1. Motivation and Objectives

As part of a larger project with the aim to create patient-specific biomechanical models and simulation, the goal of this work was to develop Multibody dynamics (MD) environment that allows easy implementation of desired improvements and is feasible to run in a co-simulation with a finite element (FE) solver. This project was split into three tasks:

- Development and validation of a MD platform for the spine that is comparable to state-of-the-art existing tools
- Implementation of changes that improve the quality of the results specifically for the spine
- Development of an interface to interact with the FE solver

2. Changes/Improvements

2.1 Dynamic Center of Rotation (CoR):
- Varying CoR position during flexion was implemented according to measurements of Aiyanger et al. [1]:

2.2 Passive resistance:
- Data (passive resistance) from 30 cadaveric lumbar spines were recorded and the results were implemented in the model:

2.3 Modified cost function:
- Cubed energy was minimized:
  \[ \text{min} \sum_{i=1}^{m} (a_i)^3 \]
- Compressive force was added to the optimization (Multi-objective optimization)
  \[ \text{min} \left[ W_1 \sum_{i=1}^{m} (a_i)^2 + W_2 |JRF|^2 \right] \]

3. Model Validation

3.1 Reasons of the observed variations
- Geometries
- Spine curvatures
- Muscles

4. Results of changes/improvements

- 4.1 Dynamic CoR

- 4.2 Passive resistance

- 4.3 Modified cost function

5. Interaction with FE environment

Subroutines created for Radioss (FE solver)
- Transfer of information possible:
  - MD to FE (230 muscle forces)
  - FE to MD (updated upper body position)
- Possible to stabilize and to move the model

6. Conclusion

- A MD platform has been successfully developed
- Results have been improved with the implemented changes
- An interface for MD-FE co-simulations has been created

Reference: