AUCKLAND BIOENGINEERING INSTITUTE
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New Actuators for Lower Limb Prosthetics and Assistive Devices

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Background

Lower limb prosthetics and assistive devices have traditionally been designed using rotary actuators. Linear actuators are better suited for this application because they are more compact and controllable.

Aim

To create a prototype design for a limb assistive device using linear actuators.

The design assumption is that the limbs are completely incapacitated and force generation is purely dependent on the linear actuators.

The device was designed to recreate the motions associated with walking at a normal pace.

Method

Lower limb locomotion was simulated using an open source simulation package (Opensim[1]). Parameters for the linear actuators required to recreate the motions associated with locomotion were obtained.

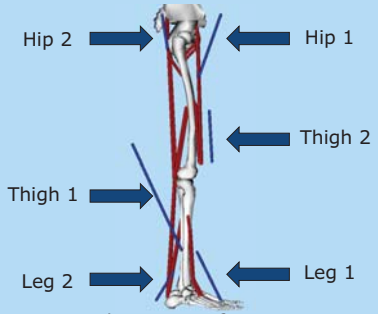


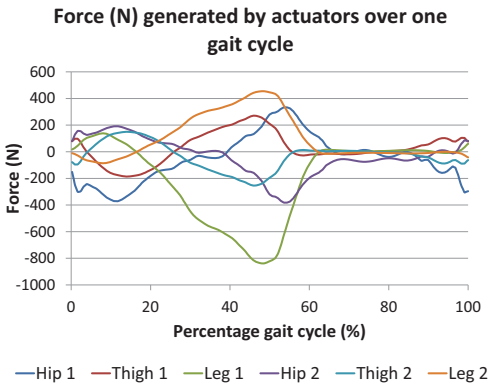
Figure 1: Side view of Opensim model showing muscles (red) and labeled actuators (blue).

A physical version of the simulated model was recreated using rapid prototyping.

Simulation Results

The simulations in Opensim provided data on actuator performance required to reproduce the action of walking.

The following graphs illustrate the force each actuator has to produce and actuator lengths over a single gait cycle for the model to "walk" without limb muscle actuation. 12 actuators were used in our model (6 actuators per leg).



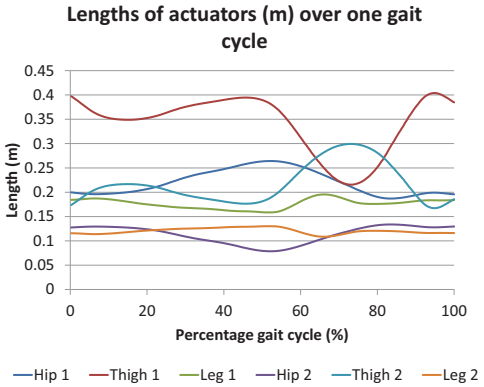


Figure 2: Graphs showing the force generated and length of each actuator attached to the right leg

Prototype

A 1:1 scale CAD model of the simulation model was created in Solidworks and this was used to create a 1:2 scale physical model using rapid prototyping techniques.

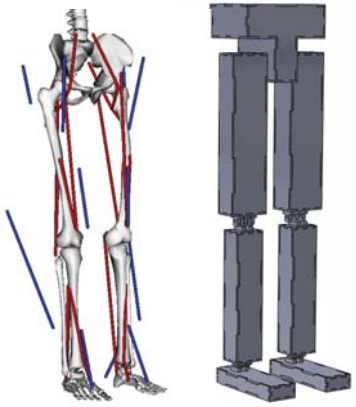


Figure 3: Opensim model and CAD model created in Solidworks

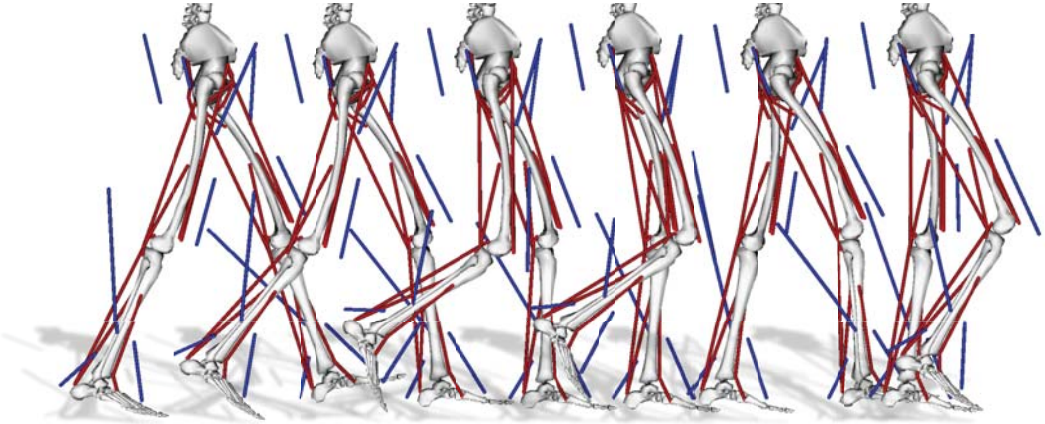


Figure 4: Opensim model recreating recorded gait of a 75kg, 1.8m tall male[2].

Future Work

- Enabling actuation of prototype by manufacturing and attaching linear actuators to the prototype
- Performing simulations for other common lower limb movements (eg: sit-to-stand, climbing stairs)
- Designing an actuator-human interface to couple the actuators to the human body
- Designing a real-time control system for the device

References

1. Delp, S. L., Anderson, F. C., Arnold, A. S., Loan, P., Habib, A., John, C. T., ... & Thelen, D. G. (2007). OpenSim: open-source software to create and analyze dynamic simulations of movement. *Biomedical Engineering, IEEE Transactions on*, *54*(11), 1940-1950.
2. Umberger, B. R. (2010). Stance and swing phase costs in human walking. Journal of The Royal Society Interface, 7(50), 1329-1340.

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