

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

 1_SideStep_Kinematic	26/11/2018 13:21	Dossier de fichiers	
 2_SideStep_Muscle	28/11/2018 21:48	Dossier de fichiers	
 3_SideStep_Force_Prediction	28/11/2018 21:48	Dossier de fichiers	 SideStep_Muscle_Opti_with_Predicted_Forces
 4_XSENS_VICON	28/11/2018 11:54	Dossier de fichiers	 PostProcessingForcePrediction1.m
			 PostProcessingForcePrediction2.m

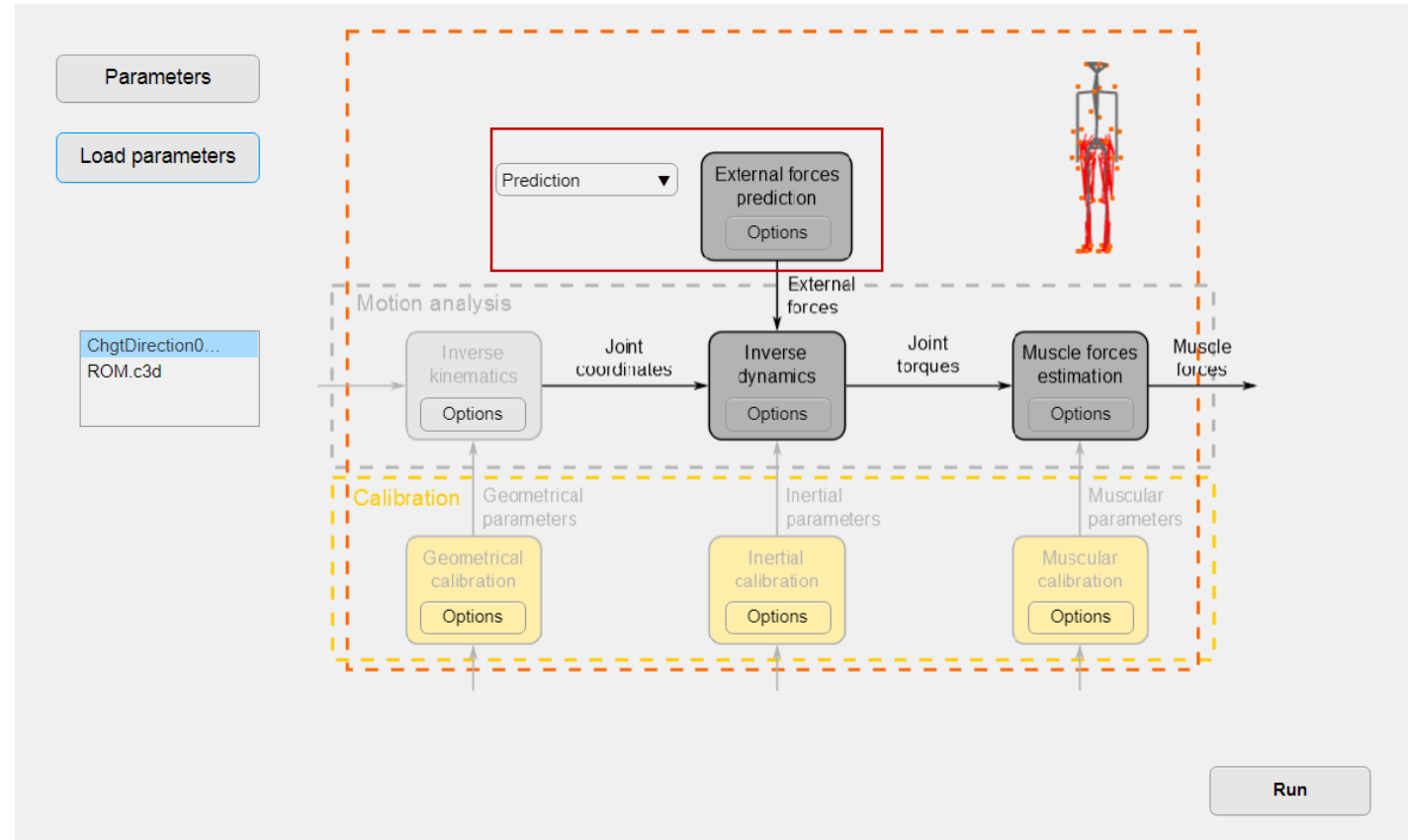
Force prediction: what does this mean ?

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 Ctrl+Click or Shift+Click to select multiple points**

OK

☒ Predicted forces filtering Cut-off frequency (Hz) 5

Position threshold (m) 0.05

Velocity threshold (m/s) 0.8

Friction coefficient 0.5

Contact Points

RFoot ▼

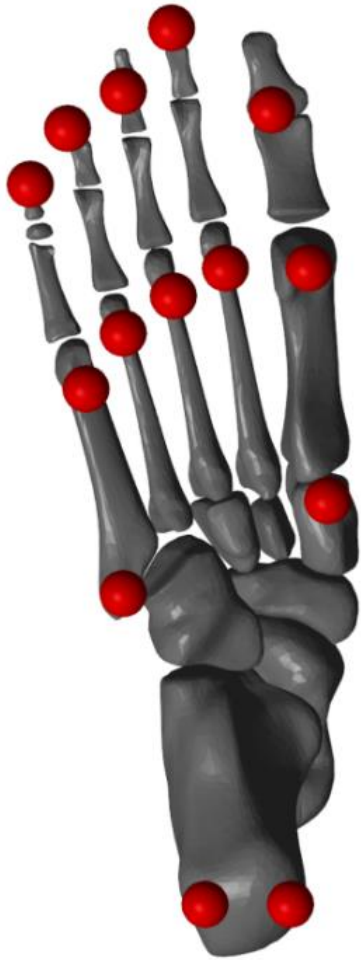
- RFootPrediction6
- RFootPrediction7
- RFootPrediction8
- RFootPrediction9

LFoot ▼

- LFootPrediction6
- LFootPrediction7
- LFootPrediction8
- LFootPrediction9

Delete Add

What are these points ?



Anatomical points defined on the feet as contact points

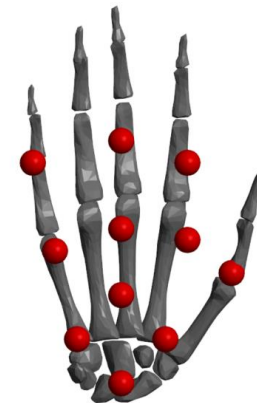
See [...\Functions\Models\Osteoarticular\Leg\ModelParts\foot.m](#)

R. Fluit, M. S. Andersen, S. Kolk, N. Verdonchot, 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

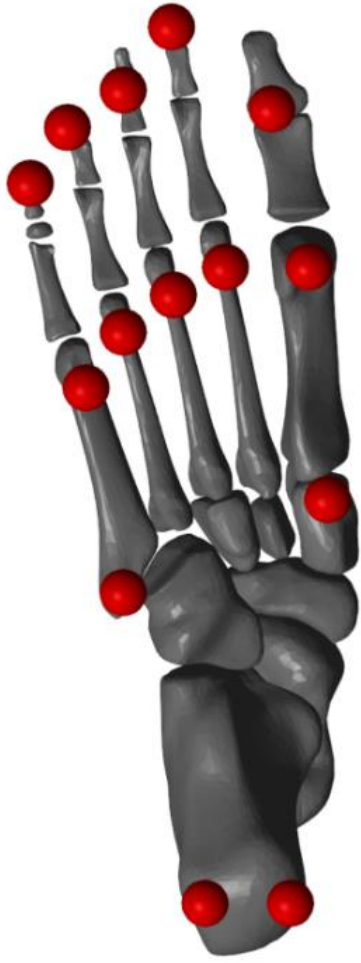
S. Skals, M. K. Jung, M. Damsgaard, and M. S. Andersen, "Prediction of ground reaction forces and moments during sports-related movements," *Multibody system dynamics*, vol. 39, no. 3, pp. 175–195, 2017

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 thresholds ?



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

<input checked="" type="checkbox"/> Predicted forces filtering	Cut-off frequency (Hz)	<input type="text" value="5"/>
Position threshold (m)	<input type="text" value="0.05"/>	
Velocity threshold (m/s)	<input type="text" value="0.8"/>	
Friction coefficient	<input type="text" value="0.5"/>	

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 ?

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

s.t.

$$M_s(q)\ddot{q} + C_s(q, \dot{q}) + G_s(q) + \lambda_s + E_s = 0;$$

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

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

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

Each contact point has a minimal contribution to
the global equilibrium

Results

Run the Post processing files...