人間-AI ロボットによる共同解体作業

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Development of safe and efficient human-AI robot collaboration system to minimize human interference in disassembly tasks

Background and objectives

Moderate solution for disassembly tasks is achieved through human-AI robot collaboration in a shared workspace

Disassembly tasks are currently manual, and full automation is challenging due to task uncertainties.

Human-robot collaboration offers a solution by sharing tasks, with adaptive robots requiring a balance between efficiency and real-time risk assessment to ensure human safety.

Research Question

How can AI robots collaborate safely and efficiently in disassembly tasks while minimizing movement interference?

Idea

Real-time robot disassembly system that understands human behavior to ensure safe collaboration during tasks

Propose collaborative control method that utilizes an AI camera to recognize the human and robot hands, assess collision risks based on distance, and visualize and share the robot's movements and status.

AI   Human brain

One goal
(Disassembly task)
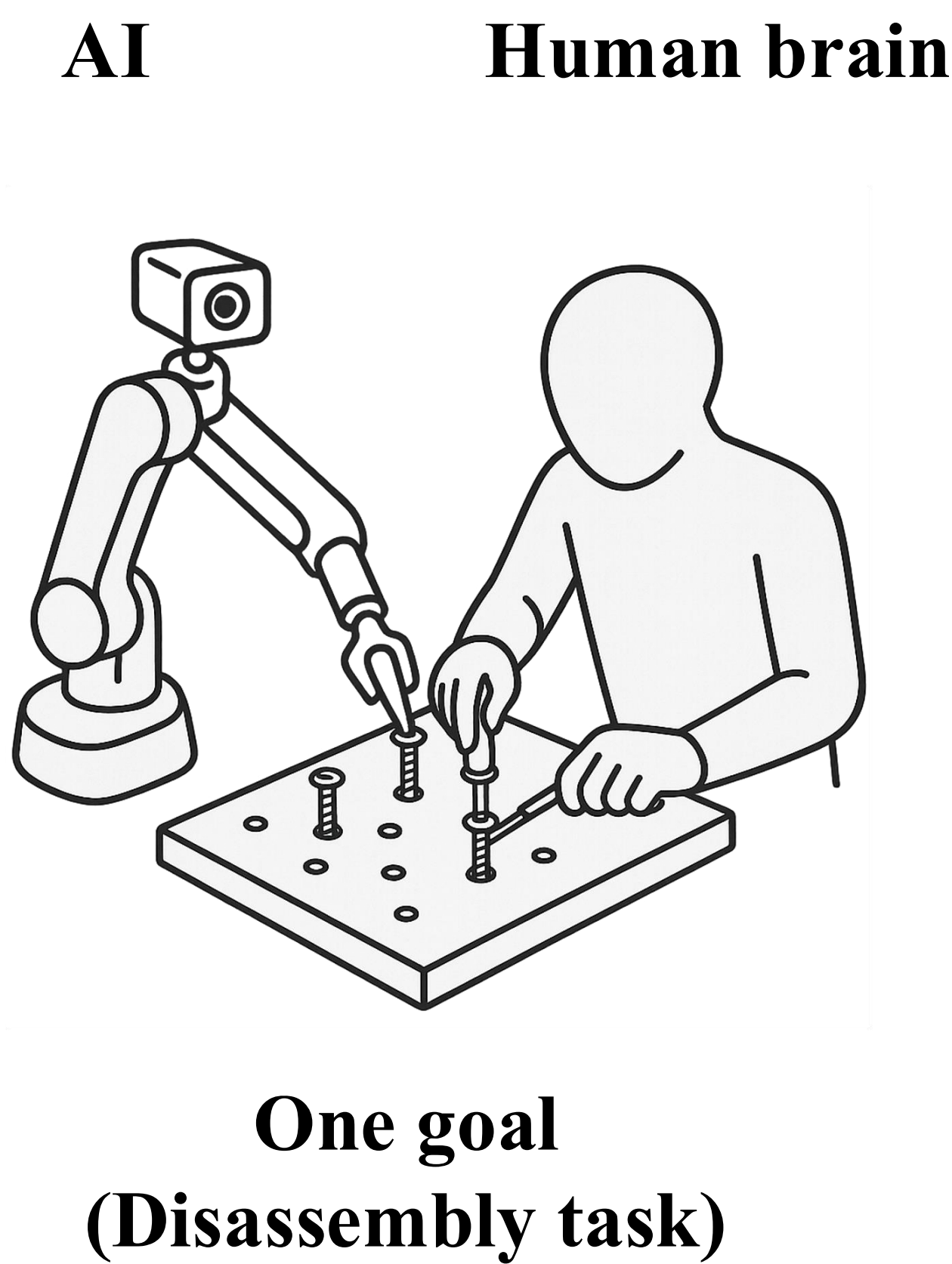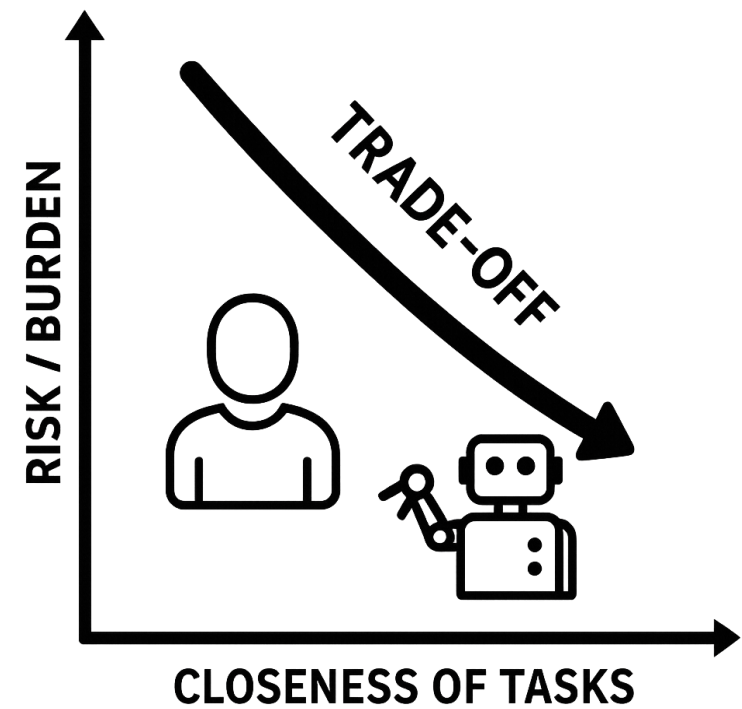
Methodology

Real-time robot disassembly system that understands human behavior to ensure safe collaboration during tasks
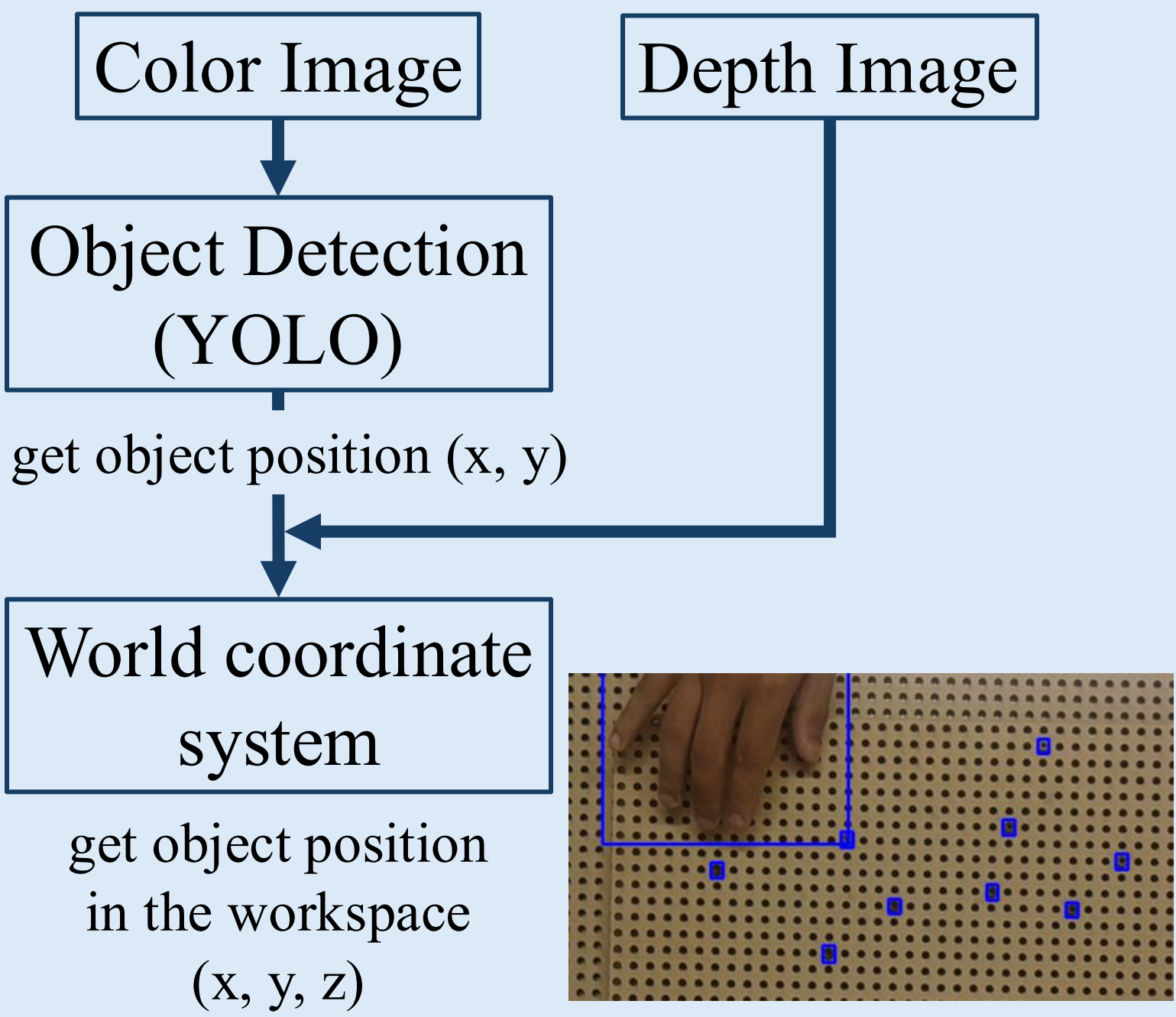
System components

Human-AI robot Collaborative Disassembly Task

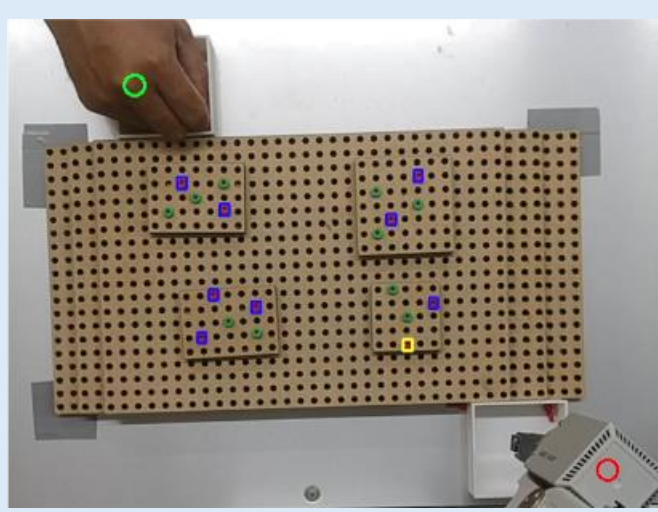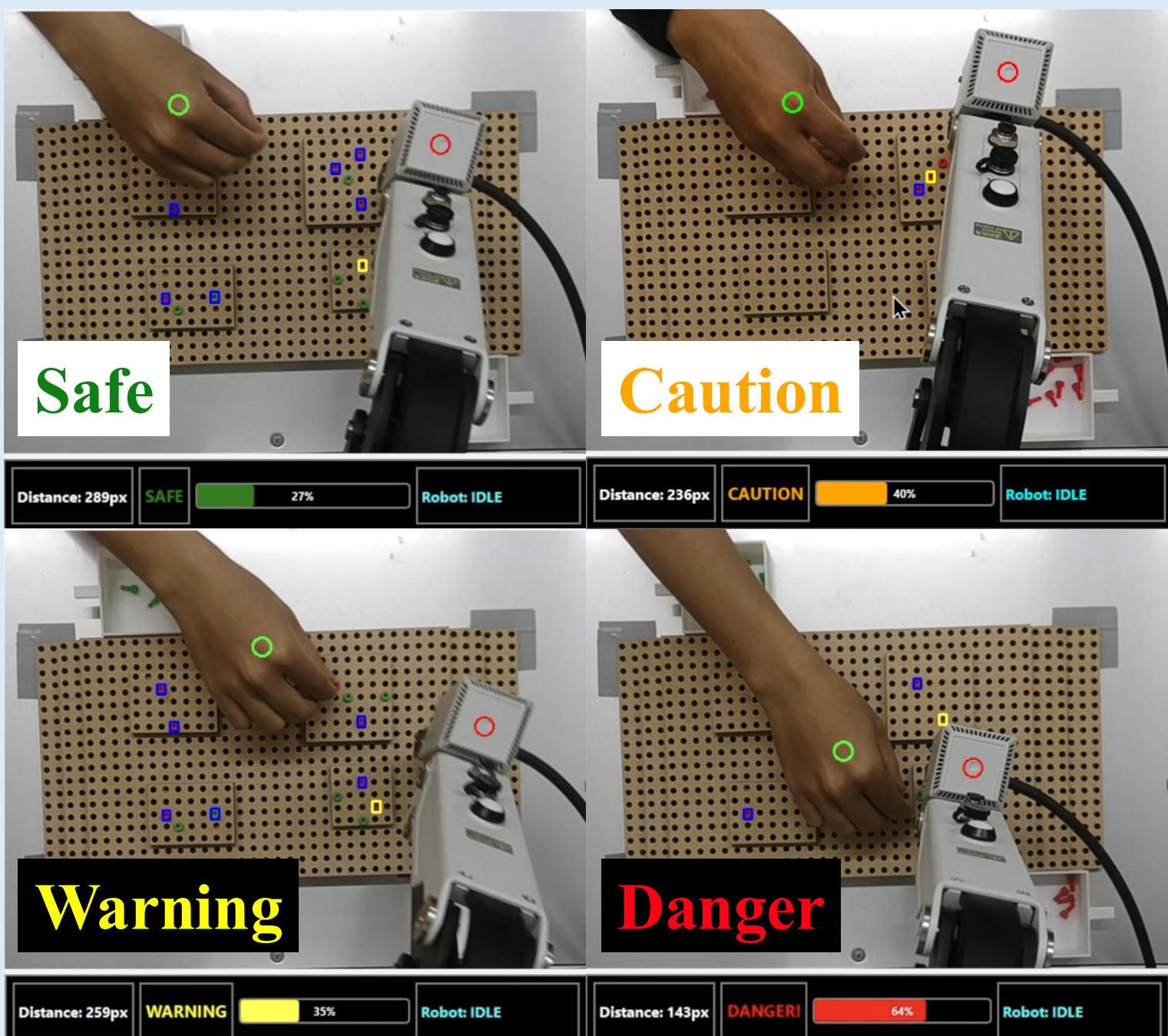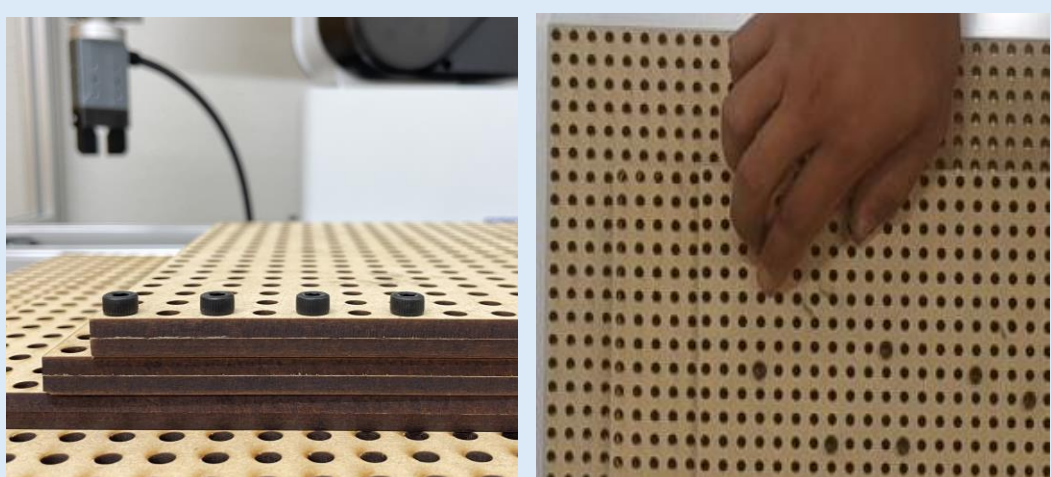Human and robot remove and collect the screw into their box

OAK-D Camera

Color Image   Depth Image

Object Detection (YOLO)

get object position (x, y)

World coordinate system

get object position in the workspace (x, y, z)

PC

Task allocation

Four levels of safty feedback

Safe   Caution

Warning   Danger

Robot

Execute task considering safety

Experimental Conditions

Humans and robots working simultaneously in the same environment.

SAFETY ARGORITHM

The robot prioritizes removing the screw that is farthest from the human's hand.

UNCONSTRAINED

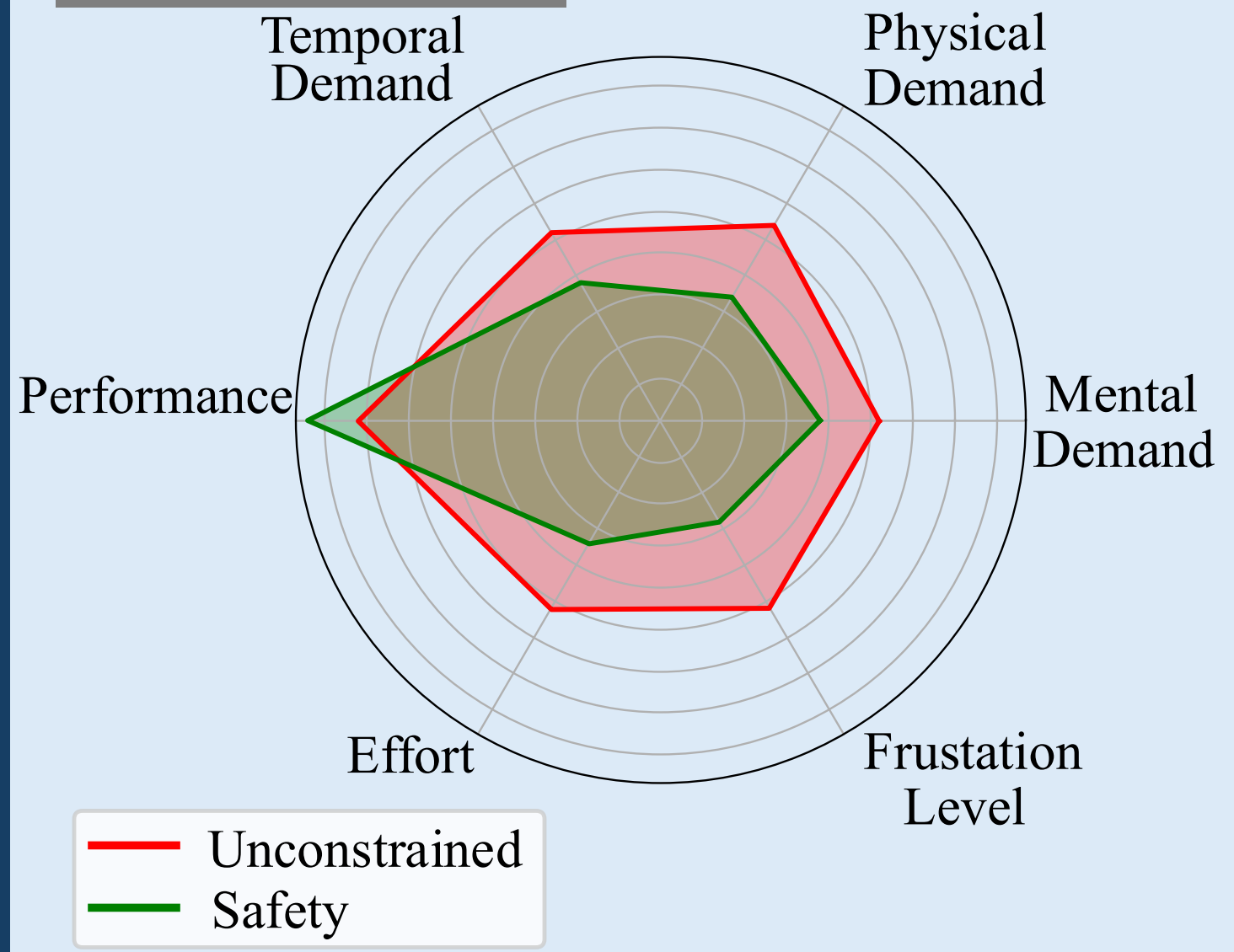The robot freely removes screws without considering the position of the human's hand.

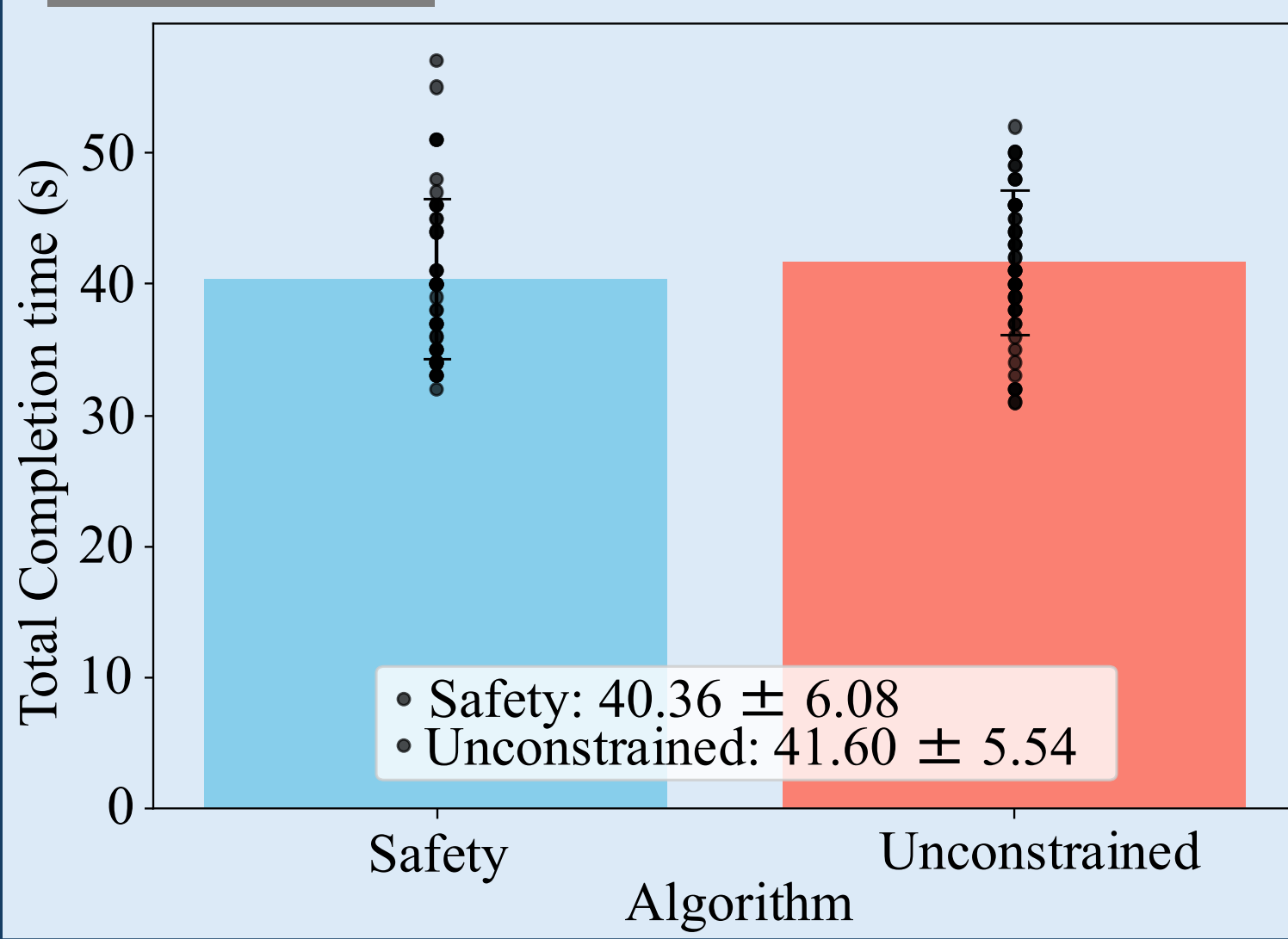| Process	Description
Task	Removing screws from board
Number of Screws	30
Control Algorithm	SAFETY, UNCONSTRAINED
Number of Subjects	5 (Age 32 ± 8.3)
Number of Trials	10

Experiment Result

Subjective workload

Temporal Demand   Physical Demand

Performance   Mental Demand

Effort   Frustation Level

— Unconstrained
— Safety

Workload decreased, as indicated by NASA-TLX assessments.

Total task time

• Safety: 40.36 ± 6.08
• Unconstrained: 41.60 ± 5.54

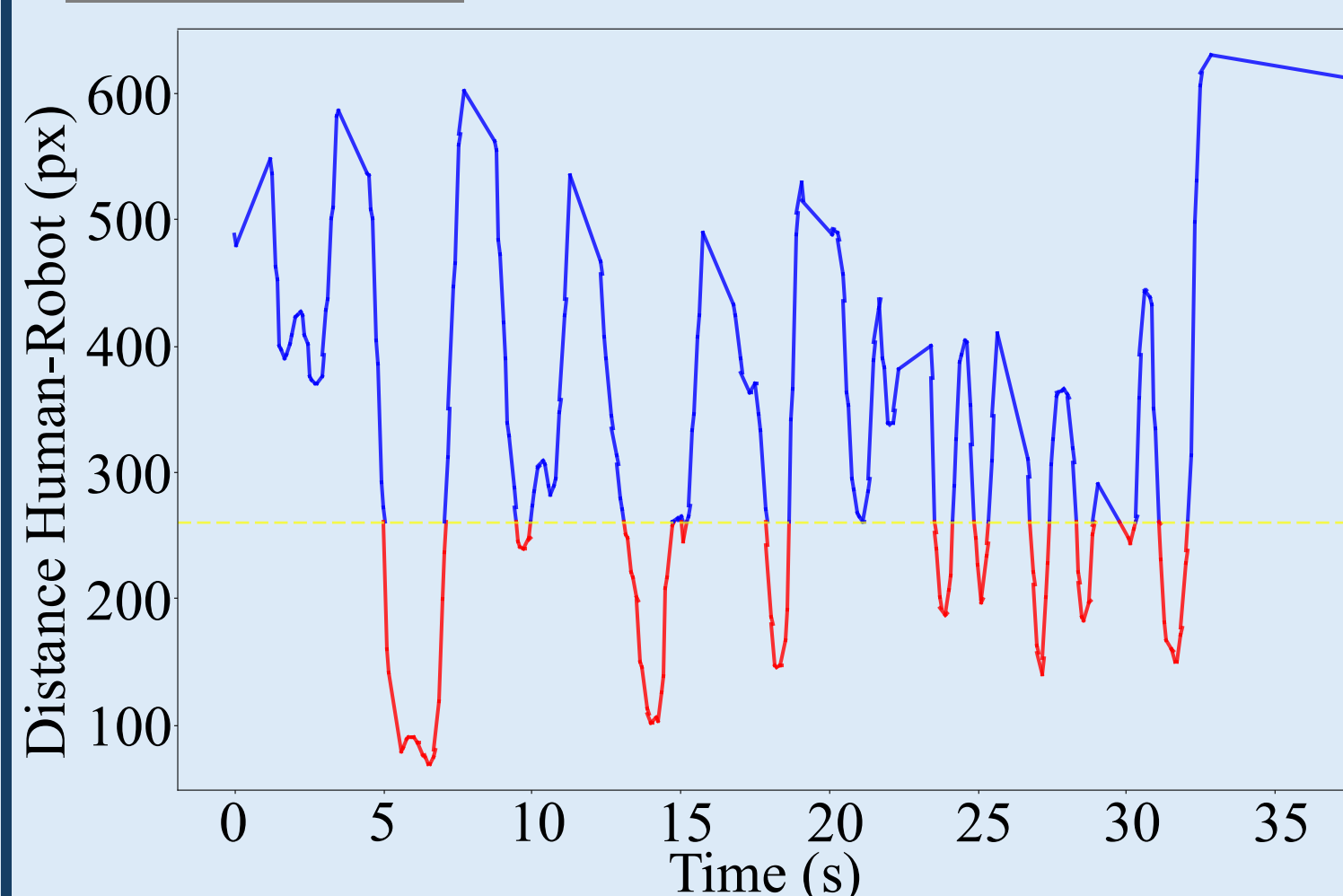**Number of collision warnings**

• Safety: 4.80 ± 2.09
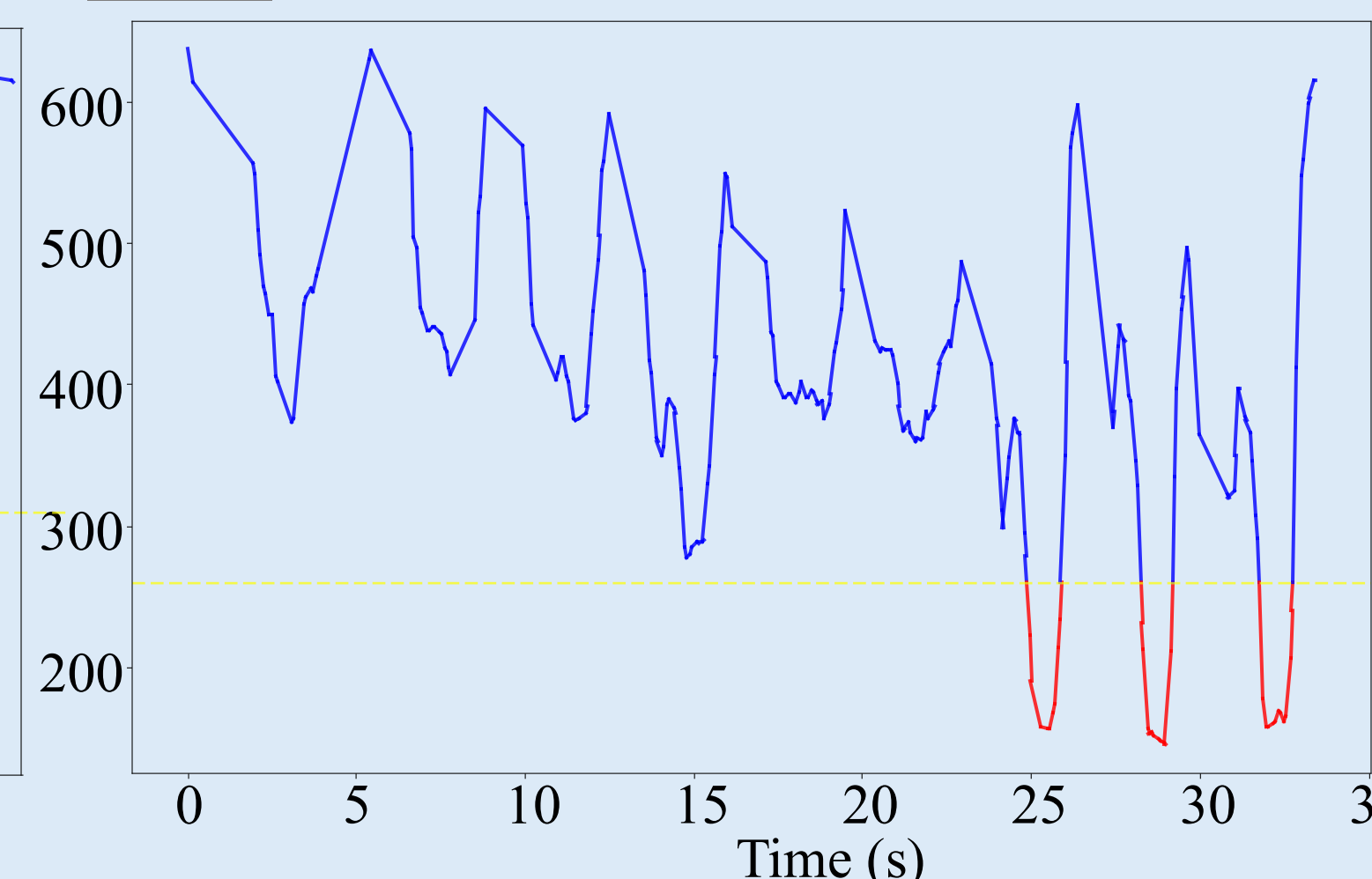• Unconstrained: 7.82 ± 2.69
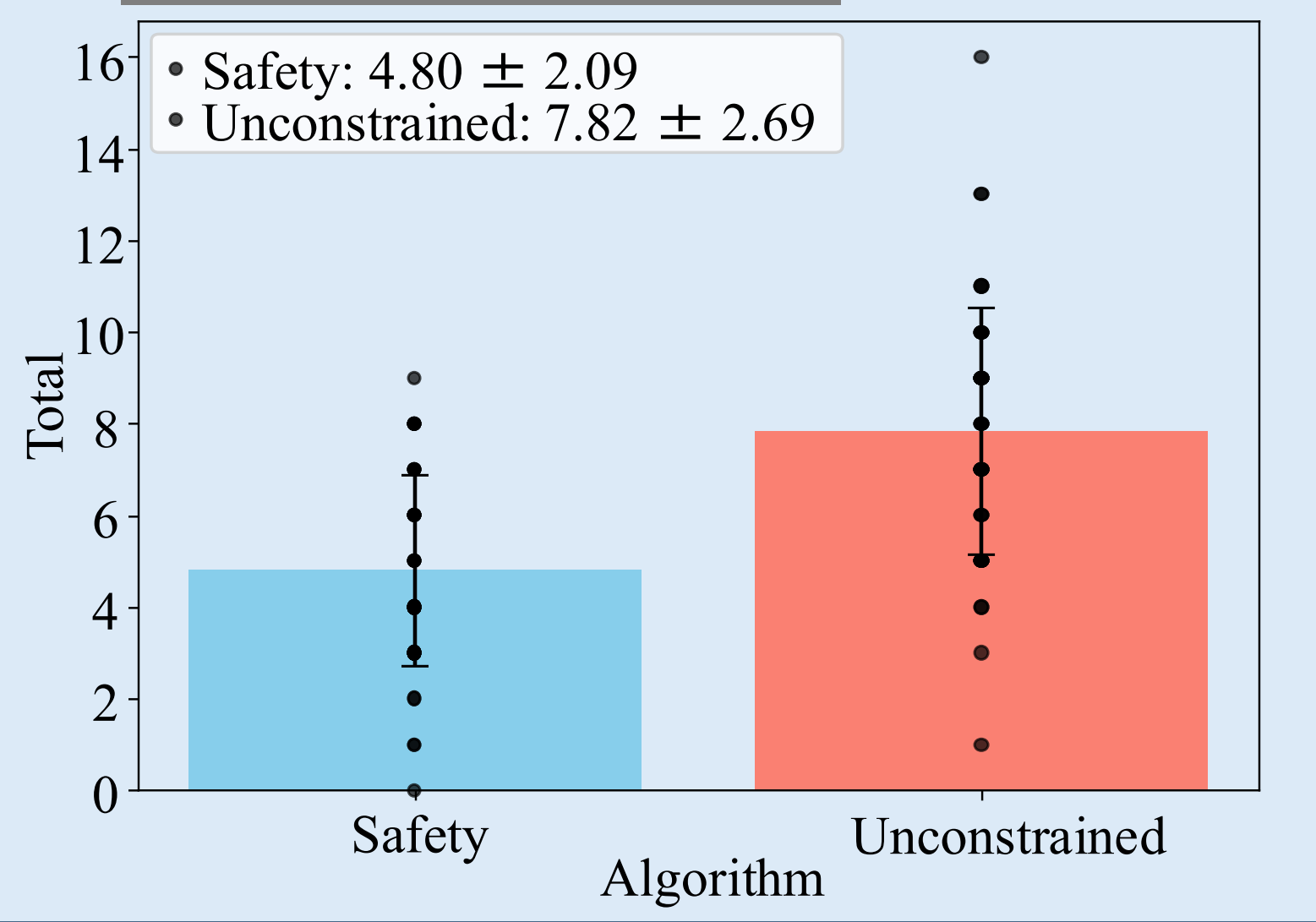
Both algorithms showed similar completion times, but performance improved as collision probability.

Unconstrained   **Safety**

Unconstrained algorithms increase collision risk, affecting human caution when working with robots.

Summary

confirmed tendency toward reduced risk of human-robot collisions and decreased mental burden

- Demonstrated the effectiveness of the double-brain disassembly system, where the agents share perception and collaborate safely and efficiently
- Provide the audio-visual GUI to enhance the communication cue between human and AI-Robot