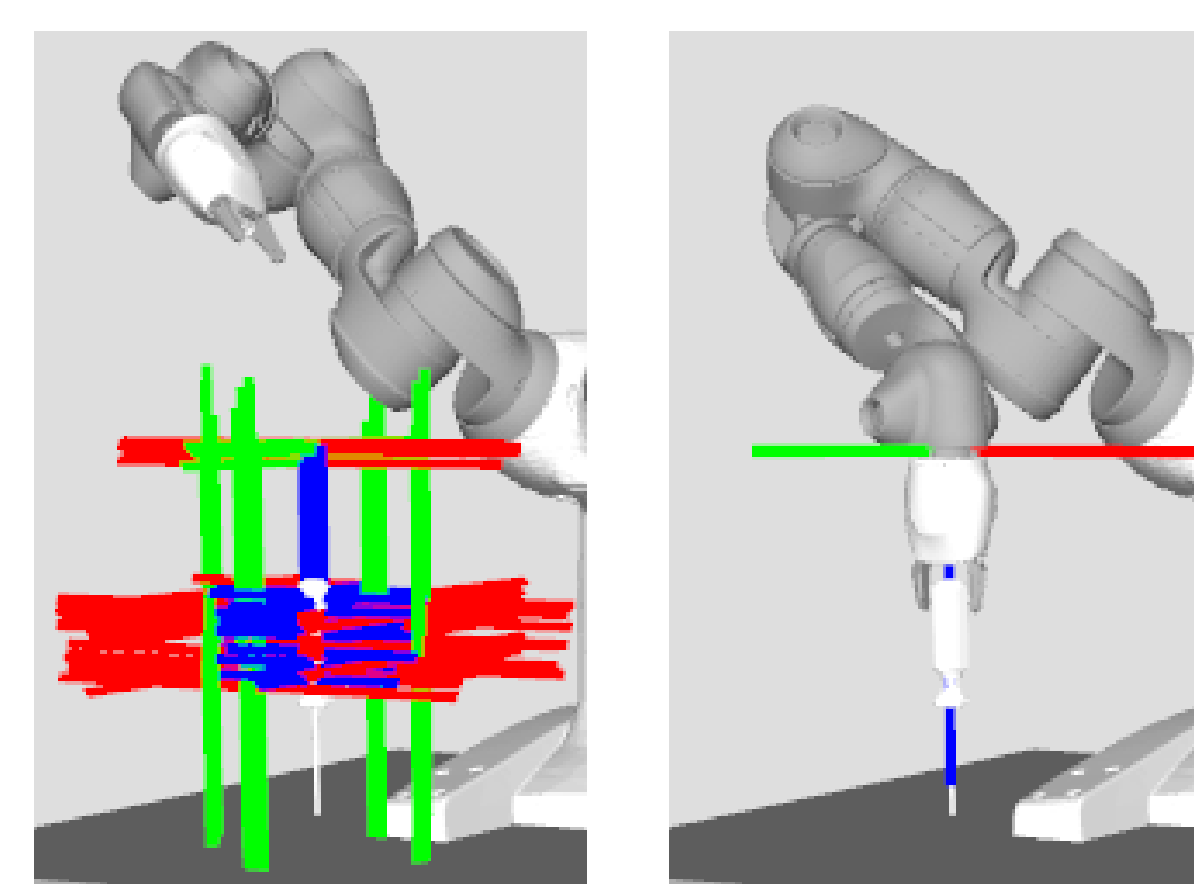
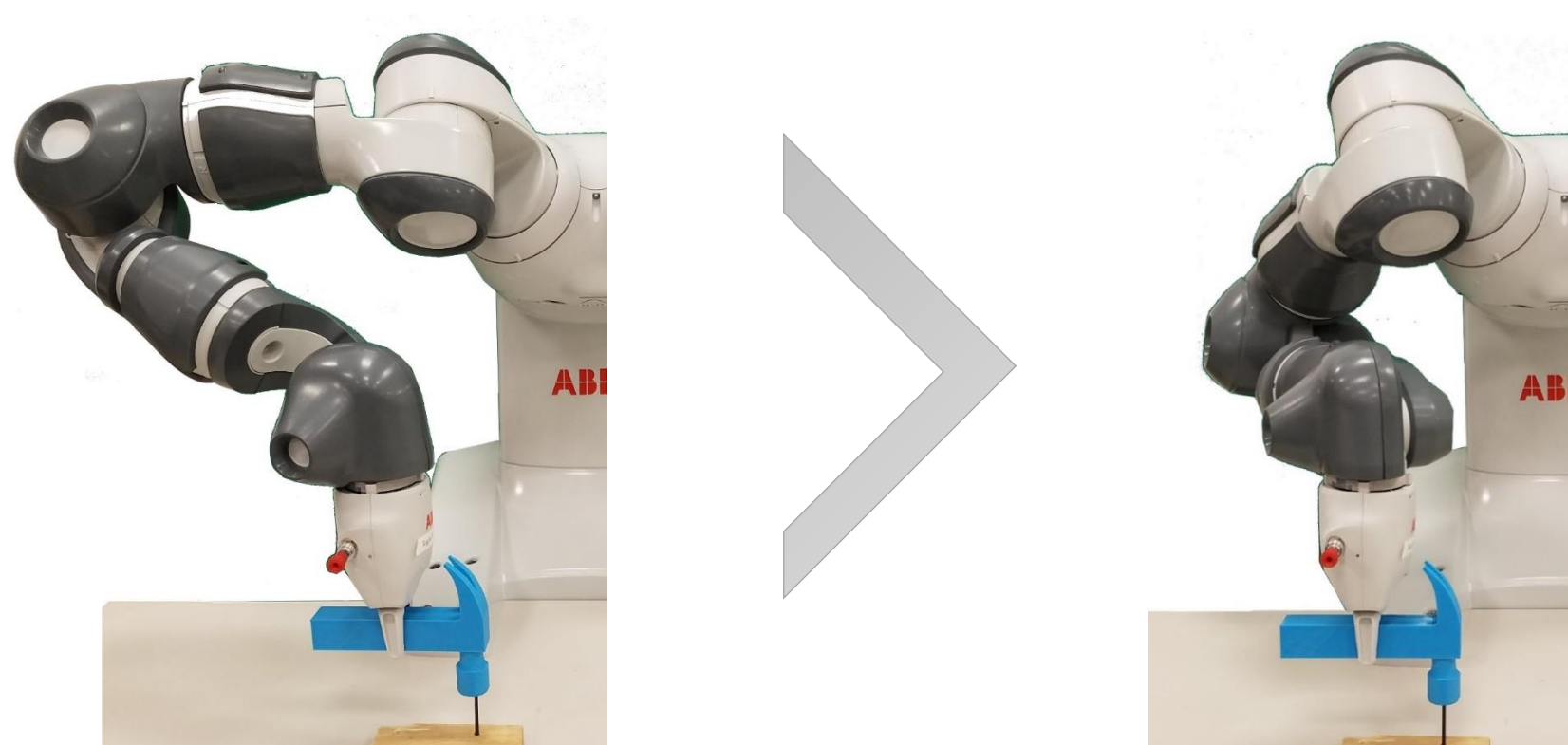
Considering Kinematic Feasibility in Grasp Selection



Stages of Sample Based Planning

Delivering task-specific forces

$$\tau = J^T(q)F_{hand}$$



Rejection sampling of grasps from TSR regions

Find $\xi : [0, 1] \rightarrow \mathcal{C}_{space}$ given constraints C_i

$$C_i(q) = \begin{cases} 1 & \text{InTorqueLimits}(q) \quad \forall q \in \xi \\ 0 & \text{otherwise} \end{cases}$$

$$C_i(q) = \begin{cases} 1 & \text{InCollision}(q) \quad \forall q \in \xi \\ 0 & \text{otherwise} \end{cases}$$

$$C_i(q) = \begin{cases} 1 & \text{StableGrasp}(FK(q)) \quad \forall q \in \xi \\ 0 & \text{otherwise} \end{cases}$$

Activate relevant constraints during each stage