CusToM Workshop

External forces prediction tutorial

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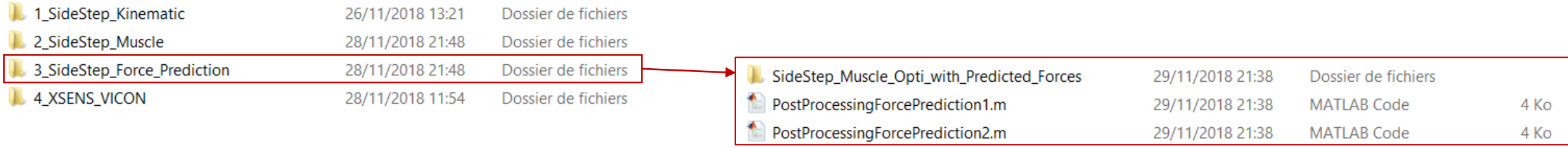
Pre-work

1. Go in `Examples / 3_SideStep_Force_Prediction`
2. Copy/paste `SideStep_Muscle_Opti` folder in `3_SideStep_Force_Prediction` and rename one of the copies `SideStep_Muscle_Opti_with_Predicted_Forces`

Should look like this:

`Examples folder`



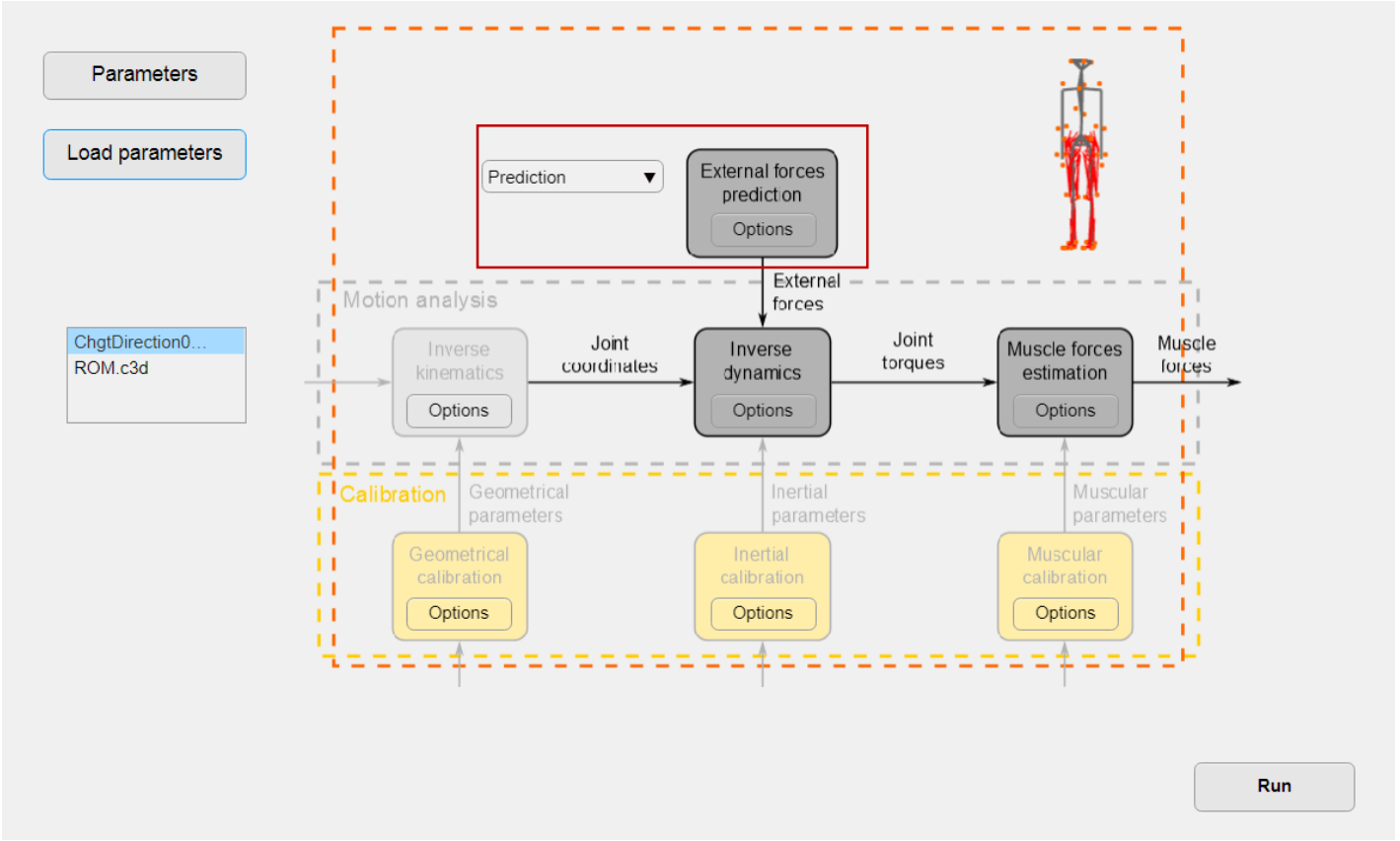
Force prediction: what does this mean ?

Sometimes, you want to do dynamics without force platforms

It is therefore necessary to generate - predict the external forces on the whole motion capture to make consistent inverse dynamics

Generate AnalysisParameters

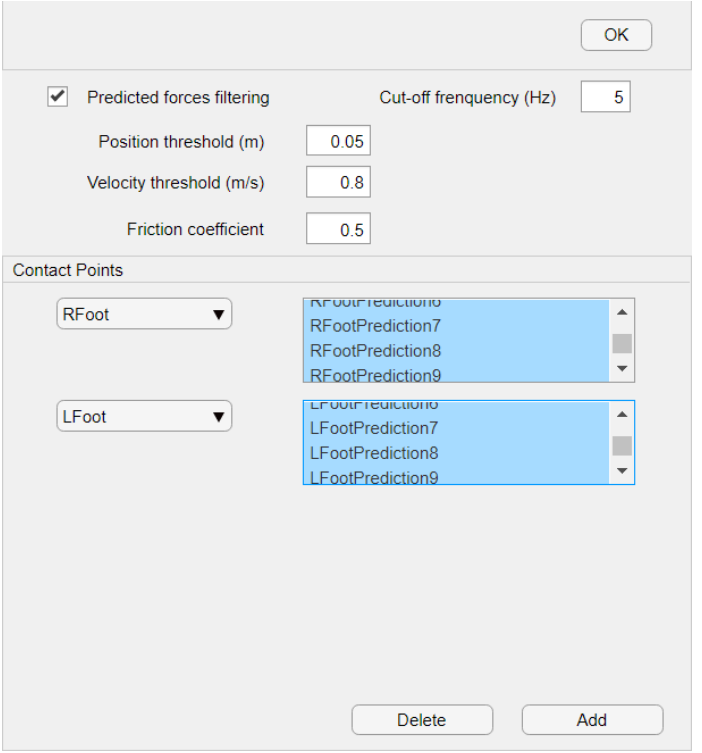
- The only thing to change is the external forces handling
- Select « Prediction » for External forces
- Open Options



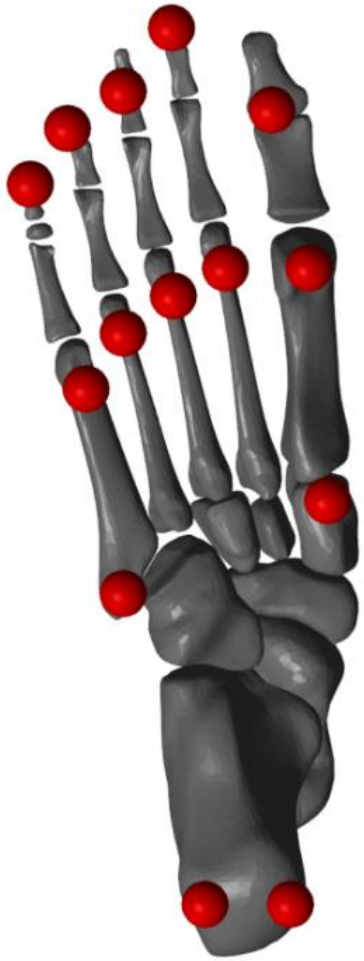
Generate AnalysisParameters

- The only thing to change is the external forces handling
- You can disable the kinematics step: kinematics does not change here
- Select « Prediction » for External forces
- Open Options
- Add contact points: « Rfoot » and select all the « RfootPrediction » points
- Add contact points: « Lfoot » and select all the « LfootPrediction » points

  Use Crtl+Click or Shift+Click to select multiple points



What are these points ?



Anatomical points defined on the feet as contact points

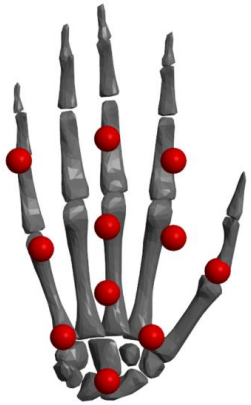
See **…\Functions\Models\Osteoarticular\Leg\ModelParts\foot.m**

R. Fluit, M. S. Andersen, S. Kolk, N. Verdonschot, and H. F. Koopman, “Prediction of ground reaction forces and moments during various activities of daily living,” Journal of biomechanics vol. 47, no. 10, pp. 2321–2329, 2014

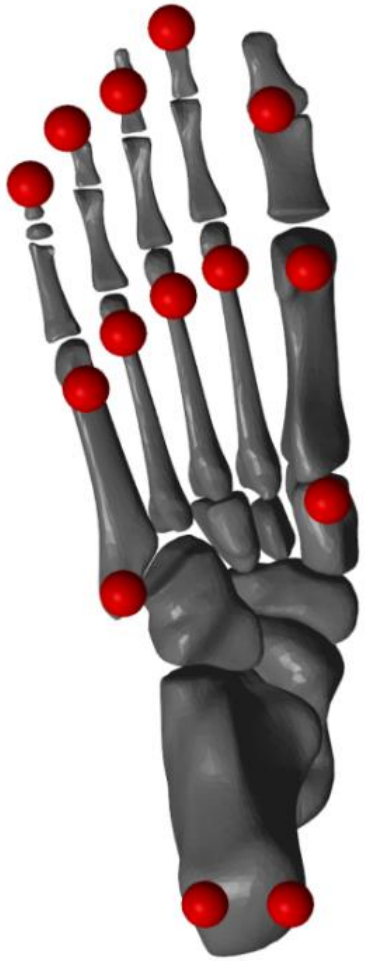
S. Skals, M. K. Jung, M. Damsgaard, and M. S. Andersen,
“Prediction of ground reaction forces and moments during sports-related movements,” Multibody system dynamics, vol. 39, no. 3,pp. 175–195, 2017

Muller A., Pontonnier C., Dumont G. Motion-based prediction of hands and feet contact efforts during asymmetric handling tasks, in review

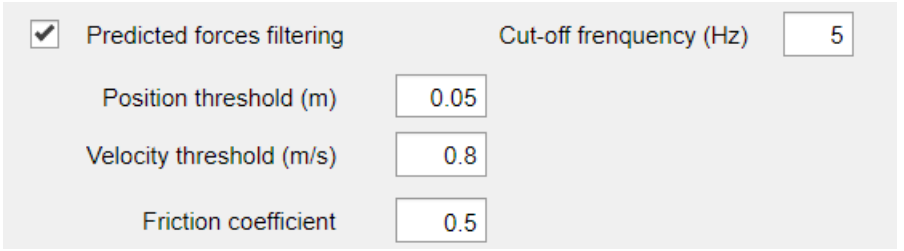
You can add contact points on any segment of the model !



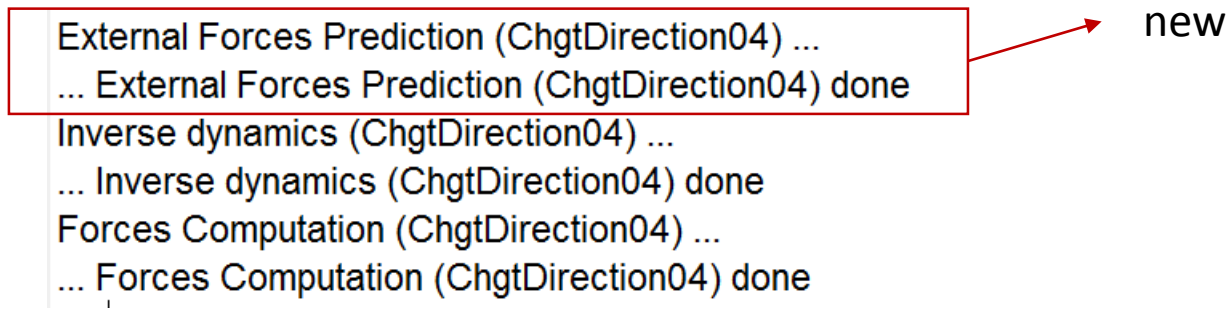
What are these tresholds ?



Contact is allowed (force is allowed to be generated on the considered point) if thresholds are reached and maximal force per point is constrained to 0.4 BW. Coulombs law links normal and tangential components of the force



RUN


External Forces Prediction (ChgtDirection04) ...
... External Forces Prediction (ChgtDirection04) done
Inverse dynamics (ChgtDirection04) ...
... Inverse dynamics (ChgtDirection04) done
Forces Computation (ChgtDirection04) ...
... Forces Computation (ChgtDirection04) done
new

What CusToM is doing ?

$$\min_{(\boldsymbol{\alpha},\boldsymbol{\beta},\boldsymbol{\gamma})} \quad \sum_{i=1}^{2N_f} \left(\alpha_i^2 + \beta_i^2 + \gamma_i^2\right)$$

$$\text{s.t.} \quad \boldsymbol{M_s}(\boldsymbol{q})\ddot{\boldsymbol{q}} + \boldsymbol{C_s}(\boldsymbol{q},\dot{\boldsymbol{q}}) + \boldsymbol{G_s}(\boldsymbol{q}) + \boldsymbol{\lambda_s} + \boldsymbol{E_s} = \boldsymbol{0};$$

$$\forall i \in [\![1, 2N_f]\!], (\alpha_i, \beta_i, \gamma_i) \in [-1, 1]^3$$

→ Equations of motion
(Newton-Euler and sum at pelvis)

$$\boldsymbol{F_i} = \alpha_i \, F_{i,x}^{max} \, \boldsymbol{x} + \beta_i \, F_{i,y}^{max} \, \boldsymbol{y} + \gamma_i \, F_{i,z}^{max} \, \boldsymbol{z}$$

→ Each contact point has a minimal contribution to the global equilibrium

Results

Run the Post processing files…