Tutorial: “In the wild” movement analysis using dynamic simulations

Answers to questions

- Q1. What does it mean when converged is equal to 1? Hint: use the toolbox documentation.
  → An optimal solution is found

- Q2. What was the final objective value?
  → 18.7804

- Q3. How long did the optimization take?
  → The wall time was 166.7922 seconds and the CPU time 166.5890 seconds.

- Q4. What variables are part of the optimization variables in this problem?
  → The optimization variables are the states, the controls, the duration, and the speed.

- Q5. What was the full objective that was solved for this problem?
  → There were 4 terms. The regularization objective, regTerm, with a weight of 10^{-3}. The effort minimization, effortTermMusclesAct, with a weight of 600. The tracking of accelerometer data, trackAcc, with a weight of 2. The tracking of the gyroscope data, trackGyro, with a weight of 1. Note that the weight of trackAcc is twice as large as for trackGyro since there are two acceleration signals and only one gyroscope signal. This way, each signal is weighted equally.

- Q6. Did we assume left-right symmetry in the problem? Hint: you can find this in the problem itself and in the constraintTerms.
  → No the property isSymmetric in problem is 0, which is also the variable input to the periodicity constraint.

- Q7. What are the different states in the model state?
  → The joint angles, q, the angular velocities, $\dot{q}$, the fibre length, s, the activation a, and for each contact point the force in the horizontal (x) and vertical (y) direction, as well as their location in the global coordinate system.

- Q8. How many degrees of freedom does the skeletal model have?

→ It has nine degrees of freedom: the position and orientation of the trunk, and for each leg the hip, knee, and ankle angle.

- Q9. Would you discard a solution as unrealistic when looking at the ground reaction forces and activations?
  → The impact peaks for effort weights 5000 and 10,000 are too high. Effort weight 1 leads to activations that are too high. They are not smooth and do not reduce to 0, which would be expected at some point in the gait cycle.

- Q10. How much difference do you see in the joint angles and joint moments of the acceptable solutions?
  → The joint angles are very similar, although effort weight 600 has larger peak flexion angles in the hip and effort weight 50 a smaller plantarflexion angle at heel strike. There are more differences in the joint moments, for example for the hip and knee at around 50% of the gait cycle, and in the peak dorsiflexion moment for the ankle.

- Q11: Do you see any differences between the three simulations?
  → The simulations starting from standing and the previous walking simulations are the same. From the midpoint, we do not find a good solution.

- Q12. What does the convergence plot tell you about a suitable number of nodes?
  → the metabolic cost continues to decrease as the number of nodes increases. The convergence seems to happen at around 100 nodes. Note that for a detailed analysis, many more data points are required.

- Q13: Based on the joint angles and joint moments, from which number of nodes do you not see a clear difference between the different simulations anymore?
  → The solutions with 5 and 25 nodes are clearly different. The solution with 50 nodes also leads to different knee and hip moments at around 10% of the gait cycle.

- Q14: Do you think that the constraint function is correct?
  → Eventually, the answer should be yes.

- Q15: Do you get a different result than when the speed is set using the bounds?
  → Yes, although there are some minor differences especially around the start and end of the gait cycle.