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Passive Dynamic System for Energy Returning on Transtibial Prosthesis

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Outline

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Recent Advances in Commercial Prosthesis

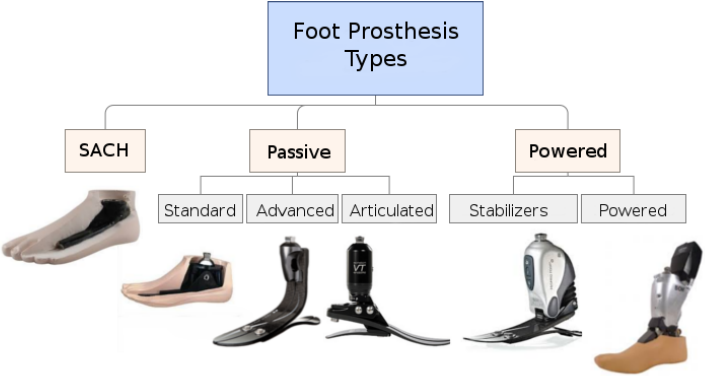


Figura 1: Commercial prosthesis classes grouping. Adapted from Cherelle *et al.* [1]

Energy Returning Principle

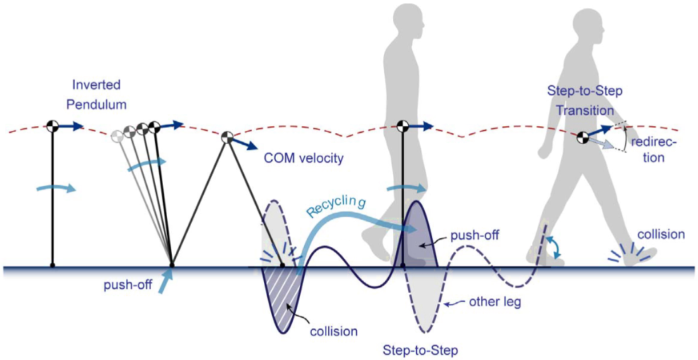


Figura 2: The leg in stance behaves similar to an inverted pendulum, supporting the body CoM until the other leg contacts the ground and mechanical energy is dissipated, then the vector velocity of the CoM is redirected. Figure modified from Collins and Kuo[26].

Principles of Prosthetic Feet

- Stiffness/flexibility.
- Damping.
- Roll-Over characteristics.
- Active push-off in late stance phase.
- Toe clearance during swing phase

The Ankle Dynamic Joint Stiffness (DJS)

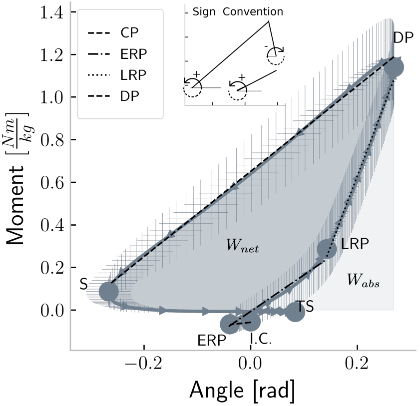


Figura 3: Description of the Ankle DJS characteristics. Turning points represented as initiating: Contact (I.C), Early Response Phase (ERP), Late Response Phase (LRP), Descending Phase (DP), Swing (S) and Terminal Swing (TS). Regression fits: Controlled Plantar-flexion (CP), ERP, LRP and DP. Ankle DJS direction, mechanical net work (W_{net}), absorbed work (W_{abs}) and SD are shown on each DJS plot.

Índice

Identificación del problema

Problem Statement

The recent passive prosthesis for transtibial amputees produce disorders in the dynamic parameters of the gait, owing to the absence of positive work of the limb loss.

Problem Identification

Research Question

Which passive ankle-foot prosthesis based on cellular solids configurations, will generate the positive work needed for push-off, taking advantage of the energy lost at initial contact of the gait?

Hipótesis

A passive dynamic system (compound of cellular solids) within a passive ankle-foot prosthesis, configured to store energy in a controlled manner at initial contact of the early stance phase, will enable to return the stored energy after dorsiflexion phase.

Índice

General Objective

To suggest an ankle-foot prosthesis being able to generate - through a passive dynamic system - the positive work needed for push-off after dual-flexion phase, taking advantage of the energy lost at initial contact of the gait.

Specific Objectives

1. Identify biomechanical parameters and the work-loop slope of ESR prosthesis users and non-amputees aiming to obtain the ankle quasi-stiffness of both cases.
2. Obtain a preliminary model of the ankle-foot prosthesis capable of storing energy (during initial contact until late dual-flexion phase), and returning it at dorsi-flexion phase in a controlled manner through the passive dynamic system.
3. Determine detailed configurations of cellular solids that accomplish the requirements of the preliminary model.
4. Validate the dynamic model of the ankle-foot prosthesis in comparison to an ESR prosthesis.

Índice

Methodology *In Silico*

Validation process

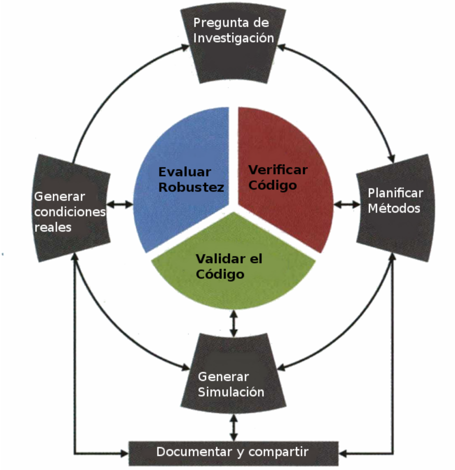
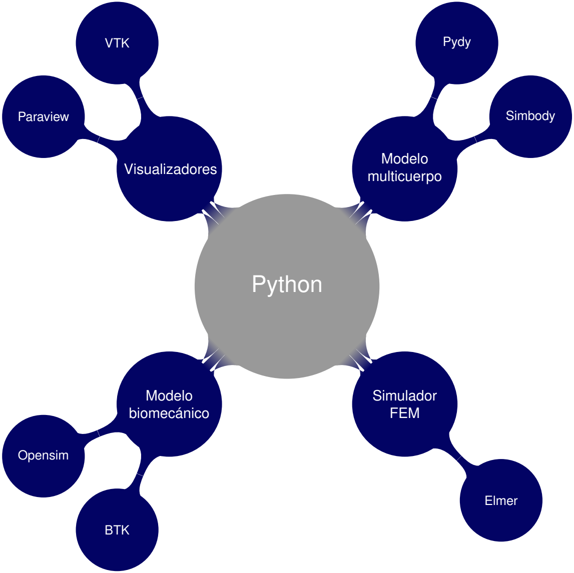


Figura 4: Proceso metodológico modelo *In silico*. Tomado de [27].

Methodology *In Silico*

Computational Framework implemented.



Development of the 1st Objective

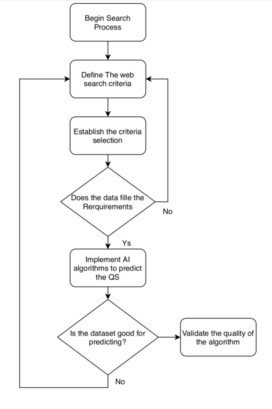


Figura 5: Execution flowchart for Obj. 1

Figura 6: Marker Experiments taken from Horst

Methodology *In Silico*
Validation process

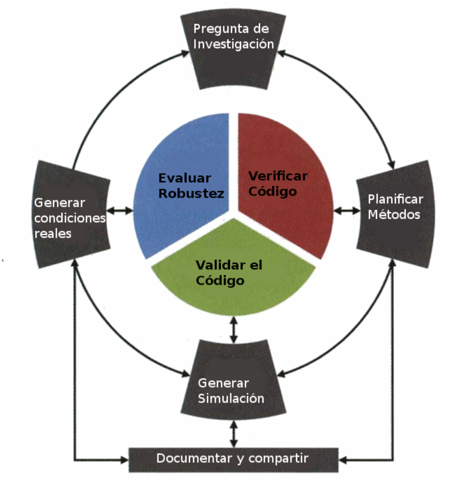


Figura 7: Proceso metodológico modelo *In silico*. Tomado de [27].

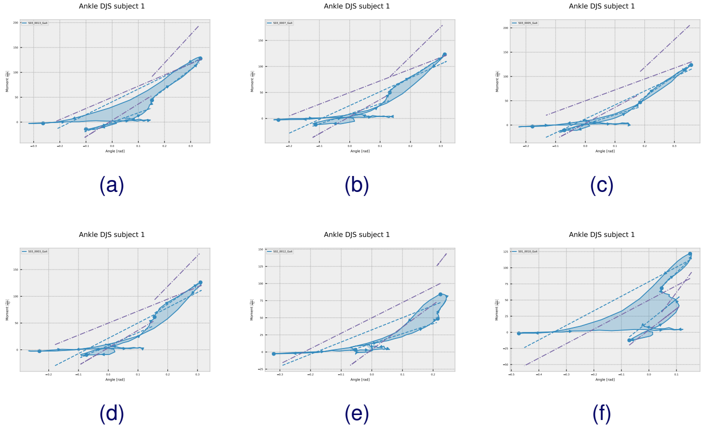
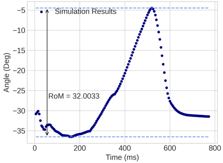
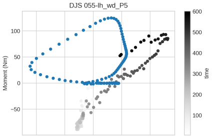


Figura 8: comparison of the predicted feature vs testing sample

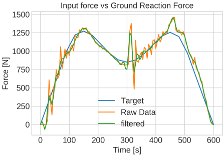
Sensitivity Analysis



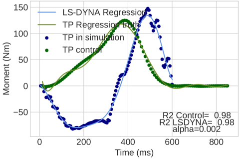
(a)



(b)



(c)



(d)

Figura 9: Variable outputs

Thickness analysis

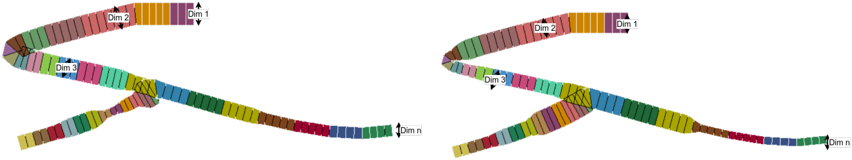


Figura 10: Thickness Varation samples

Shape Optimization analysis

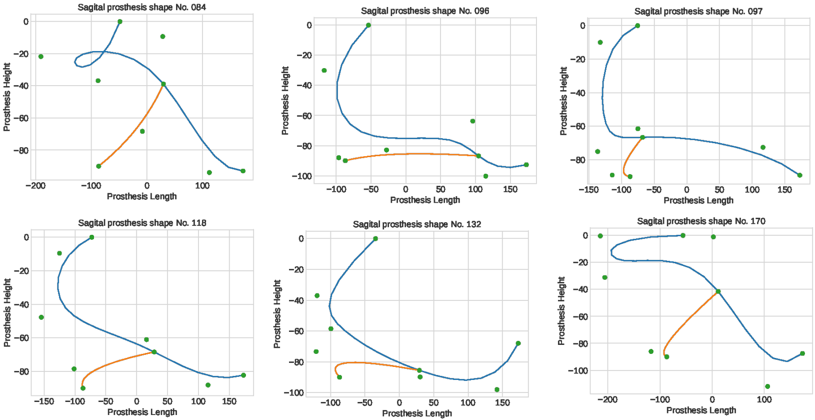


Figura 11: Thickness Varation samples

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Thank You!

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