A standardized benchmark for humanoid whole-body manipulation and loco-manipulation

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Abstract

- EUROBENCH aims at providing a unified benchmarking framework for robotic systems in Europe
  - Two benchmarking facilities for academia and industry
  - REEM-C available for humanoid robotics benchmarking
- Benchmarking allows for comparison of performance between robots and control methods
- Why benchmark humanoid robot manipulation?
  - Quantify performance of large object manipulation
  - Test kinematic workspace and stability limitations
  - Easy and affordable to replicate
  - Inspired by need from real world pick and place scenarios

Results

KPI	Separate upper and lower body control	Whole-body control
Average time (s)	52.96	62.41
2.5% placement accuracy	60%	100%
5% placement accuracy	100%	100%
Cost of operation (Amps s/kg)	10802.08	20245.68
Mechanical work (J)	2585.25	561.69

Initial box manipulation scenario

Purpose:
- Inform the development of a whole-body manipulation benchmark for humanoid robots

Study:
- Pick box from middle shelf and place it on top shelf
- Using Uwaterloo's REEM-C "Seven"
- Two different motion generation and control techniques
  - Separate upper and lower body control
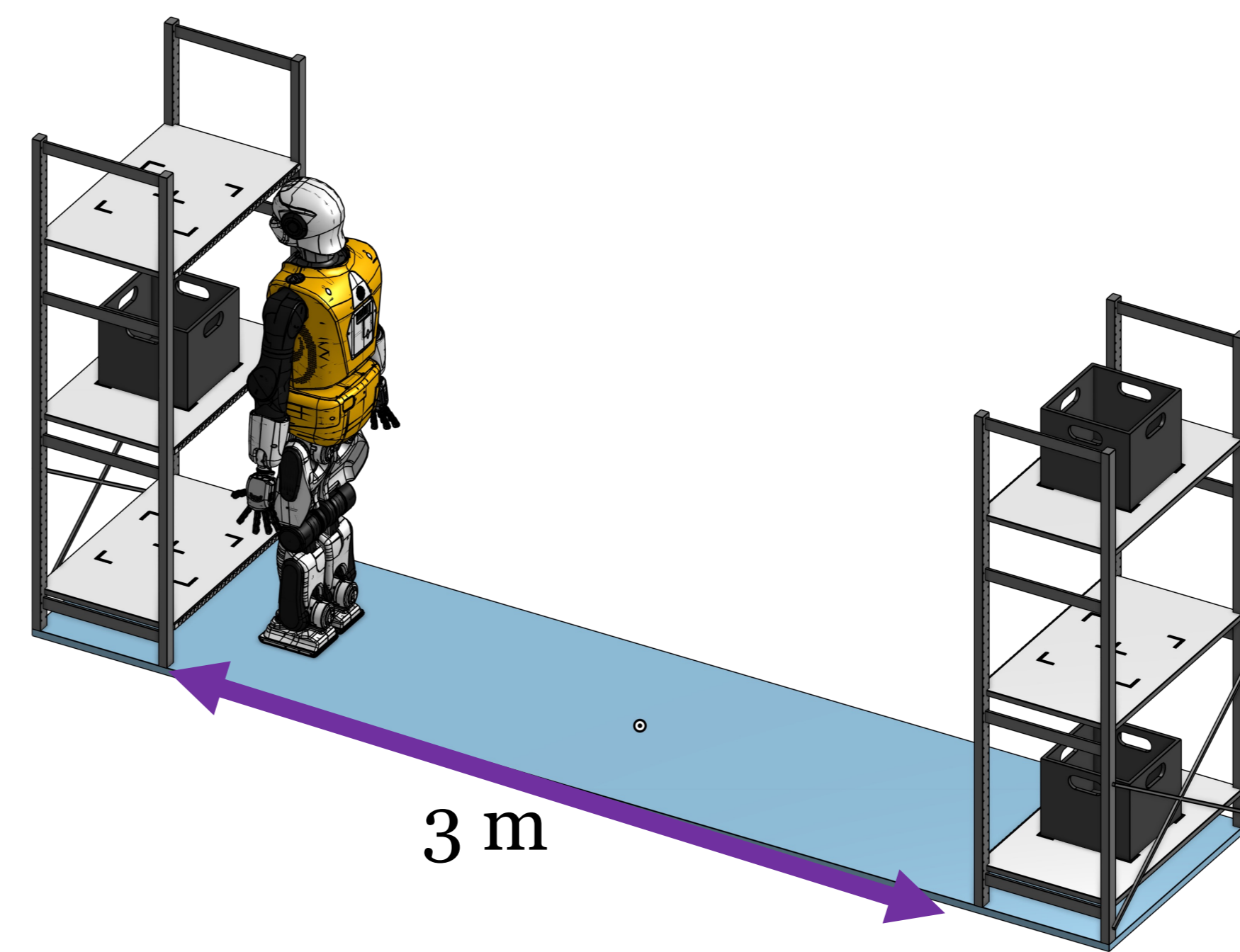 - Whole-body control

Motions

Separate upper and lower body control:

Whole-body control:

Proposed benchmarks

Whole-body manipulation test bed and protocols:
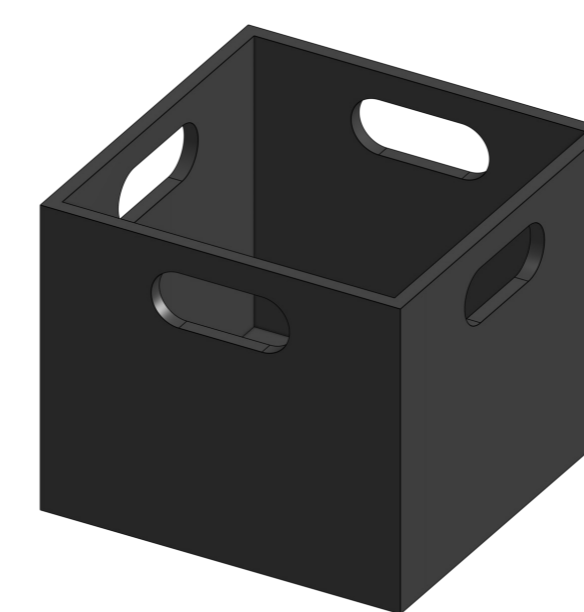

LED light strip

1 m² workspace
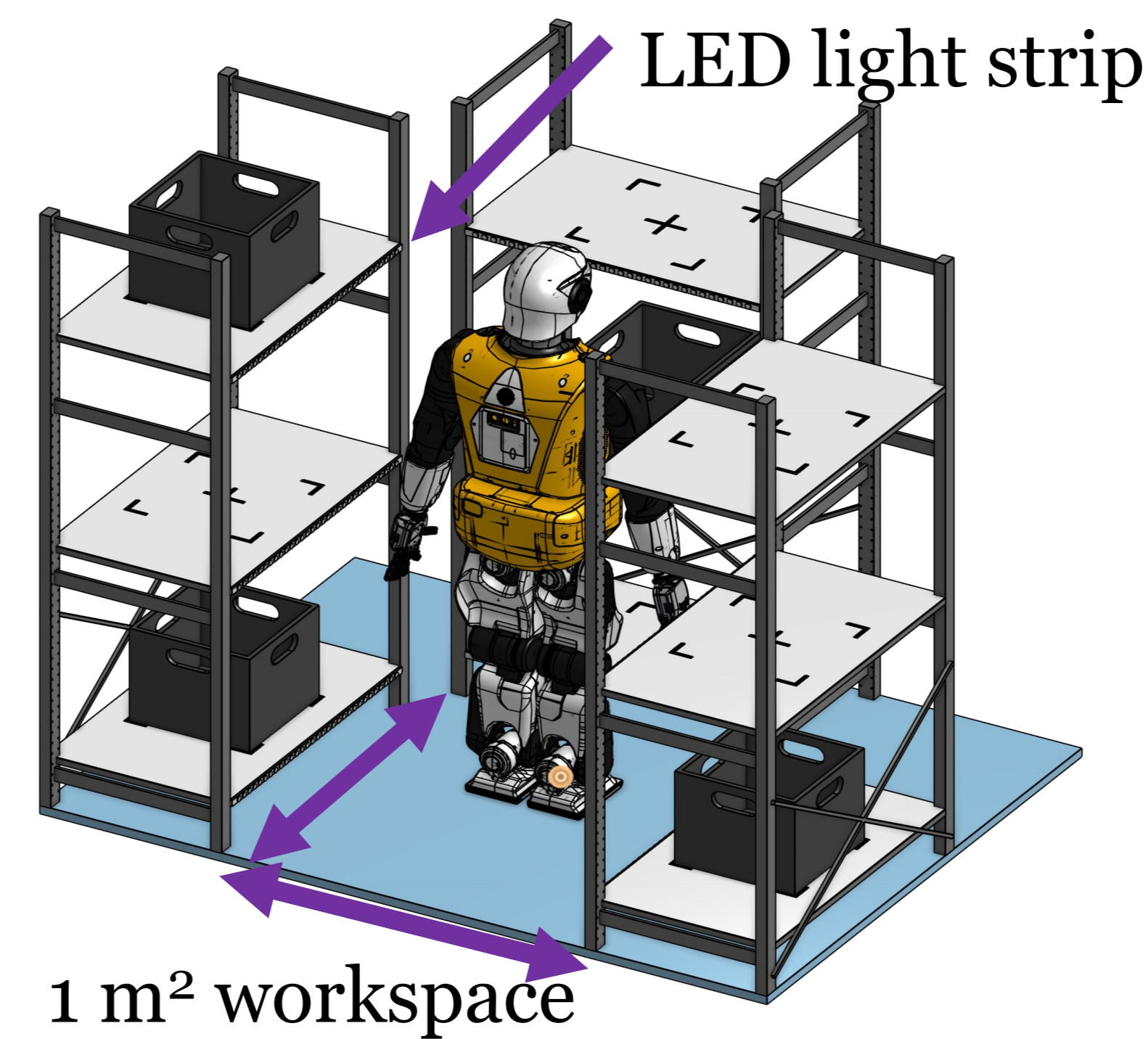
1. Predefined frontal placement
2. Predefined lateral placement
3. Predefined combined placement
4. Variable combined placement
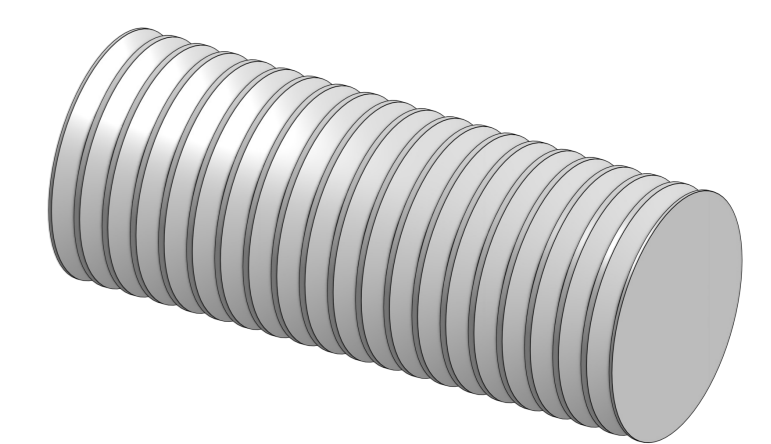
Pick and carry test bed and protocols:

3 m

1. Basic carrying
2. Increasing weight carrying
3. Increasing weight carrying at given velocity
4. Endurance carrying
5. Endurance pick and carry

Objects:
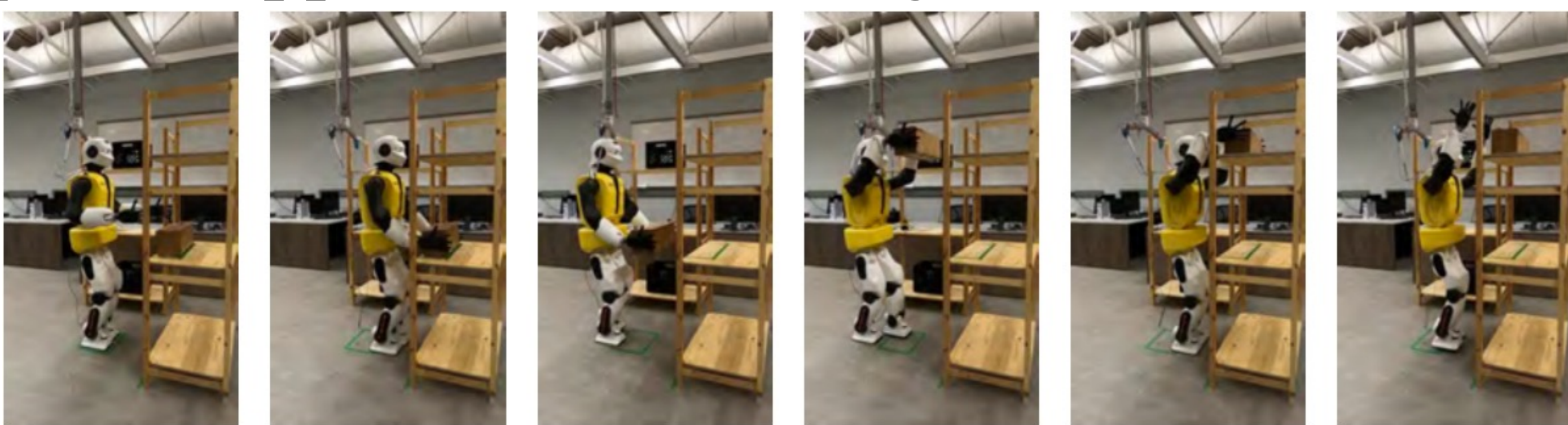

Milk crate

Bubble wrap roll

Key performance indicators:

- Success rate
- Placement error
- Maximum weight
- Maximum height[1]
- Minimum height[1]
- Mechanical work
- Cost of operation
- Battery consumed
- Human-likeness
- Cautious handling factor
- Collision occurrence
- Picking time[2]
- Maximum walking speed[2]

1 – Whole-body manipulation only
2 – Pick and carry only