Virtual Prototyping of a Compliant Robotic Wrist

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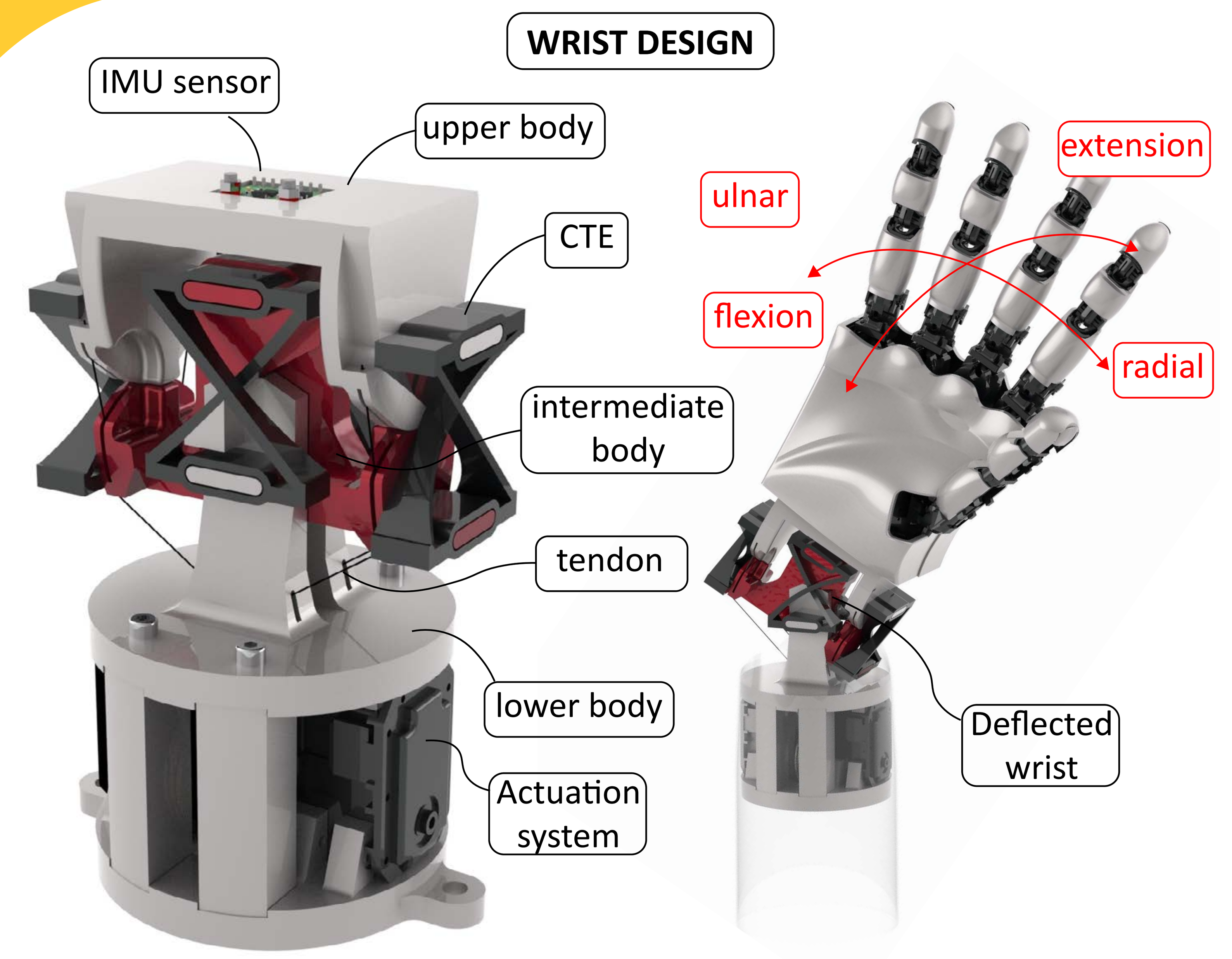
Introduction

In the development of collaborative robots possible collisions can occur so the need for safety is one of the main objectives.
The introduction of a Compliant Transmission Element (CTE) is an effective way to ensure safety in collaborative tasks and limit damage in case of unwanted impacts. The wrist presented in this work is characterized by two functional modules, one for each of its degrees of freedom, namely flexion/extension and ulnar/radial modules.

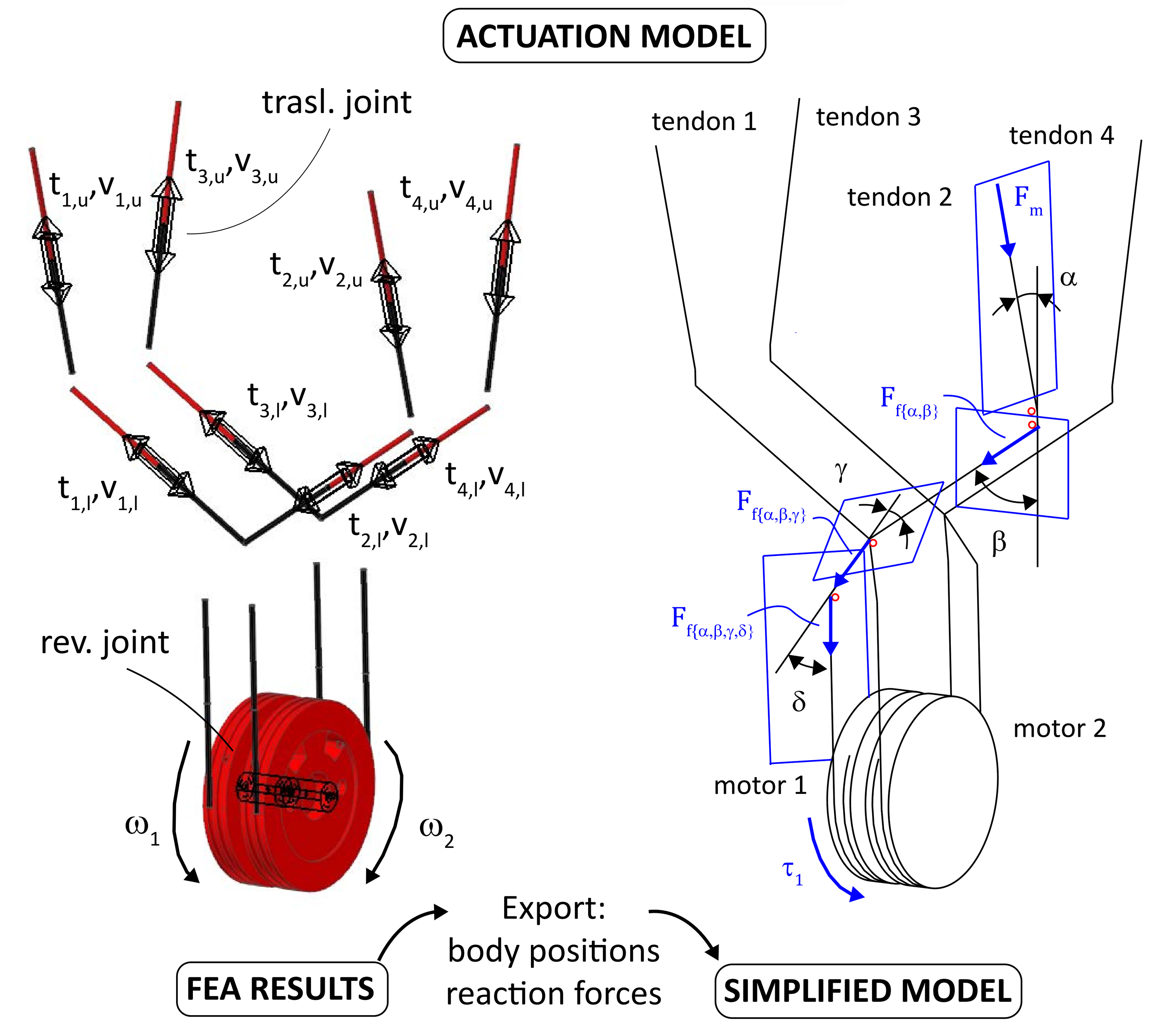


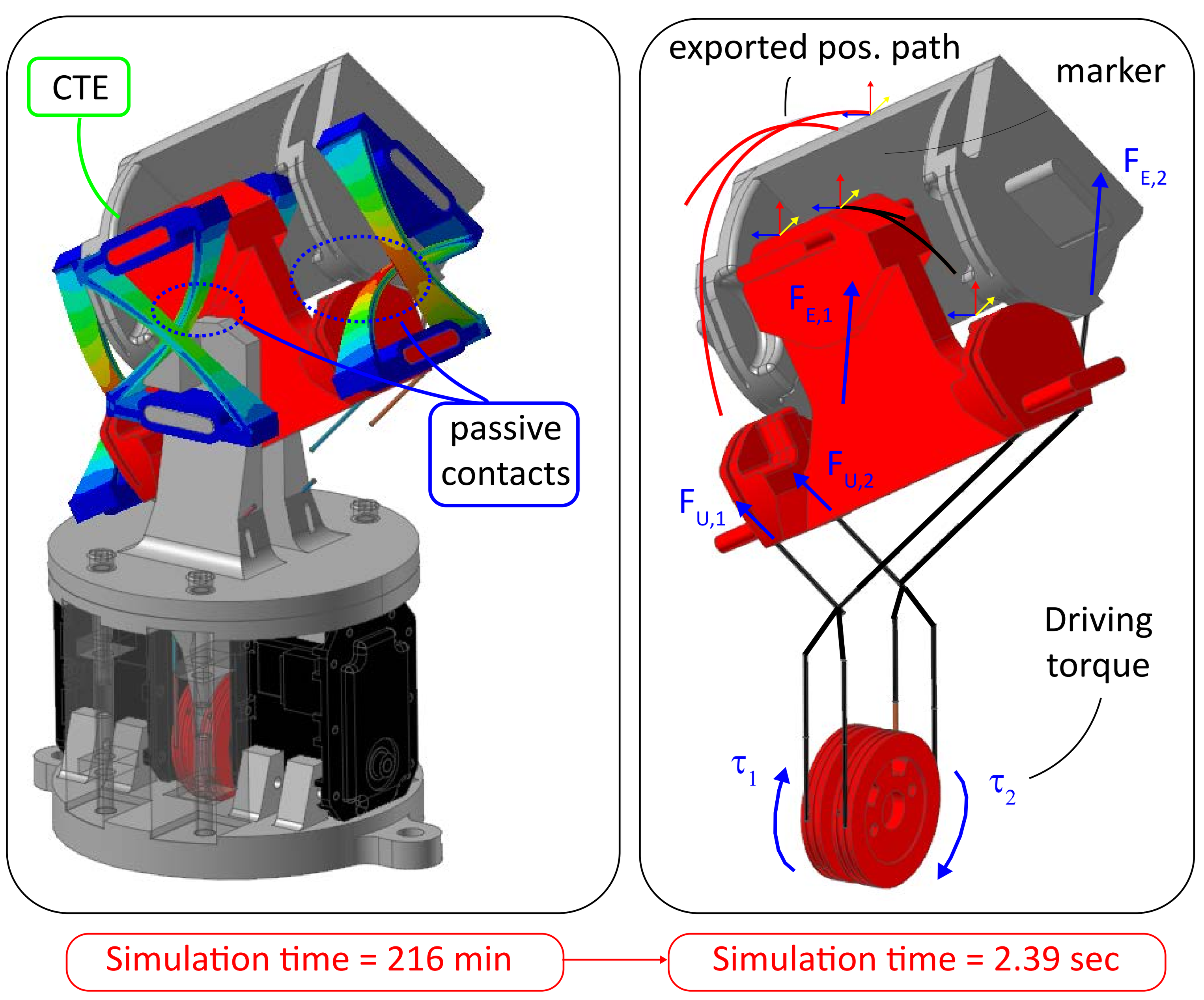
Virtual Prototype

The actuation system is simulated by using rigid cable sections connected by translational joints that behave like linear actuators. Thus, each tendon is modeled as two different cable sections, the upper one ($t_{1,u}...t_{4,u}$) for the flexion/extension module and the lower one ($t_{1,l}...t_{4,l}$) for the ulnar/radial module. All contributions due to friction were mathematically estimated via the Euler-Eytelwein formula:

$$F_{f\{\alpha,\beta,\gamma,\delta\}} = F_m e^{\mu\{\alpha+\beta+\gamma+\delta\}}$$

The virtual prototype of the wrist is then computed by using meshed CTEs and applying passive contacts between the bodies. The model thus created results unsuitable to be employed in a co-simulation environment due to its high computational time. To simplify the model, the position of two markers for each of the two moving bodies was exported as a 3D path, then four so-called “point-on-curve” joints were added to the model, binding each marker to move only along its respective exported spline. Following the same principle, all reaction forces measured at the translational joints were exported and added to the model as active forces. This allows both the meshed bodies and passive contacts to be removed from the calculations, resulting in a hightly faster simulation.



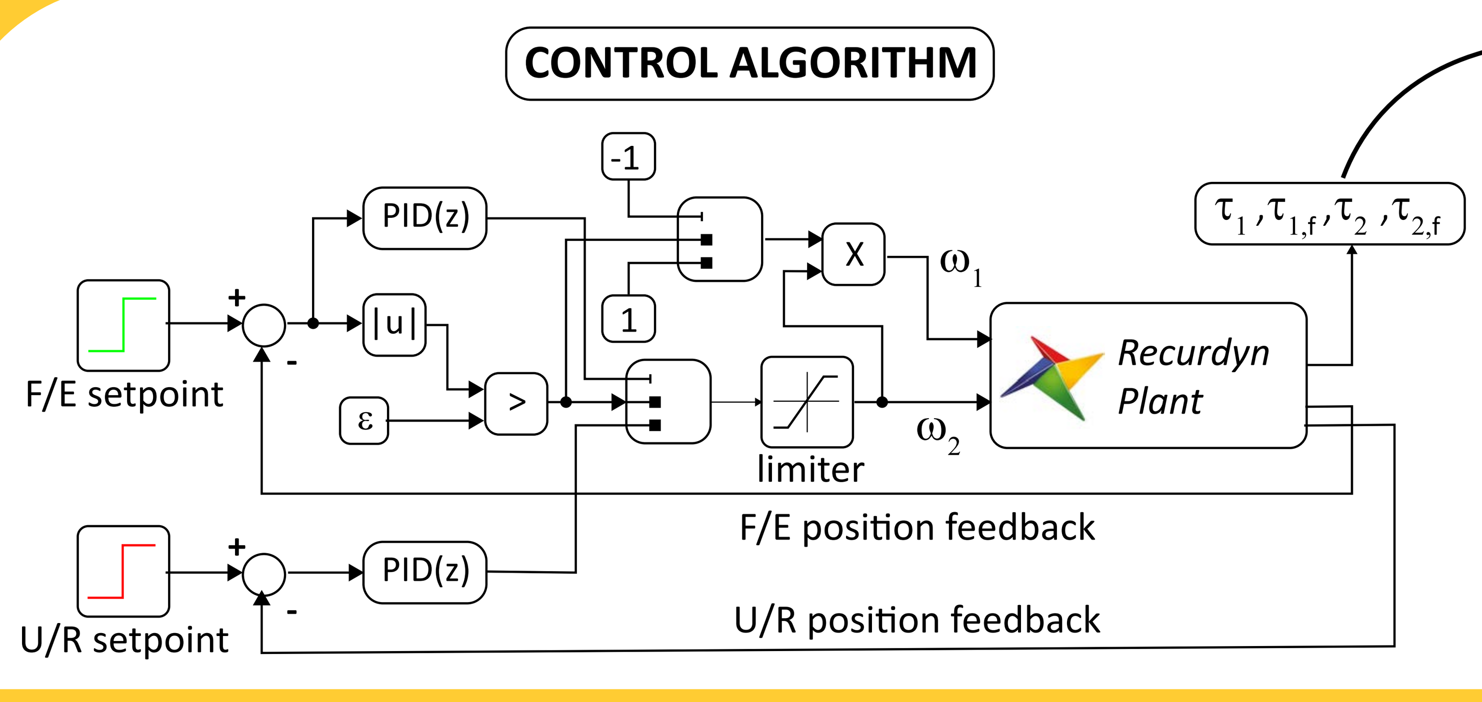


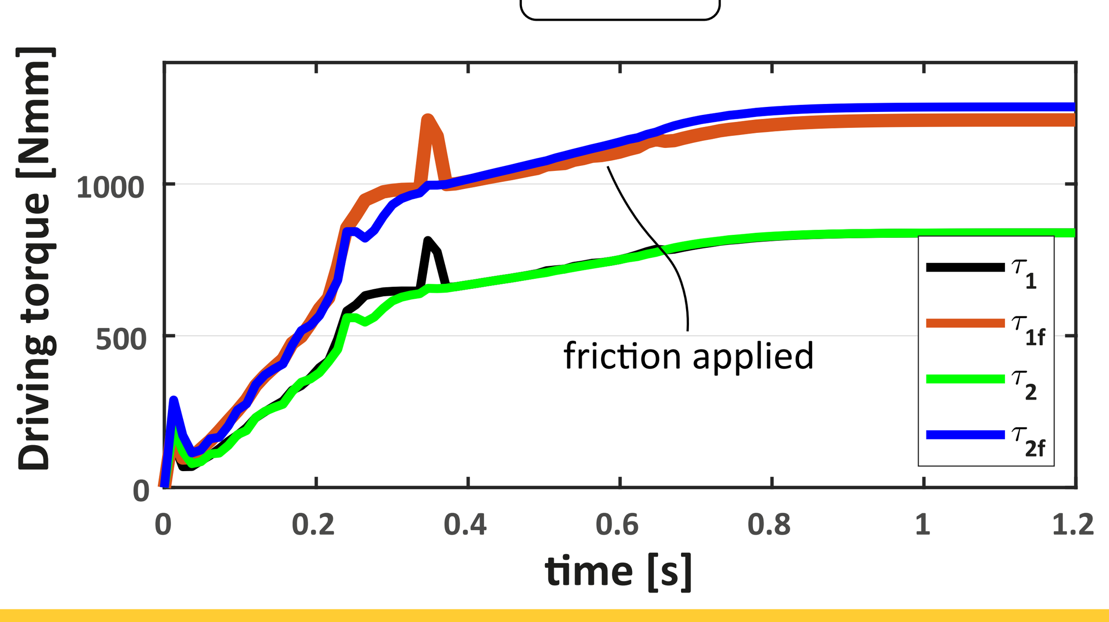
Simulation case study

A control algorithm is tested in a Colink/Recurdyn multisoftware environment. This algorithm uses two different PID controllers to tune either the flexion/extension and ulnar/radial modules.
The algorithm takes as inputs the setpoints of the two modules closing the position loop using the wrist feedback positions (given, in its physical counterparts, by an IMU sensor installed on the upper body). Based on the position error, the algorithm modifies the velocity value of the two servo-motors, making sure to limit it at the maximum value allowed by the tested servo-motors by using a limiter block.

Conclusions

A simplified model of a compliant robotic wrist is proposed and virtually prototyped using a Colink/Recurdyn multi software environment. This prototype allows to easily test all of the wrist motion possibilities, to safely optimize the PID controller as well as to determine the torque requirements of the motors.





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