LIRIS

UMR 5205 CNRS

Simulation musculo-squelettique, temps-réel et prédictive de marches pathologiques

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OMEGA project

Optimization-based forward musculoskeletal simulation of pathological gait

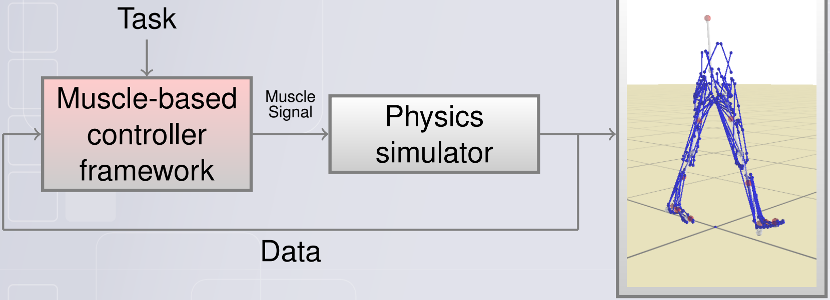
Collaboration

Laboratory for Biomechanics and Biomaterials of Medical School of Hannover.

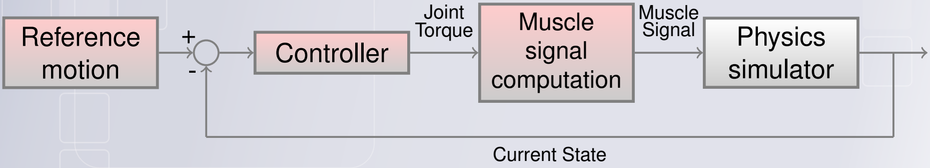
Objective

Predict influences of modification on locomotion with clincal accuracy

Forward Musculoskeletal Simulation

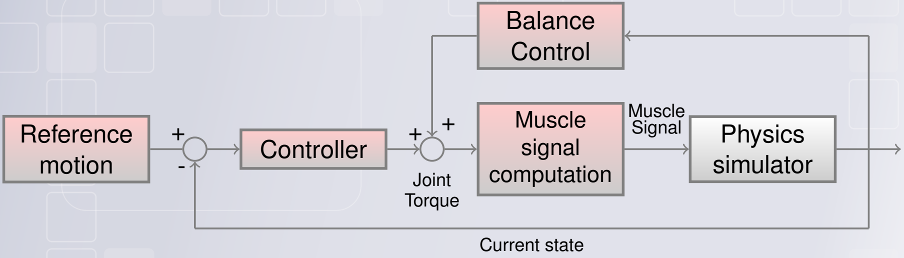


Feedback control



- Controller : PD-controller[9][8], optimal control [5].
- Offline optimisation : Efficiency, pose difference, contact force[5], robustness[7].

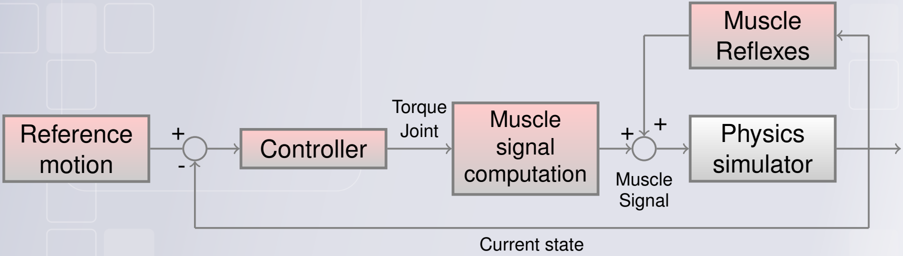
Balance control



- Methods : Inverted pendulum[1], Jacobian transpose control[9]

"Bio-inspired" strategies

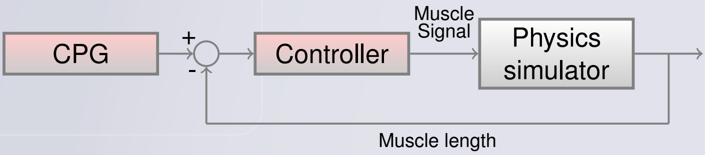
Muscle reflexes



- Muscle Reflexes : Positive force feedback, Positive length feedback [8][3], PD control[4]

"Bio-inspired" strategies

Central Pattern Generator



- Equivalence with pose control but more "bio-inspired".
- CPG : trained with kinematic data[6].

Conclusion

Other method :

- Feedback error learning [9]

Smart association of feedback and feedforward lead to controlability and stability :

- Reference motion optimization and balance control[5]
- CPG and muscle reflexes [2]

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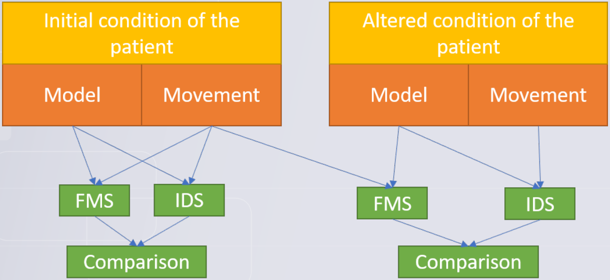
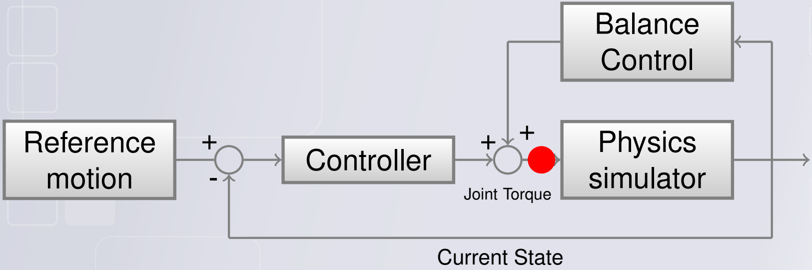
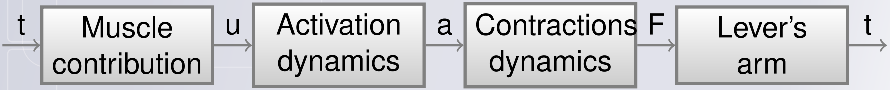


SimBiCon Framework Graph

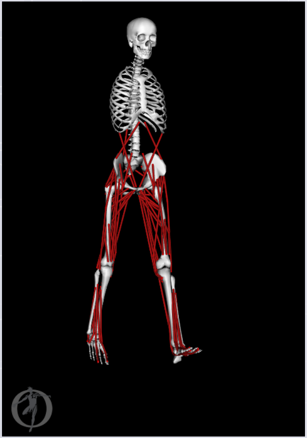


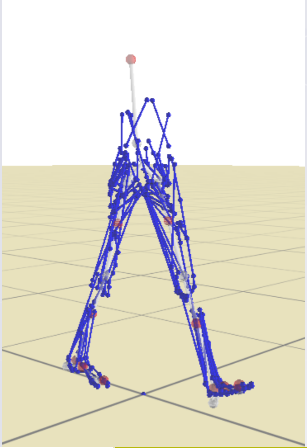
SimBiCon Framework Graph



Open Sim models

- Add tools for importation of OpenSim and AnyBody models





MoCap as reference

Changes :

- Add importation of MoCap data (1 gait cycle)
- Add CMA optimization
- Motion compression and movement summarization

Perspective

Objective :

Minimaze keyposes and tracking of MoCap Data to be as predictive as possible.

- Add objectives terms
- Find optimal keyposes using optimization lead by keyframe selection methods.

Thank you for your attention !

[1] Stelian Coros, Philippe Beaudoin, and Michiel van de Panne. “Generalized biped walking control”. In: *ACM Transactions on Graphics* 29.4 (2010), p. 1.

[2] César Ferreira, Joana Figueiredo, and Cristina P. Santos. “Quadruped locomotion based on central pattern generators and reflexes”. In: *Proceedings - 2015 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2015* (2015), pp. 29–34.

[3] Thomas Geijtenbeek, Michiel van de Panne, and A. Frank van der Stappen. “Flexible muscle-based locomotion for bipedal creatures”. In: *ACM Transactions on Graphics* 32.6 (Nov. 2013), pp. 1–11.

[4] Hartmut Geyer and Hugh Herr. “A Muscle-Reflex Model That Encodes Principles of Legged Mechanics Produces Human Walking Dynamics and Muscle Activities”. In: *IEEE Transactions on Neural Systems and Rehabilitation Engineering* 18.3 (June 2010), pp. 263–273.

[5] Yoonsang Lee et al. “Locomotion control for many-muscle humanoids”. In: *ACM Transactions on Graphics* 33.6 (2014), pp. 1–11.

[6] Weiguang Si. “Realistic Simulation and Control of Human Swimming and Underwater Movement”. In: *PhD thesis, University of California, Los Angeles, Computer Science Department* (2013).

[7] Jack M. Wang, David J. Fleet, and Aaron Hertzmann. “Optimizing walking controllers for uncertain inputs and environments”. In: *ACM Transactions on Graphics* 29.4 (2010), p. 1.

[8] Jack M. Wang et al. “Optimizing locomotion controllers using biologically-based actuators and objectives”. In: *ACM Transactions on Graphics* 31.4 (2012), pp. 1–11. arXiv: `15334406`.

[9] KangKang Yin, Kevin Loken, and Michiel Van De Panne. “SIMBICON: simple biped locomotion control”. In: *ACM SIGGRAPH 2007 papers* ab (2007), p. 105.