H-L-3

Biomechanics case study

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A case study

Digital Human Model

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Tracker

01. Basic functions
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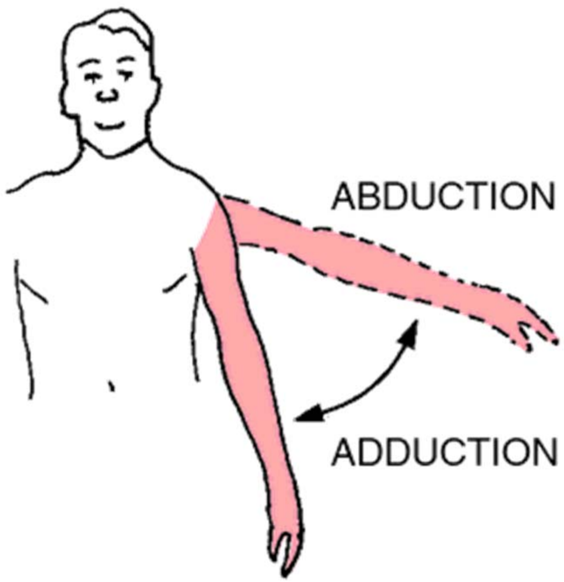
Summary

1	• This is not a complete case study (Demo only)
2	• The main purpose: How to use the tools

Case brief

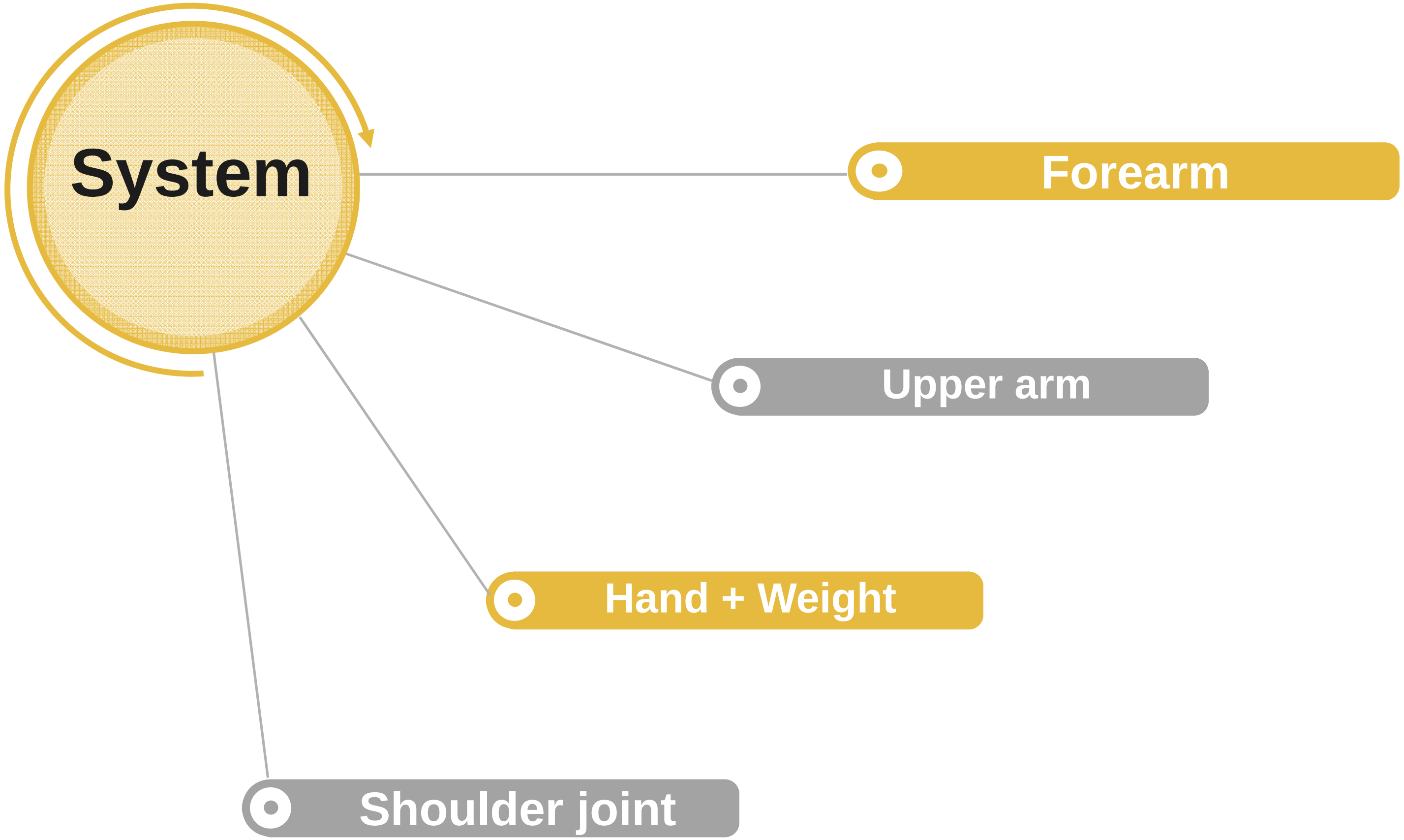


Case brief

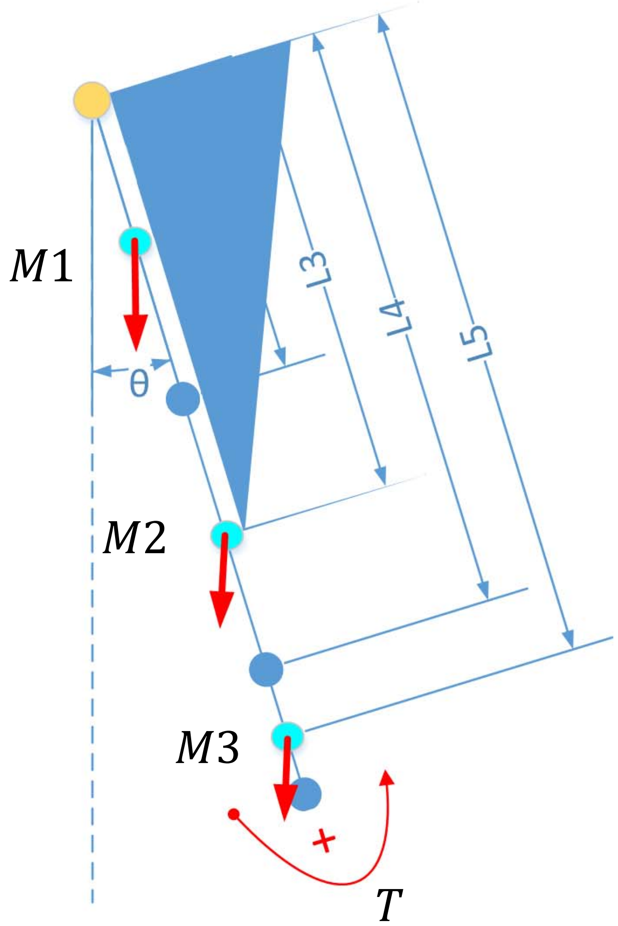
To explore how much torque a person applied on his/her shoulder joint in an abduction movement.

Courtesy of http://medical-dictionary.thefreedictionary.com/adduction

Analysis



Modelling - Sketch



Modelling - Model

$$-(M1L1^2 + M2L3^2 + M3L5^2)\frac{d^2\theta(t)}{dt^2} - (M1gL1 + M2gL3 + M3gL5)sin\theta(t) + T = 0$$

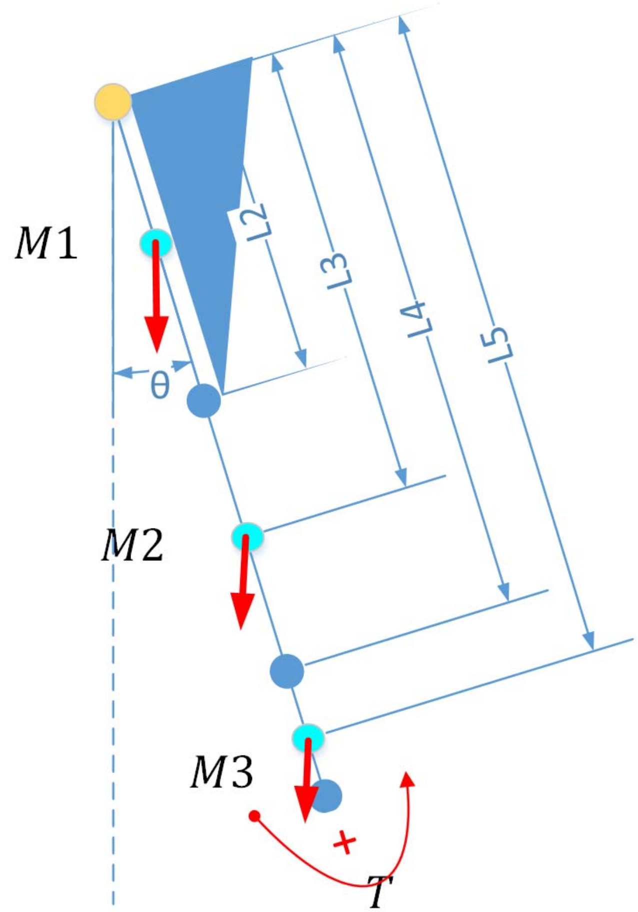
$L2, L4, L5$
Measurement (individual) or
Digital human model

$M1, M2, M3, L1, L3$

Body mass segments

$\theta(t)$

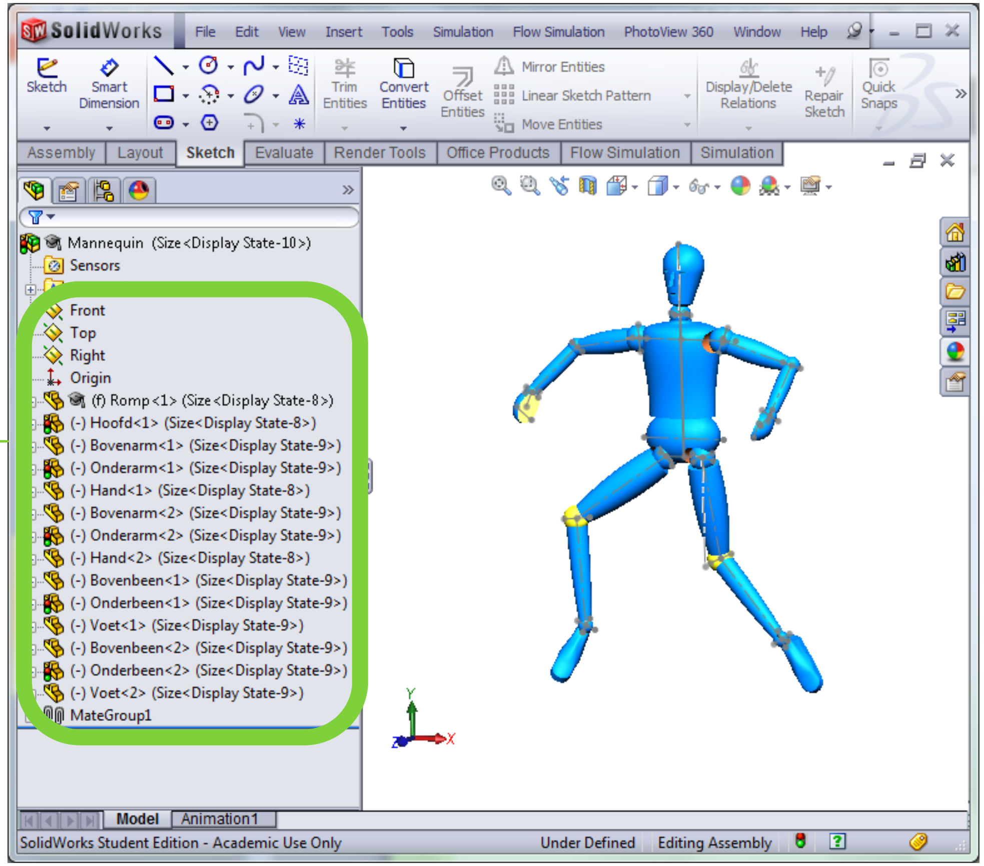
Tracker



The digital human Model

The model - Components

- Romp (trunk)
- Hoofd (head)
- 2* Bovenarm (forearm)
- 2* Onderarm (lower arm)
- 2* Hand
- 2* Bovenbeen (upper leg)
- 2* Onderbeen (lower leg)
- 2* Voet (foot)

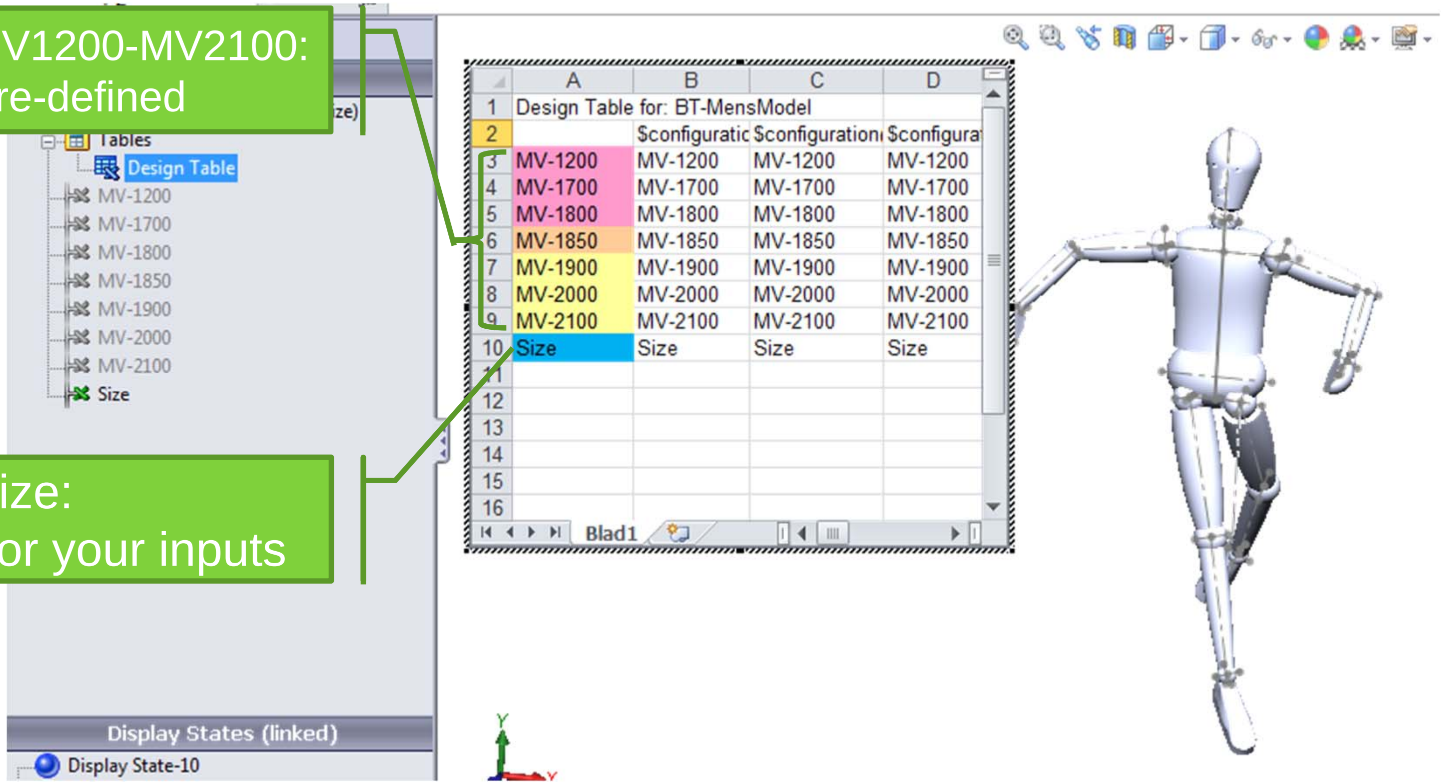


The model

A design table driven DHM: Assembly

MV1200-MV2100:
Pre-defined

Size:
For your inputs

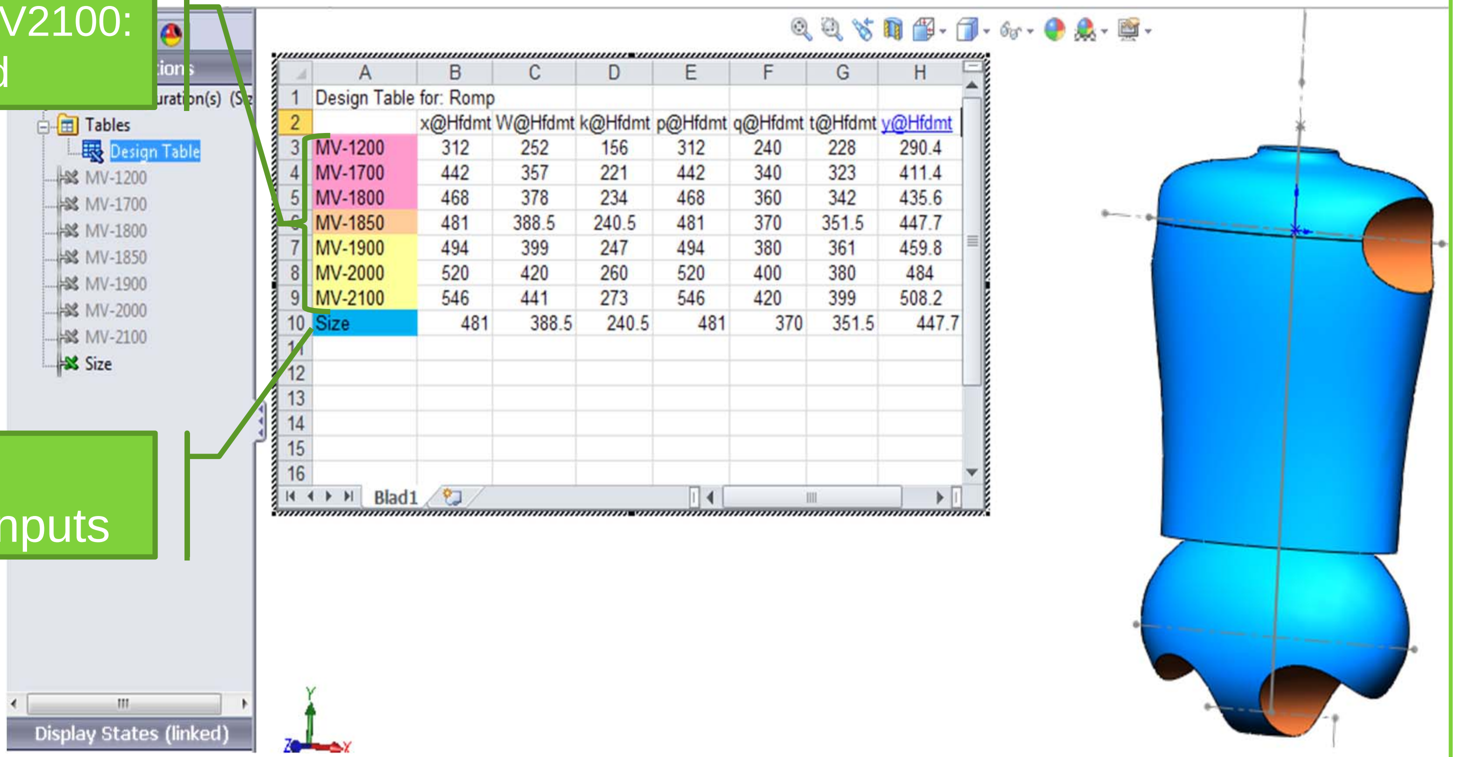


For an individual part

A design table driven DHM: Part

MV1200-MV2100:
Pre-defined

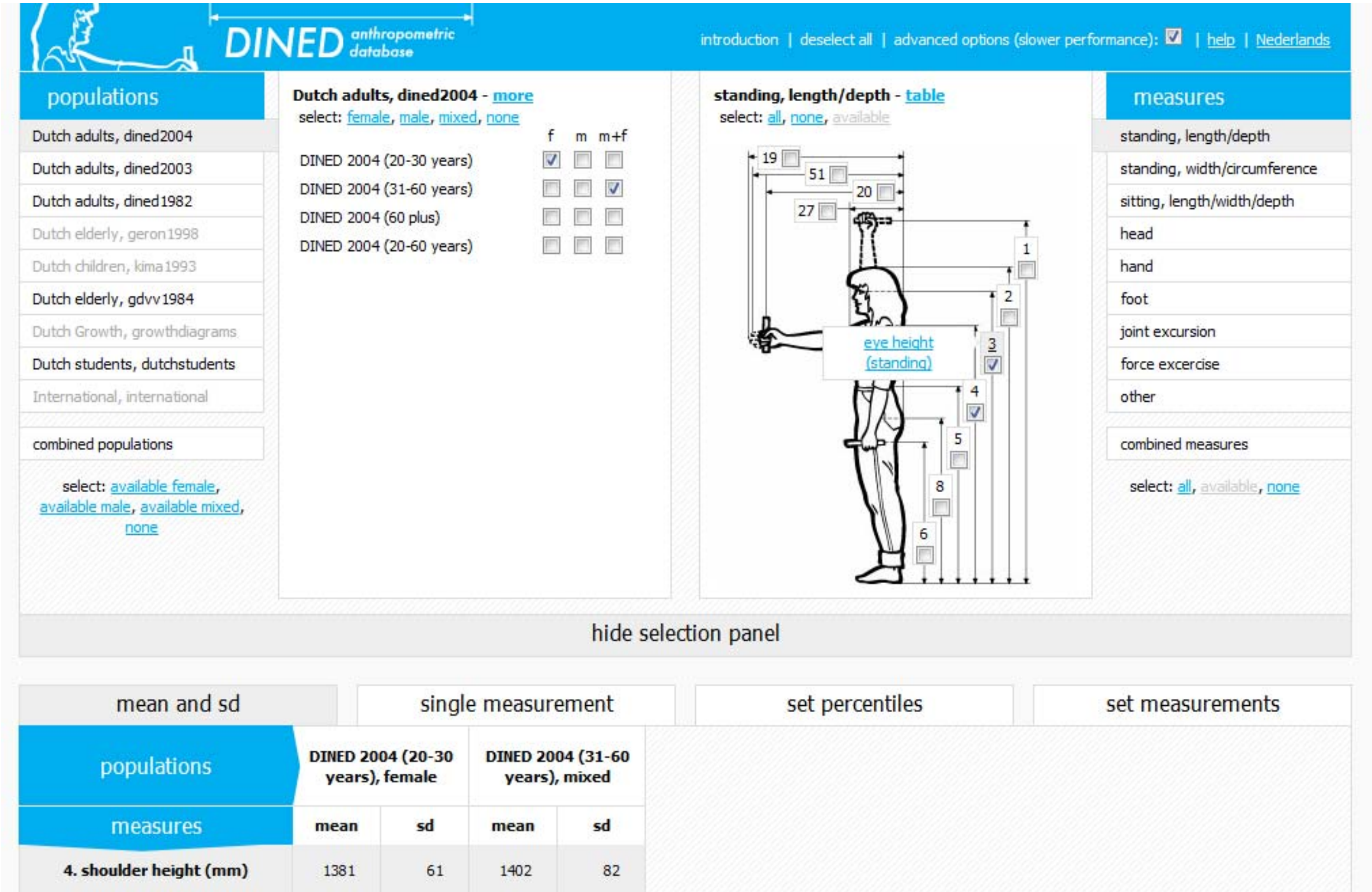
Size:
For your inputs



	A	B	C	D	E	F	G	H
1	Design Table for: Romp							
2		x@Hfdmt	W@Hfdmt	k@Hfdmt	p@Hfdmt	q@Hfdmt	t@Hfdmt	y@Hfdmt
3	MV-1200	312	252	156	312	240	228	290.4
4	MV-1700	442	357	221	442	340	323	411.4
5	MV-1800	468	378	234	468	360	342	435.6
6	MV-1850	481	388.5	240.5	481	370	351.5	447.7
7	MV-1900	494	399	247	494	380	361	459.8
8	MV-2000	520	420	260	520	400	380	484
9	MV-2100	546	441	273	546	420	399	508.2
10	Size	481	388.5	240.5	481	370	351.5	447.7

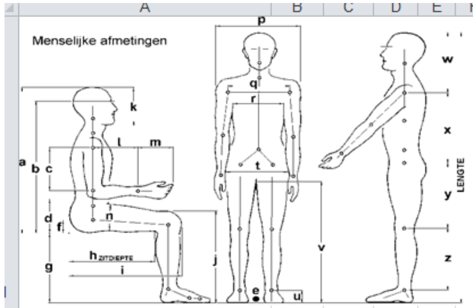
The source of data

dined.io.tudelft.nl/dined/



A simplified version

The excel file



Input the statue **Size** here ↓

HumanMeasures The desired statue is 1850 mm

Do NOT change the table

Neck Hinge (W-K)*0.3 under chin

Average measure regarding the length in %

Length	A	B	C	D	E	G	H	I	J	K	L	M	N	P	Q	R	T1	T2	U	V	W	X	Y	Z	
1473-1981	52%	46%	16.0%	13%	4.3%	25%	27%	34%	31%	13%	14.0%	11%	9.4%	26%	20.0%	17.0%	20%	19%	5.0%	47%	21.0%	26.0%	24.2%	23.6%	100%
																									Default Data
1200	624	552	192	156	52	300	324	408	372	156	168	132	113	312	240	204	240	228	60	564	252	312	290	283	MV-1200
1700	884	782	272	221	73	425	459	578	527	221	238	187	160	442	340	289	340	323	85	799	357	442	411	401	MV-1700
1800	936	828	288	234	77	450	486	612	558	234	252	198	169	468	360	306	360	342	90	846	378	468	436	425	MV-1800
1850	962	851	296	241	80	463	500	629	574	241	259	204	174	481	370	315	370	352	93	870	389	481	448	437	MV-1850
1900	988	874	304	247	82	475	513	646	589	247	266	209	179	494	380	323	380	361	95	893	399	494	460	448	MV-1900
2000	1040	920	320	260	86	500	540	680	620	260	280	220	188	520	400	340	400	380	100	940	420	520	484	472	MV-2000

Check the validity of your model

Attention:

1. It is simplification of DINED data;
2. It is a linear approximation, the most accurate region is 1473mm~1981mm

How to setup customized data

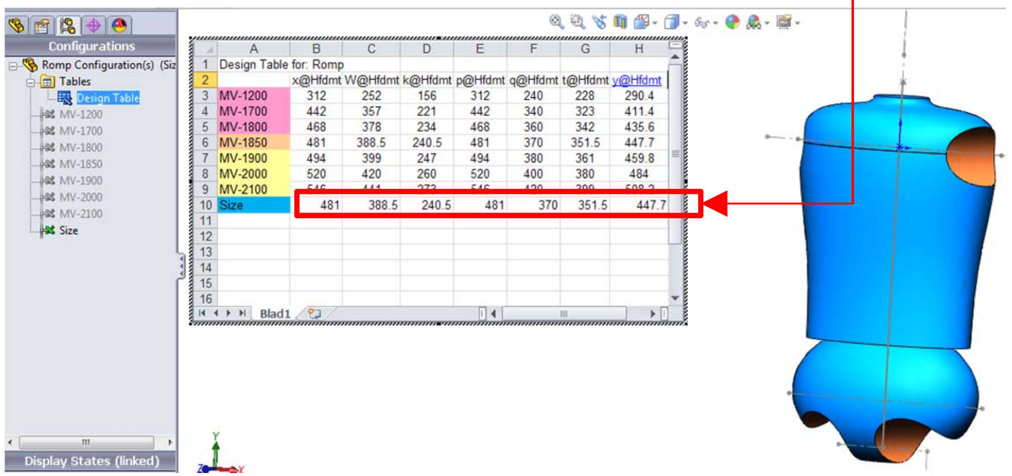
The excel file (each part)

Design Table for: Hull (Romp)							
Parameters	X	W	K	P	Q	T2	Y
MV-1200	312	252	156	312	240	228	290
MV-1700	442	357	221	442	340	323	411
MV-1800	468	378	234	468	360	342	436
MV-1850	481	389	241	481	370	352	448
MV-1900	494	399	247	494	380	361	460
MV-2000	520	420	260	520	400	380	484
MV-2100	546	441	273	546	420	399	508
Size	481	389	241	481	370	352	448

Usage

1. Input the desired stature in the blue Region of excel
2. Copy the data of “size” to the design table of each part, respectively (use paste values option).

The design table of a component in Solidworks

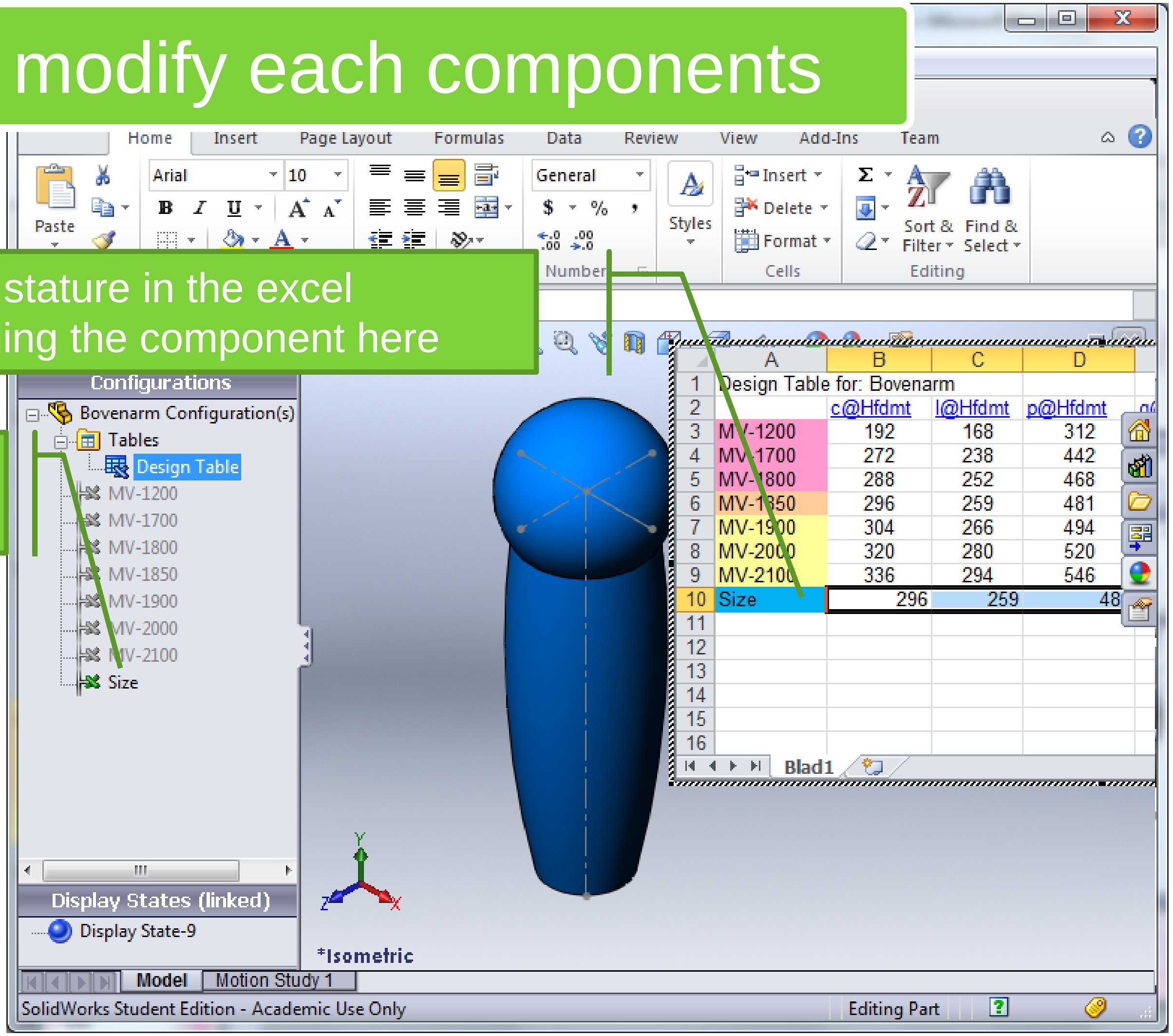


Sizing - Customize

You must modify each components

Input the desired stature in the excel
Copy data regarding the component here

Using “Size”



Direct Sizing – In Assembly

?

MV-1200

MV-1700

MV-1800

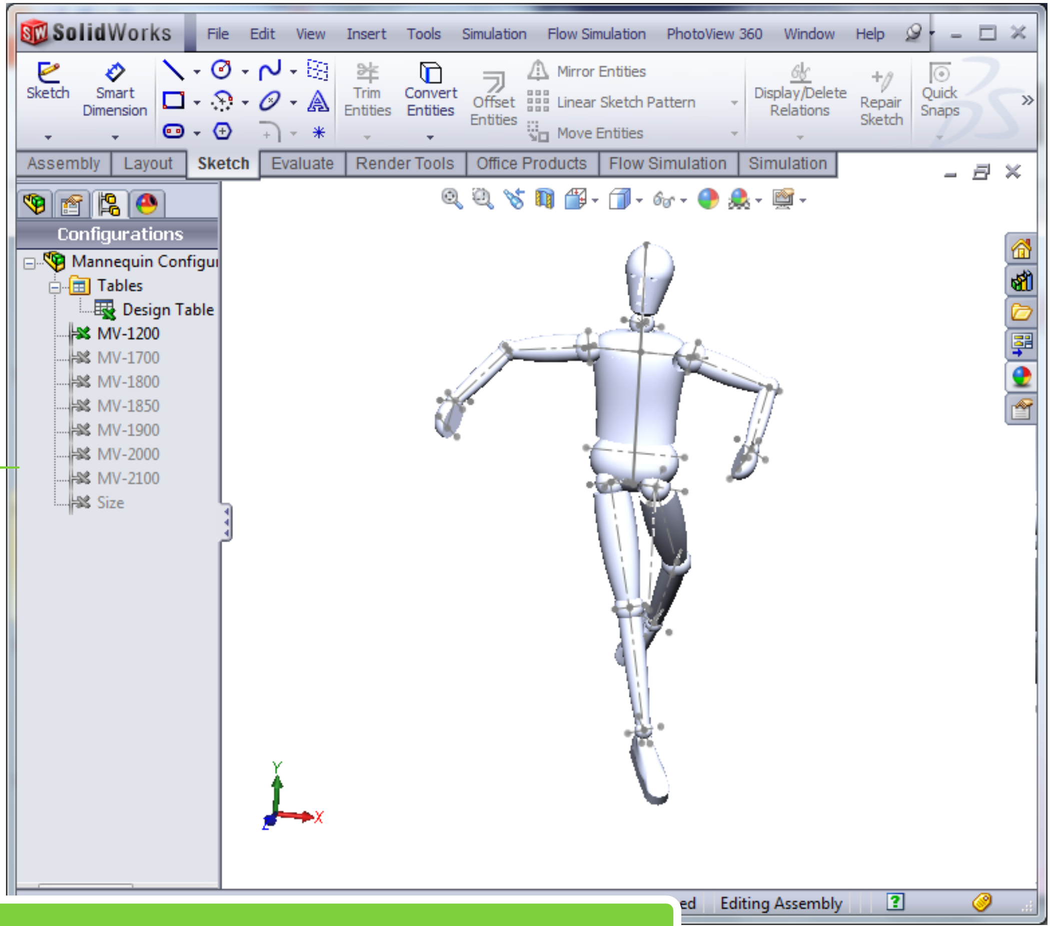
MV-1900

?

MV-2000

?

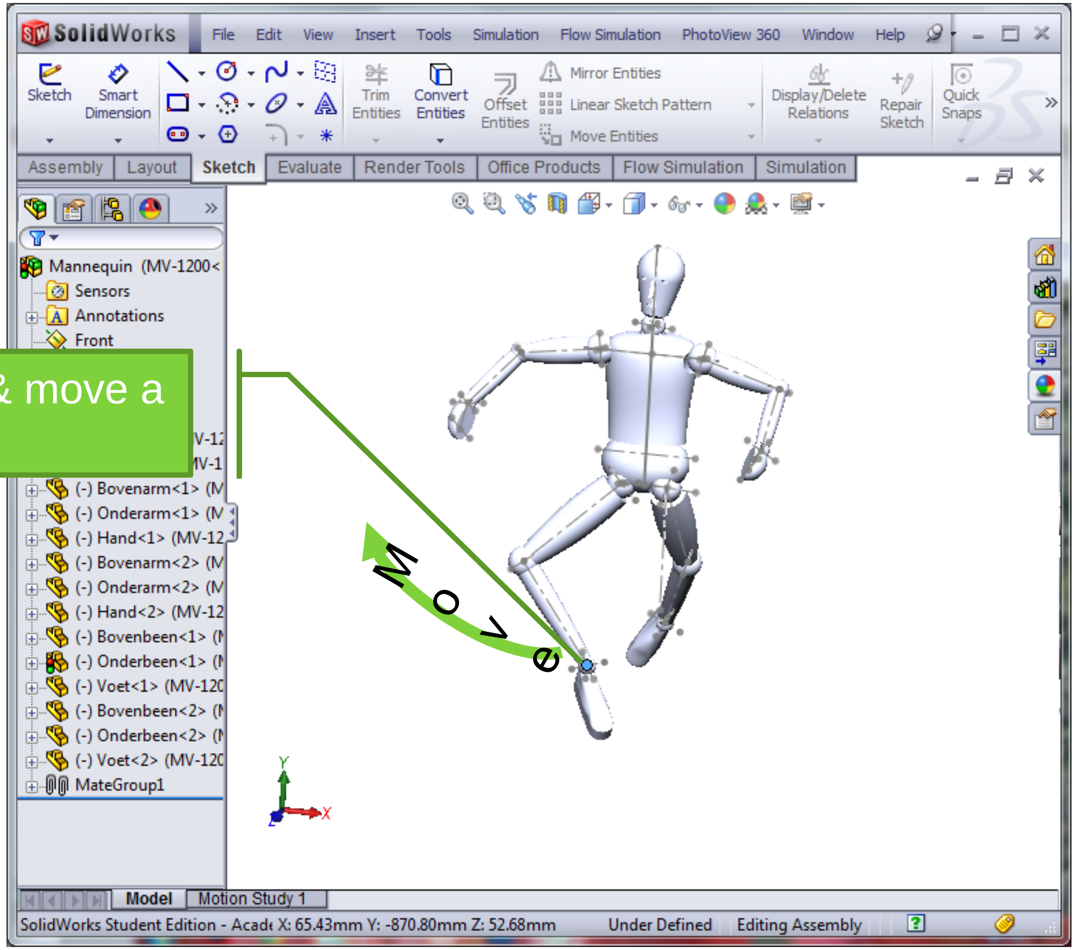
MV-2100



Attention: The validity of your model

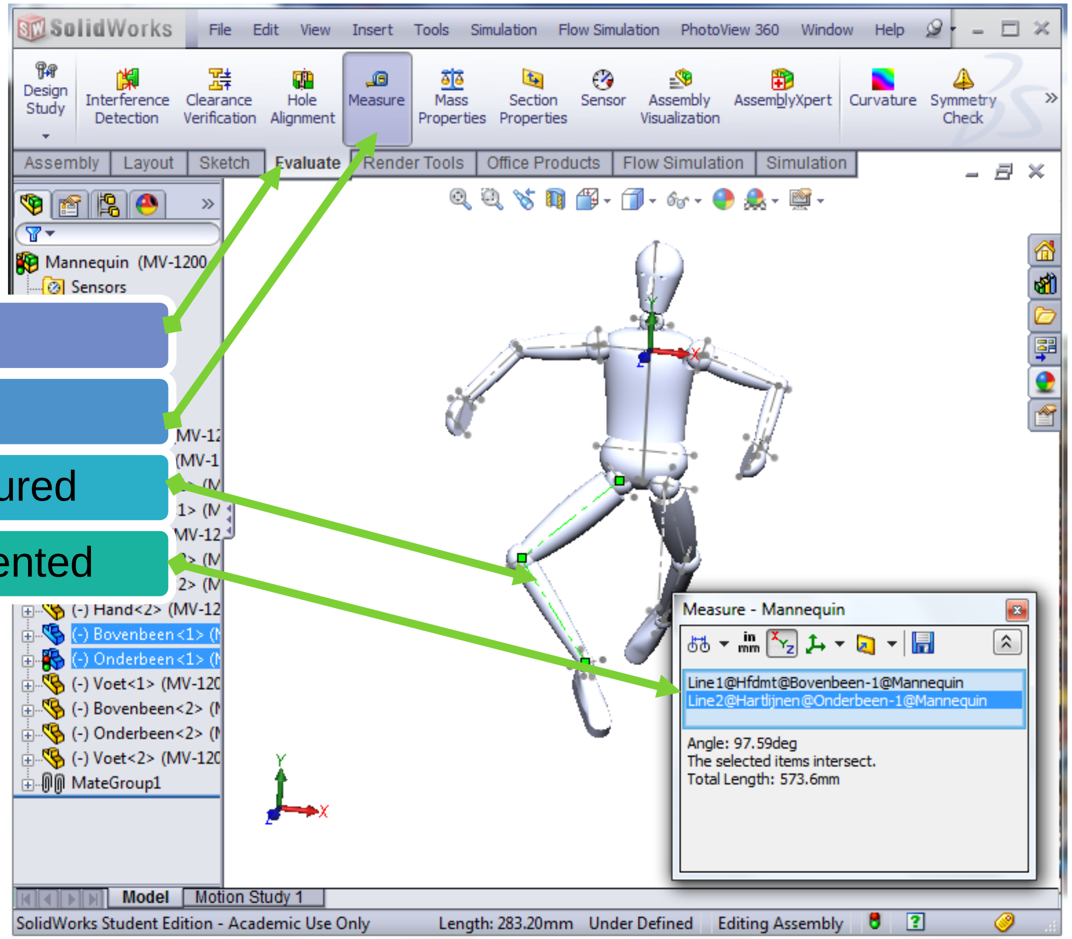
Pose

Using mouse drag & move a part

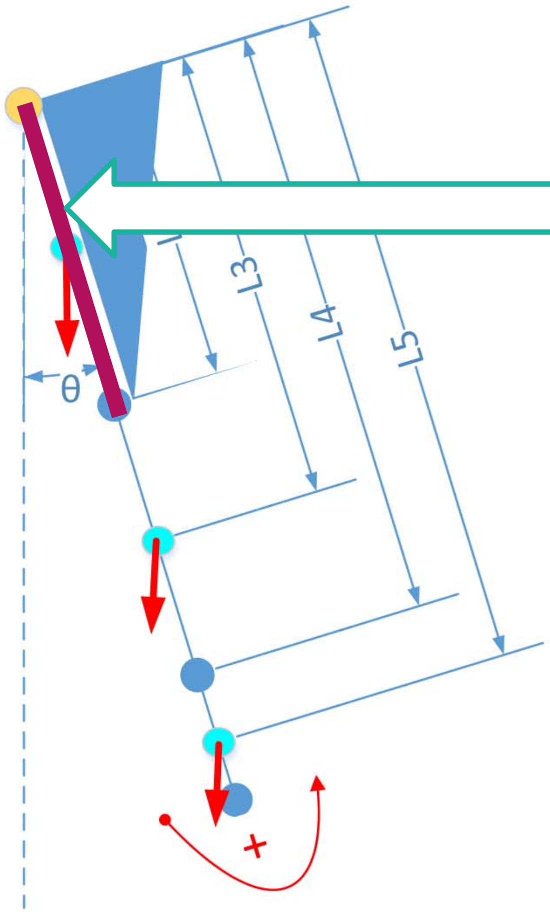


Measurement

1. Click - Tab Evaluate
2. Click - Button Measure
3. Click - The items to be measured
4. The measurements are presented

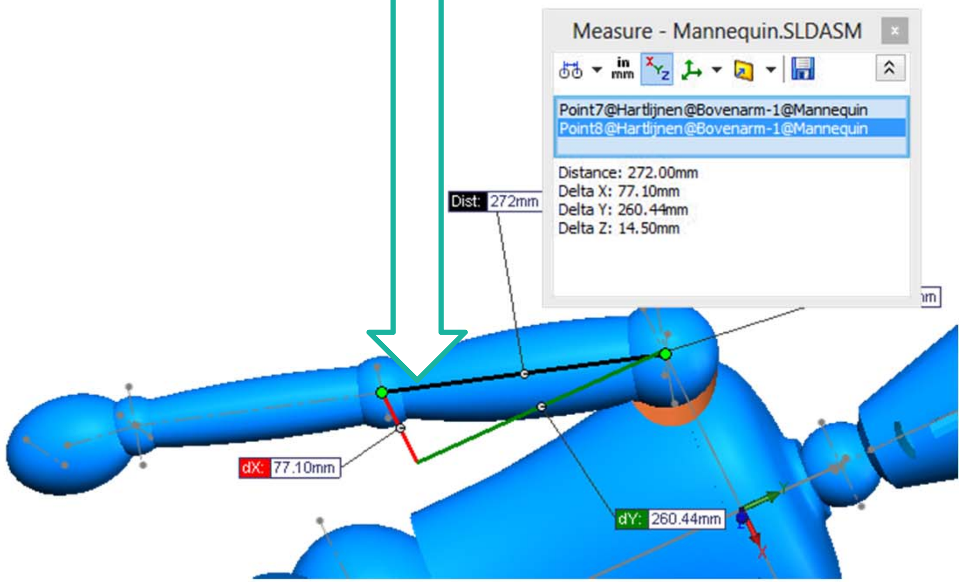


Measuring length

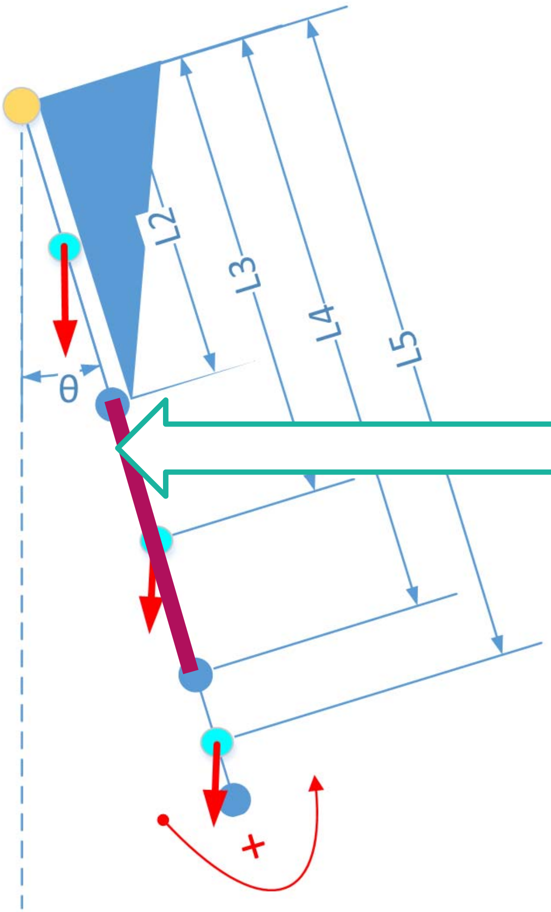


Upper arm length

0.272 meter

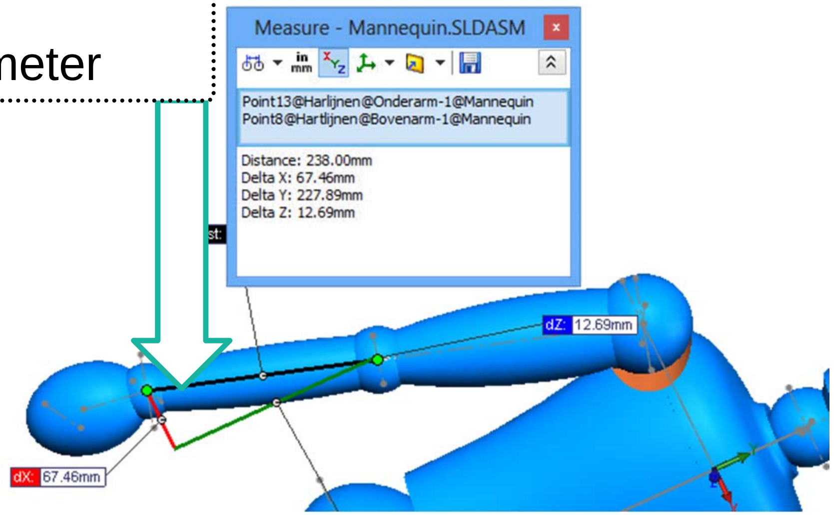


Measuring length

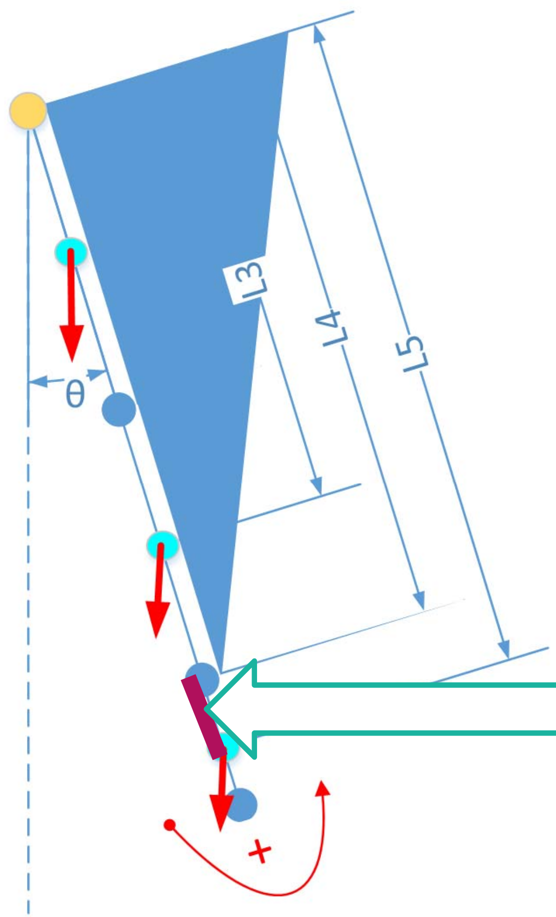


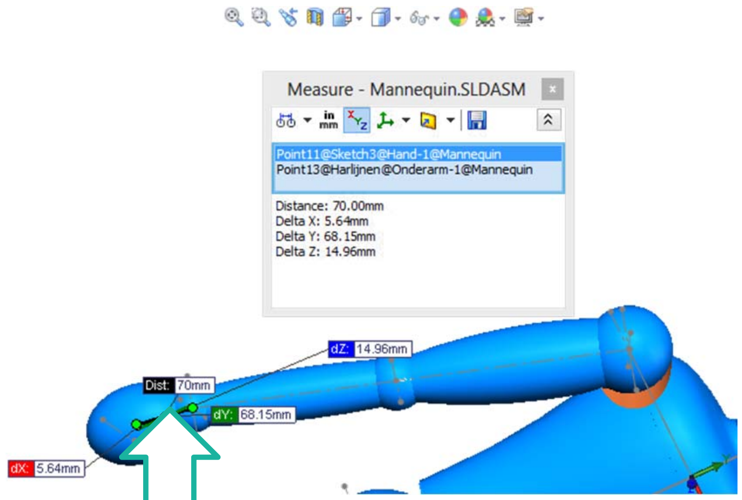
Forearm length

0.238 meter



Measuring length

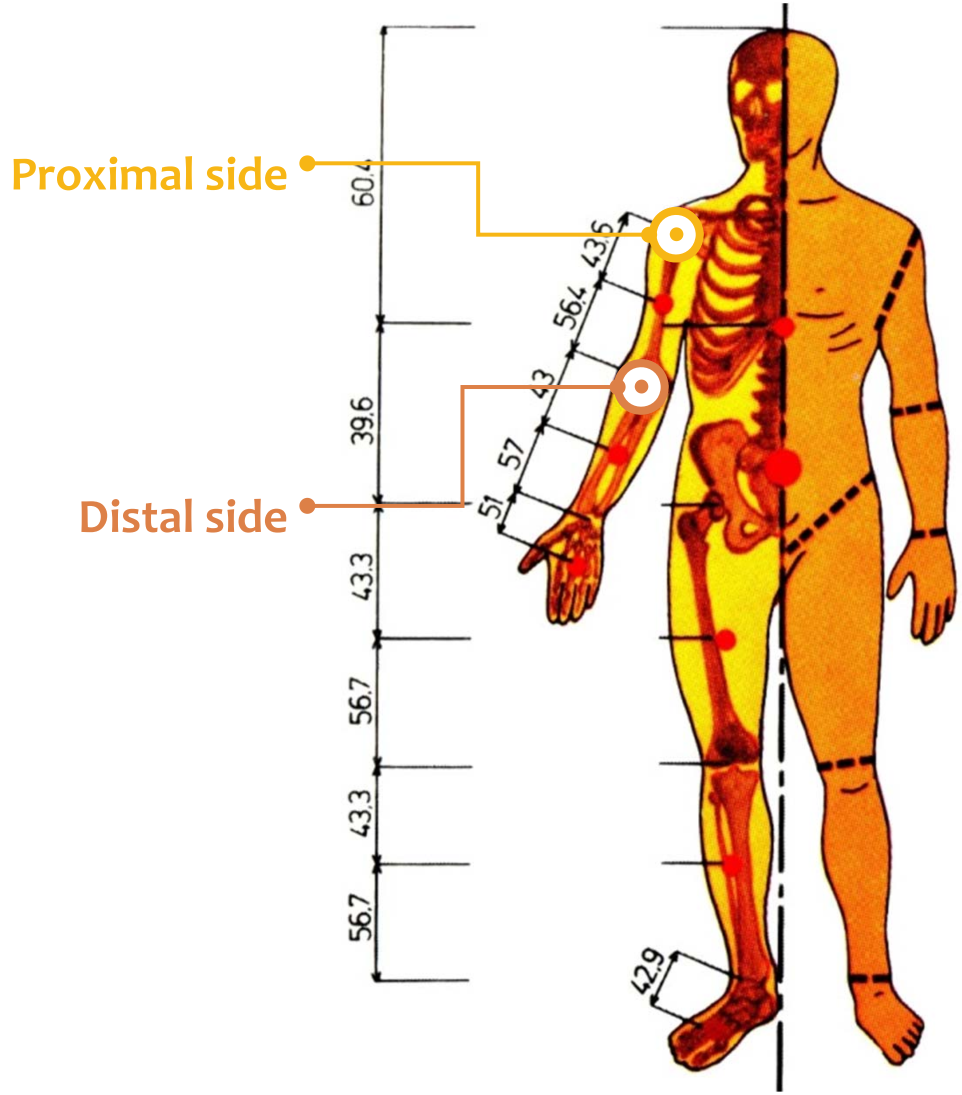




From wrist to center of the hand 0.07 meter

Body mass segments

Centre of gravity (c.g.) of body segments



Mass of body segment

Following Biomechanics and Motor Control of Human Movement

Segment	Segment / Total Body Weight	Centre of Mass / Segment length	Centre of Mass / Segment length
		Proximal	Distal
Hand	0.006	0.506	0.494
Forearm	0.016	0.43	0.57
Upper arm	0.028	0.436	0.564
F'arm+hand	0.022	0.682	0.318
Upper limb	0.05	0.53	0.47
Foot	0.0145	0.5	0.5
Shank	0.0465	0.433	0.567
Thigh	0.1	0.433	0.567
Foot + shank	0.061	0.606	0.394
Lower Limb	0.161	0.447	0.553
Head, neck, trunk	0.578	0.66	0.34
Head, neck, arms, trunk	0.678	0.626	0.374
Head and neck	0.081		

Segment	Segment / Total Body Weight	Centre of Mass / Segment length	Centre of Mass / Segment length
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Foot	0.0145	0.5	0.5
Shank	0.0465	0.433	0.567
Thigh	0.1	0.433	0.567
Foot + shank	0.061	0.606	0.394
Lower Limb	0.161	0.447	0.553
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Head and neck	0.081		

Ref. http://books.google.nl/books?id=_bFHL08IWfwC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=snippet&q=mass%20segment&f=false

Mass of body segment

by Zatsiorskji and Selujanov (1979), based on athlete's data

Mass of the segment (kg)

$$m_i = B_0 + B_1 m + B_2 H$$

Coefficient

Mass (**kg**)

Height (**cm**)

Segment name	B_0[kg]	B_1	B_2[kg/cm]
Head+neck	1.296	0.0171	0.0143
Hand	-0.1165	0.0036	0.00175
Forearm	0.3185	0.01445	-0.00114
Upperarm	0.25	0.03012	-0.0027
Leg	-0.829	0.0077	0.0073
Shank	-1.592	0.03616	0.0121
Thigh	-2.649	0.1463	0.0137
Trunk			
Upper part of the trunk	8.2144	0.1862	-0.0584
Middle part of the trunk	7.181	0.2234	-0.0663
Lower part of the trunk	-7.498	0.0976	0.04896

Courtesy of http://biomech.ftvs.cuni.cz/pbpk/kompendium/biomechanika/geometrie_hmotnost_en.php

Take a simple approach

Upper arm

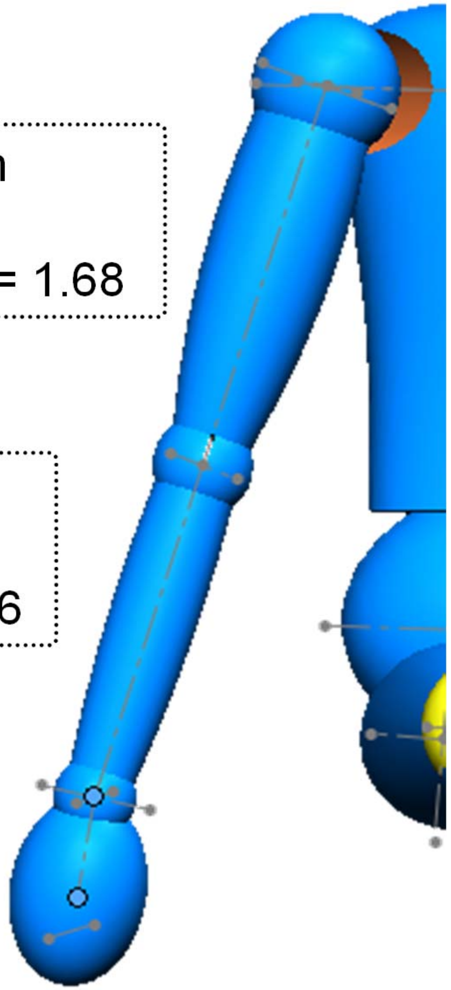
M1= 60 * 0.028 = 1.68

Forearm

M2 = 60 * 0.016 = 0.96

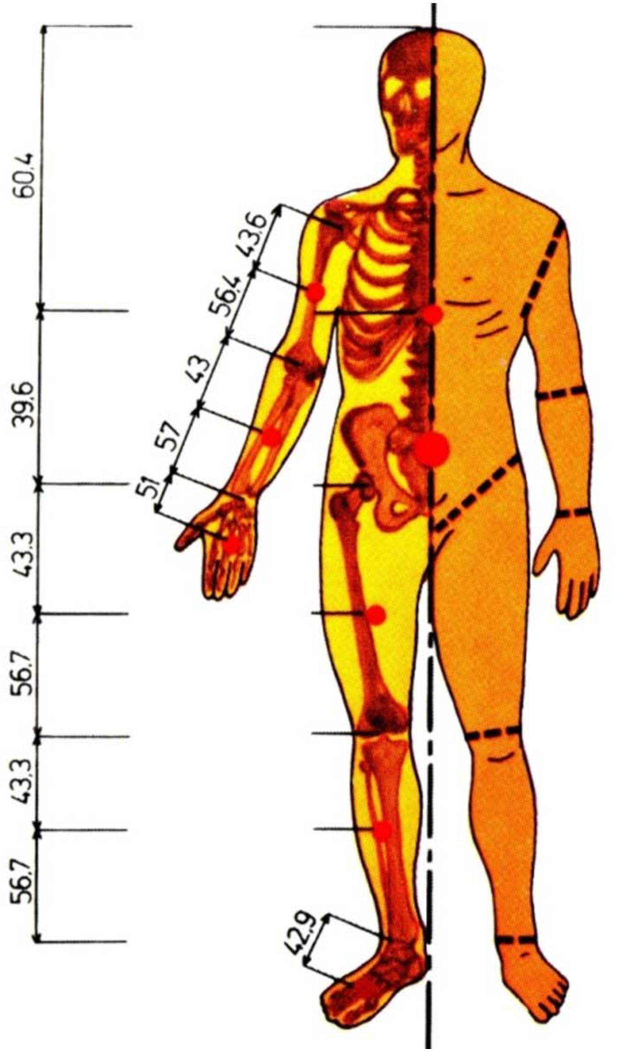
Hand

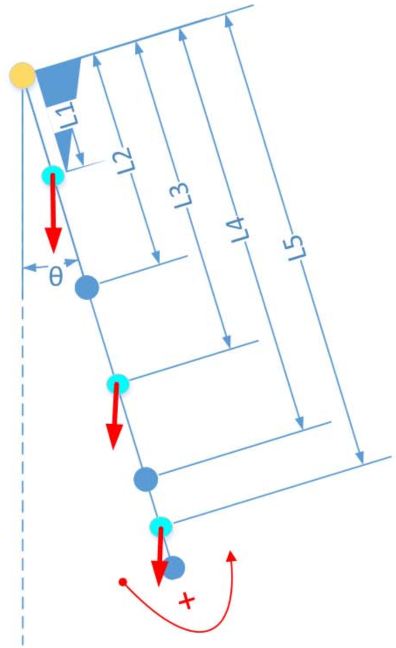
M3 = 60 * 0.006 = 0.36



If the mass of the person is 60kg

Gravity center





> *restart;*

> *upperArmLength* := 0.272;

$$upperArmLength := 0.272 \tag{1}$$

> *ForeArmLength* := 0.238;

$$ForeArmLength := 0.238 \tag{2}$$

> *WristHandCenter* := 0.07;

$$WristHandCenter := 0.07 \tag{3}$$

> *L1* := *upperArmLength*·0.436;

$$L1 := 0.118592 \tag{4}$$

> *L4* := *upperArmLength* + *ForeArmLength*·0.43;

$$L4 := 0.37434 \tag{5}$$

> *L5* := *upperArmLength* + *ForeArmLength* + *WristHandCenter*;

$$L5 := 0.580 \tag{6}$$

The tracker

Tracker

Tracker

The Tracker is a free video analysis and modeling tool built on the Open Source Physics(OSP) Java framework. It is designed to be used in physics education

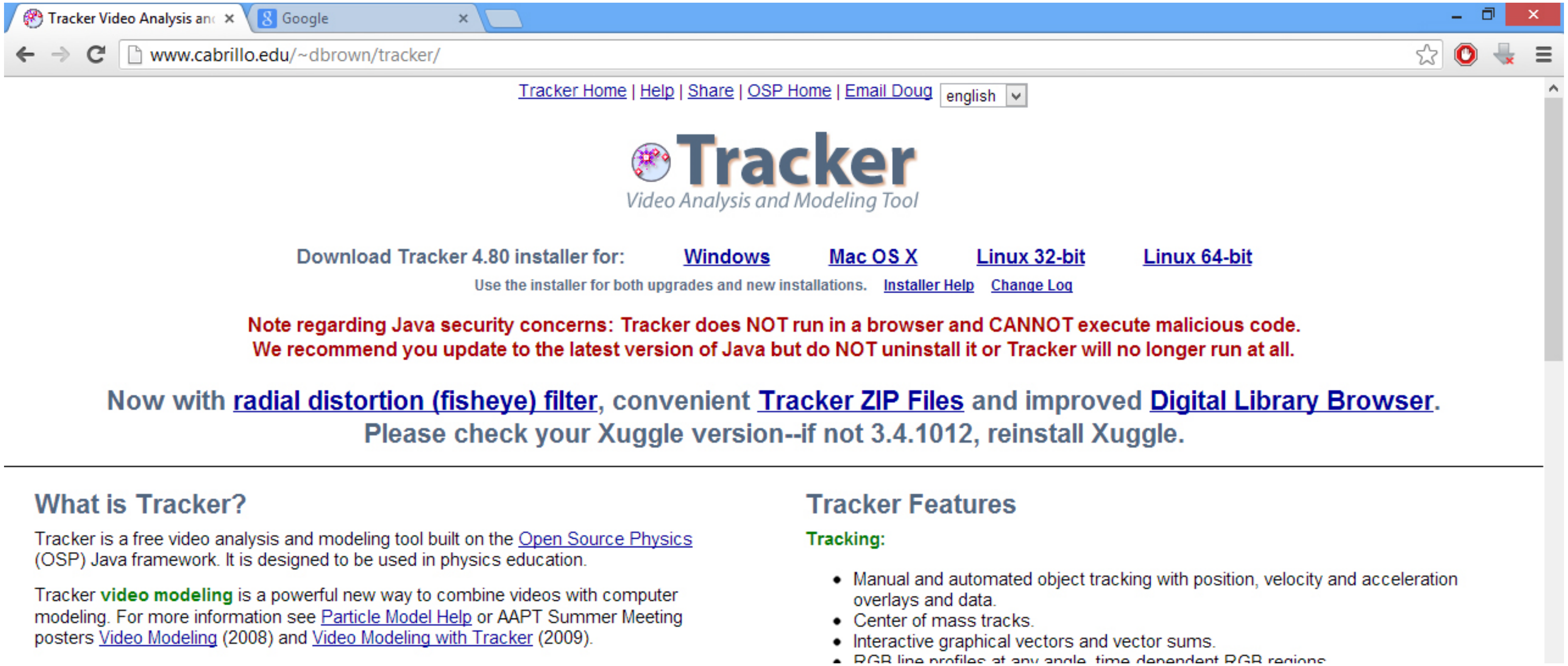
Tracker
Video Analysis and Modeling Tool

Extract position (angle), velocity (angular) and acceleration (angular) of an object in the video

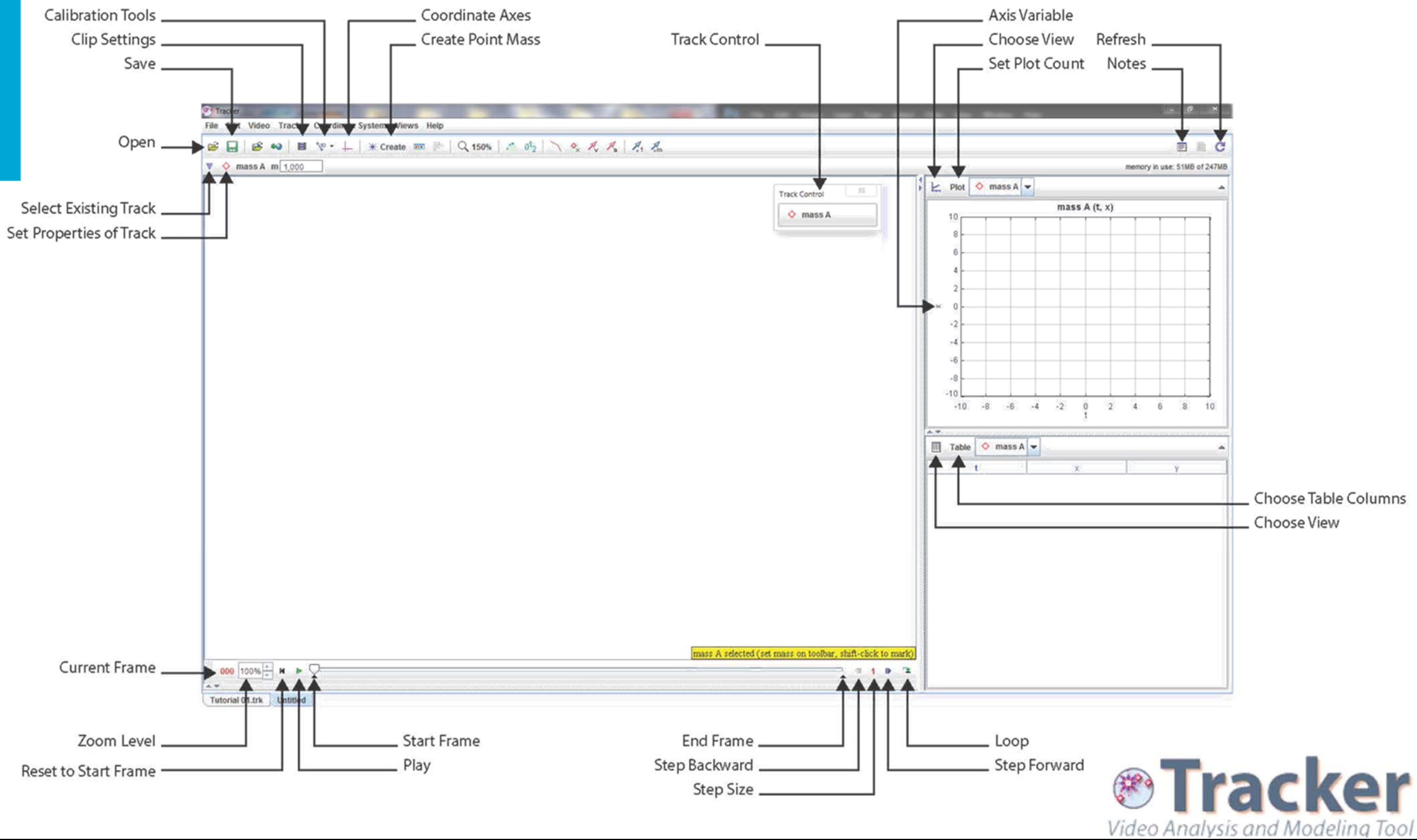
Tracker

Download

http://www.cabrillo.edu/~dbrown/tracker/



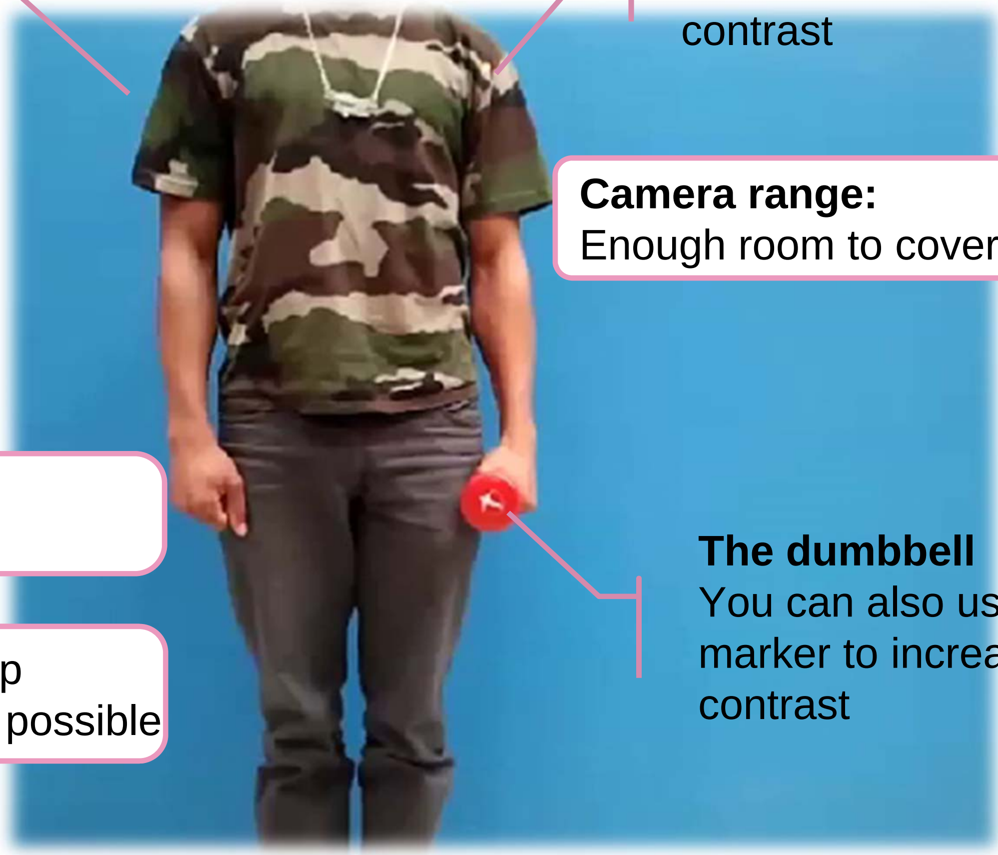
Basic interface



Prepare a video for Tracker

Background
Uniform & different from the subject

Origin marker
Increase the contrast



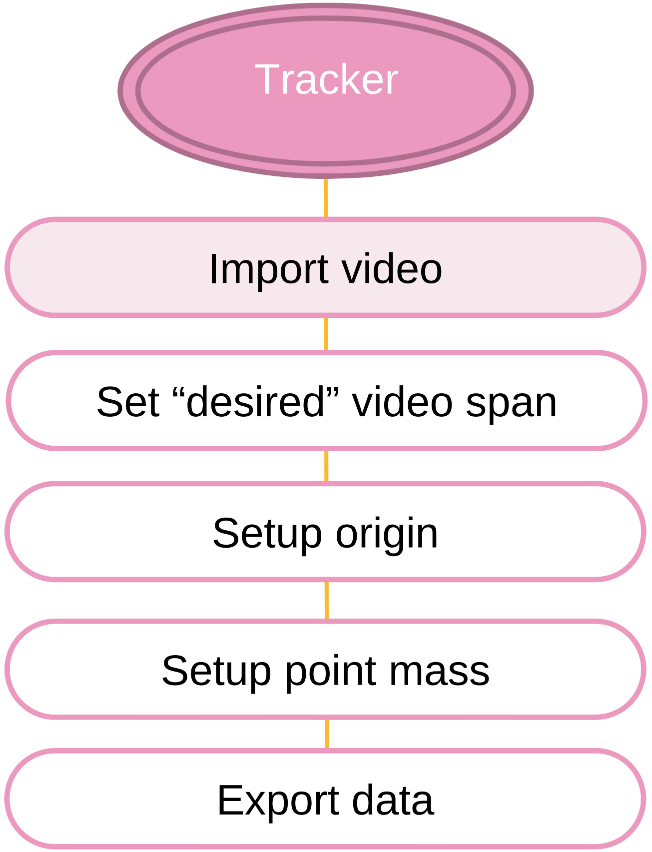
Camera range:
Enough room to cover the movements

Camera direction:
Perpendicular

The dumbbell
You can also use marker to increase the contrast

Frame rate: At least 24p
Resolution: as high as possible

Procedure



Open

Or

Drag video in Tracker

Procedure

Tracker

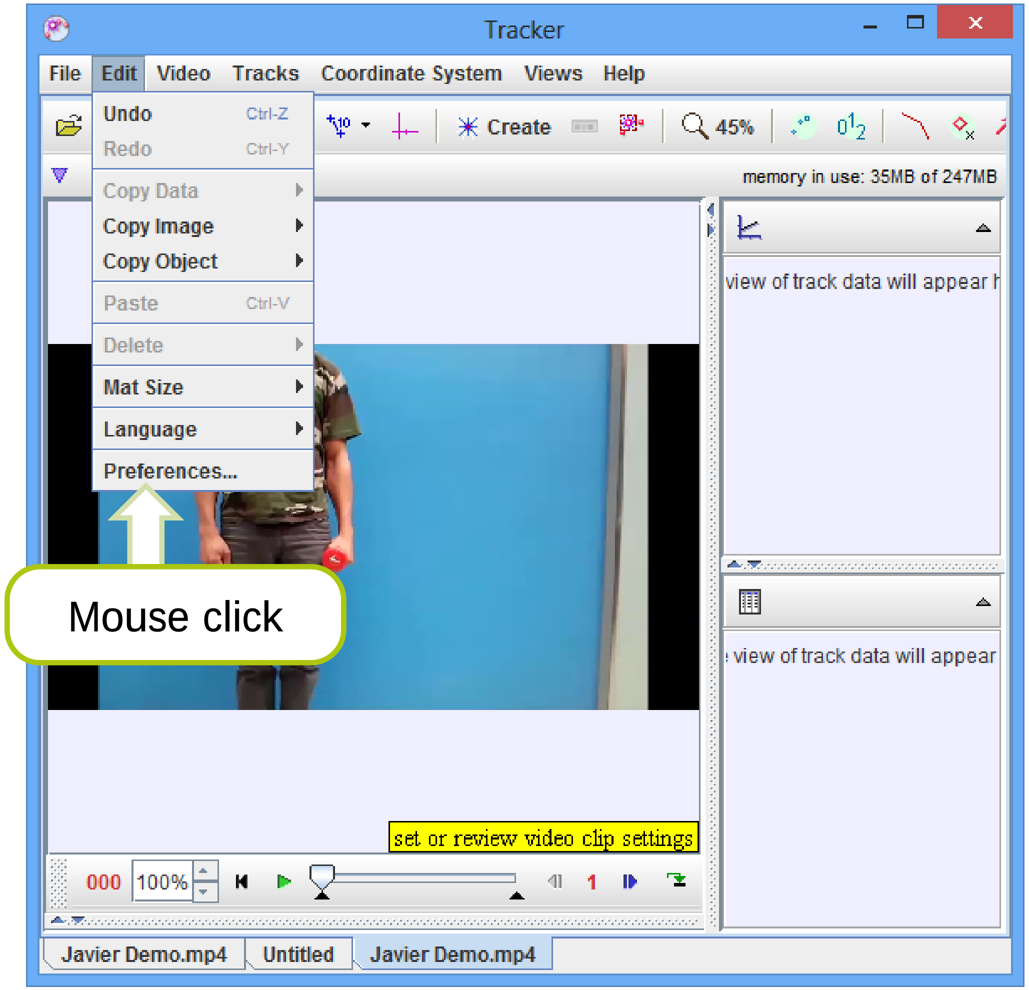
Import video

Set “desired” video span

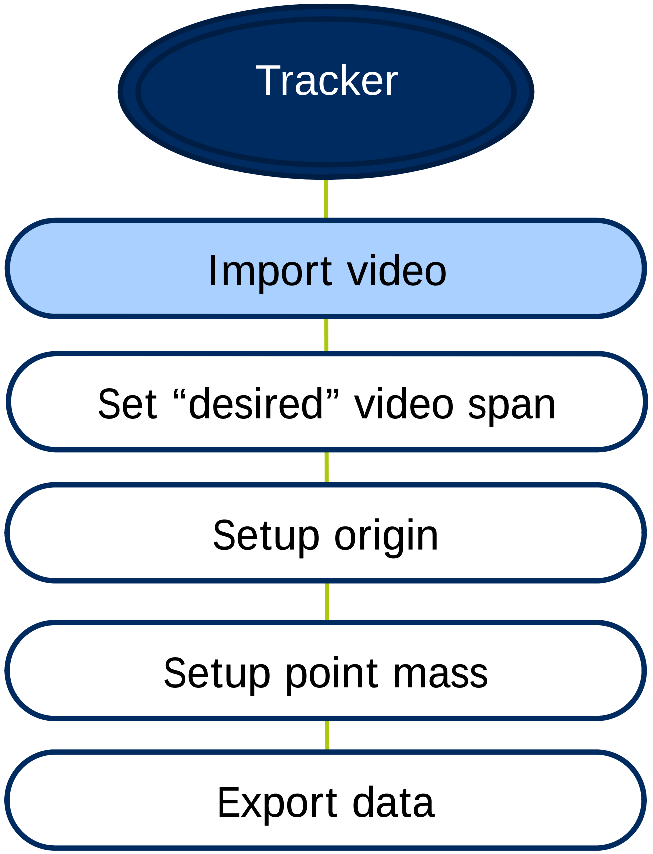
Setup origin

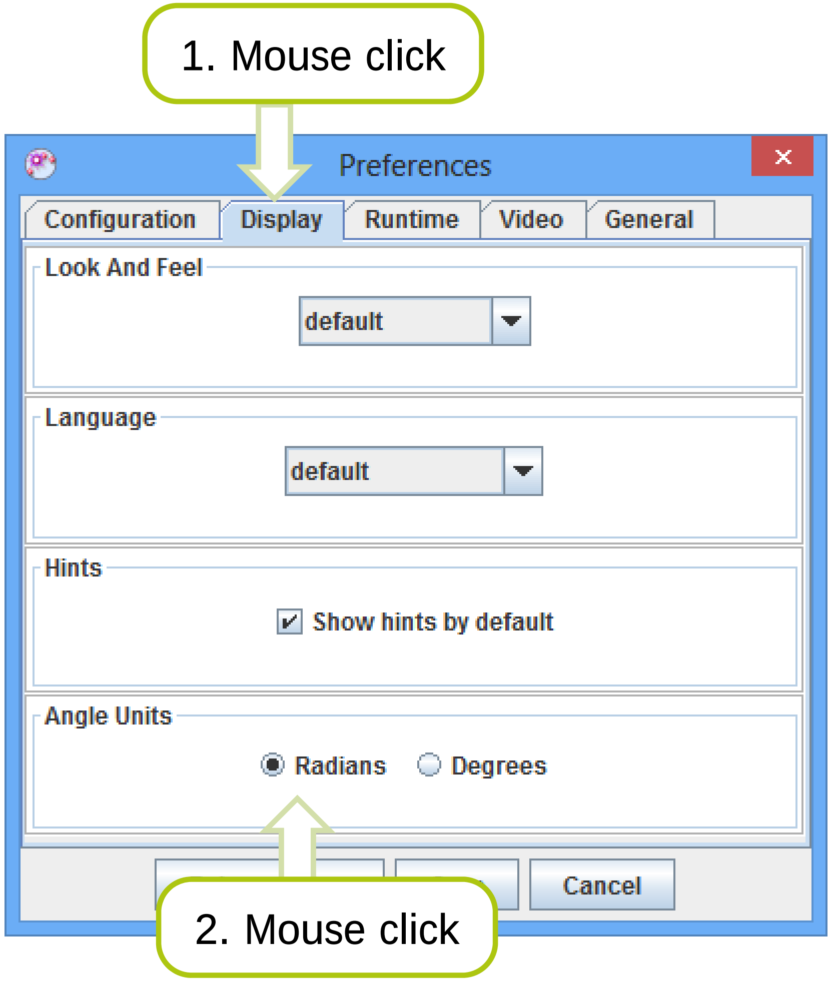
Setup point mass

Export data



Procedure


Tracker
Import video
Set “desired” video span
Setup origin
Setup point mass
Export data


1. Mouse click
Preferences
Configuration
Display
Runtime
Video
General
Look And Feel
default
Language
default
Hints
Show hints by default
Angle Units
Radians
Degrees
Cancel
2. Mouse click

Procedure

Tracker

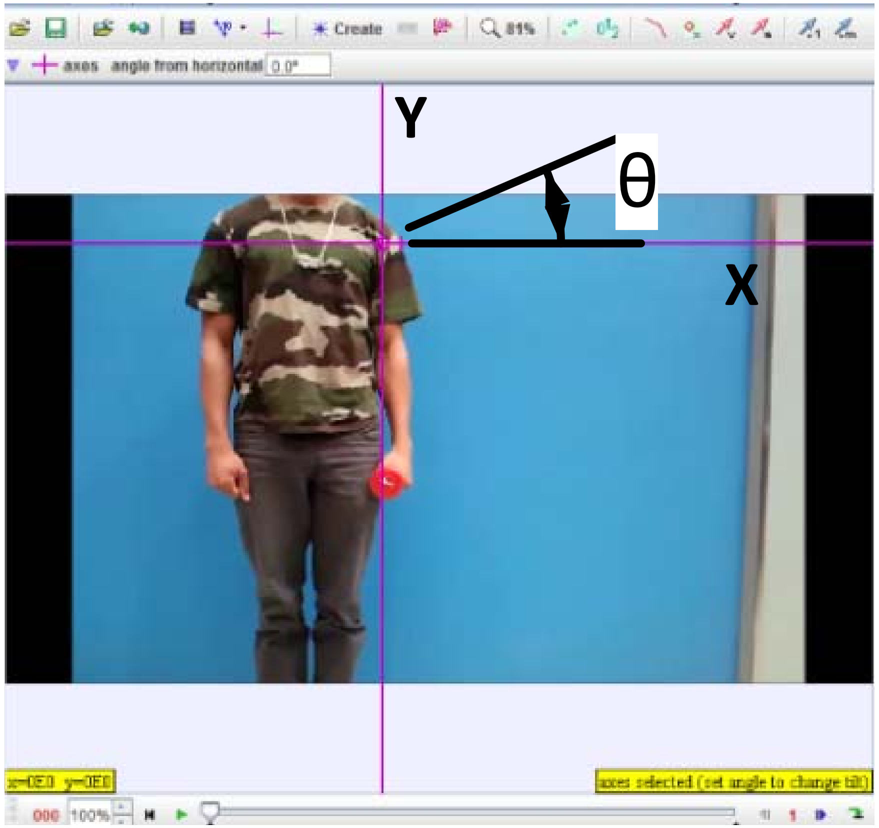
Import video

Set “desired” video span

Setup origin

Setup point mass

Export data



Procedure

Tracker

Import video

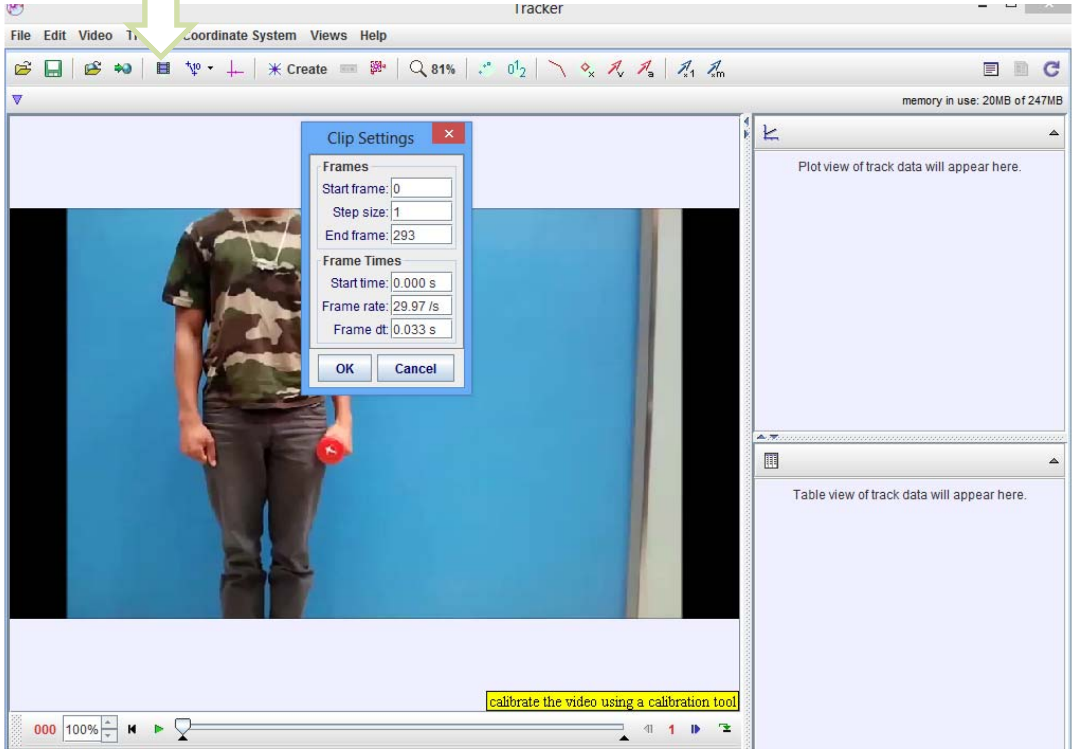
Set “desired” video span

Setup origin

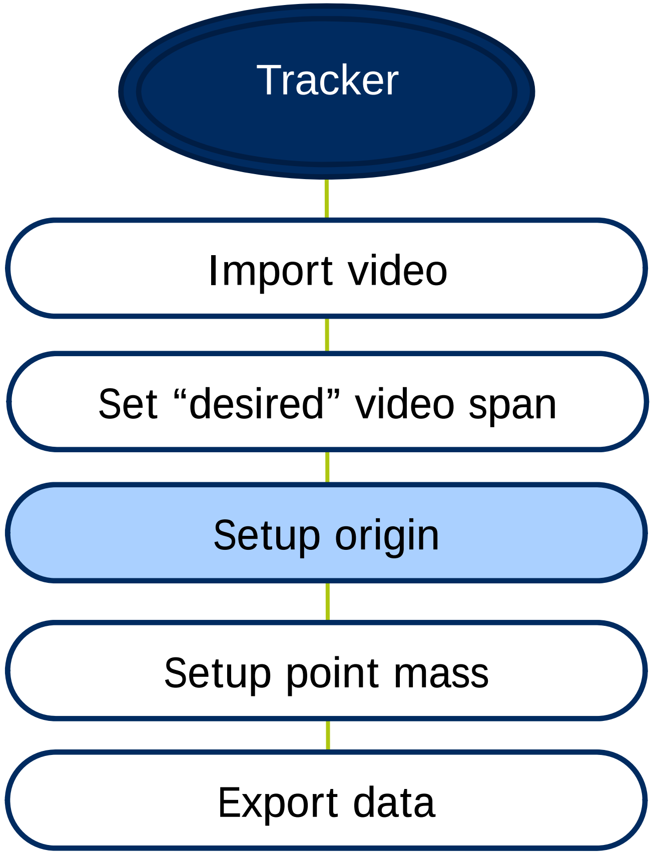
Setup point mass

Export data

Mouse click



Procedure



Fixed

Or

Dynamic (Demo is dynamic)

Procedure

Tracker

Import video

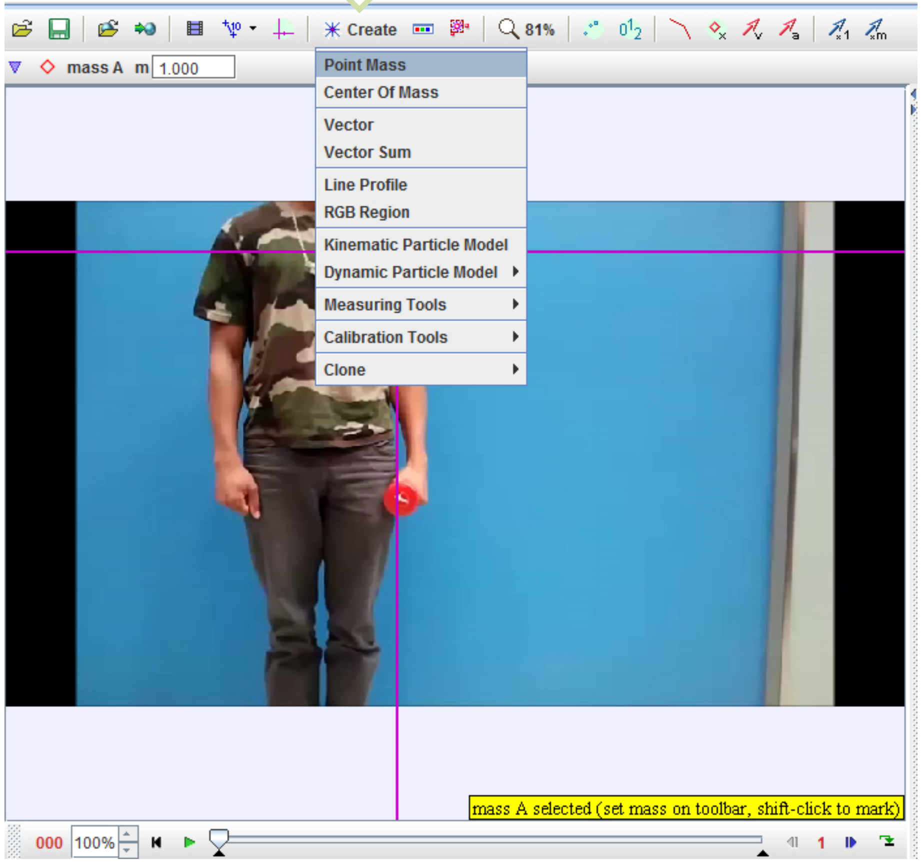
Set “desired” video span

Setup origin

Setup point mass

Export data

Mouse click



Procedure

Tracker

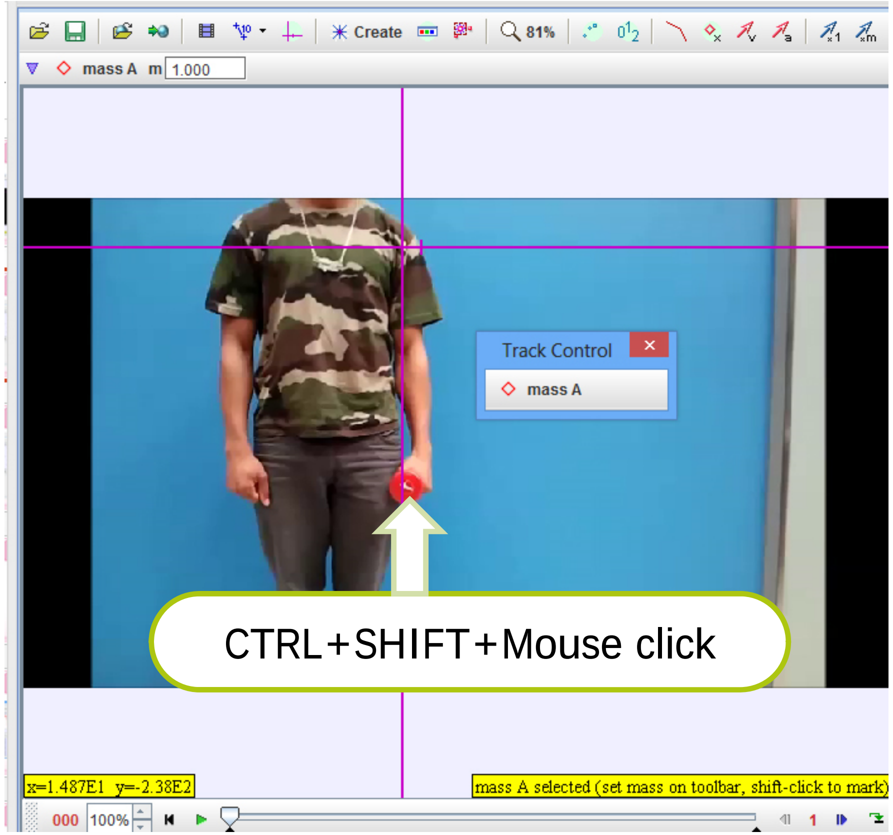
Import video

Set “desired” video span

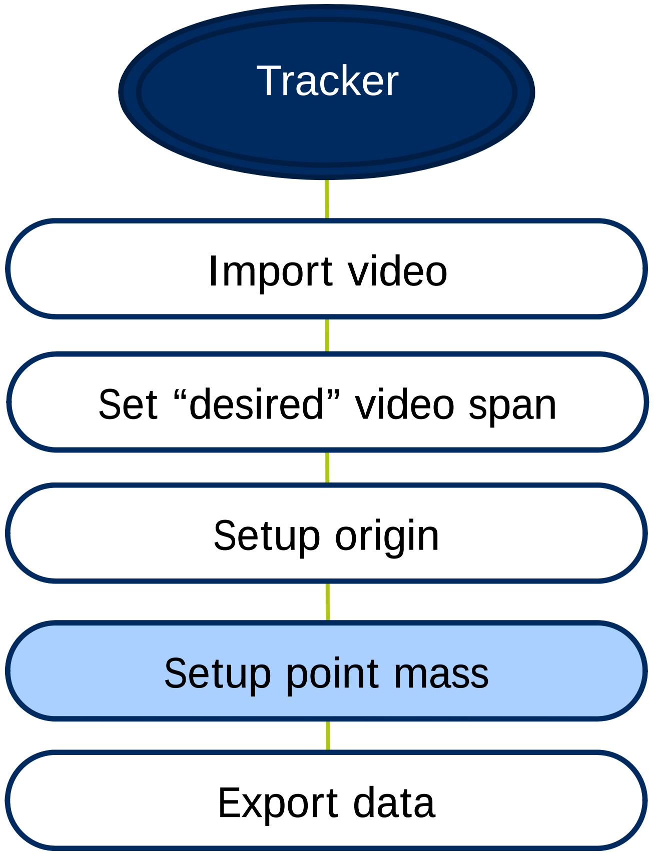
Setup origin

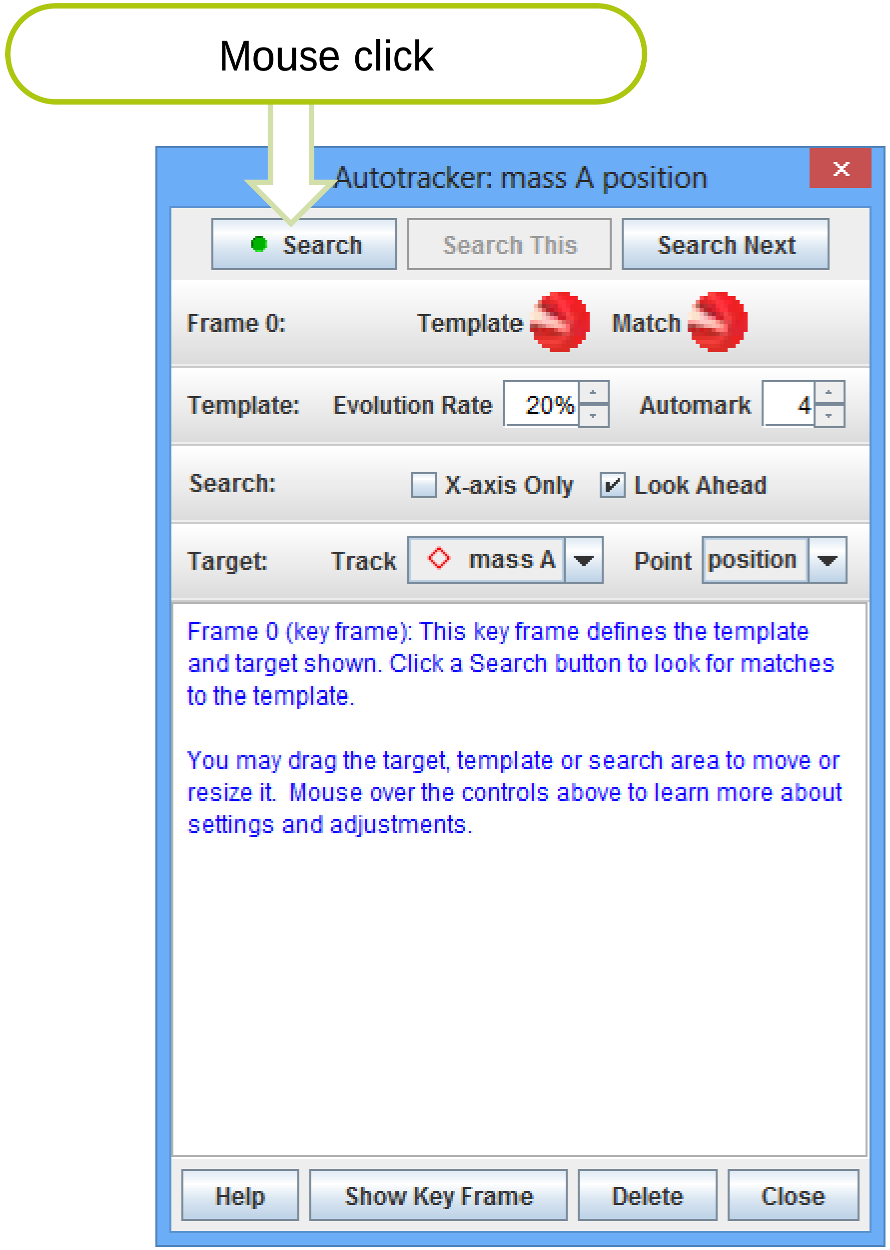
Setup point mass

Export data



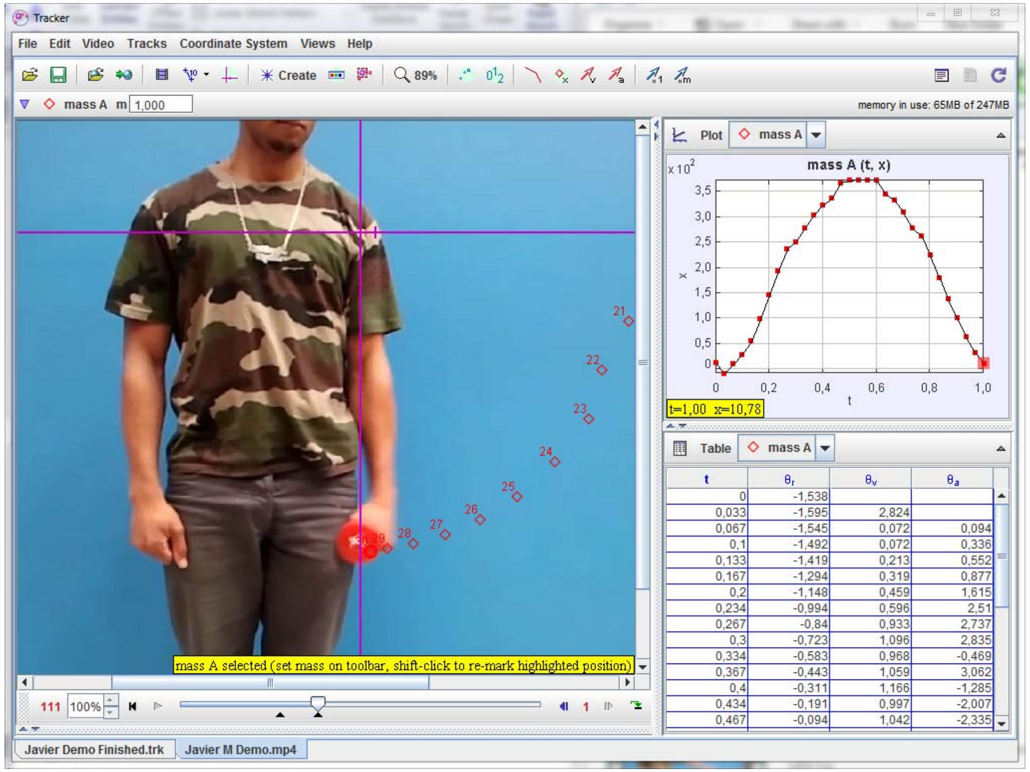
Procedure


Tracker
Import video
Set “desired” video span
Setup origin
Setup point mass
Export data


Mouse click
Autotracker: mass A position
Search
Search This
Search Next
Frame 0:
Template
Match
Template:
Evolution Rate
20%
Automark
4
Search:
X-axis Only
Look Ahead
Target:
Track
mass A
Point
position
Frame 0 (key frame): This key frame defines the template and target shown. Click a Search button to look for matches to the template.
You may drag the target, template or search area to move or resize it. Mouse over the controls above to learn more about settings and adjustments.
Help
Show Key Frame
Delete
Close

Procedure

- Tracker
- Import video
- Set “desired” video span
- Setup origin
- **Setup point mass**
- Export data



Procedure

Tracker

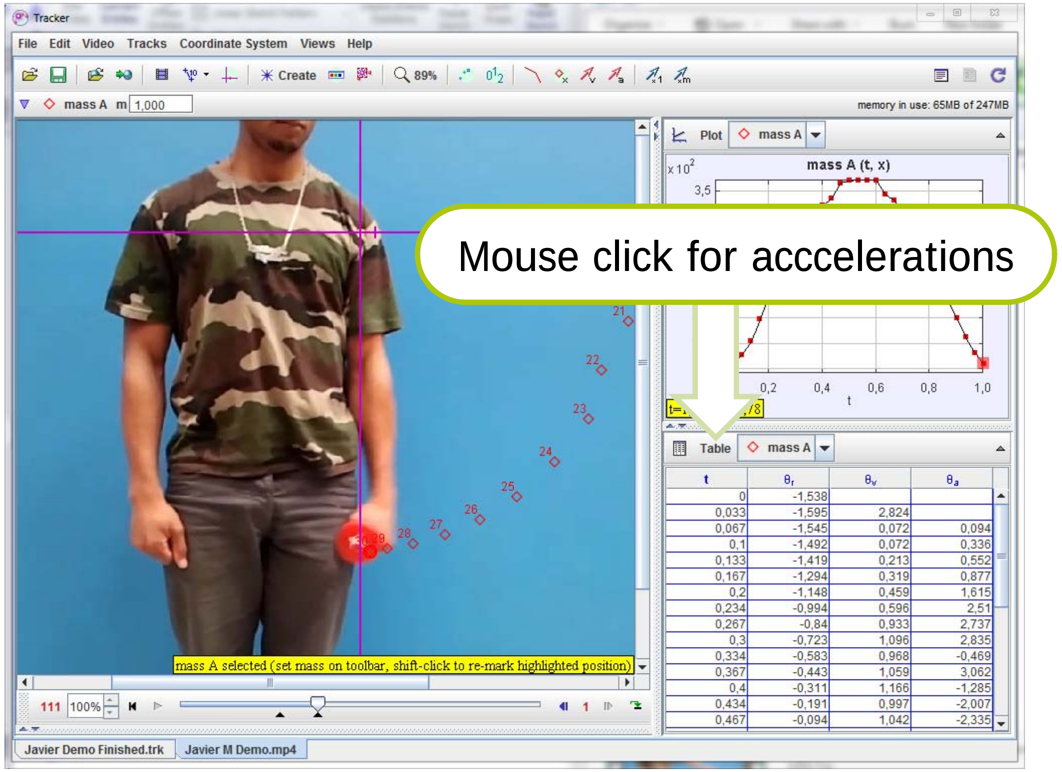
Import video

Set “desired” video span

Setup origin

Setup point mass

Export data



The calculation

The result

Calculation

Change model to a function

Input anthropometric & biomechanics data

Input data from tracker
(angle, angular velocity & acceleration)

Plot

The result

Calculation

Change model to a function

```
> restart; with(plots) :
> model := -(m1·L1^2 + m2·L3^2 + m3·L5^2)·diff(theta(t), t$2) - (m1·g·L1 + m2·g·L3 + m3·g·L5)sin(theta(t)) + T = 0 :
>
> T := (m1·L1^2 + m2·L3^2 + m3·L5^2)·diff(theta(t), t$2) + (m1·g·L1 + m2·g·L3 + m3·g·L5)sin(theta(t)) :
>
> T := subs(diff(theta(t), t$2) = angleA, T) :
>
> T := subs(theta(t) = angle, T) :
>
> T := unapply(T, (angle, angleA));
```

$$T := (angle, angleA) \rightarrow (m1\,L1^2 + m2\,L3^2 + m3\,L5^2)\,angleA + (m1\,g\,L1 + m2\,g\,L3 + m3\,g\,L5)\,\sin(angle)$$

The result

- Calculation
- Change model to a function
- Input anthropometric & biomechanics data
- Input data from tracker (angle, angular velocity & acceleration)
- Plot

Input parameter (from model & biomechanics)

```
>
> upperArmLength := 0.272;
> ForeArmLength := 0.238;
> WristHandCenter := 0.07;
> L1 := upperArmLength·0.436;
> L3 := upperArmLength + ForeArmLength·0.43;
> L5 := upperArmLength + ForeArmLength + WristHandCenter;
> m1 := 1.68
> m2 := 0.96
> m3 := 0.36 + 3; g := 9.81
```

we add 3 kilo to m3 to add the weight

The result

Calculation

- Change model to a function
- Input anthropometric & biomechanics data
- Input data from tracker
  (angle, angular velocity & acceleration)
- Plot

Column by column copy your excel data to arrays in Maple

The result

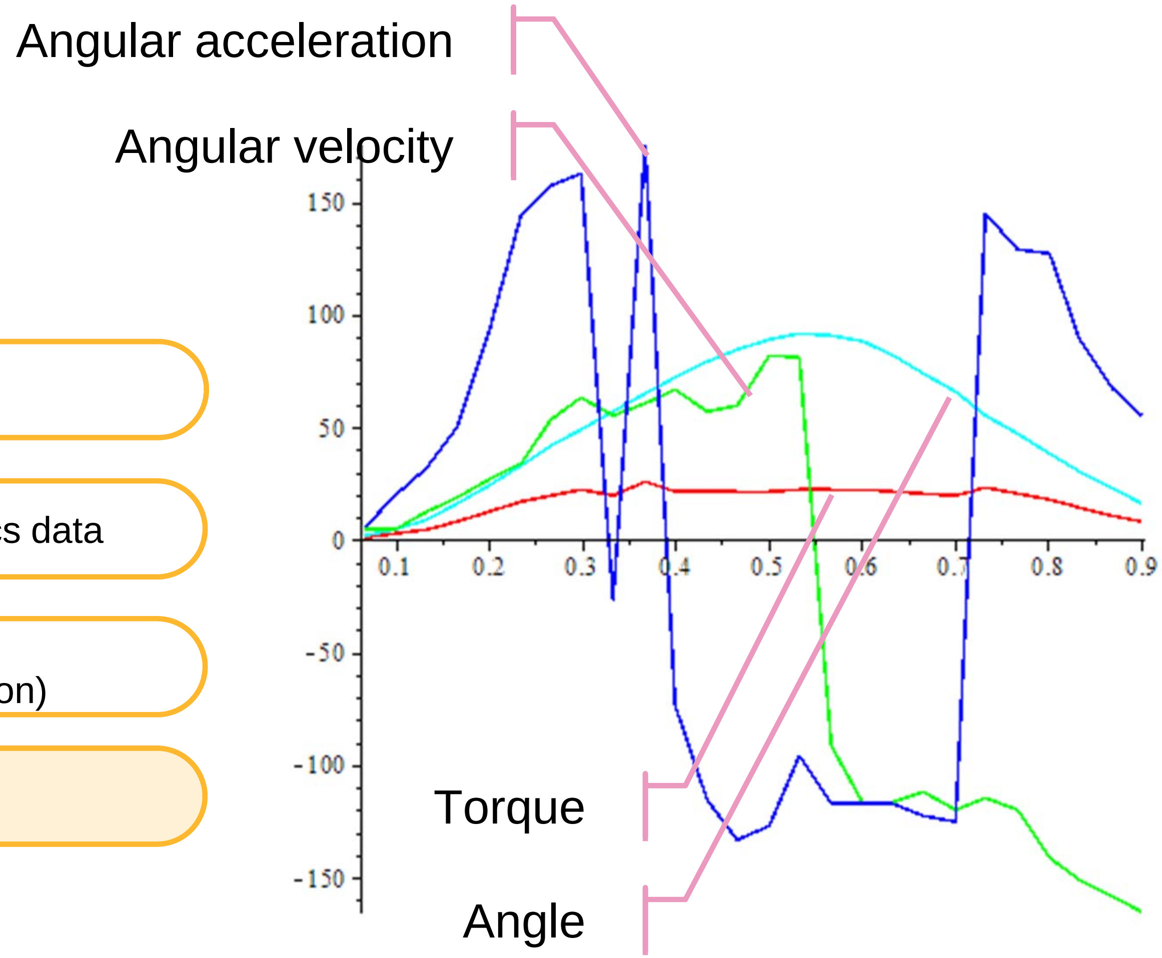
Calculation

Change model to a function

Input anthropometric & biomechanics data

Input data from tracker
(angle, angular velocity & acceleration)

Plot



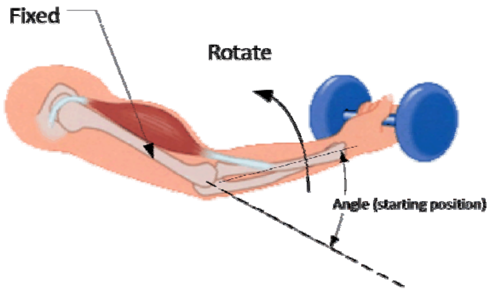
H-A-1 assignments

H-A-1-F

H-A-1-F

In the new set of dumbbells, CAP Barbell® want to specify the optimal weight and training positions in the manual.

For this, they have asked you to help them to explore the relations between the mass of the dumbbells, the maximum angular velocity, the torques applied on the elbow joints and the start position (angle) as in the figure.



Think

- Target group
- Model
- Improvements
- ...

Report – Logical: Grading Criteria

1
- Introduction
- Problem Definition

2
- Abstract Model with Maple® file (appendix?)
- Experiment and its contribution in Modelling

3
- Evaluation
- Optimization (possible new advices?)

4
- Conclusions & recommendations

Success!

The Modelling Team
Faculty of Industrial Design Engineering
Delft University of Technology