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Motion analysis and synthesis – Basic tools

Multimedia, Simulation and Virtual Reality Group

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asf (acclaim skeleton file)

Anyway we refer to them as "asf-files"...

HDM_bk2.asf - Editor

Datei Bearbeiten Format Ansicht ?

```
# AST/ASF file generated using VICON BodyLanguage
# ----------------------------------------------
:version 1.10
:name VICON
:units
  mass 1.0
  length 0.45
  angle deg
:documentation
   .ast/.asf automatically generated from VICON
   data using VICON BodyBuilder and BodyLanguage
   model FoxedUp or BRILLIANT.MOD
:root
   order TX TY TZ RX RY RZ
   axis XYZ
   position 0 0 0
   orientation 0 0 0
:bonedata
  begin
     id 1
     name lhipjoint
     direction 0.440178 -0.822639 0.359871
     length 2.53113
     axis 0 0 0  XYZ
  end
  begin
     id 2
     name lfemur
     direction 0.34202 -0.939693 0
     length 7.88132
     axis 0 0 20  XYZ
    dof rx ry rz
    limits (-160.0 20.0)
           (-70.0 70.0)
           (-60.0 70.0)
  end
  begin
     id 3
```

HDM_bk2.asf - Editor

Datei Bearbeiten Format Ansicht ?

```
  begin
     id 30
     name rthumb
     direction -0.707107 -6.34713e-011 0.707107
     length 1.56195
     axis -90 -45 -2.85299e-015   XYZ
    dof rx rz
    limits (-45.0 45.0)
           (-45.0 45.0)
  end
:hierarchy
  begin
    root lhipjoint rhipjoint lowerback
    lhipjoint lfemur
    lfemur ltibia
    ltibia lfoot
    lfoot ltoes
    rhipjoint rfemur
    rfemur rtibia
    rtibia rfoot
    rfoot rtoes
    lowerback upperback
    upperback thorax
    thorax lowerneck lclavicle rclavicle
    lowerneck upperneck
    upperneck head
    lclavicle lhumerus
    lhumerus lradius
    lradius lwrist
    lwrist lhand lthumb
    lhand lfingers
    rclavicle rhumerus
    rhumerus rradius
    rradius rwrist
    rwrist rhand rthumb
    rhand rfingers
  end
```

Handling MoCap data in MATLAB: The skel-structure

- Import of an asf-file to a structure variable in MATLAB
  - `skel = readASF(asf_filename);`
    - ⇨ `asf_filename` = MATLAB string (e.g. `'C:\mocap\skeleton.asf'`)
    - ⇨ structure variable `skel` is referred to as **"skel-structure"** in our parlance
    - ⇨ creation of an empty skel-structure: `skel = emptySkeleton();`
- Analogous: Export of a skel-structure to an asf-file
  - `writeASF(skel,asf_filename);`

Handling MoCap data in MATLAB: The skel-structure

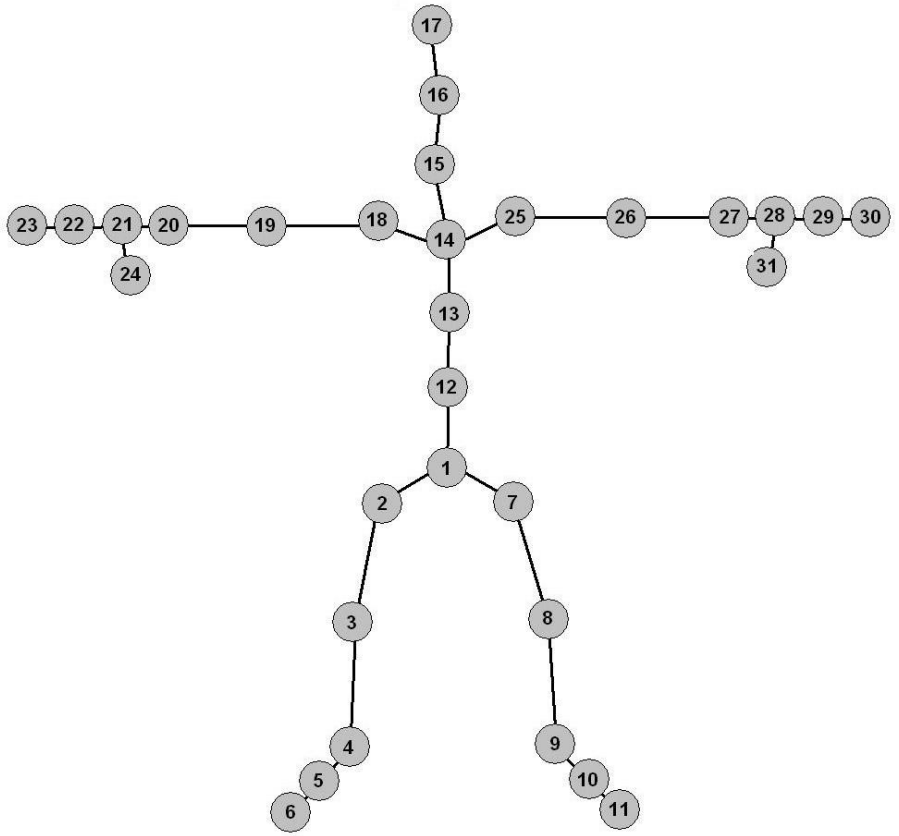
File Edit View Graphics Debug Desktop Window Help

Stack: Base

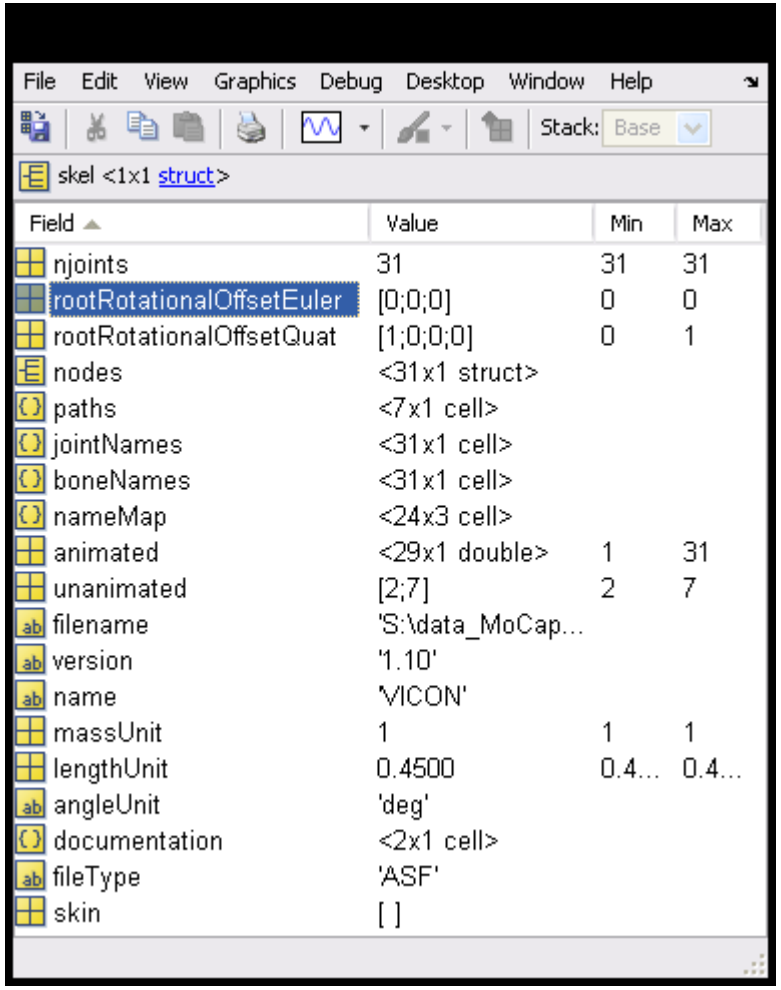
skel <1x1 struct>

Field	Value	Min	Max
njoints	31	31	31
rootRotationalOffsetEuler	[0;0;0]	0	0
rootRotationalOffsetQuat	[1;0;0;0]	0	1
nodes	<31x1 struct>		
paths	<7x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 double>	1	31
unanimated	[2;7]	2	7
filename	'S:\data_MoCap...		
version	'1.10'		
name	'VICON'		
massUnit	1	1	1
lengthUnit	0.4500	0.4...	0.4...
angleUnit	'deg'		
documentation	<2x1 cell>		
fileType	'ASF'		
skin	[ ]		

skel.njoints



Handling MoCap data in MATLAB: The skel-structure



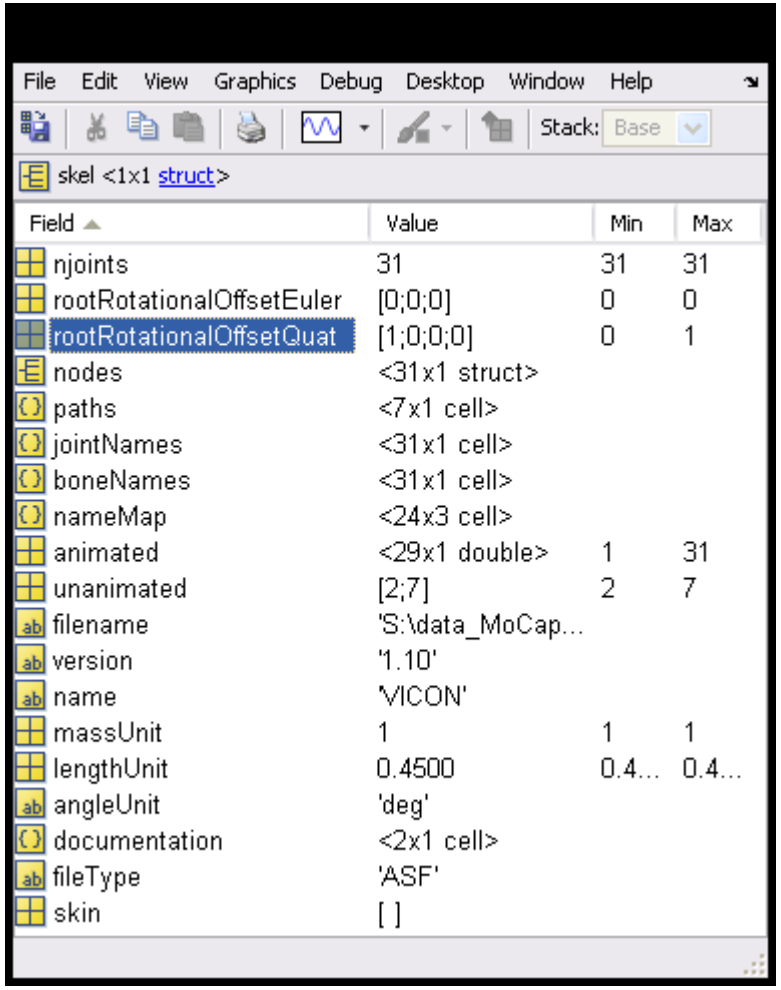
skel.rootRotationalOffsetEuler

Rotational offset of the root in Euler angles

“These are typically, but not always zero.”

[http://www.cs.wisc.edu/graphics/Courses/cs-838-1999/Jeff/ASF-AMC.html]

Handling MoCap data in MATLAB: The skel-structure



skel.rootRotationalOffsetQuat

Rotational offset of the root in quaternions

(redundant)

Handling MoCap data in MATLAB: The skel-structure

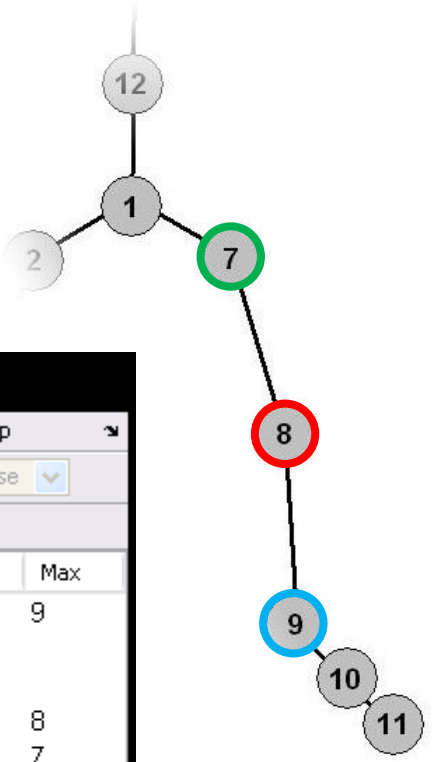
File Edit View Graphics Debug Desktop Window Help

Stack: Base

skel <1x1 struct>

Field	Value	Min	Max
njoints	31	31	31
rootRotationalOffsetEuler	[0;0;0]	0	0
rootRotationalOffsetQuat	[1;0;0;0]	0	1
nodes	<31x1 struct>		
paths	<7x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 double>	1	31
unanimated	[2;7]	2	7
filename	'S:\data_MoCap...		
version	'1.10'		
name	'VICON'		
massUnit	1	1	1
lengthUnit	0.4500	0.4...	0.4...
angleUnit	'deg'		
documentation	<2x1 cell>		
fileType	'ASF'		
skin	[ ]		

skel.nodes



File Edit View Graphics Debug Desktop Window Help

Stack: Base

skel.nodes(8,1) <1x1 struct>

Field	Value	Min	Max
children	9	9	9
jointName	'rhipjoint_@_rfemur'		
boneName	'rfemur'		
ID	8	8	8
parentID	7	7	7
offset	[-5.8889;-16.1795;0]	-16.1...	0
direction	[-0.3420;-0.9397;0]	-0.93...	0
length	17.2179	17.2...	17.2...
axis	[0;0;-20]	-20	0
DOF	<3x1 cell>		
rotationOrder	'XYZ'		
limits	[-160,20;-70,70;-70,60]	-160	70

Handling MoCap data in MATLAB: The skel-structure

File Edit View Graphics Debug Desktop Window Help

Stack: Base

skel <1x1 struct>

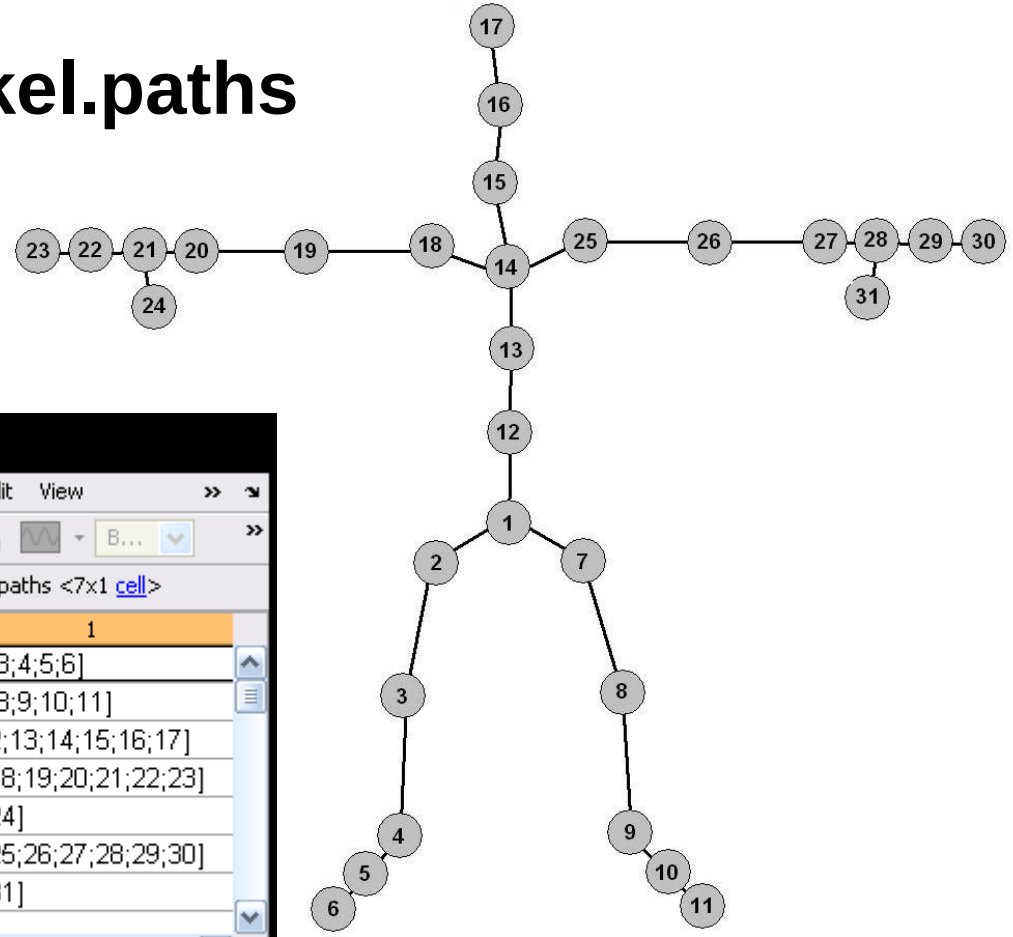
Field	Value	Min	Max
njoints	31	31	31
rootRotationalOffsetEuler	[0;0;0]	0	0
rootRotationalOffsetQuat	[1;0;0;0]	0	1
nodes	<31x1 struct>		
paths	<7x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 double>	1	31
unanimated	[2;7]	2	7
filename	'S:\data_MoCap...		
version	'1.10'		
name	'VICON'		
massUnit	1	1	1
lengthUnit	0.4500	0.4...	0.4...
angleUnit	'deg'		
documentation	<2x1 cell>		
fileType	'ASF'		
skin	[ ]		

skel.paths

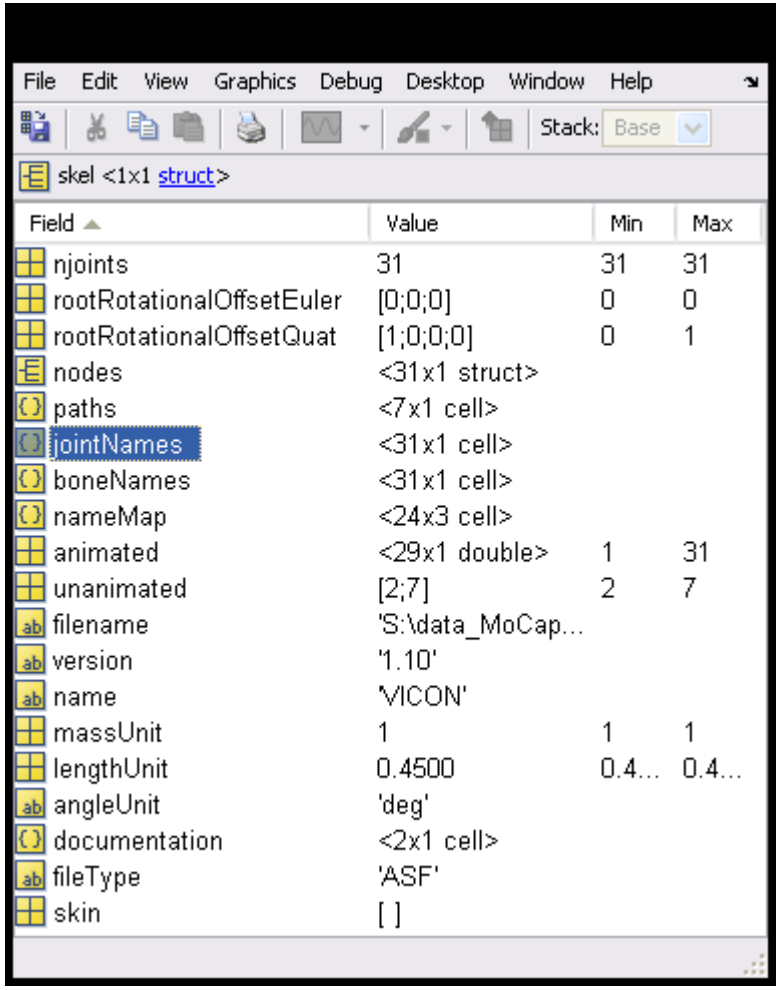
File Edit View

skel.paths <7x1 cell>

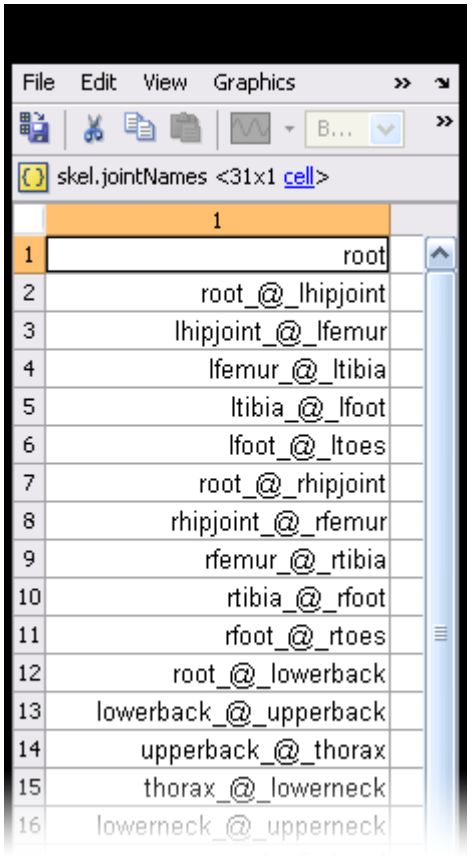
	1
1	[1;2;3;4;5;6]
2	[1;7;8;9;10;11]
3	[1;12;13;14;15;16;17]
4	[14;18;19;20;21;22;23]
5	[21;24]
6	[14;25;26;27;28;29;30]
7	[28;31]



Handling MoCap data in MATLAB: The skel-structure



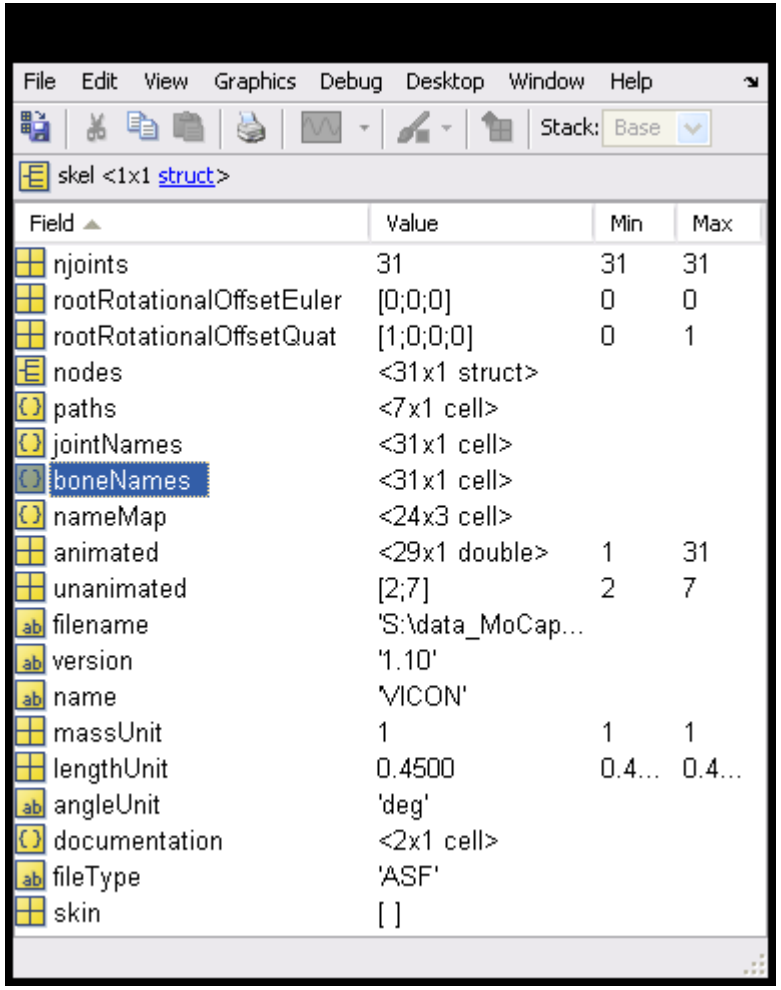
skel.jointNames



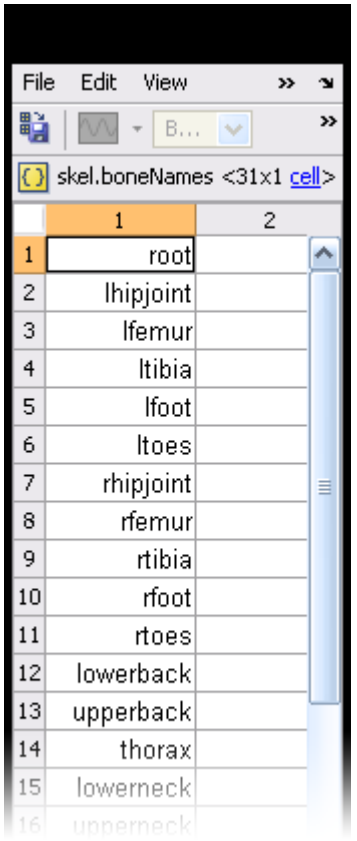
redundancy:

```
skel.jointNames{i} ==
skel.nodes{i}.jointName
```

Handling MoCap data in MATLAB: The skel-structure



skel.boneNames

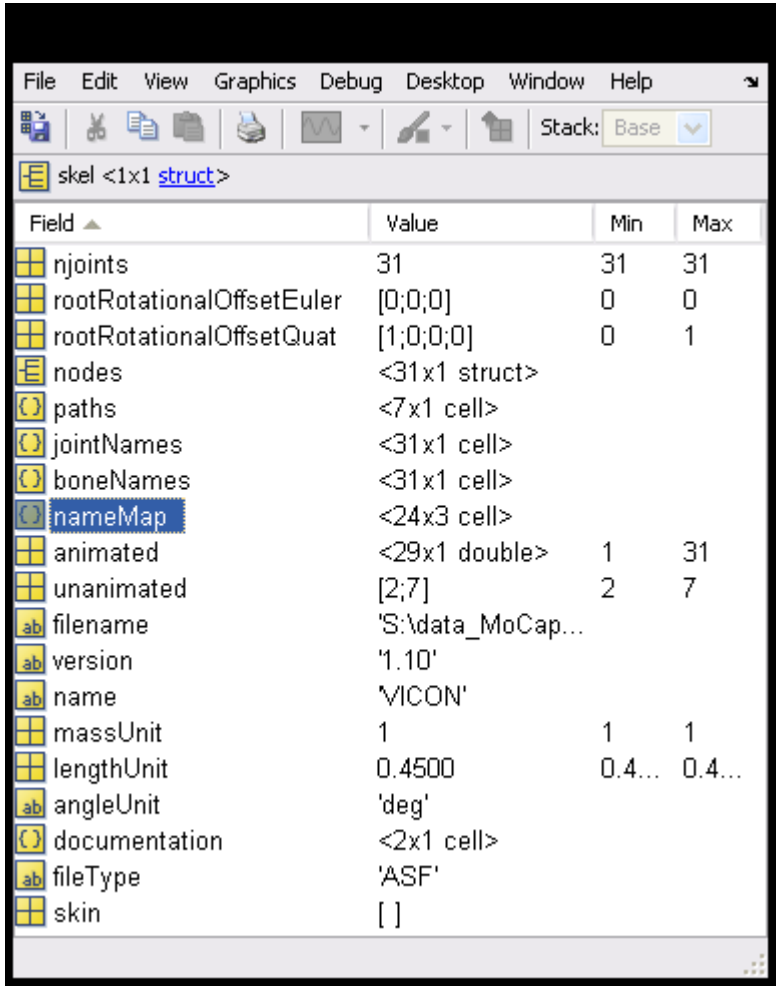


redundancy:

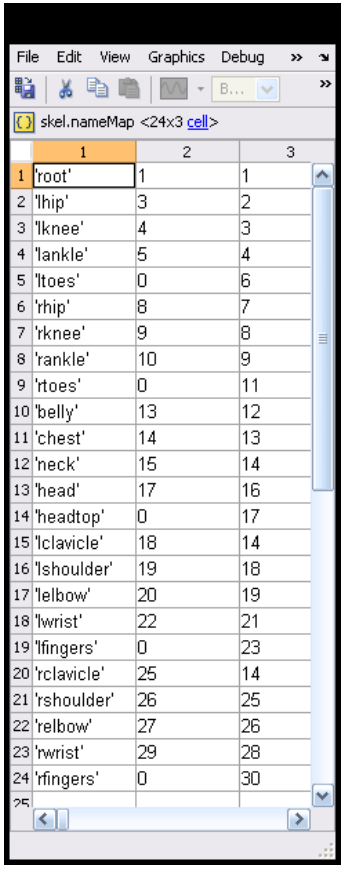
```
skel.boneNames{i} ==

skel.nodes{i}.boneName
```

Handling MoCap data in MATLAB: The skel-structure



skel.nameMap



Handling MoCap data in MATLAB: The skel-structure

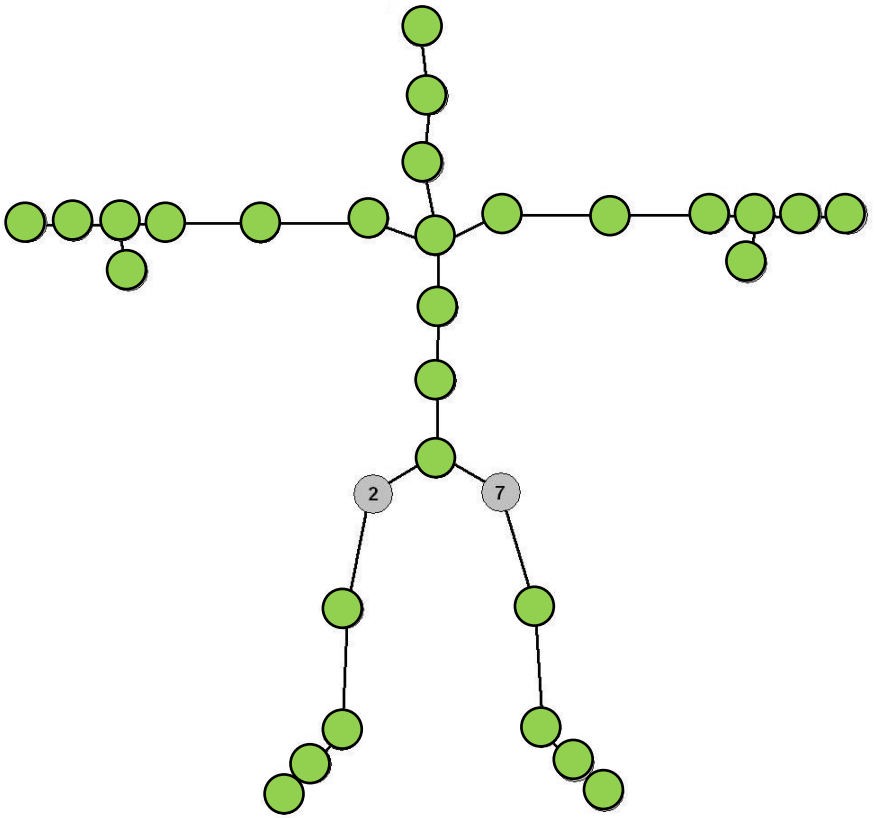
File Edit View Graphics Debug Desktop Window Help

Stack: Base

skel <1x1 struct>

Field	Value	Min	Max
njoints	31	31	31
rootRotationalOffsetEuler	[0;0;0]	0	0
rootRotationalOffsetQuat	[1;0;0;0]	0	1
nodes	<31x1 struct>		
paths	<7x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 double>	1	31
unanimated	[2;7]	2	7
filename	'S:\data_MoCap...		
version	'1.10'		
name	'VICON'		
massUnit	1	1	1
lengthUnit	0.4500	0.4...	0.4...
angleUnit	'deg'		
documentation	<2x1 cell>		
fileType	'ASF'		
skin	[ ]		

skel.animated



Handling MoCap data in MATLAB: The skel-structure

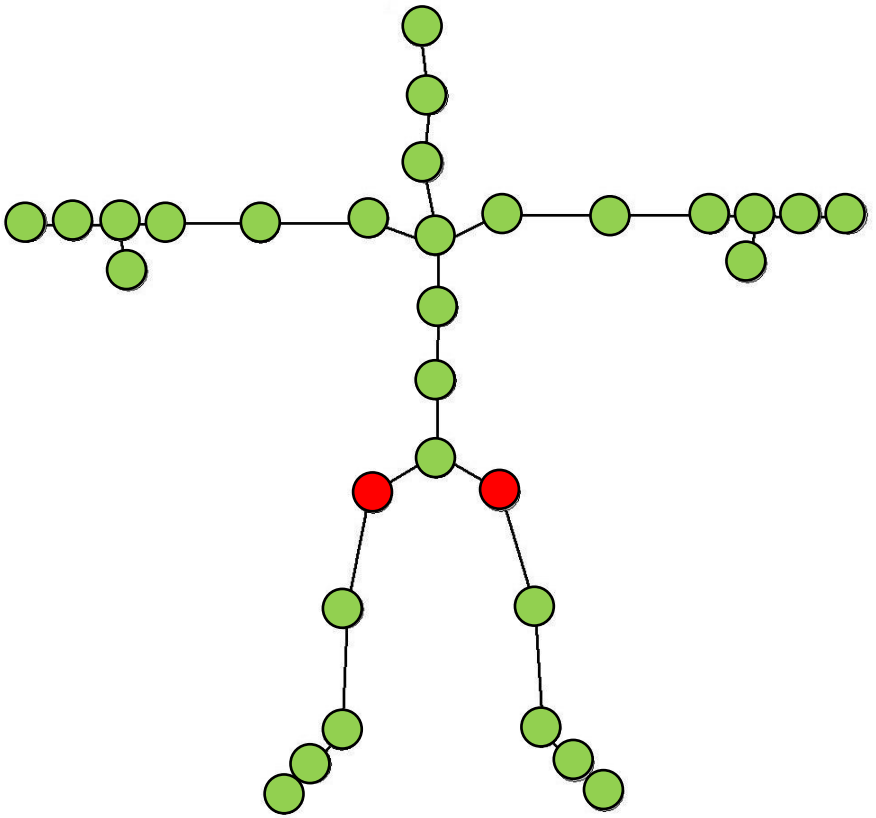
File Edit View Graphics Debug Desktop Window Help

Stack: Base

skel <1x1 struct>

Field	Value	Min	Max
njoints	31	31	31
rootRotationalOffsetEuler	[0;0;0]	0	0
rootRotationalOffsetQuat	[1;0;0;0]	0	1
nodes	<31x1 struct>		
paths	<7x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 double>	1	31
unanimated	[2;7]	2	7
filename	'S:\data_MoCap...		
version	'1.10'		
name	'VICON'		
massUnit	1	1	1
lengthUnit	0.4500	0.4...	0.4...
angleUnit	'deg'		
documentation	<2x1 cell>		
fileType	'ASF'		
skin	[ ]		

skel.unanimated



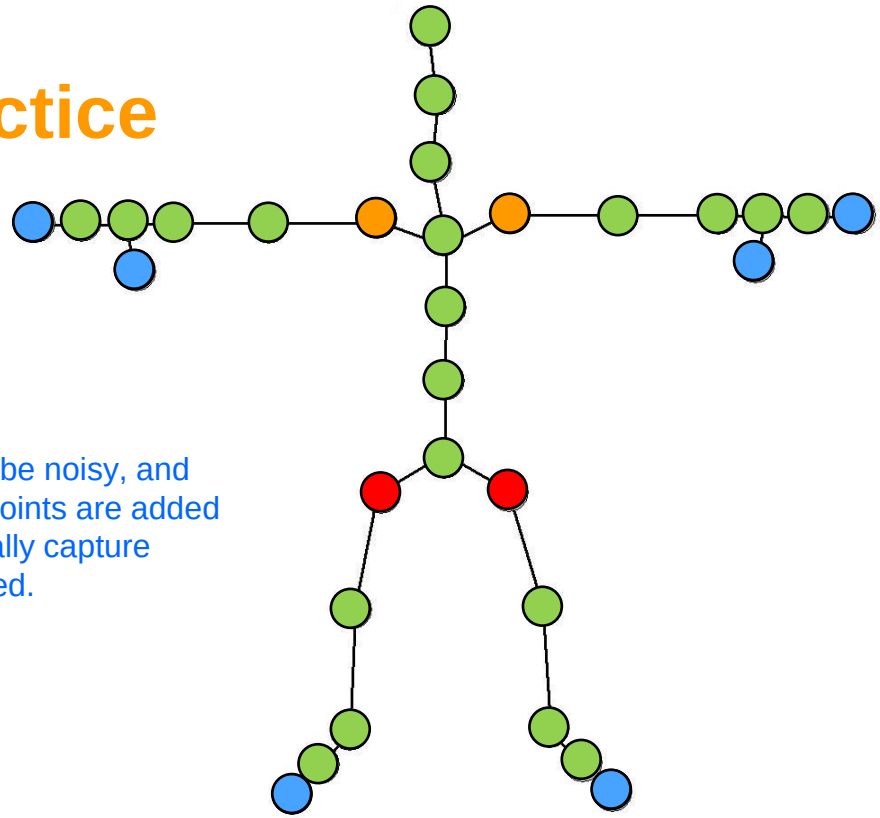
Handling MoCap data in MATLAB: The skel-structure

animated (#DOFs>0)

unanimated (#DOFs=0)

rather unanimated in practice

error-prone

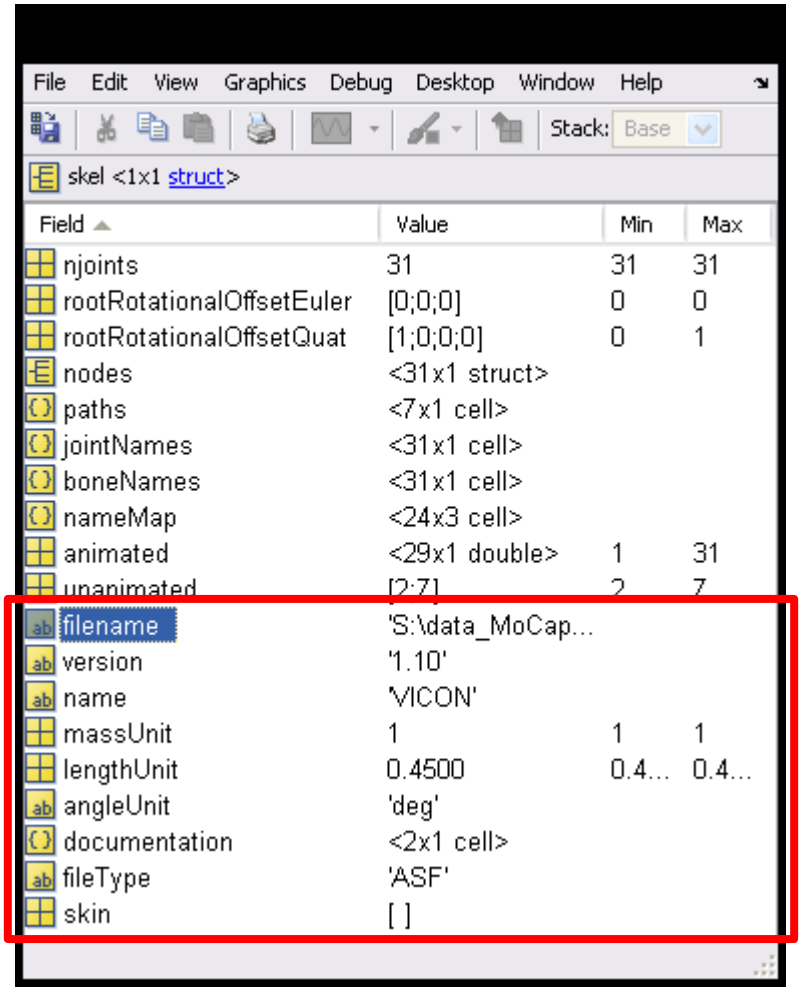


Citation:

> **Note:** The "toe" and "hand" joints in our motions tend to be noisy, and may require some smoothing. The "finger" and "thumb" joints are added to the skeleton for editing convenience - we do not actually capture these joints' motions and any such data should be ignored.

[http://mocap.cs.cmu.edu/]

Handling MoCap data in MATLAB: The skel-structure



General information:

skel.filename

skel.version

skel.name

skel.massUnit

skel.lengthUnit

skel.angleUnit

skel.documentation

skel.fileType

skel.skin

amc (acclaim motion capture)

HDM_bk_01-01_01_120.amc - Editor

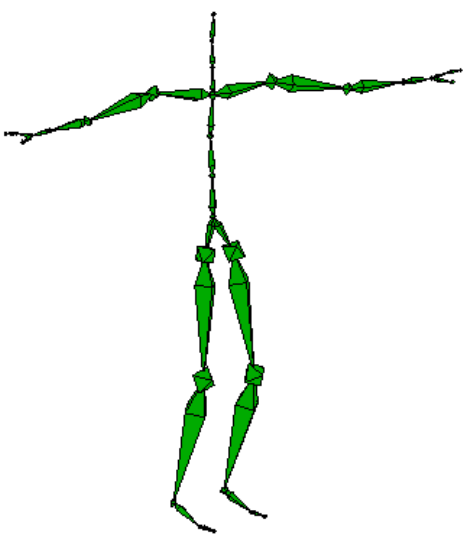
Datei Bearbeiten Format Ansicht ?

```
#!OML:ASF X:\für Bonn\!DataBase\2005_08_10_Bjorn_Final\c3d\bjorn.ASF
:FULLY-SPECIFIED
:DEGREES
1
root 0.863967 19.3167 1.67809 -174.519 3.19426 -178.293
lowerback -6.64711 1.49787 2.79472
upperback 1.83451 1.92762 -2.48232
thorax 5.82983 1.11554 -3.94217
lowerneck -2.34466 -2.5319 6.36288
upperneck 1.32406 -3.60751 -0.560933
head 0.677219 -1.79511 -1.28337
rclavicle 4.26393e-014 1.59028e-014
rhumerus -4.13653 -30.4357 -12.7934
rradius 12.1024
rwrist -0.406418
rhand -15.002 4.06821
rfingers 7.12502
rthumb 11.1628 -25.6149
lclavicle 4.26393e-014 1.59028e-014
lhumerus 20.8796 66.879 29.2662
lradius 10.8565
lwrist -56.004
lhand -10.9501 2.14884
lfingers 7.12502
lthumb 15.0686 31.5804
rfemur -15.0038 -11.0824 16.9303
rtibia 28.7704
rfoot -12.578 19.517
rtoes -5.47547
lfemur -12.4248 16.4872 -14.8054
ltibia 28.8182
lfoot -14.6858 -9.20676
ltoes -3.5653
2
root 0.864323 19.3169 1.6784 -174.517 3.22749 -178.29
lowerback -6.66494 1.51094 2.81111
upperback 1.83483 1.94465 -2.49818
thorax 5.84318 1.1253 -3.96577
lowerneck -2.32145 -2.58895 6.2772
```

frame numbers

+ skeleton information

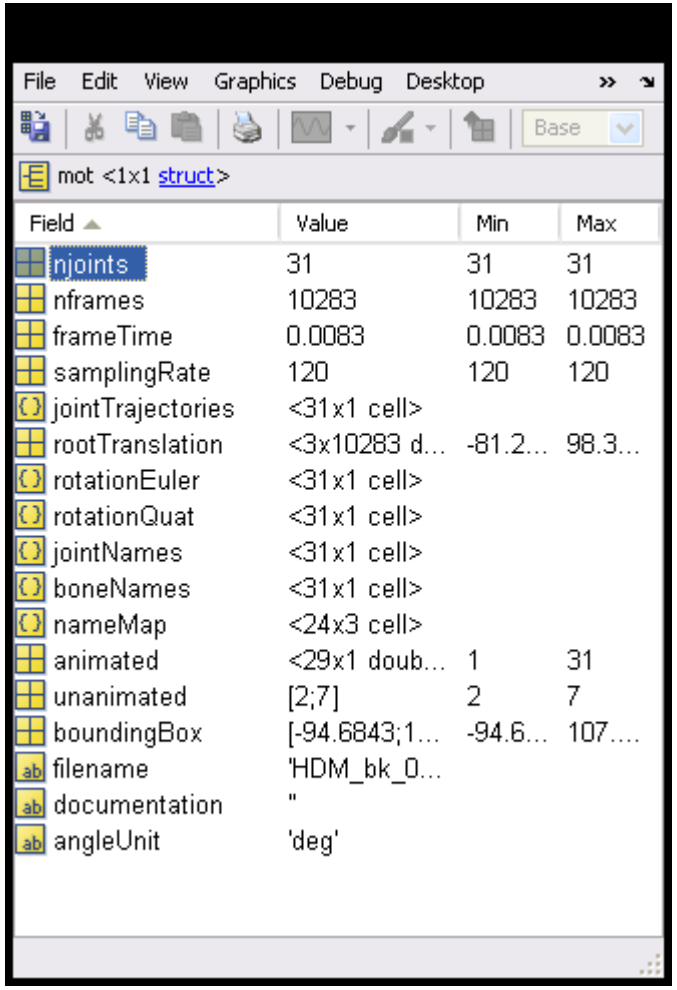
(forward kinematics)



Handling MoCap data in MATLAB: The mot-structure

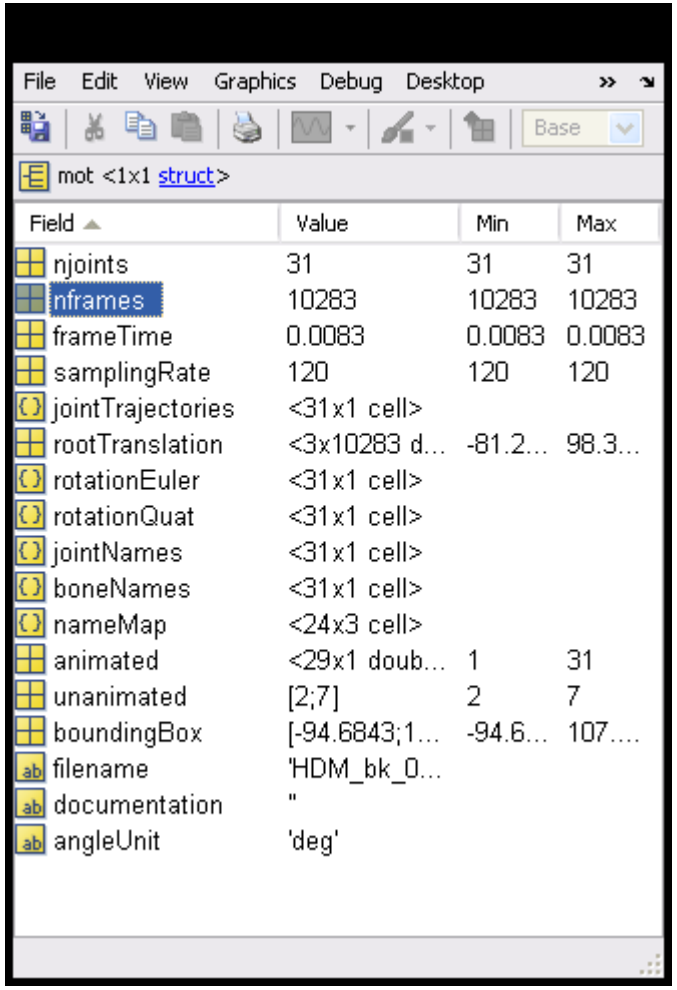
- Import of an amc-file to a structure variable in MATLAB
  - `mot = readAMC(amc_filename,skel);`
    - ⇨ structure variable `mot` is referred to as **“mot-structure”** in our parlance
    - ⇨ creation of an empty mot-structure: `mot = emptyMotion();`
- Analogous: Export of a mot-structure to an amc-file
  - `writeAMC(skel,mot,amc_filename);`

Handling MoCap data in MATLAB: The mot-structure



mot.njoints

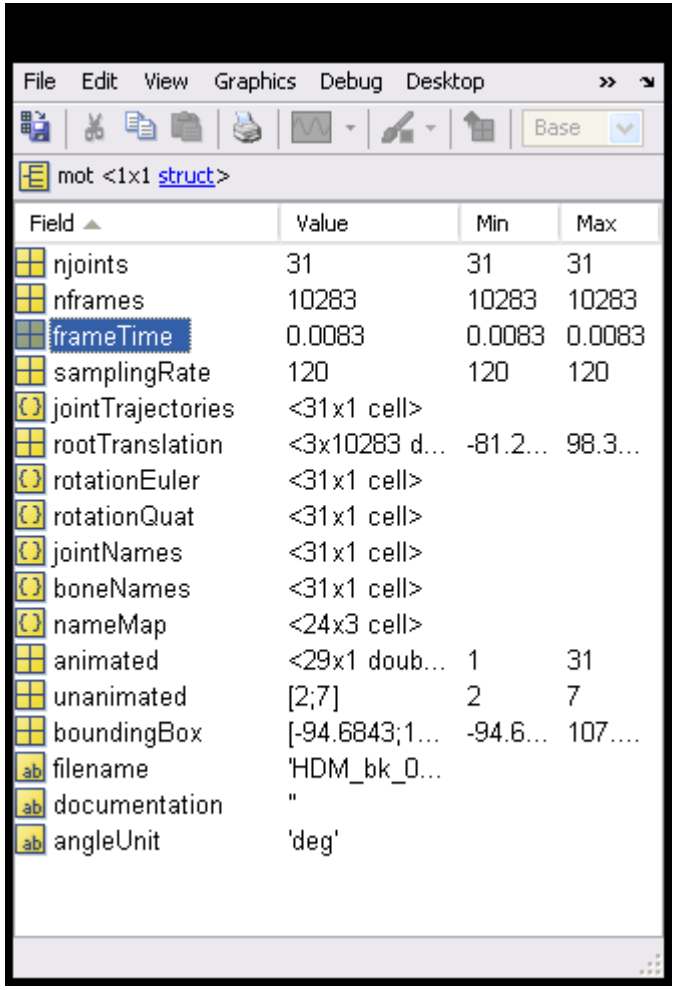
Handling MoCap data in MATLAB: The mot-structure



mot.nframes

```
mot = cutMotion(mot,startFrame,endFrame);
```

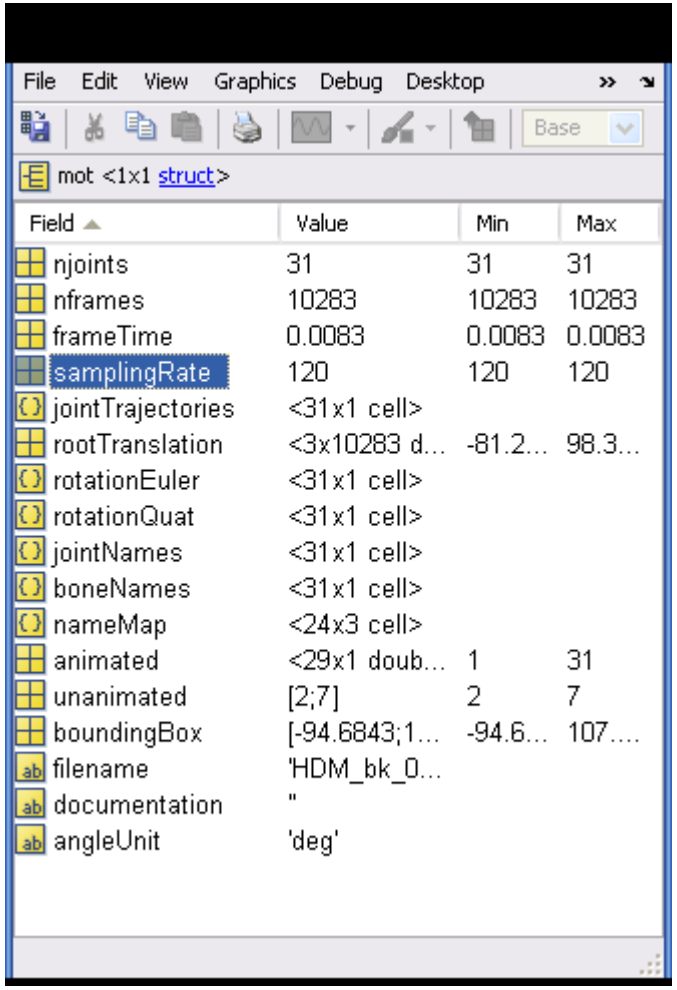
Handling MoCap data in MATLAB: The mot-structure



mot.frameTime

= 1/mot.samplingRate

Handling MoCap data in MATLAB: The mot-structure



mot.samplingRate

Samples per second usually not defined in amc-file!

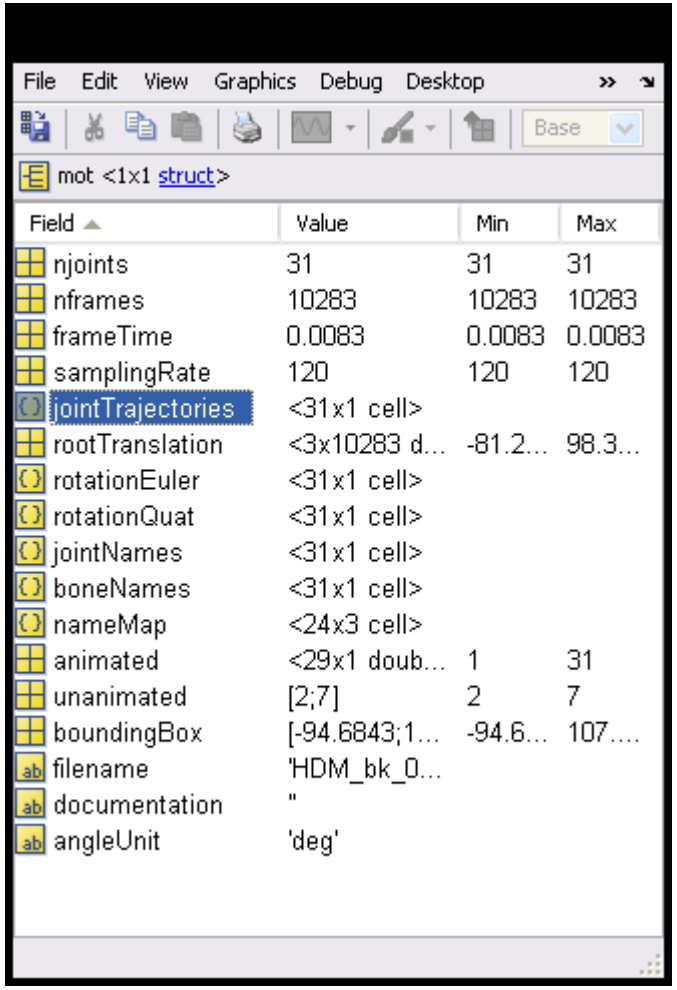
> "The AMC file format is as simple as it is impractical to parse. Neither does it contain a field for the sampling rate, nor does its header specify the total number of frames, nor does it give the name of the associated ASF file."
>
> **[Documentation Mocap Database HDM05]**

Change of frame rate:

```
mot = changeFrameRate(skel,mot,newFrameRate)
```

(using spline interpolation)

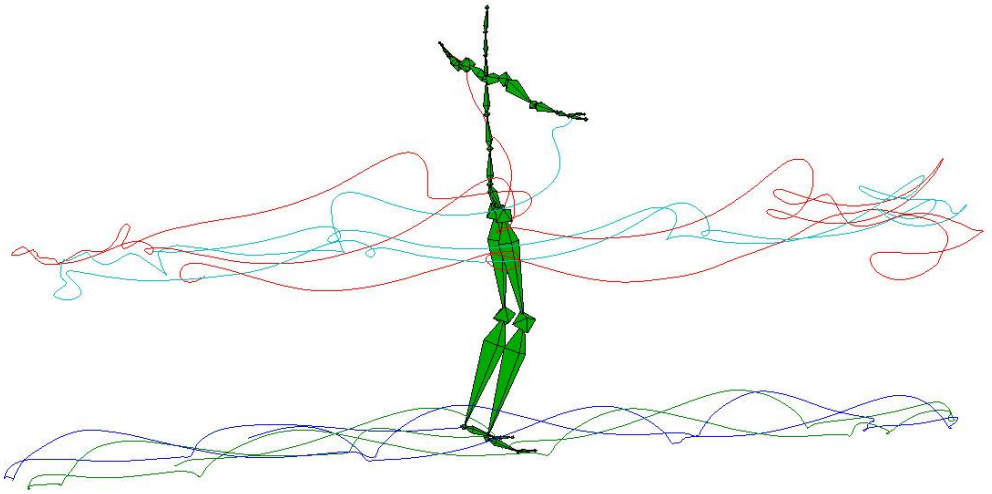
Handling MoCap data in MATLAB: The mot-structure



mot.jointTrajectories

```
mot.jointTrajectories = ...
    forwardKinematicsQuat(skel,mot);

mot.jointTrajectories = ...
    C_forwardKinematicsQuat(skel,mot);
```



Handling MoCap data in MATLAB: The mot-structure

File Edit View Graphics Debug Desktop

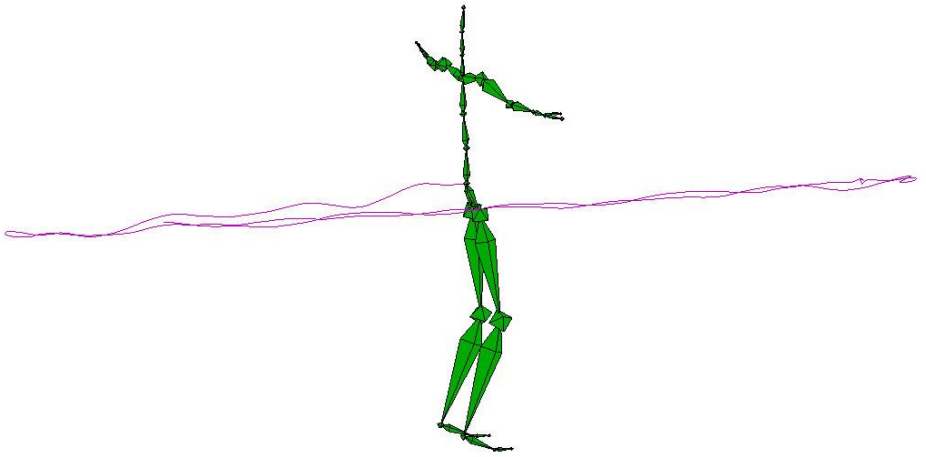
mot <1x1 struct>

Field	Value	Min	Max
njoints	31	31	31
nframes	10283	10283	10283
frameTime	0.0083	0.0083	0.0083
samplingRate	120	120	120
jointTrajectories	<31x1 cell>		
rootTranslation	<3x10283 d...	-81.2...	98.3...
rotationEuler	<31x1 cell>		
rotationQuat	<31x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 doub...	1	31
unanimated	[2;7]	2	7
boundingBox	[-94.6843;1...	-94.6...	107....
filename	'HDM_bk_0...		
documentation	''		
angleUnit	'deg'		

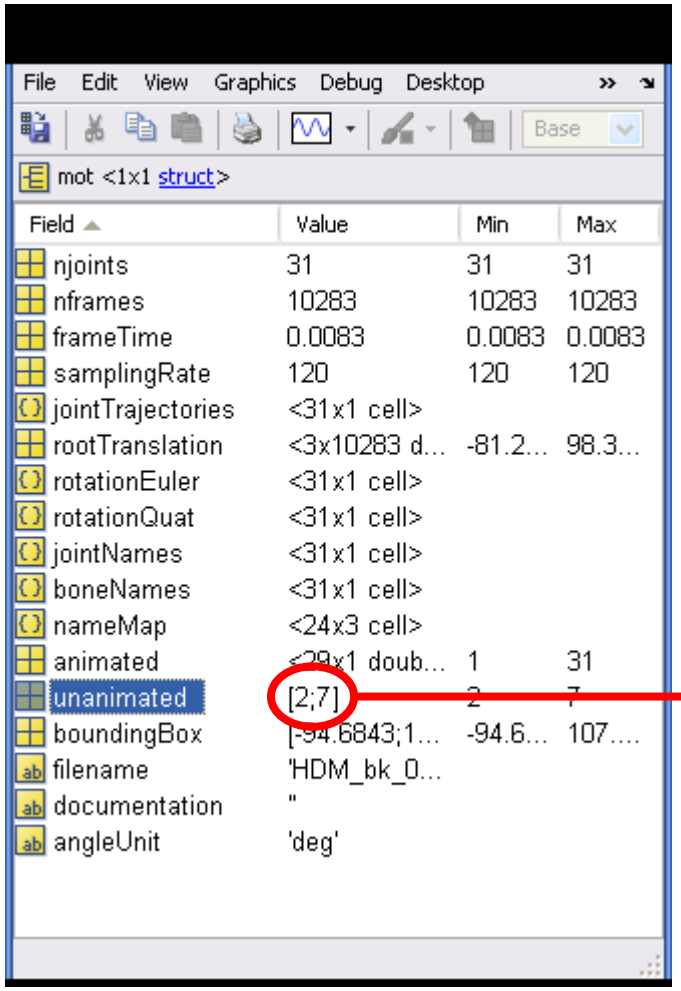
mot.rootTranslation

Note: 3D positions (mot.rootTranslation, mot.jointTrajectories) are given in inches!

(going metric is still being planned…)

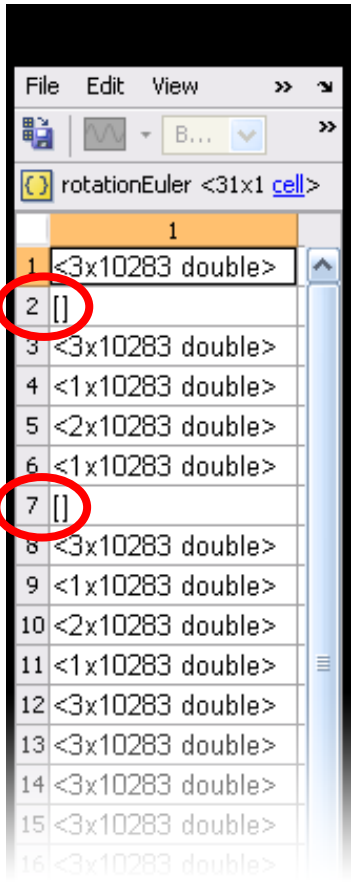


Handling MoCap data in MATLAB: The mot-structure

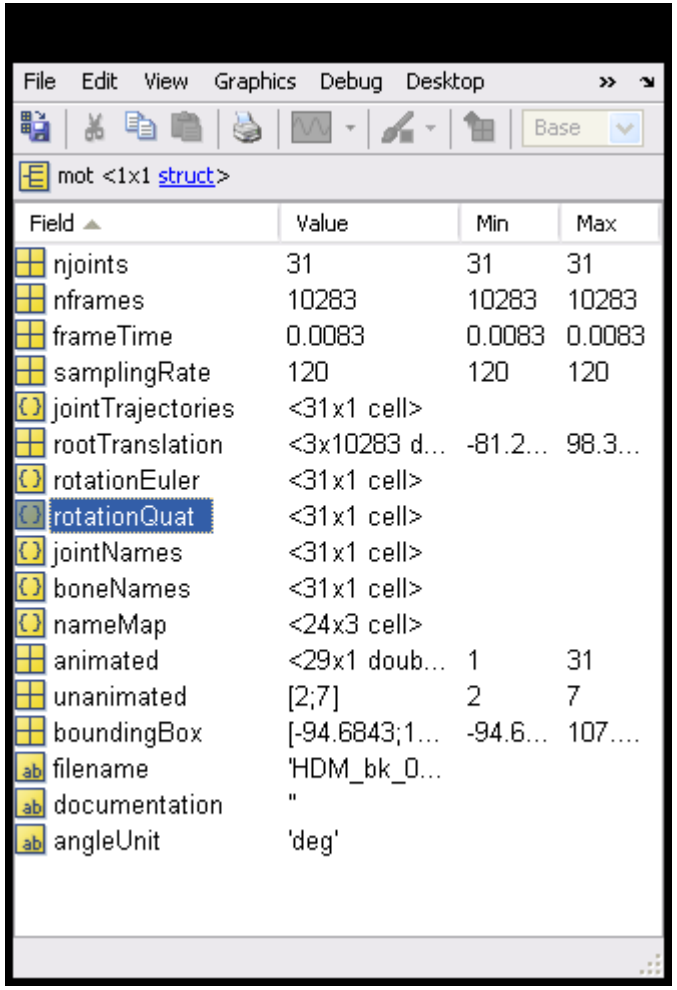


mot.rotationEuler

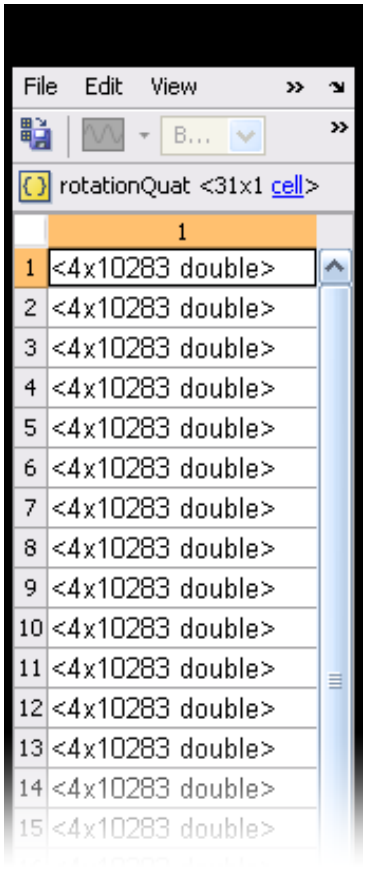
 # rotational DOFs = 59



Handling MoCap data in MATLAB: The mot-structure

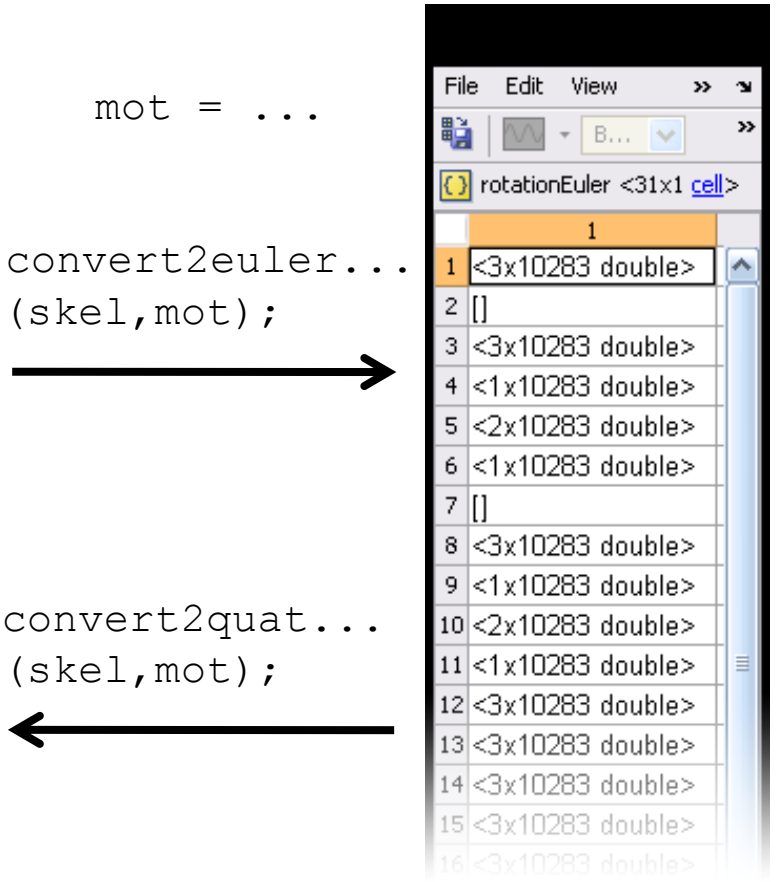


mot.rotationQuat




```
mot = ...

convert2euler...
(skel,mot);
```



```
convert2quat...
(skel,mot);
```


mot.rotationEuler

Handling MoCap data in MATLAB: The mot-structure

File Edit View Graphics Debug Desktop

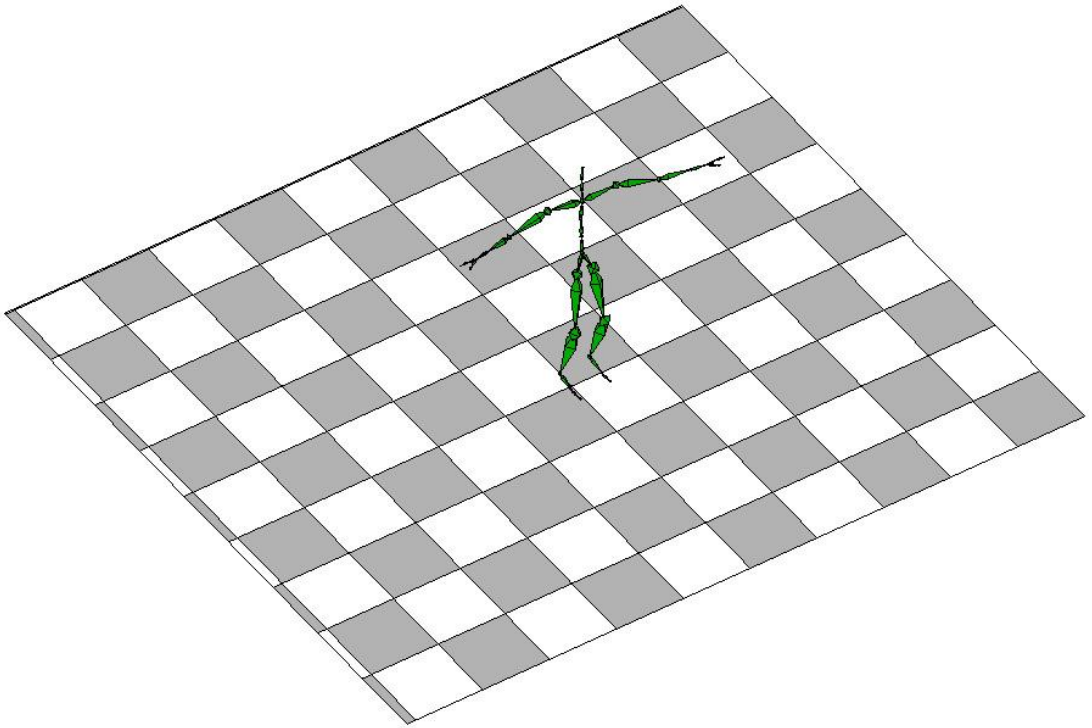
Base

mot <1x1 struct>

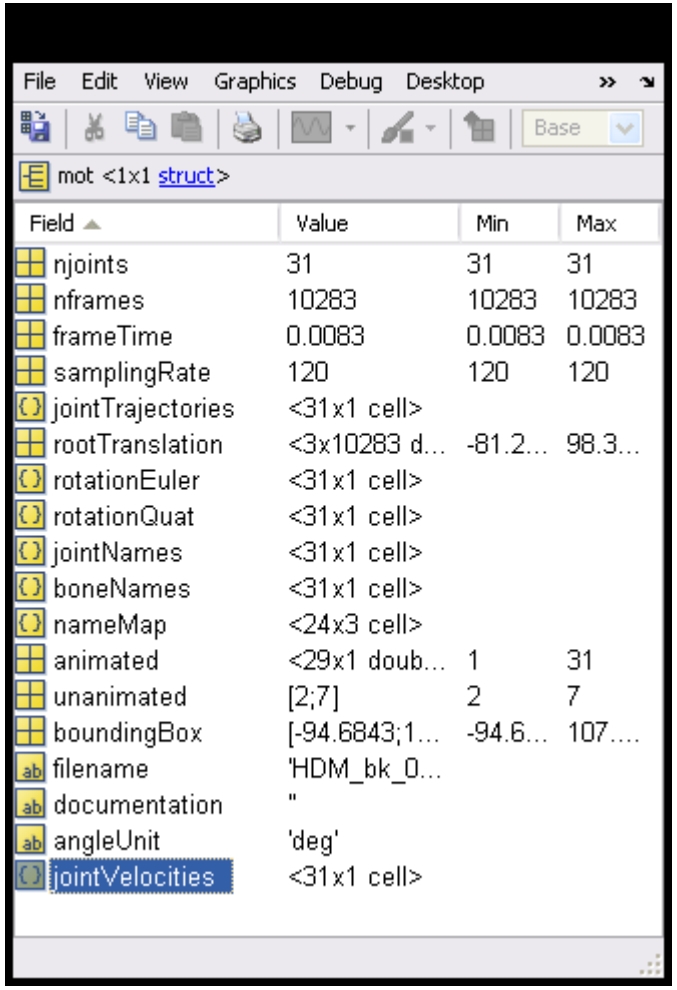
Field	Value	Min	Max
njoints	31	31	31
nframes	10283	10283	10283
frameTime	0.0083	0.0083	0.0083
samplingRate	120	120	120
jointTrajectories	<31x1 cell>		
rootTranslation	<3x10283 d...	-81.2...	98.3...
rotationEuler	<31x1 cell>		
rotationQuat	<31x1 cell>		
jointNames	<31x1 cell>		
boneNames	<31x1 cell>		
nameMap	<24x3 cell>		
animated	<29x1 doub...	1	31
unanimated	[2;7]	2	7
boundingBox	[-94.6843;1...	-94.6...	107....
filename	'HDM_bk_0...		
documentation	''		
angleUnit	'deg'		

mot.boundingBox

```
mot.boundingBox = computeBoundingBox(mot);
```



Handling MoCap data in MATLAB: The mot-structure



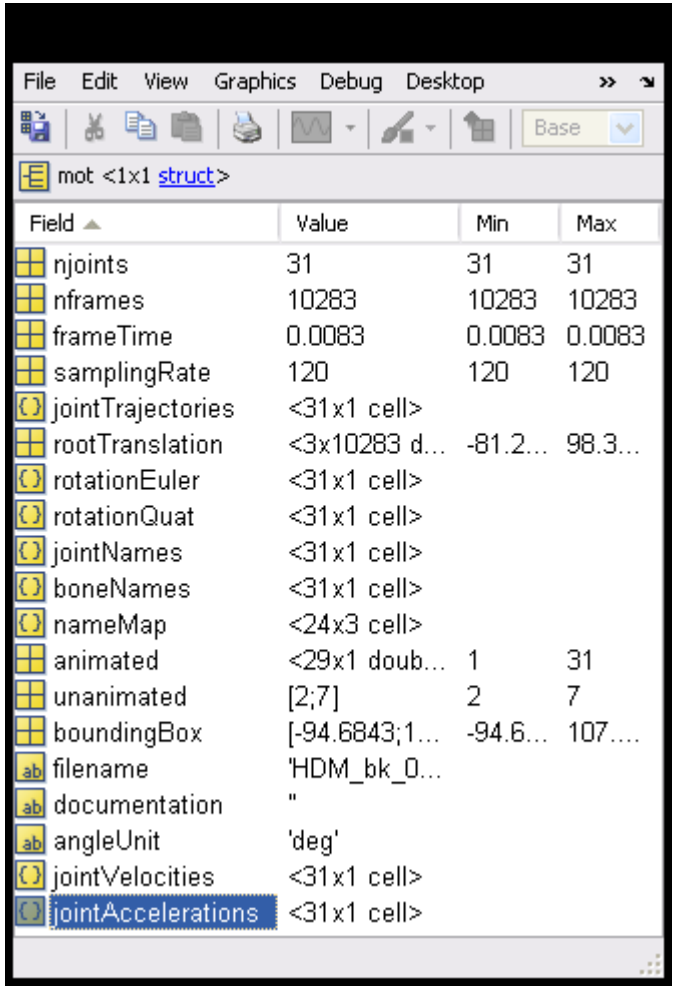
mot.jointVelocities

```
mot = addVelToMot(mot);
```

Using 5-point-derivation:

$$\dot{p}_t = v_t = \frac{1 \cdot p_{t-2} - 8 \cdot p_{t-1} + 8 \cdot p_{t+1} - 1 \cdot p_{t+2}}{12 \cdot \Delta t}$$

Handling MoCap data in MATLAB: The mot-structure



mot.jointAccelerations

```
mot = addAccToMot(mot);
```

Using 5-point-derivation:

$$\ddot{p}_t = a_t = \frac{-1 \cdot p_{t-2} + 16 \cdot p_{t-1} - 30 \cdot p_t + 16 \cdot p_{t+1} - 1 \cdot p_{t+2}}{12 \cdot \Delta t^2}$$

More parsing…

- `[skel,mot] = readMocap('asf_filename','amc_filename');`
- `[skel,mot] = readMocapGUI();`