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# Multi-task Optimization to Evaluate Workstation Suitability over a Population of Virtual Humans.

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## Introduction

- **Musculoskeletal disorders** (MSD) in the industry are a major health issue with important productivity losses.
- **Virtual workstations** and **digital human models** (DHM) help ergonomists prototype safer workstations with lower risks of MSD.

## Scientific problems

- For a given virtual workstation and a population of workers:
- 1) How to study the **impact of the morphology** on the ergonomics?
  - 2) How to generate **behaviors adapted to each morphology**?

## Main idea

Compute **workstation fitness maps** over large populations of virtual workers, by combining whole-body control and multi-task optimization.

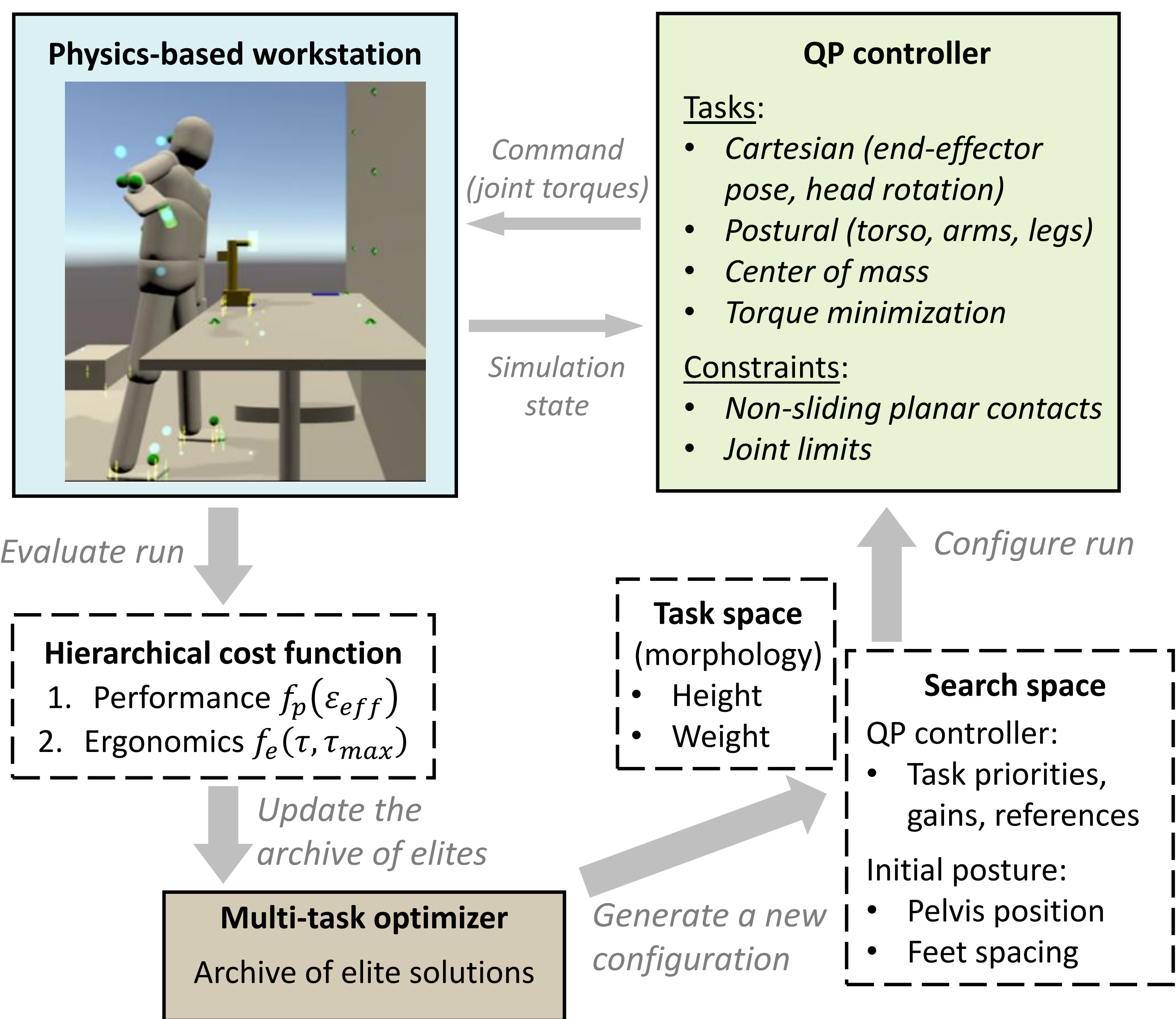
## Method overview

### Activity simulation with physics-based DHM:

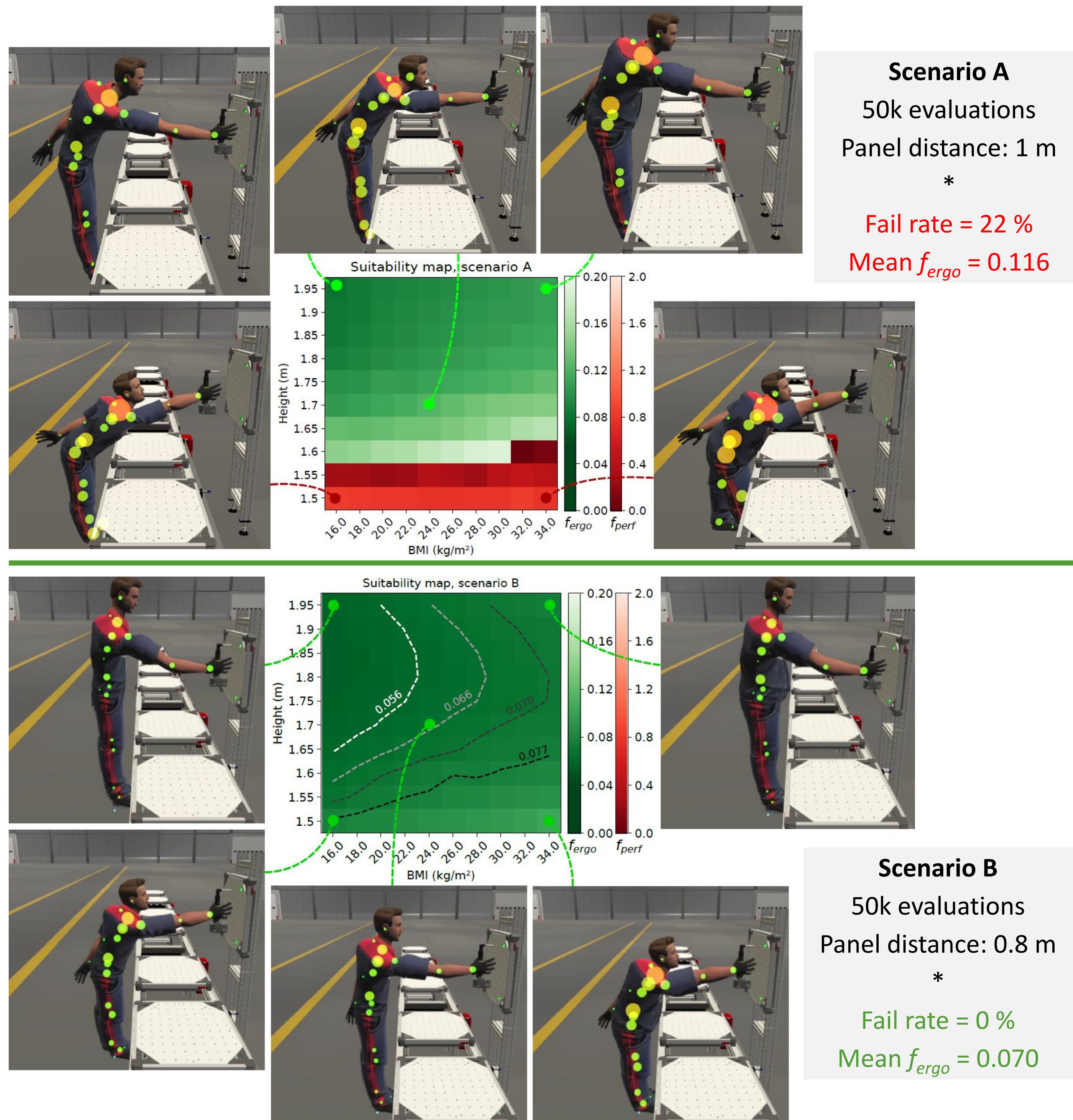
- Virtual workstation created with the XDE/XSM framework [1]
- Configurable DHM (47 DoFs) performing the activity
- Quadratic-programming (QP) controller based on the TSID library [2]

### Behavioral adaptation with Multi-Task optimization:

- Intuition: similar morphologies have similar solutions
- Simultaneously optimize all morphologies with Multi-task MAP-Elites [3]



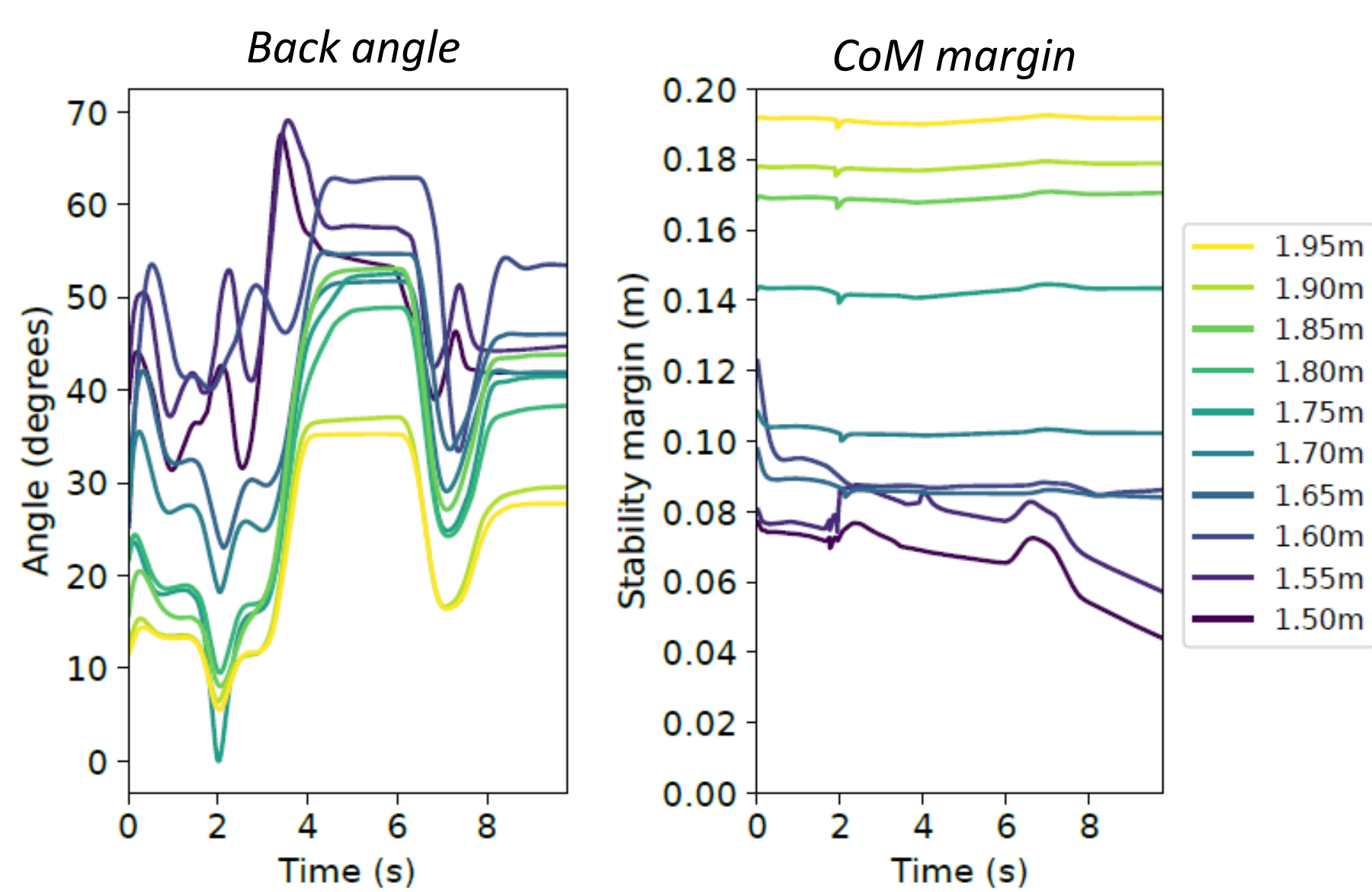
## Suitability maps – Screwdriving activity



## Behavioral strategies

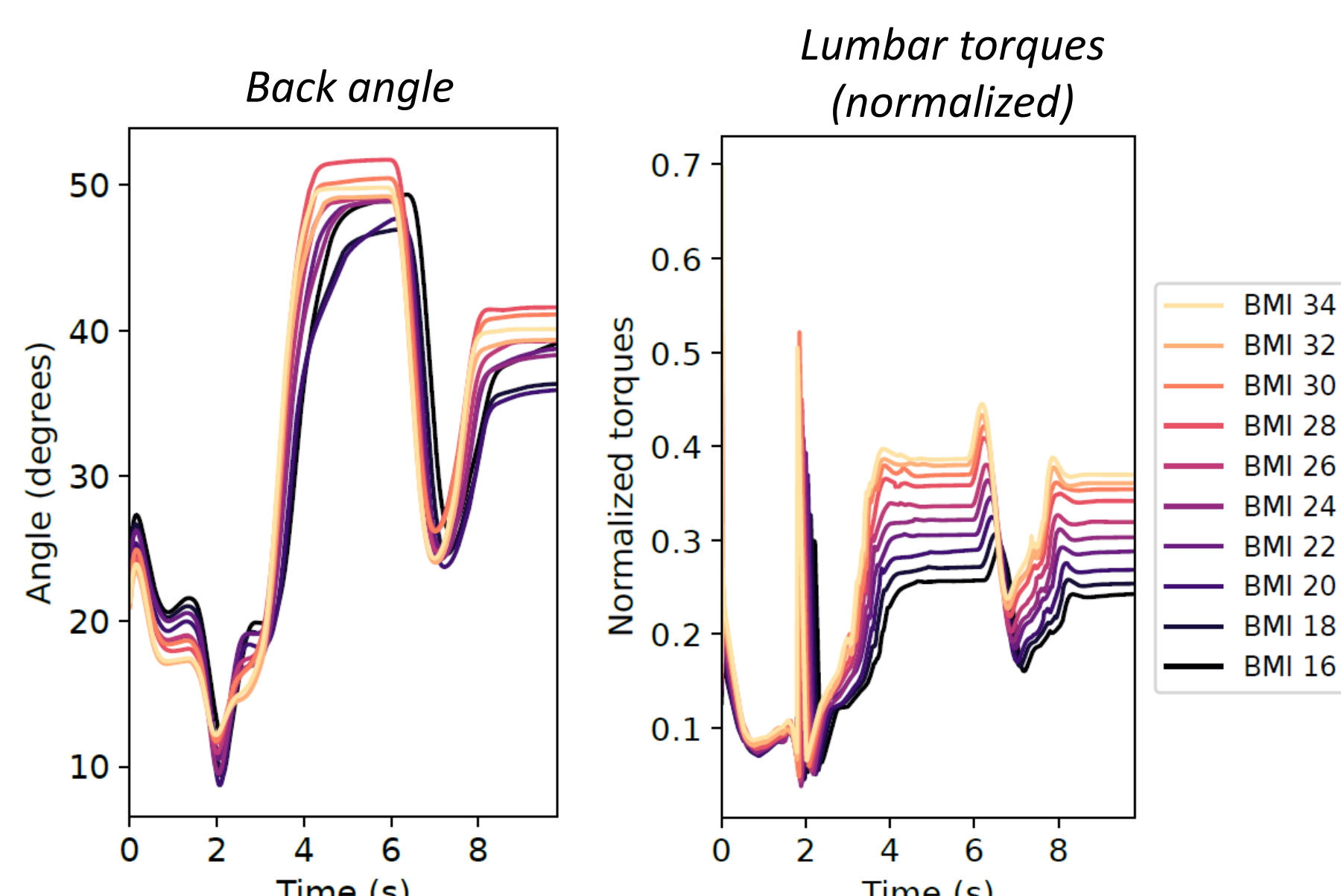
**Effects of height**  
 (scenario A, BMI = 24)

- Smaller DHM need to lean forward more
- Smaller DHM have less stable postures

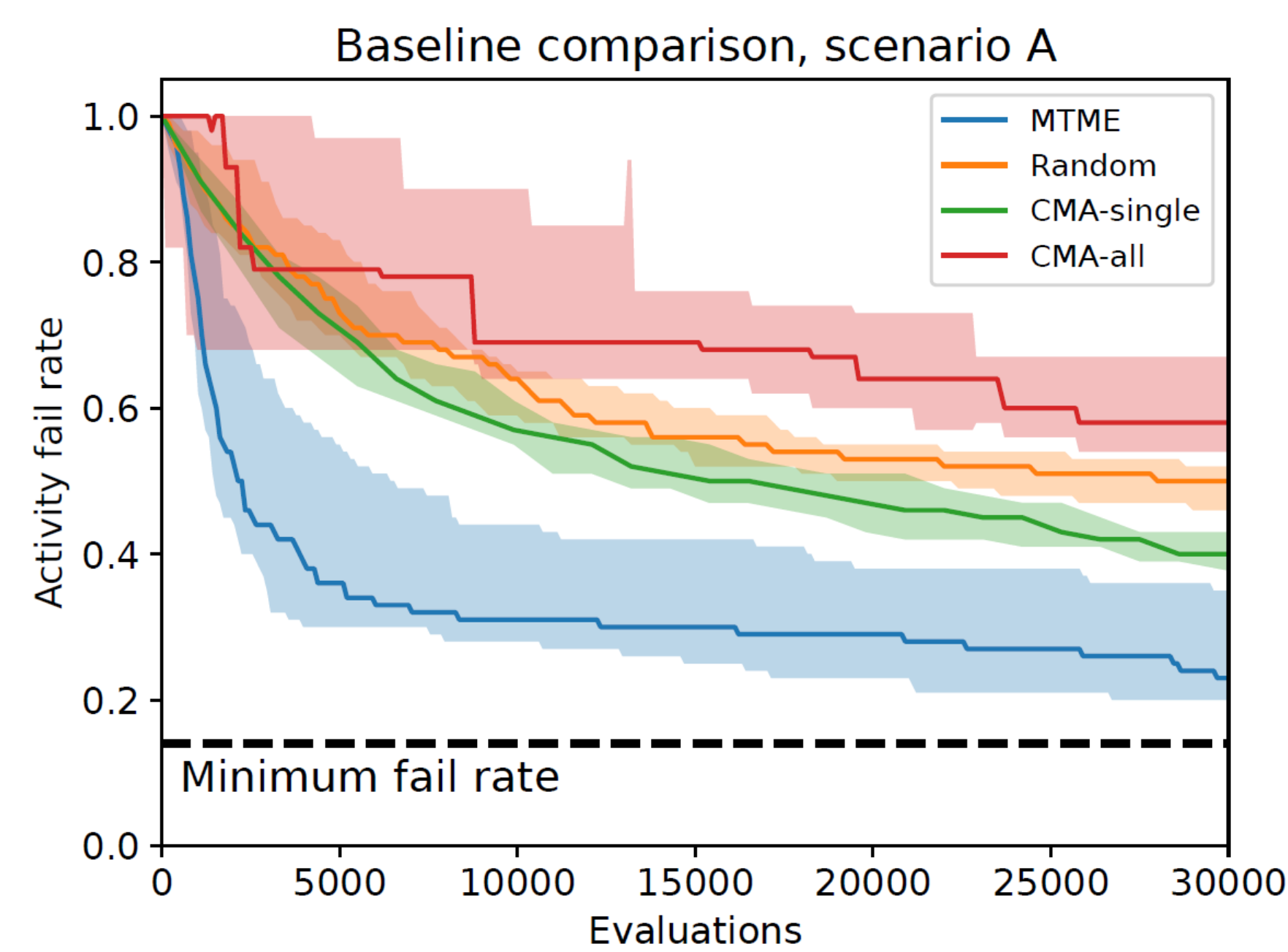


**Effects of BMI**  
 (scenario A, H = 1.8m)

- Similar postures
- Higher BMI means higher torques on lumbar and lower body joints



## Benchmarking



### Baselines

- MTME:** Multi-task MAP-Elites
- Random:** Evaluate with random solutions and morphologies
- CMA-single:** Optimize each morphology separately with CMA-ES
- CMA-all:** Find one solution for all morphologies with CMA-ES

⇒ MTME outperforms all the other baselines.

## Conclusion

With MTME, we were able to efficiently generate a large amount of morphology-adapted behaviors in order to assess workstation suitability.

### Perspectives:

- Validate with an ergonomist on different scenarios
- Enrich the behaviors of the DHM: multi-contact, self-collision, ...
- Reduce computational cost

## References

- [1] Merhlot, X. (2012) 'The XDE mechanical kernel: Efficient and robust simulation of multibody dynamics with intermittent nonsmooth contacts'
- [2] Del Prete, A. et al. (2016) 'Implementing Torque Control with High-Ratio Gear Boxes and Without Joint-Torque Sensors'
- [3] Mouret, J.-B. and Maguire, G. (2020) 'Quality diversity for multi-task optimization'