

OPTIMAL CONTROL FOR MAXIMIZING TWIST ROTATION ON TRAMPOLINE

Abstract

A direct multiple-shooting algorithm has been used to maximize twists in somersaults on trampoline. Arm positions and velocities were constrained to feasible movements. Optimization has shown that a large variety of techniques can be used to perform twisting somersaults.



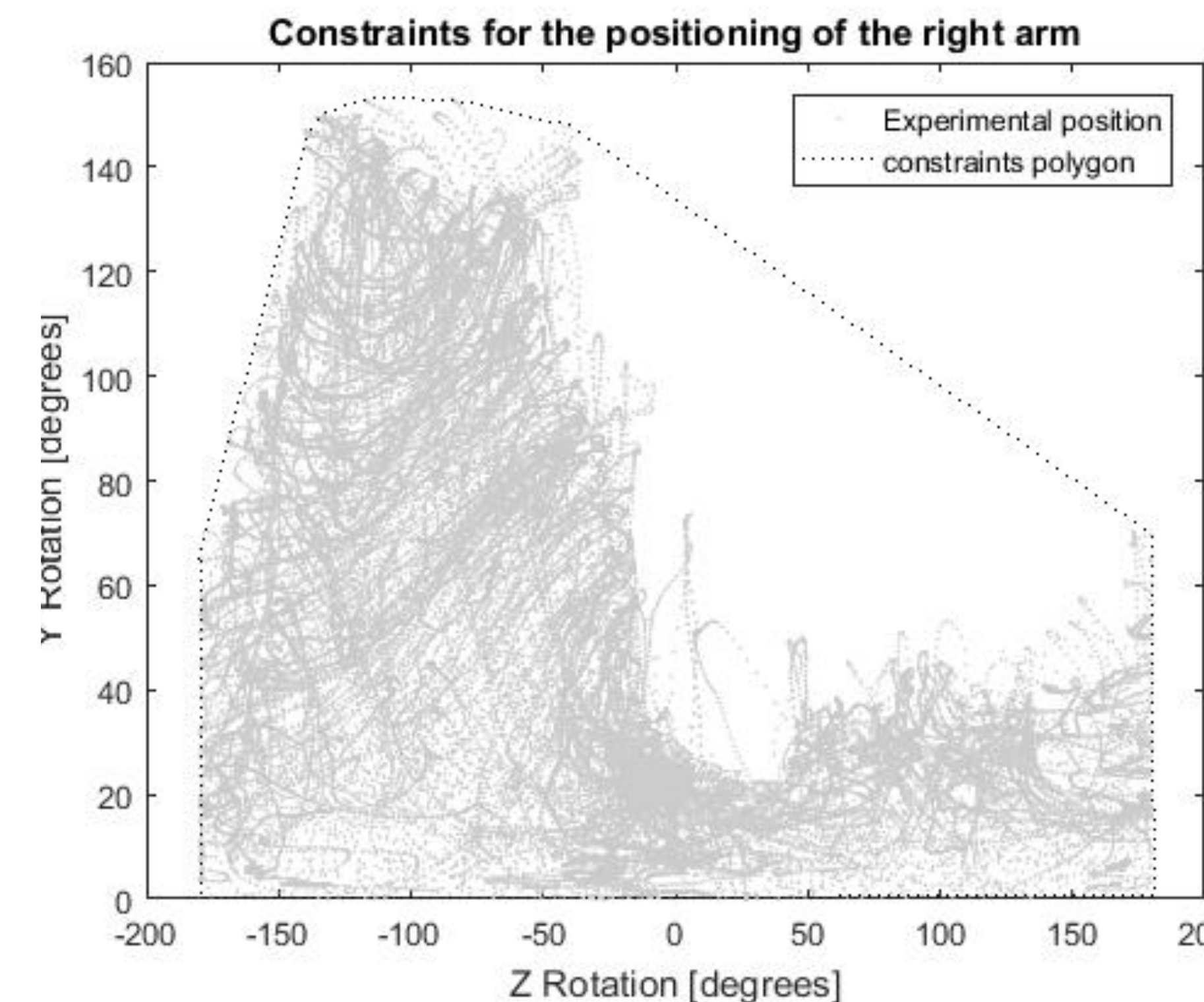
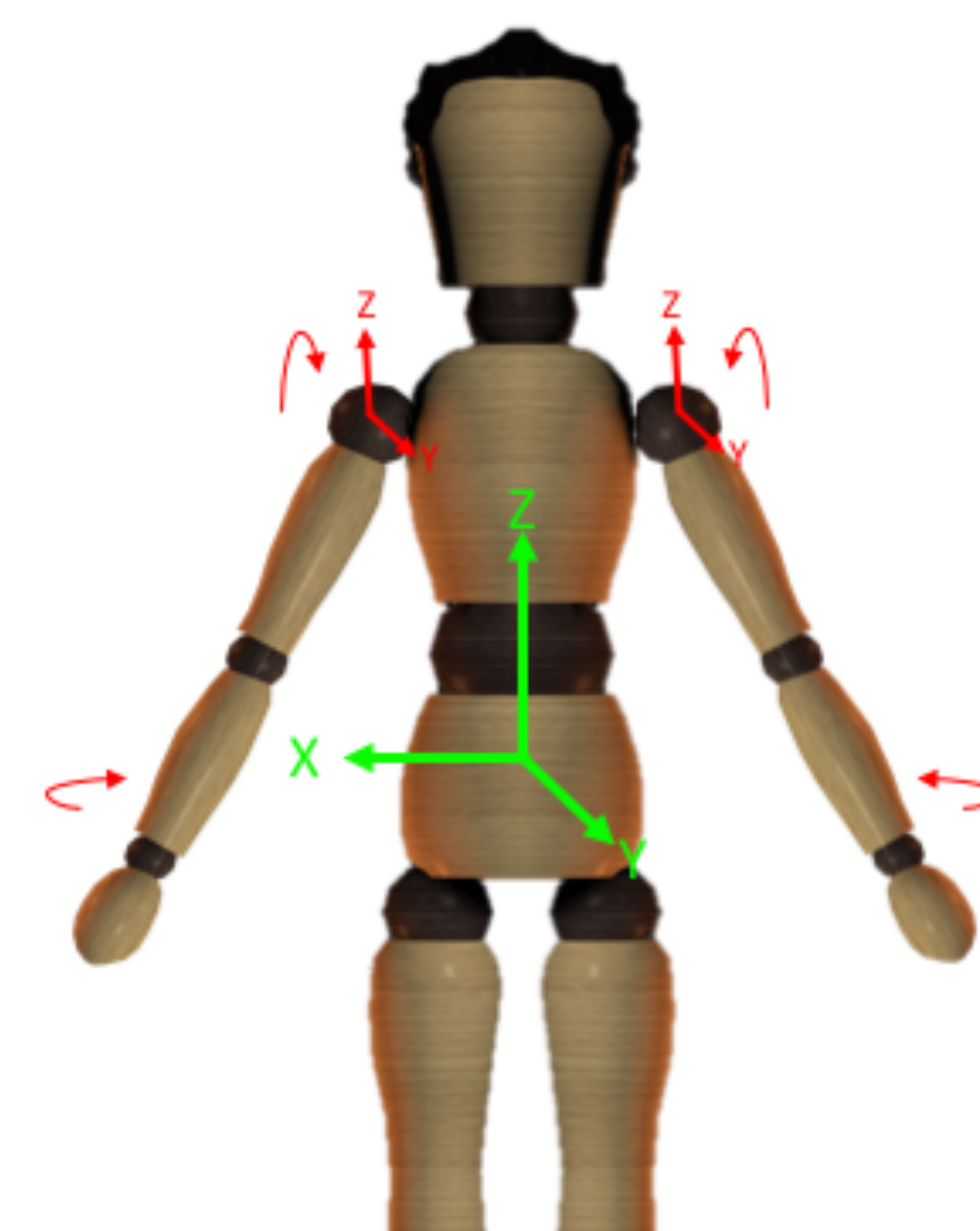
Key words: Optimization, trampoline, twisting somersaults

Introduction

- Aerial twists in straight position are mainly performed using arm adduction to transfer angular momentum from transversal axis to longitudinal axis [1].
- Until now, optimization of arm movements to maximize the twists has been limited to optimal timing of 2D adduction arm movements [2].
- 3D arm position and velocity have an impact on the twist rotation during a somersault.
- Contact twists have undesirable side-effect, such as height loss. Efficient aerial twisting techniques may permit athletes to perform the same skills with a higher time of flight.
- The computer simulation makes it possible to try an infinity of arm techniques.

Objective: Explore complex and anatomically feasible arm movements to generate efficient innovative twisting techniques.

Method



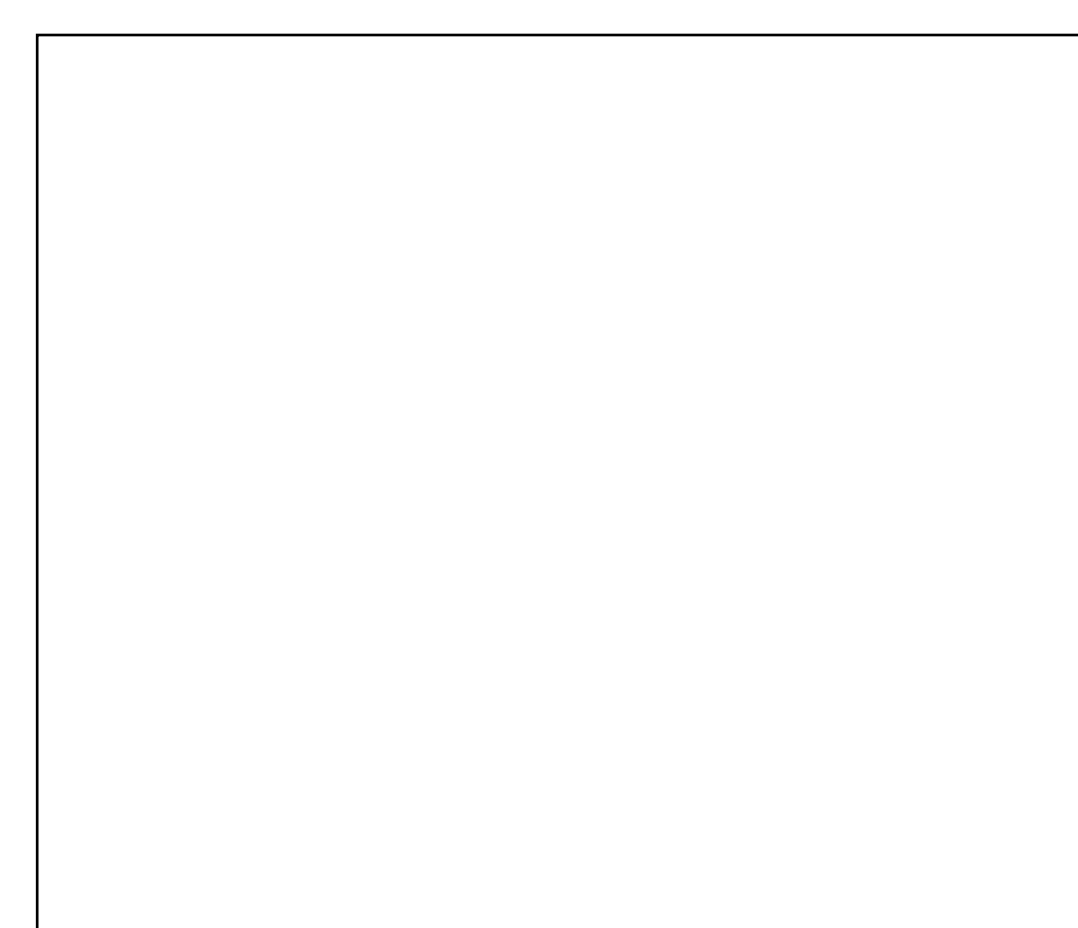
Accessible arm positions and movements according to the reference frames. Arm and body movements are solution of the differential equation:

$$\tau = M(q)\ddot{q} + N(q, \dot{q}) + G(q)$$

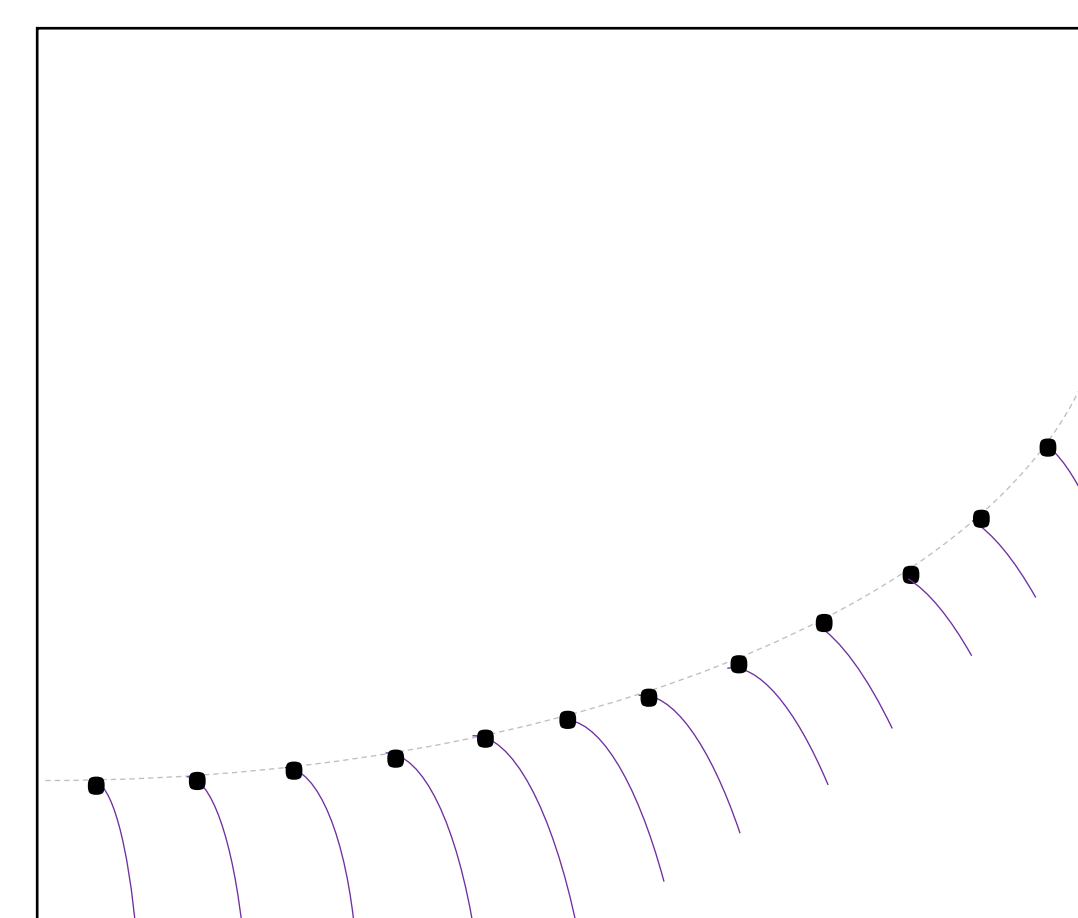
Schematic of the direct multiple-shooting

Initial guess

Piecewise constant controls

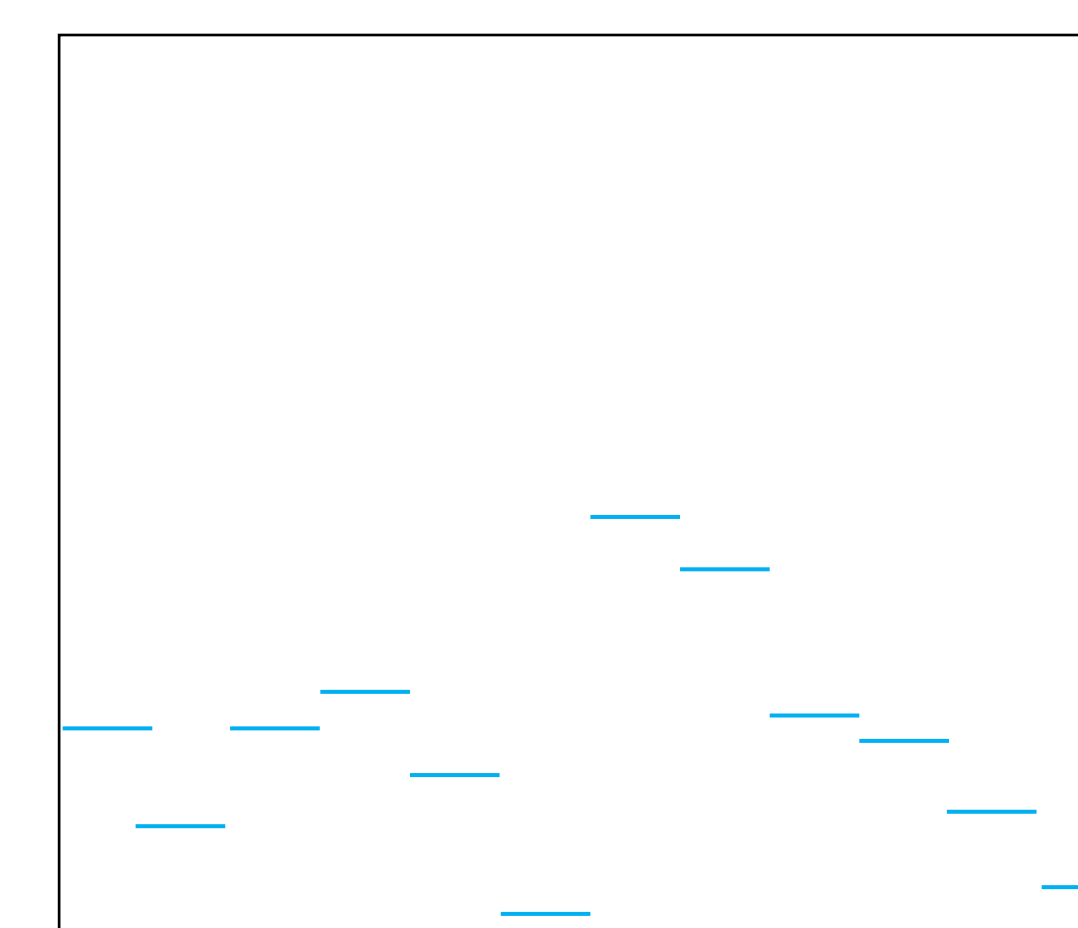


Position of the arm

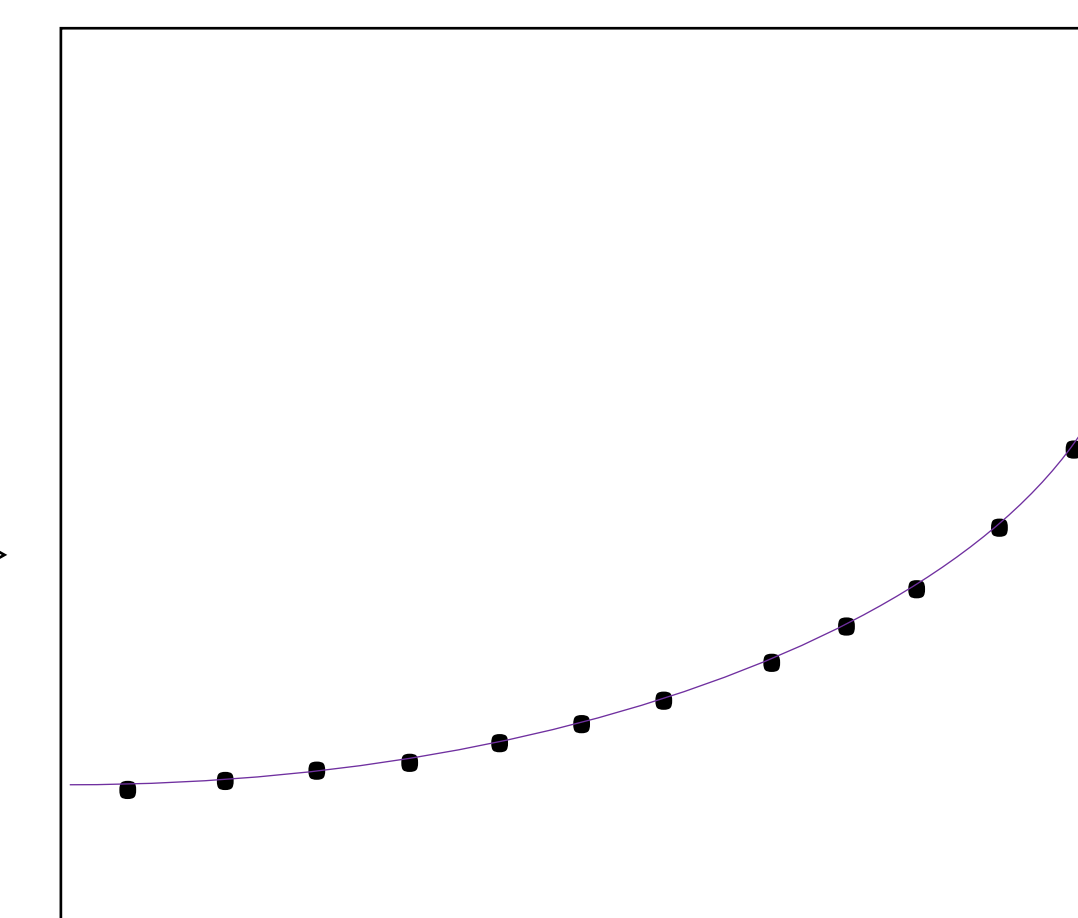


Optimized solution

Piecewise constant controls



Position of the arm



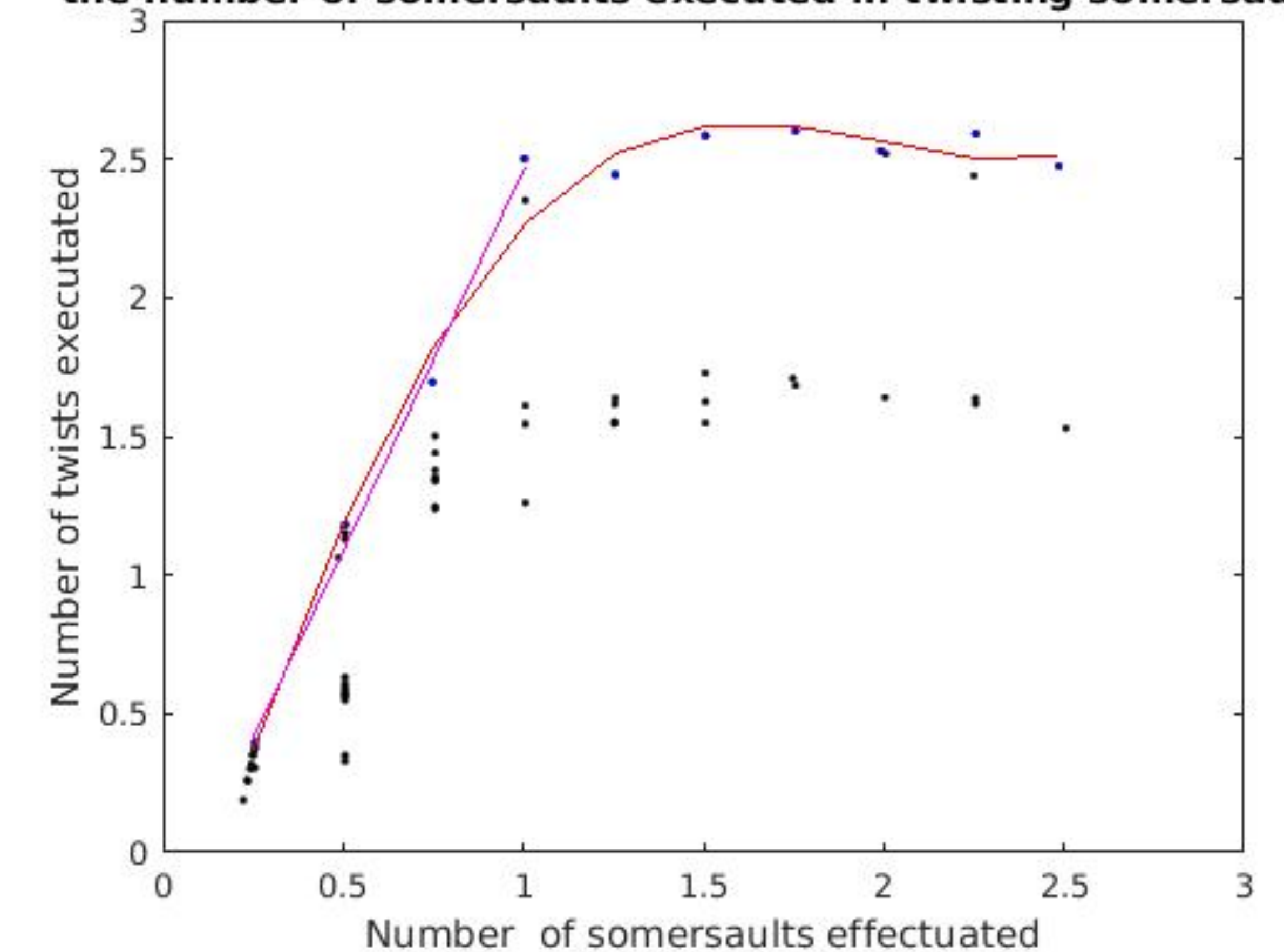
Results & Discussion



Representation with fixed COM of 1 of the 59 optimizations that converged out of 320 multi-start conditions.

The arm movements are anatomically feasible, but not necessarily feasible from a motor control point of view because arm movements require different phases.

Maximum number of twists effectuated in function of the number of somersaults executed in twisting somersaults



The multi-start approach combined with direct multiple shooting has shown its efficiency concluding that up to 2.5 twists may be performed in 1 somersault using only aerial arm techniques.

Future work

Robustness of the technique will be assessed by including noise [3] and we will try to teach the techniques.

References

1. Yeadon (1999) Int Symp of Biomech in Sports
2. Yeadon et al. (2017) J of Biomech.
3. Hiley et al. (2013) Hum Mov Sc.