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Musculoskeletal-based upper limb force feasible set estimation

Thesis by Gautier LAISNÉ¹, supervised by Jean-Marc SALOTTI¹ and Nasser REZZOUG^{1,2}
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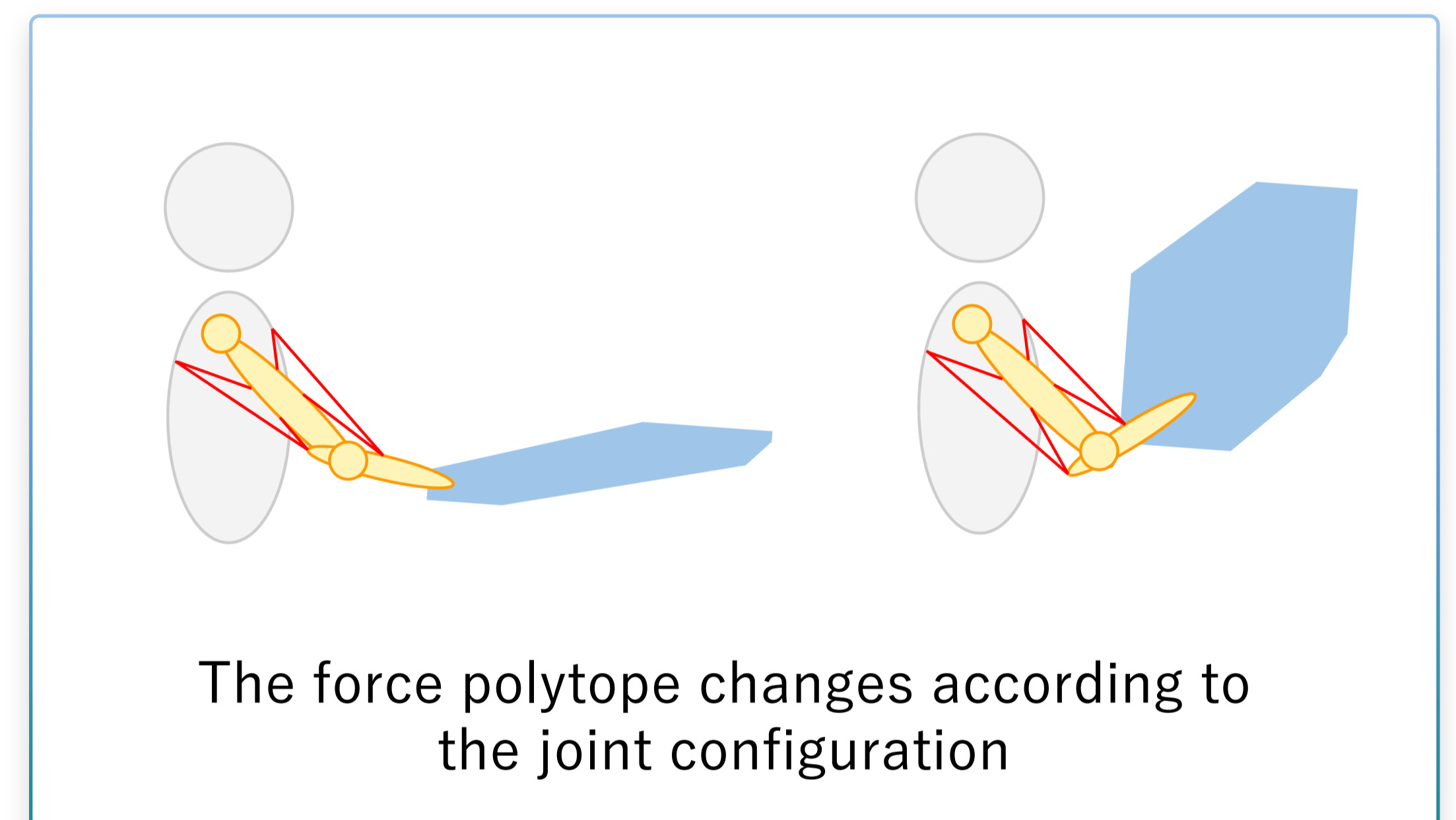
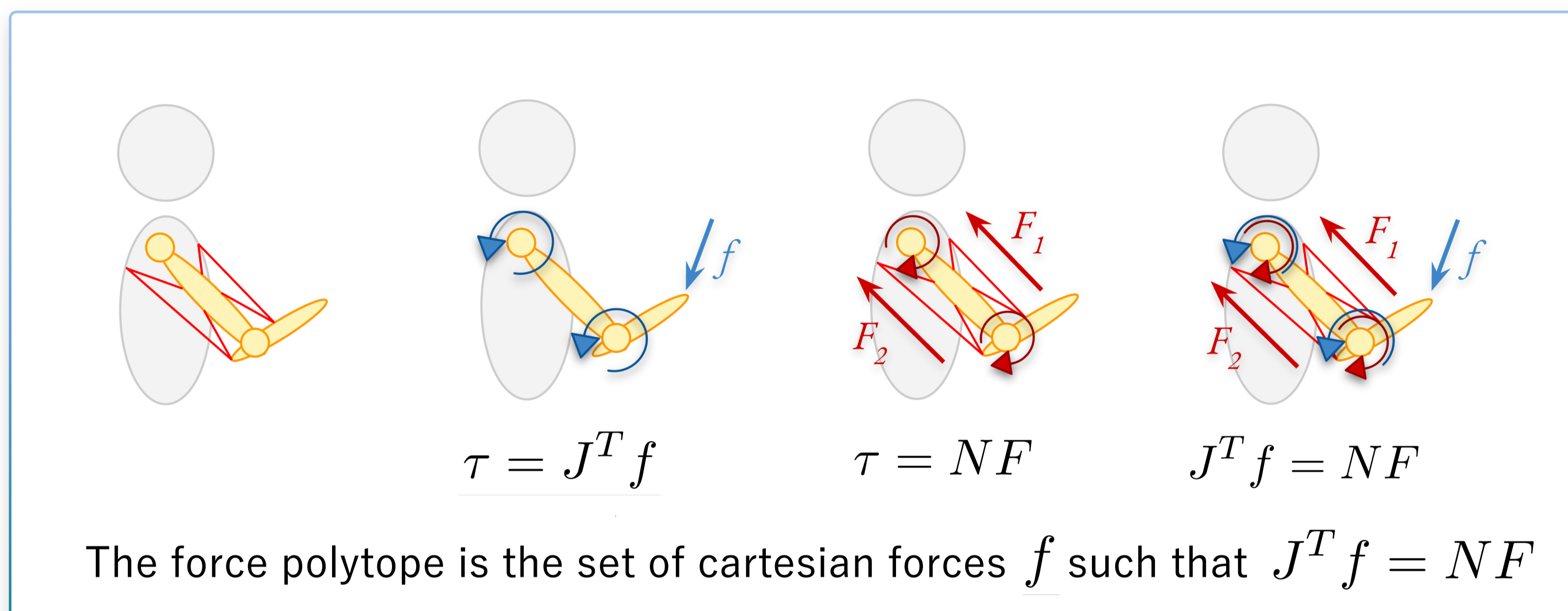
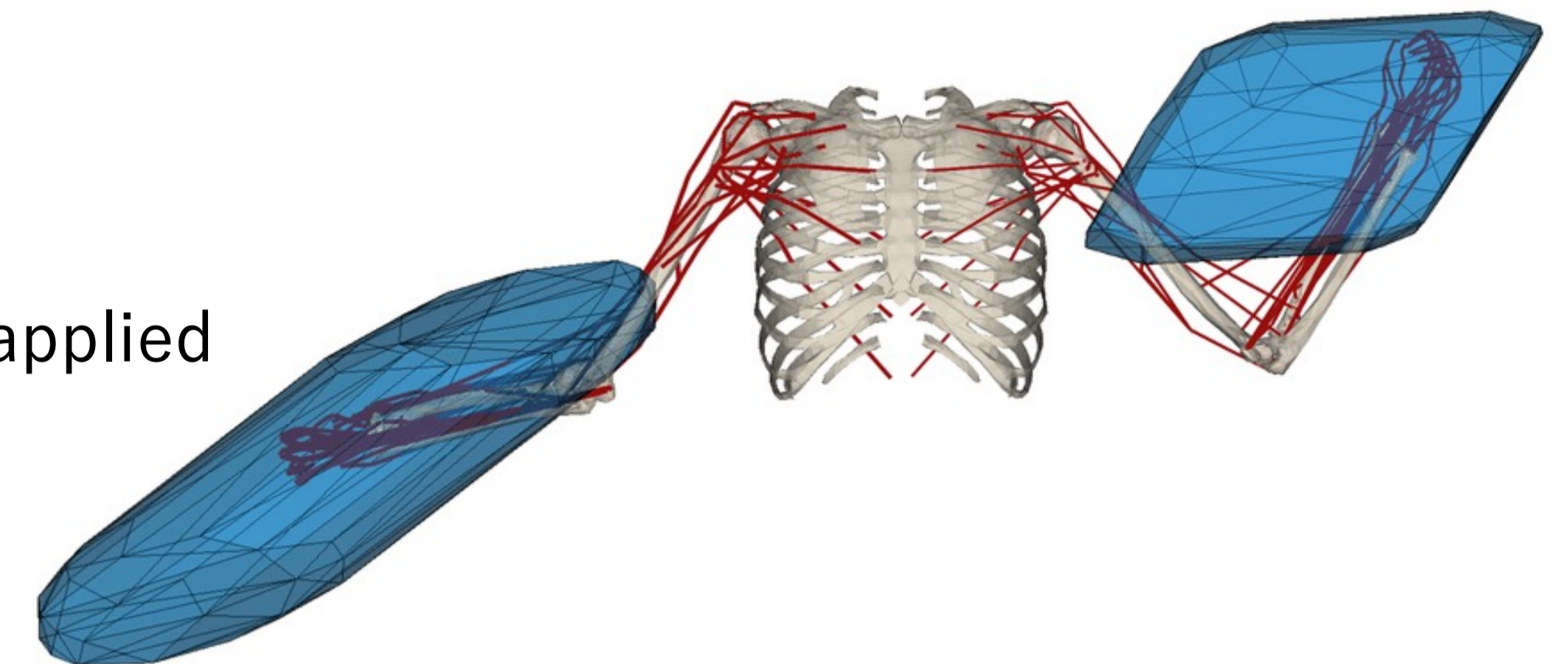
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Thesis goal

Develop personalized musculoskeletal models which accurately represent the upper limb force capacities of a subject for given static postures. However, the force capacities are extremely sensitive to muscular parameters and to joint configurations.

Force feasible set

The force capacities of an individual are the maximal forces which can be applied by the individual to the environment in any task space direction for a given static posture. Determined from a musculoskeletal model, the force feasible set is represented by a convex polytope called the **force polytope**.

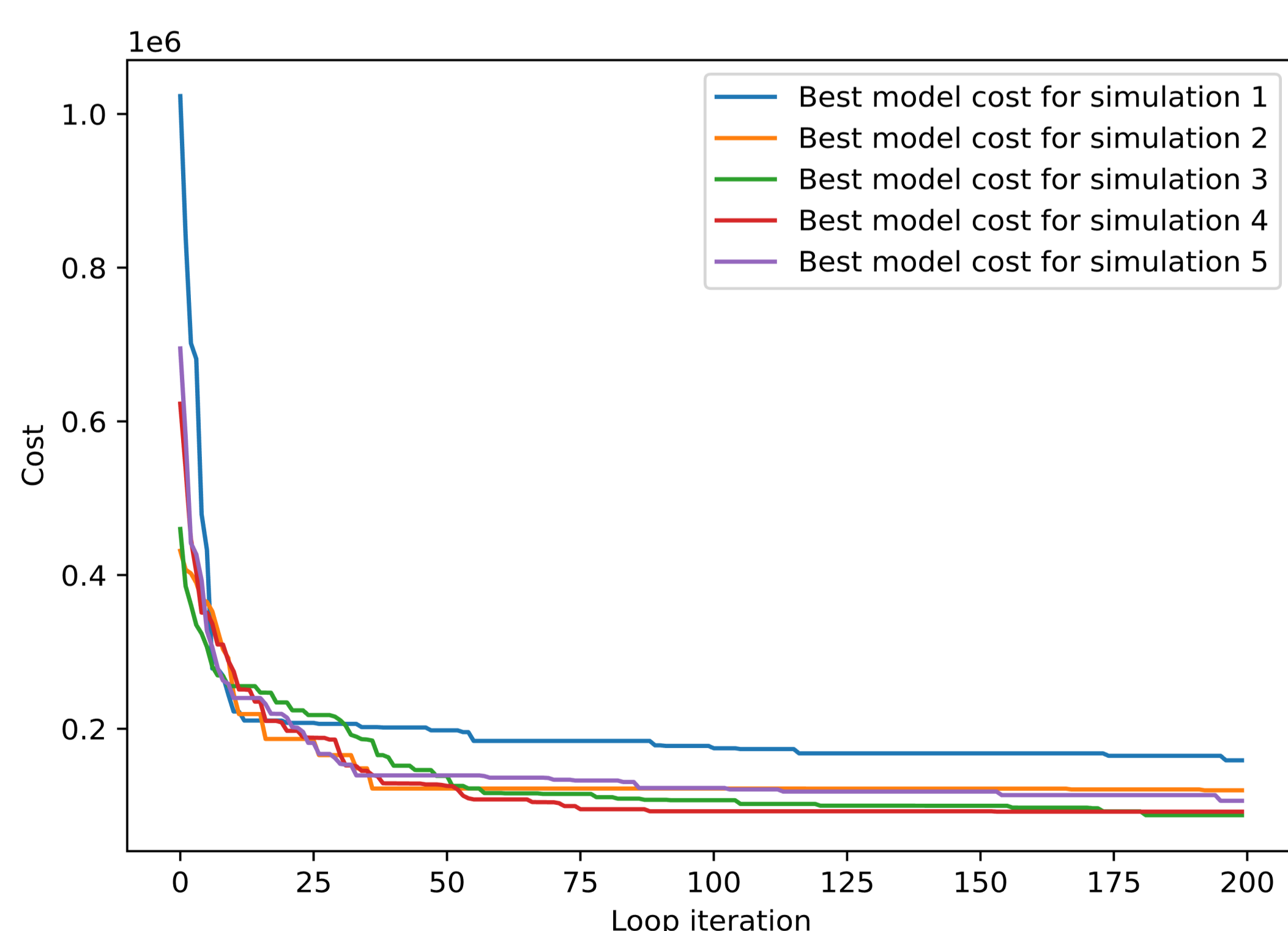


Musculoskeletal model fitting

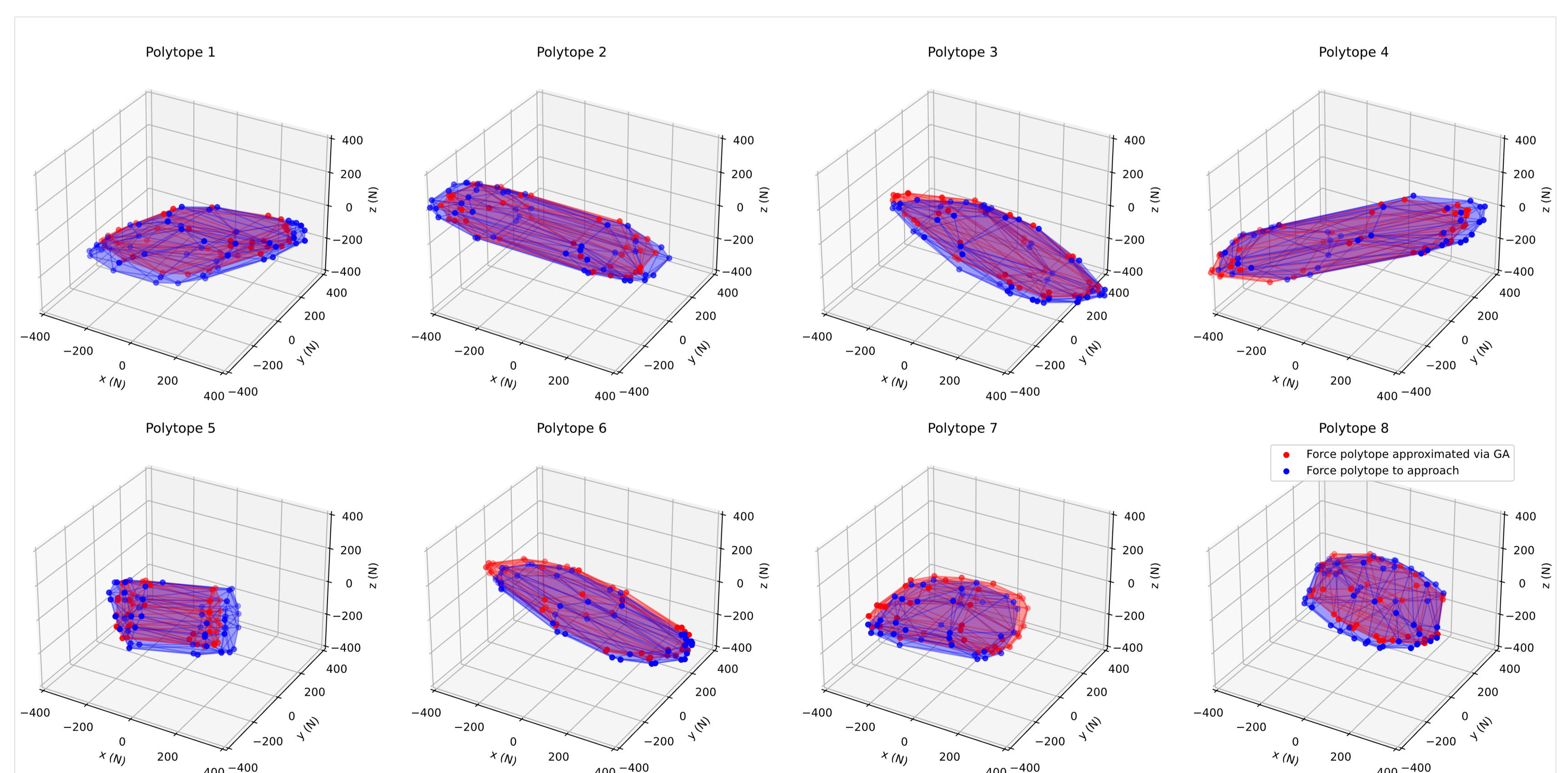
Can we retrieve a musculoskeletal model which would produce force polytopes measured experimentally on a subject?

Genetic Algorithm (GA) approach

1. Create a population of random musculoskeletal models.
2. At each loop, compute a cost function for each model of the population.
3. Create a new population:
 - Keep the 3 best models such that the cost is minimized
 - Create 3 new weakly-perturbated models for each
 - Fill the rest by totally random musculoskeletal models.
4. Restart from step 2 with this new population.



This graph shows the cost evolution of each loop iteration's best model for different simulations. In each simulation, we try to find a MSK model which approximates 8 force polytopes generated by a random MSK model.



Comparison between the force polytopes created by the solution found by the GA (in red) to approximate the force polytopes of the MSK model in simulation 3 (in blue). Each force polytope corresponds to a different joint configuration.