



# Introduction to (loco)motion

Multibody dynamics and musculoskeletal modelling



UNIVERSITATEA  
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# Agenda

- Multibody analysis
- Basic human anatomy
- Types of joints
- Movement production
- Simulations



# Muskuloskeletal modeling

## Human anatomy

What does the word 'musculoskeletal' mean to you?



# Muskuloskeletal modeling

## Human anatomy

What does the word 'musculoskeletal' mean to you?



# Muskuloskeletal modeling

## Human anatomy

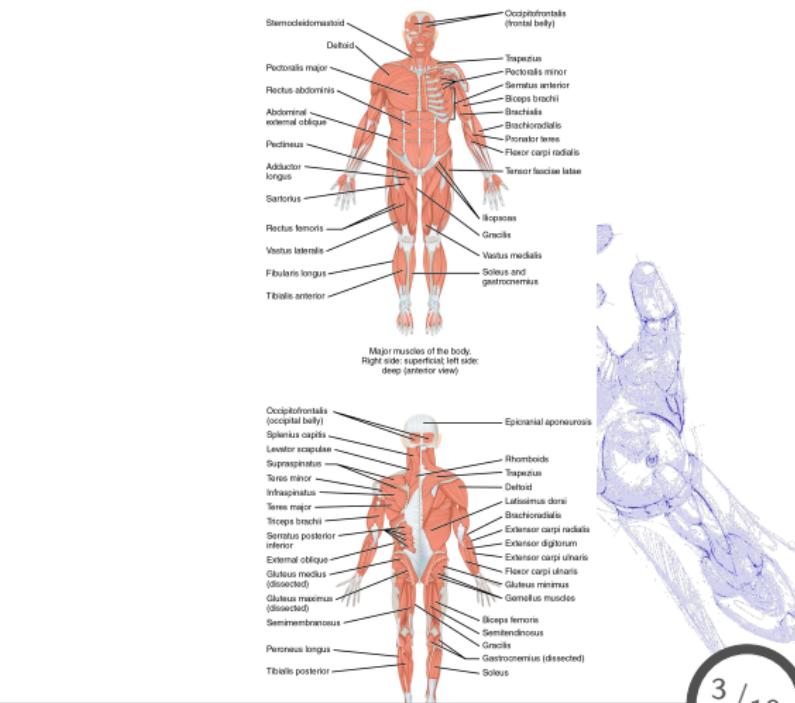
What does the word 'musculoskeletal' mean to you?



# Muskuloskeletal modeling

## Human anatomy

What does the word 'musculoskeletal' mean to you?



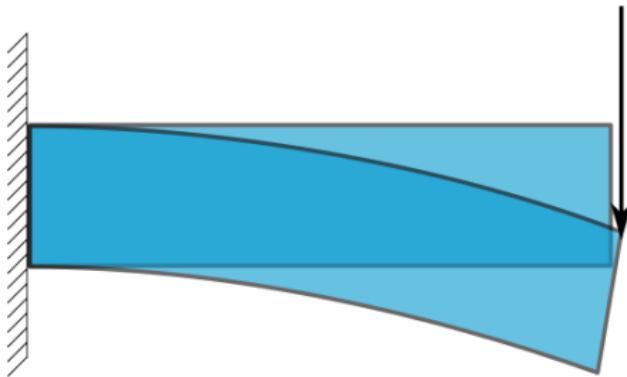
# Multibody analysis

Until now, we studied single bodies



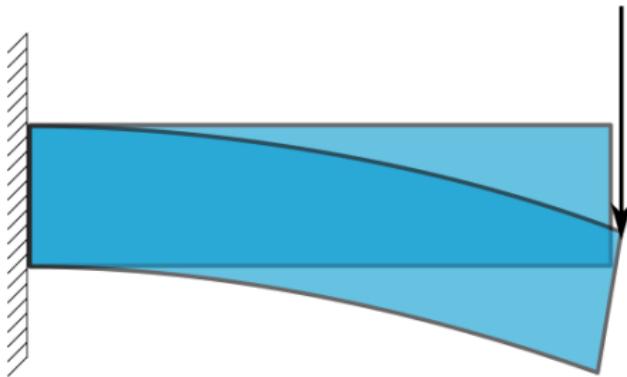
# Multibody analysis

Until now, we studied single bodies, and how they respond to external loading



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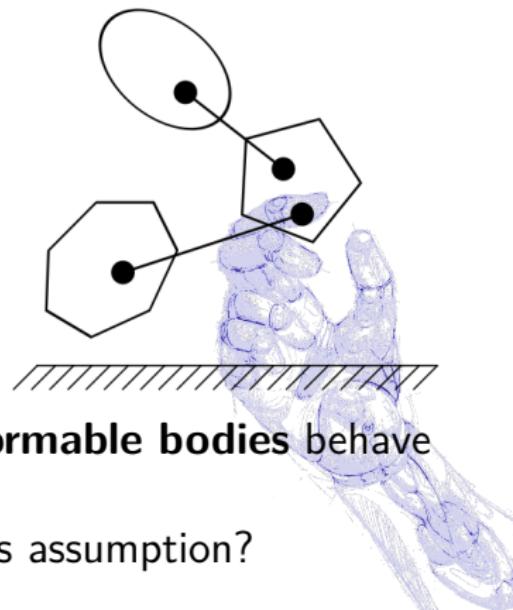
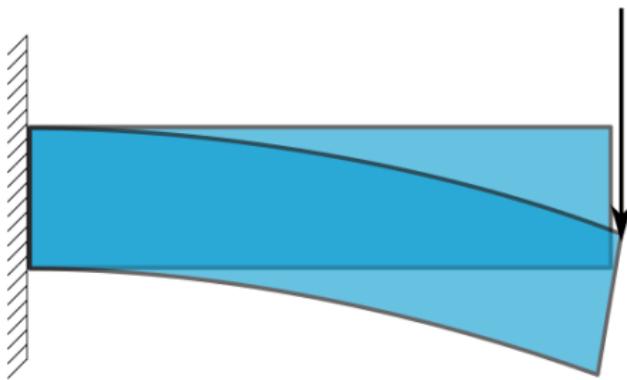


We will now study how multiple non-deformable bodies behave under external forces



# Multibody analysis

Until now, we studied single bodies, and how they respond to external loading



We will now study how multiple **non-deformable bodies** behave under external forces

Why non-deformable? How relevant is this assumption?

# Musculoskeletal modeling

## Joints

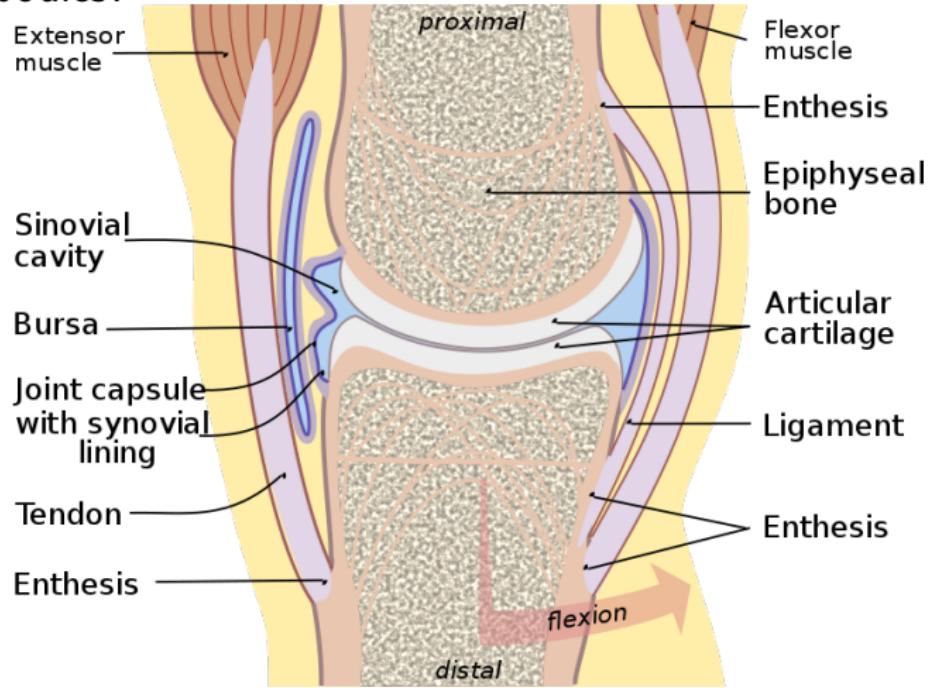
How come we have motion if we have rigid, non-deformable bodies?



# Musculoskeletal modeling

## Joints

How come we have motion if we have rigid, non-deformable bodies?



# Articulated joints

## Types of joints

Characterization based on degrees of freedom



# Articulated joints

## Types of joints

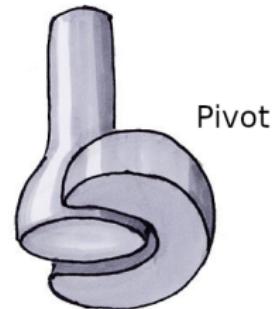
Characterization based on **degrees of freedom**



# Articulated joints

## Types of joints

Characterization based on **degrees of freedom**



By Produnis



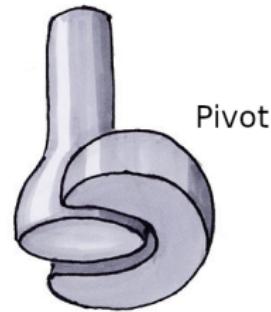
# Articulated joints

## Types of joints

Characterization based on **degrees of freedom**



Hinge



Pivot

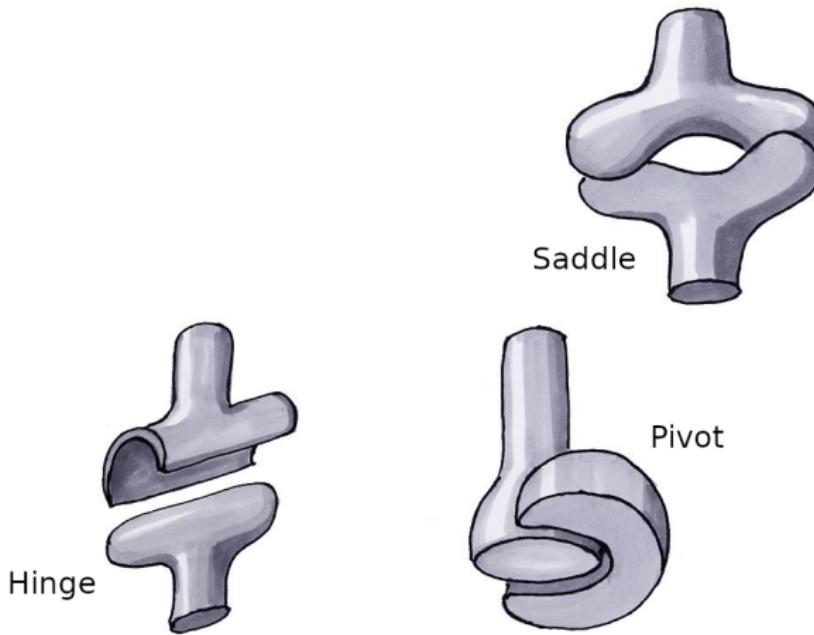
By Produnis



# Articulated joints

## Types of joints

Characterization based on **degrees of freedom**

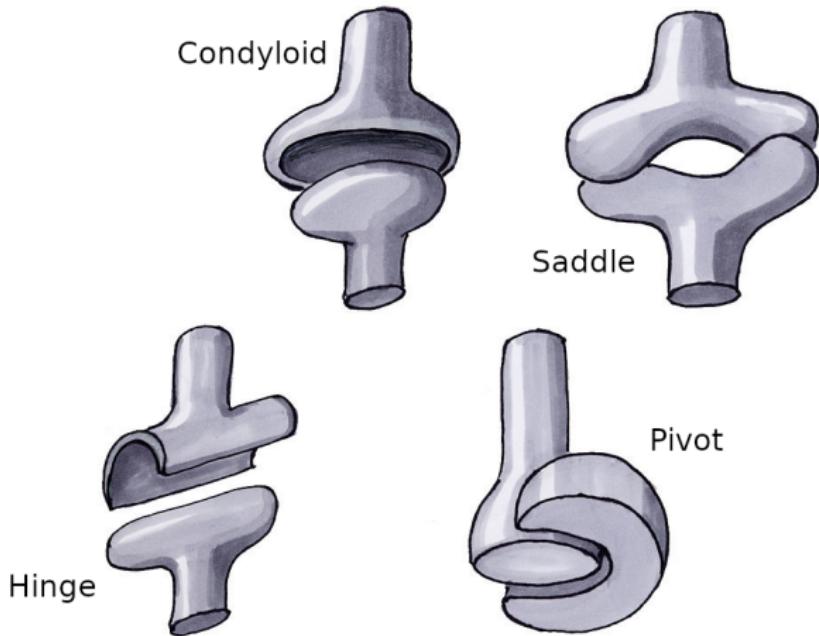


By Produnis

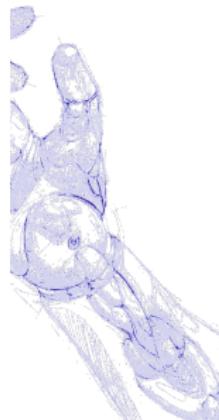
# Articulated joints

## Types of joints

Characterization based on **degrees of freedom**



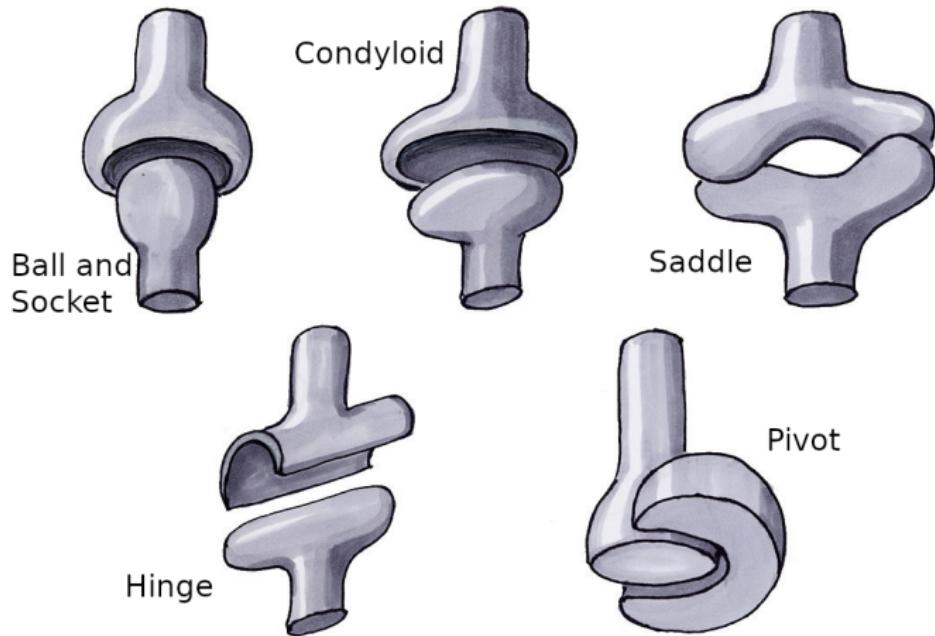
By Produnis



# Articulated joints

## Types of joints

Characterization based on **degrees of freedom**



By Produnis

# Articulated joints

## Types of joints

# Exercise time!

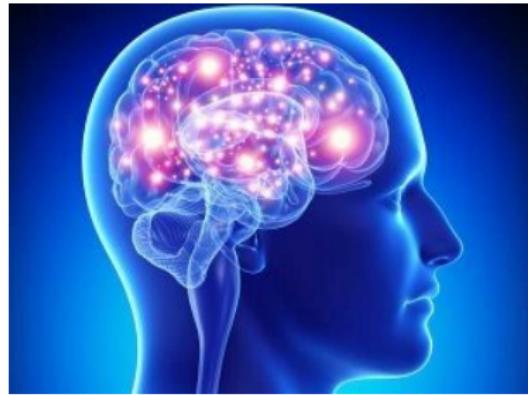
Which type for which joint in the body?



# Musculoskeletal modelling

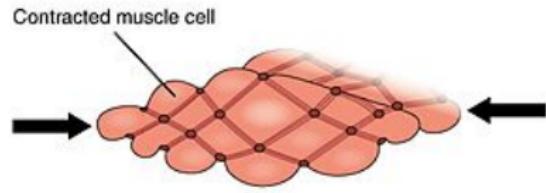
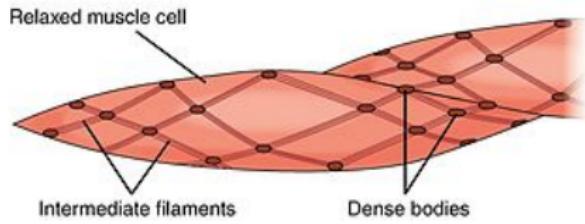
## Movement production

Neural  
Command



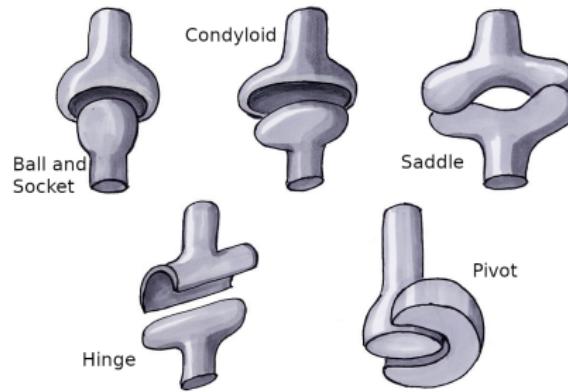
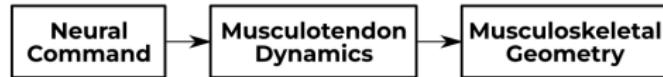
# Musculoskeletal modelling

## Movement production



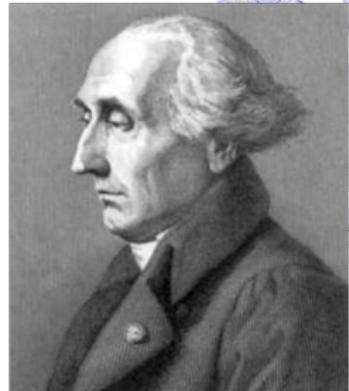
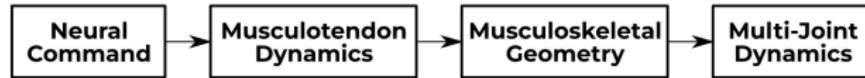
# Musculoskeletal modelling

## Movement production



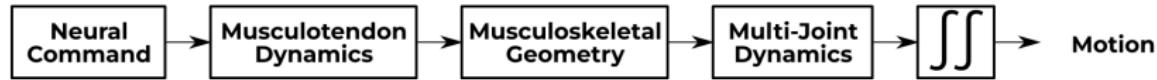
# Musculoskeletal modelling

Movement production



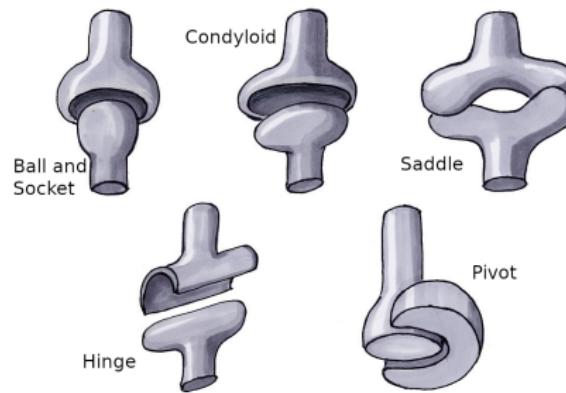
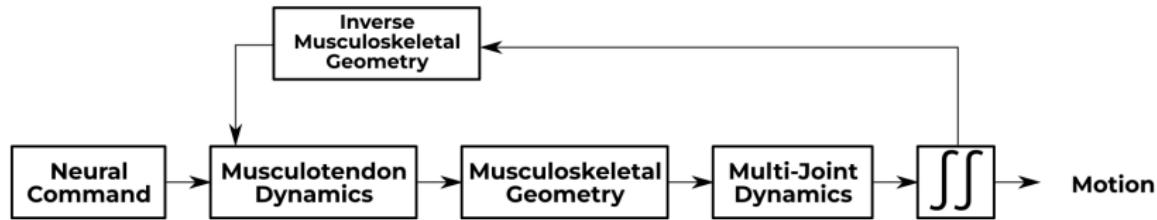
# Musculoskeletal modelling

Movement production



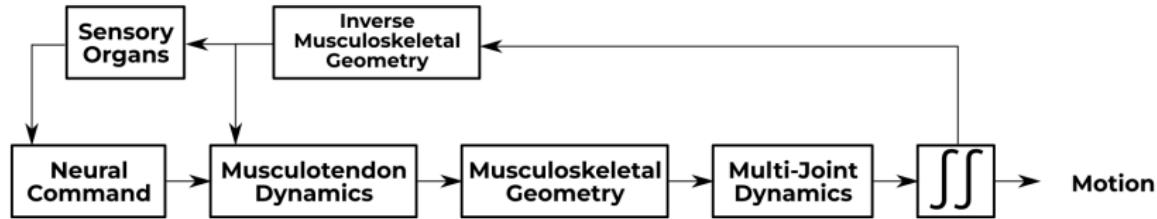
# Musculoskeletal modelling

## Movement production



# Musculoskeletal modelling

## Movement production



# Musculoskeletal modelling

## Feedback

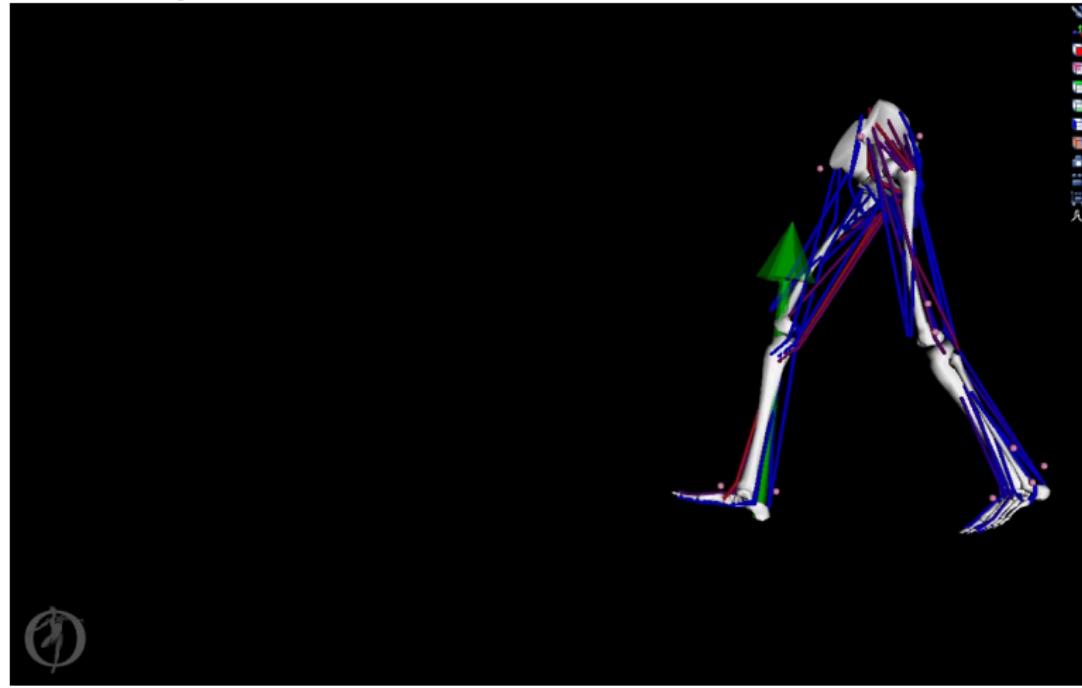
What is feedback?



# Musculoskeletal modelling

## Models

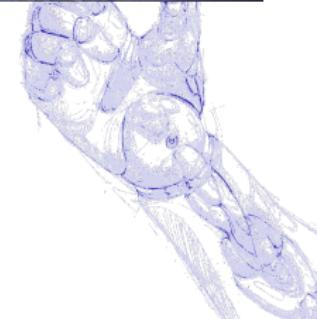
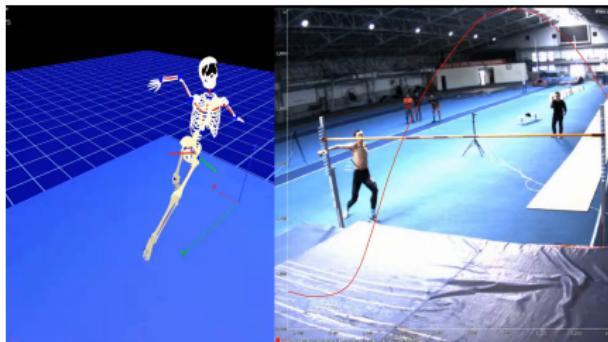
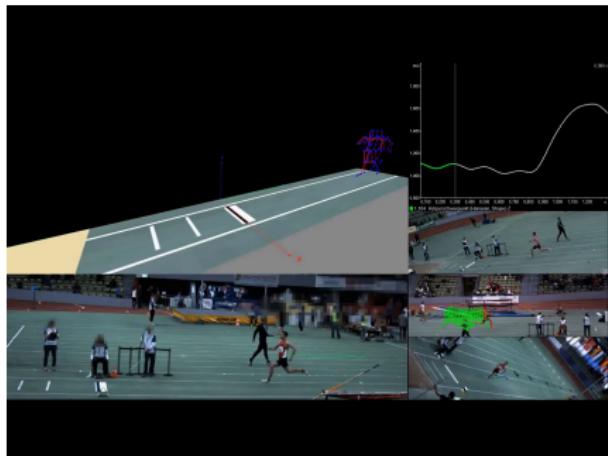
### Gait analysis



# Musculoskeletal modelling

## Models

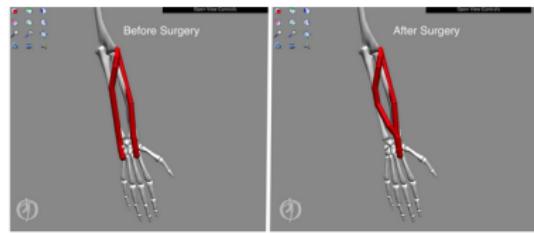
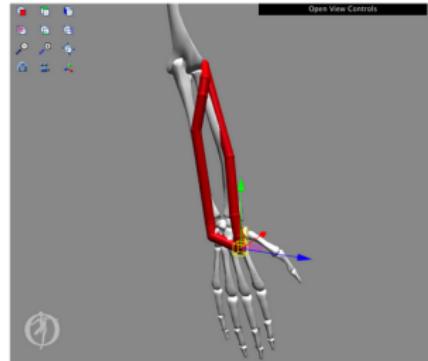
### Sports performance



# Musculoskeletal modelling

## Models

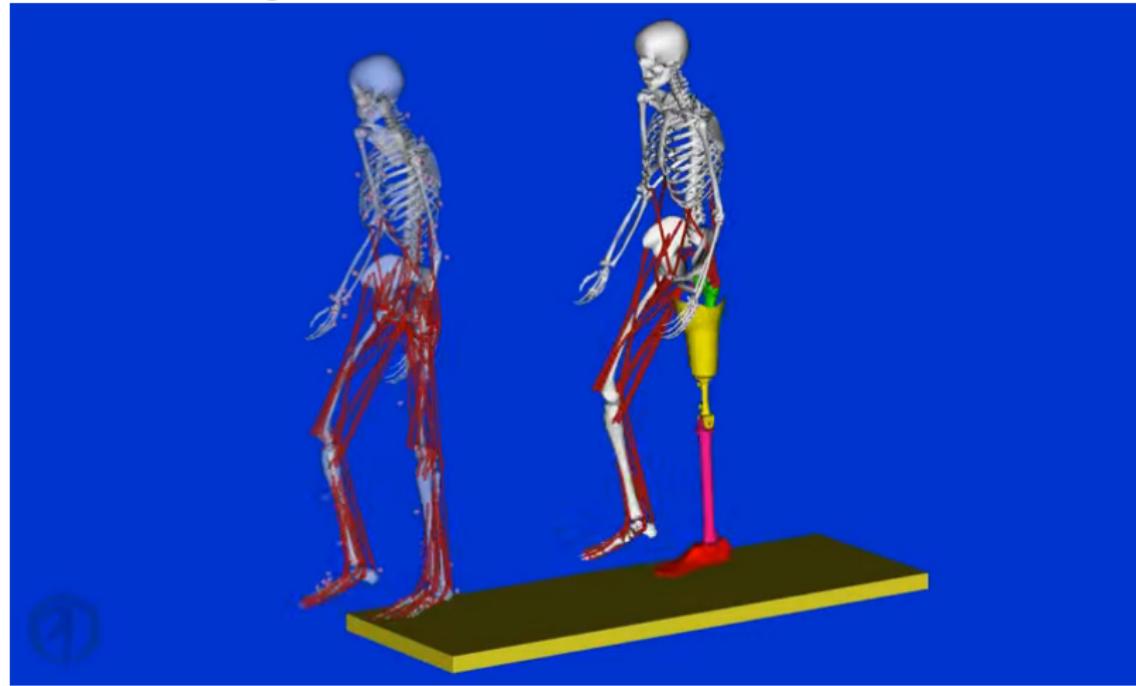
### Surgery planning



# Musculoskeletal modelling

## Models

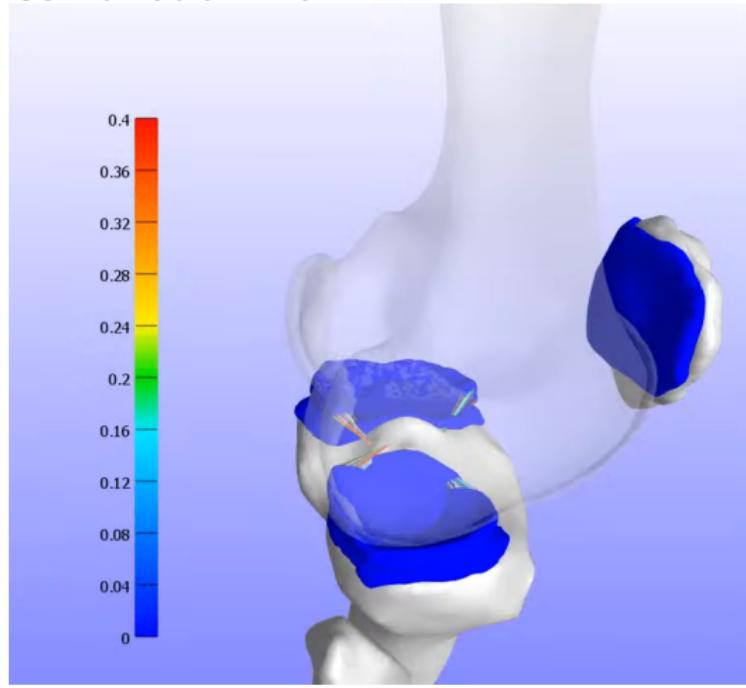
### Prothesis design



# Musculoskeletal modelling

## Models

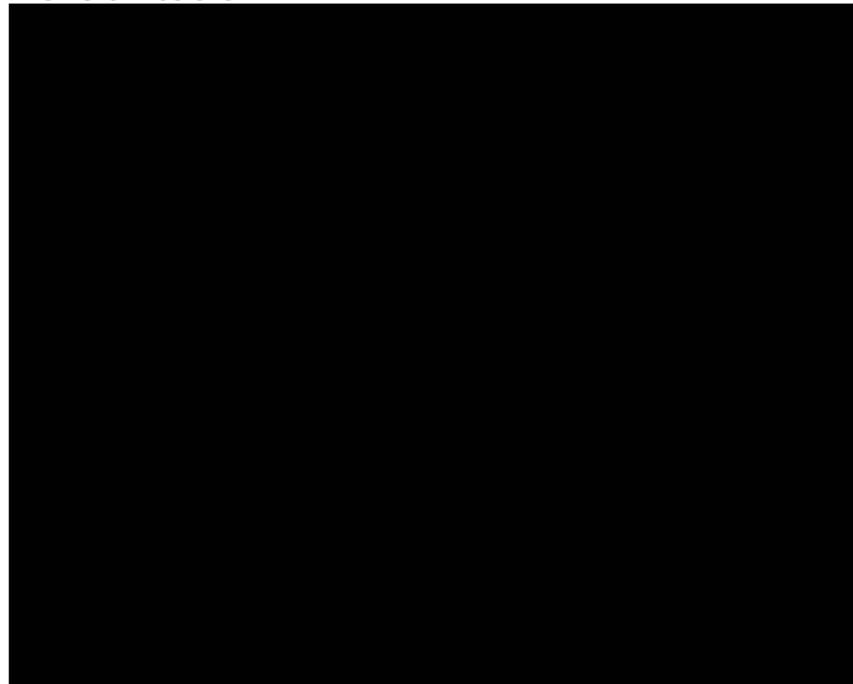
### Combination with FE



# Musculoskeletal modelling

## Models

### Rehabilitation



# Musculoskeletal modelling

## Software

Various software available



# Musculoskeletal modelling

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Various software available

- OpenSim



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- MSMS



# Musculoskeletal modelling

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- MSMS
- SIMM



# Musculoskeletal modelling

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# Musculoskeletal modelling

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- LifeModeler



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# Musculoskeletal modelling

## OpenSim

OpenSim:

- Developed at NIH Center for Biomedical Computation at Stanford University

Video presentation



# Musculoskeletal modelling

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[Video presentation](#)



# Musculoskeletal modelling

## OpenSim

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- Free, open-source
- Global thriving community

[Video presentation](#)



# Coming up next

How muscles work!





# Questions?