Western Norway University of Applied Sciences

Human-Robot cooperation for CoBotAGVs

Methods and roles (and application)

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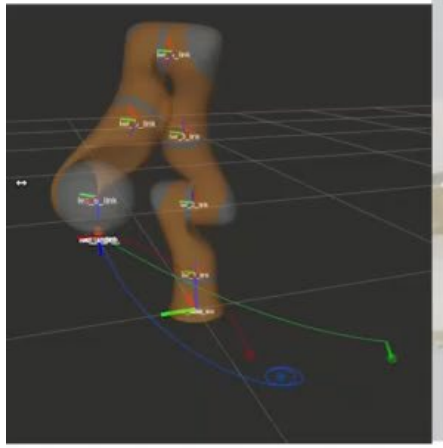
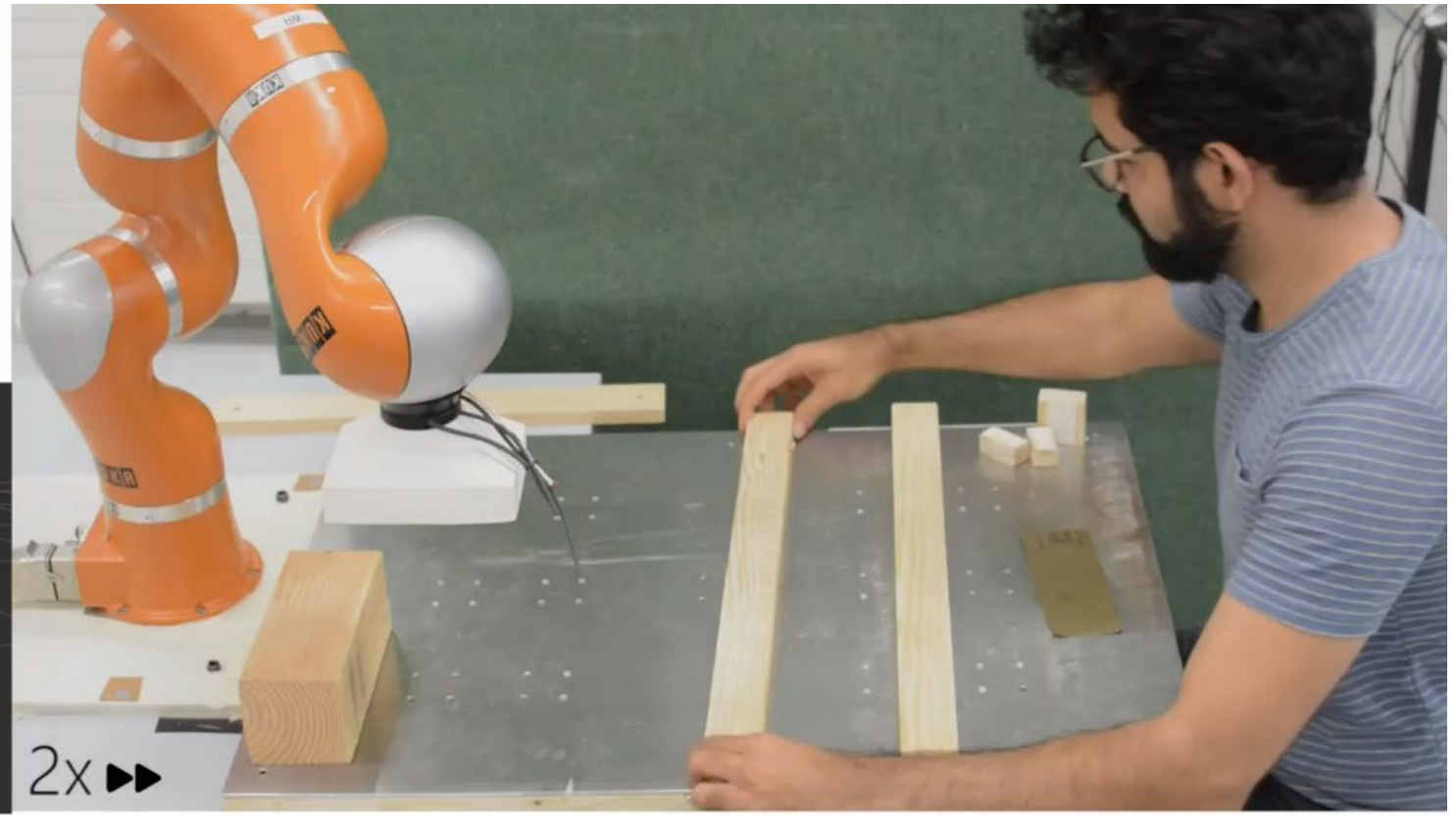
What is human-robot cooperation?

Robot's view with four possible tasks:

Circular polish
Linear polish
Retreat
Push down





Adapted Task

Retreat

What is safe human-robot cooperation?

Safety – collisions between humans and robots

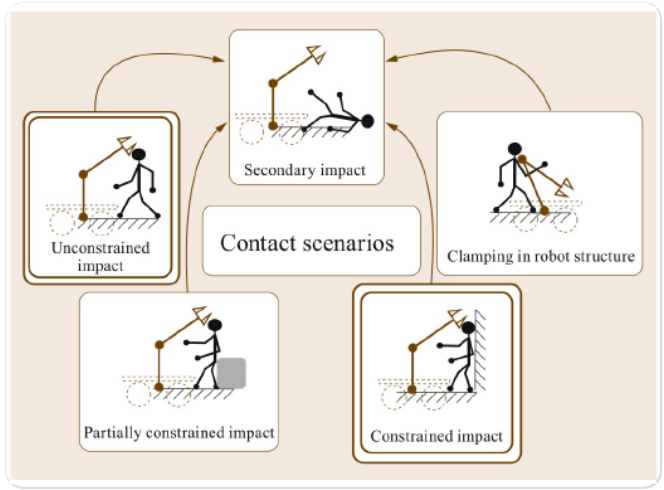


Fig. 69.4 Robot–human impact scenario classes. Unconstrained and constrained impacts are considered the two main scenarios

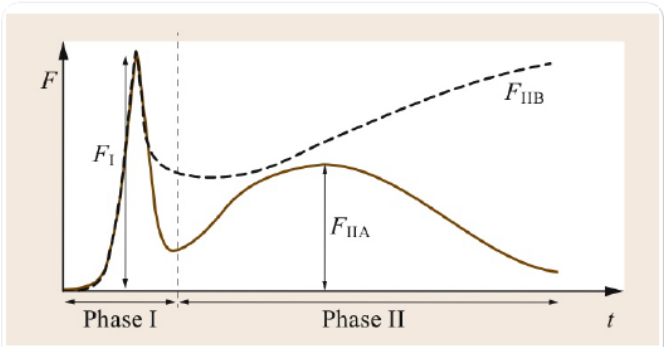


Fig. 69.6 Typical robot–human collision force profiles

Phase IIA: No clamping
Phase IIB: Clamping

Safety standards:
- ISO 10218 (safety requirements for industrial robots)
- Technical specification (TS) 15066 (guidance for collaborative robot operation where a robot and a person share the same workspace)
- ISO 13482 nonindustrial standard that allows/regulates close pHRI

-haddadin2016_no_notes, p.12

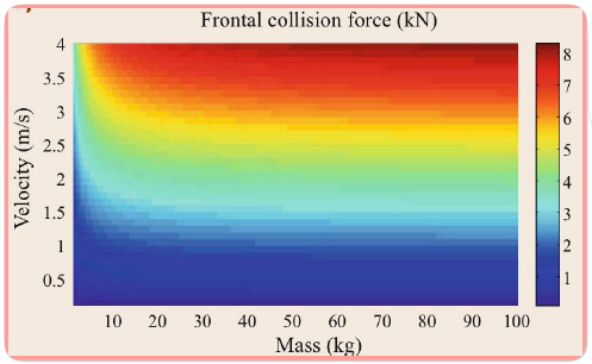
Influence of Robot Mass and Velocity.

Assume a simple mass–spring-mass model for the impact between human and robot
-haddadin2016_no_notes, p.9

Solving the corresponding differential equation leads to the maximum contact force:
-haddadin2016_no_notes, p.9

$$\mathcal{F}_{\text{ext}}^{\max} = \sqrt{\frac{m_u M_{\text{H}}}{m_u + M_{\text{H}}}} \sqrt{K_{\text{H}}} \dot{x}_{\text{re}}^0 .$$

REFLECTED INERTIA (HUMAN)
RELATIVE IMPACT VELOCITY
CONTACT STIFFNESS
ROBOT MASS



Collision force (which is a well-known bone fracture indicator) generally increases with velocity.
-haddadin2016_no_notes, p.9

For increasing mass, however, a saturation effect takes place
-haddadin2016_no_notes, p.9

$m_u \gg M_H$ ($m_m \approx 20\,kg$):

$$\mathcal{F}_{\text{ext}}^{\max}(m_u \gg M_{\text{H}}) = \sqrt{K_{\text{H}} M_{\text{H}}} \dot{x}_{\text{re}}^0 .$$

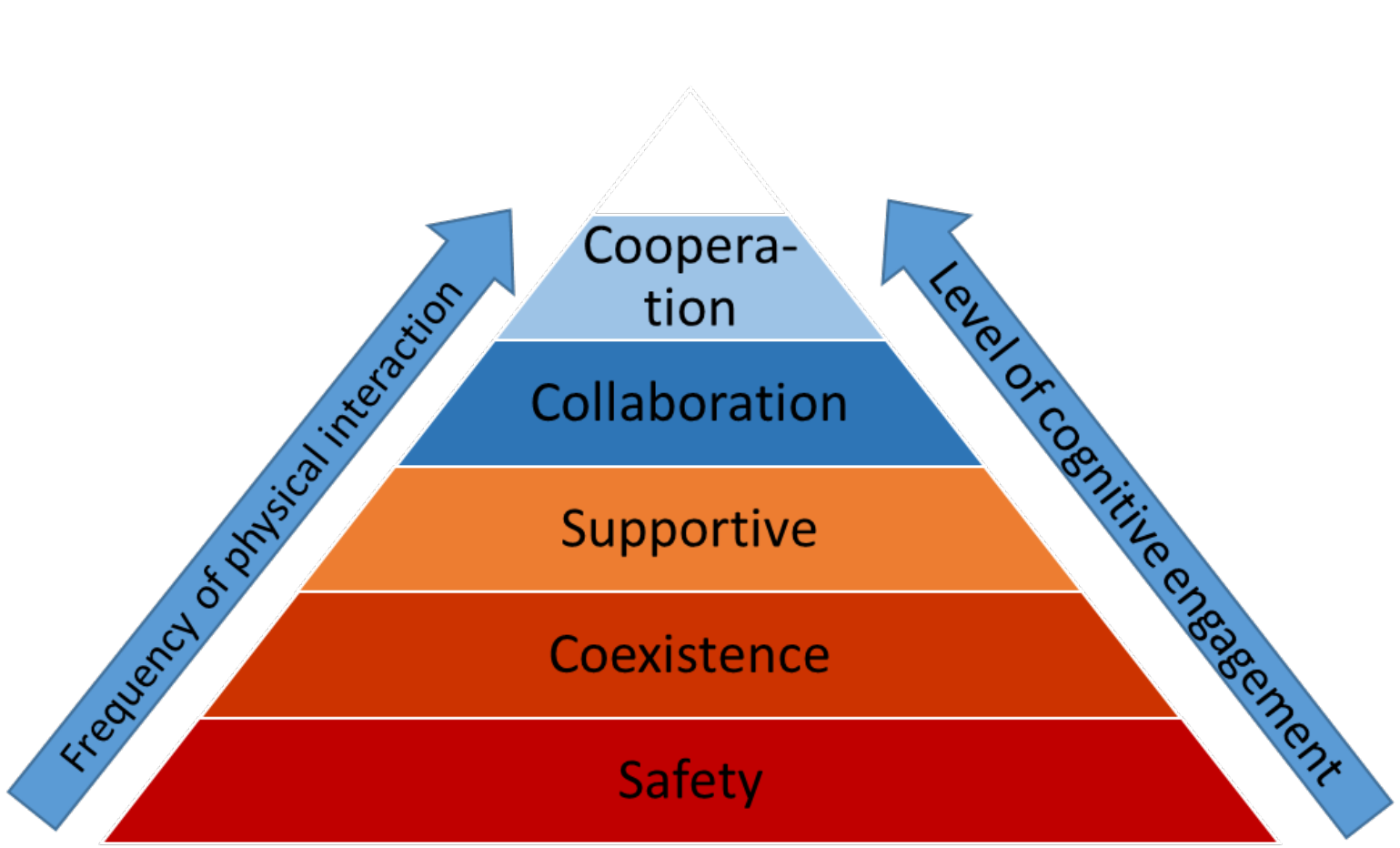
only the contact stiffness, the impact velocity, and the mass of the human head are relevant but not the robot mass.
-haddadin2016_no_notes, p.9

Haddadin, S. and Croft, E. (2016), Ch 69: *Physcial Human Robot Interaction,* p 1836-1874 In: Springer Handbook of Robotics, Eds Siciliano, B. and Khatib, O.

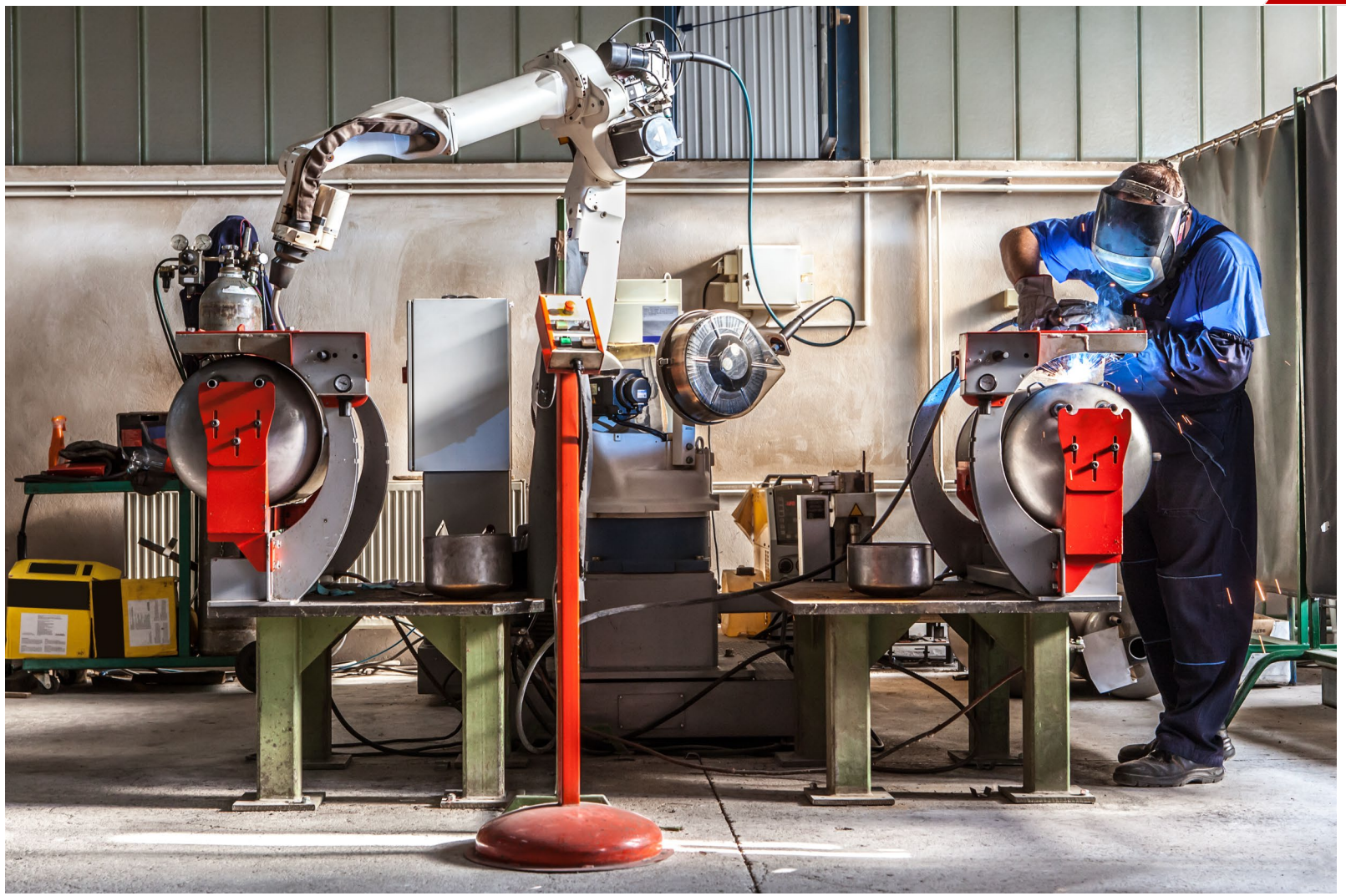
Human-robot cooperation

Methods and roles

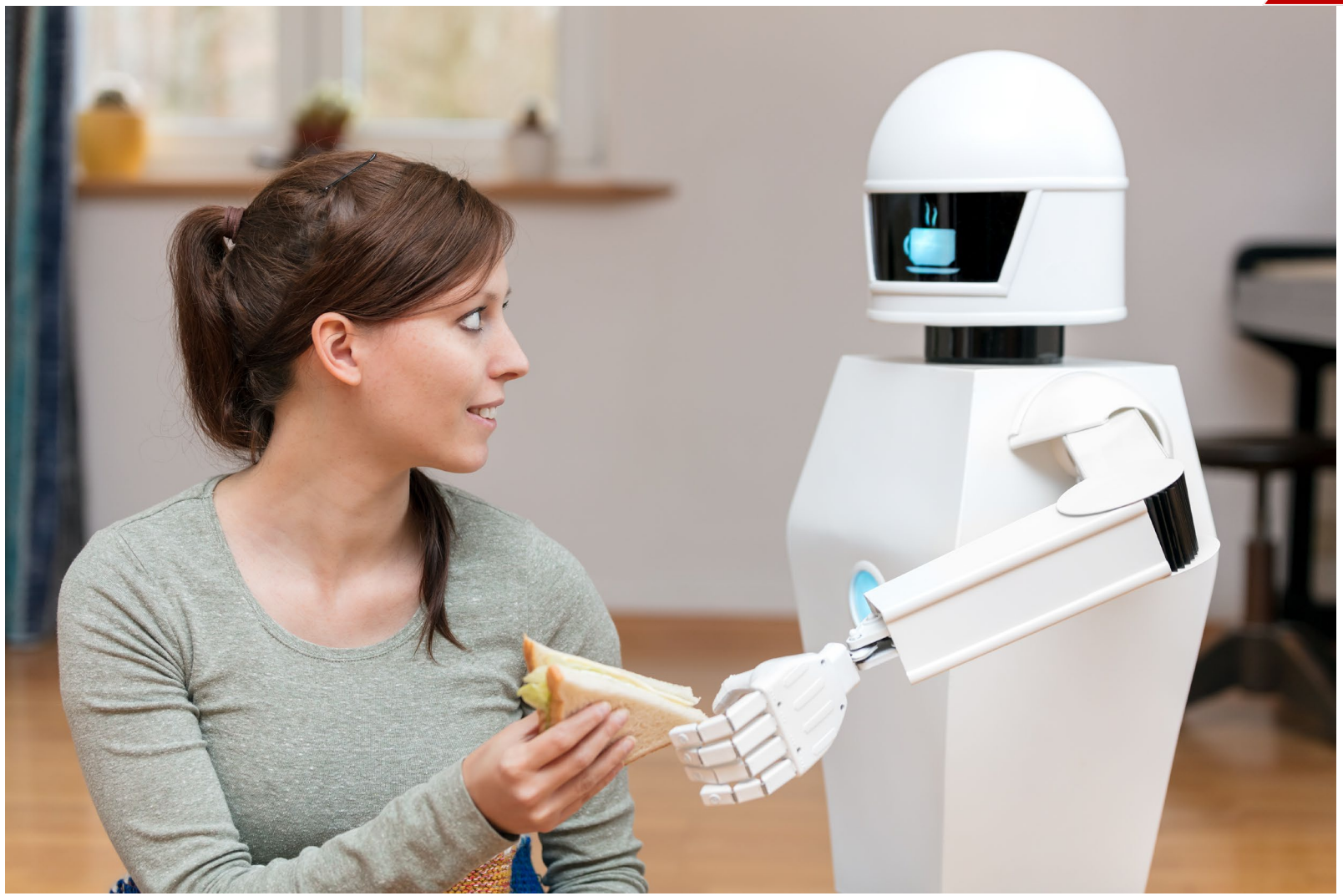
physical Human-Robot Cooperation



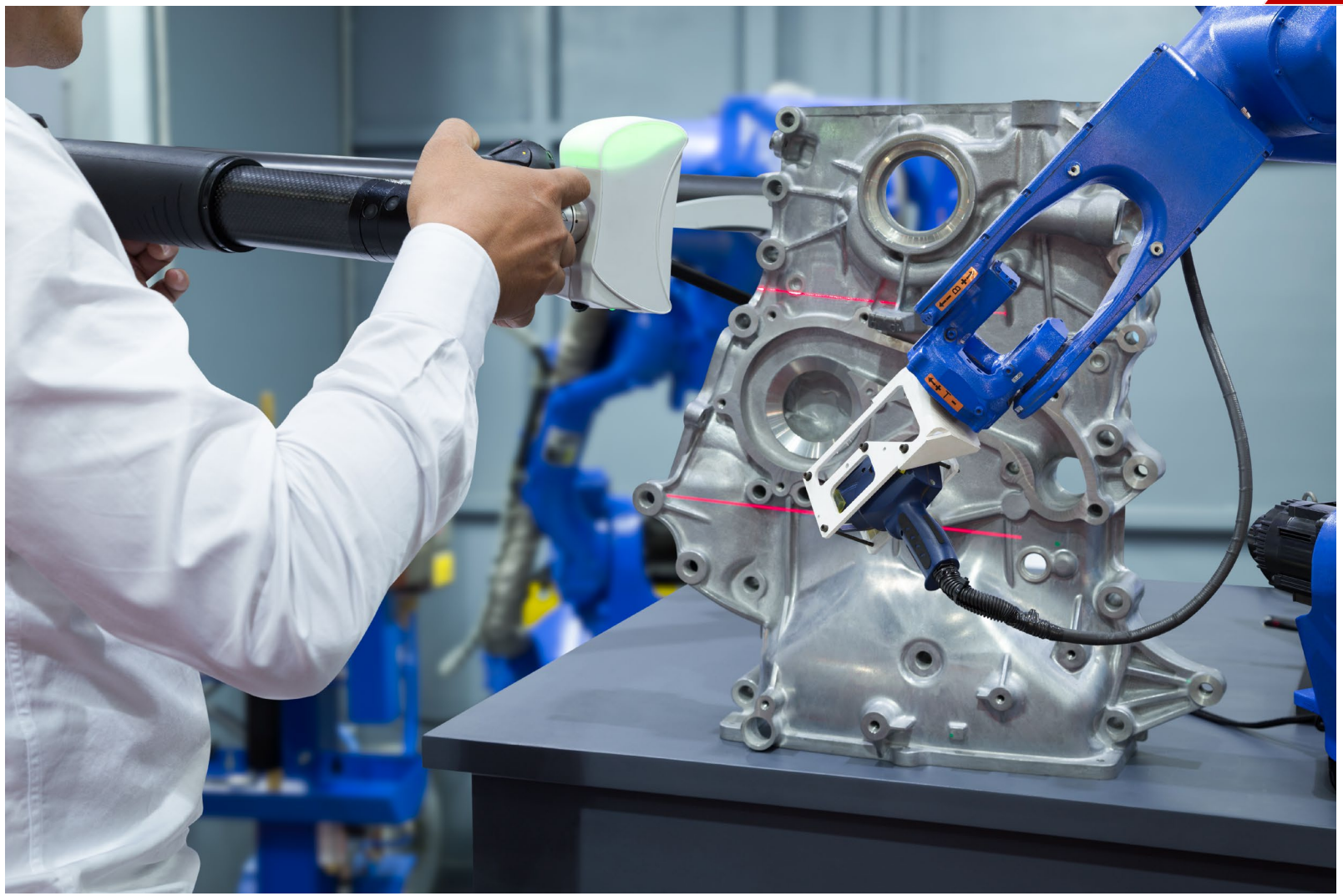
Coexistence – working next to each other



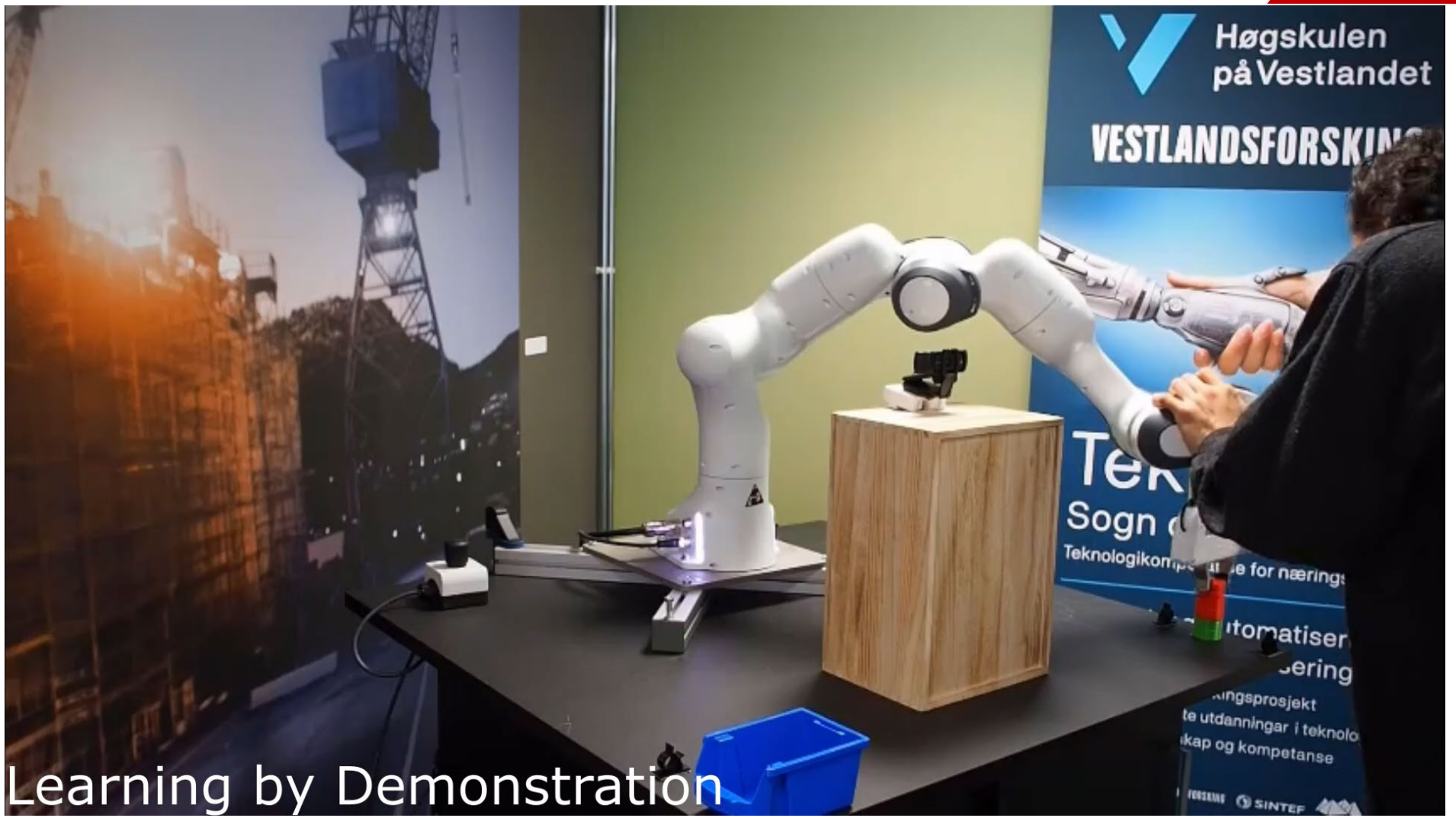
Supportive – hand-overs



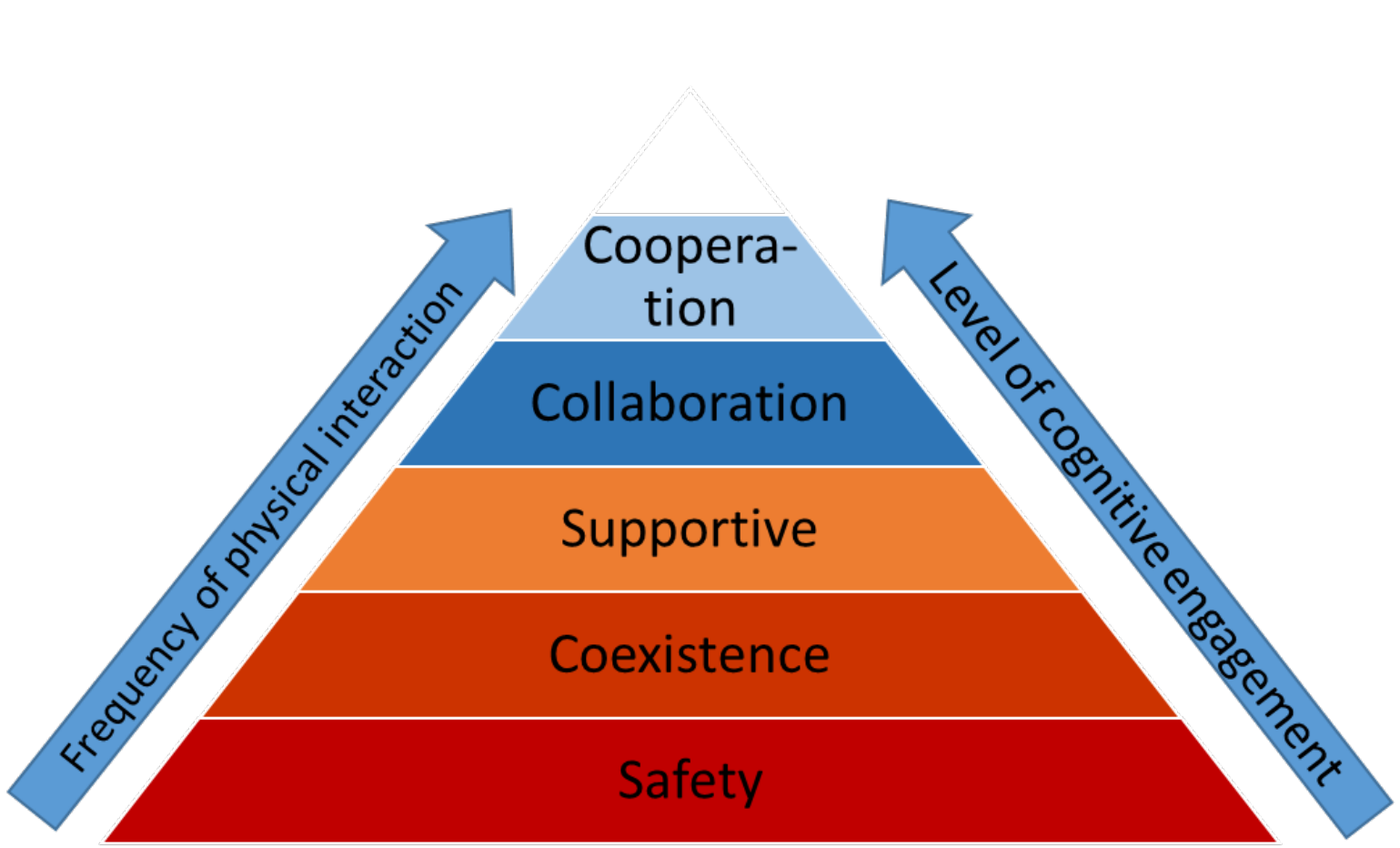
Collaborative – taking turns on the workpiece



Cooperative – continous physical interaction



physical Human-Robot Cooperation – roles



Collaborative robots on AGVs

Scenarios

Scenarios for CoBotAGVs

Scenario	pHRC classifiers	pHRC roles
Pick-transport-place	Safe, Coexistence	None
Flexible assistant	Supportive or Collaborative	None
Cooperative learning	Cooperative	Leader-follower
Cooperative lift-carry-place	Cooperative	Peer, leader-follower, teacher-student

An application

Cooperative learning of a gluing process

Cooperative learning – of a gluing process