ART-Human

Motion Capture User Manual

Version 2.1

Advanced Realtime Tracking GmbH

October 2014

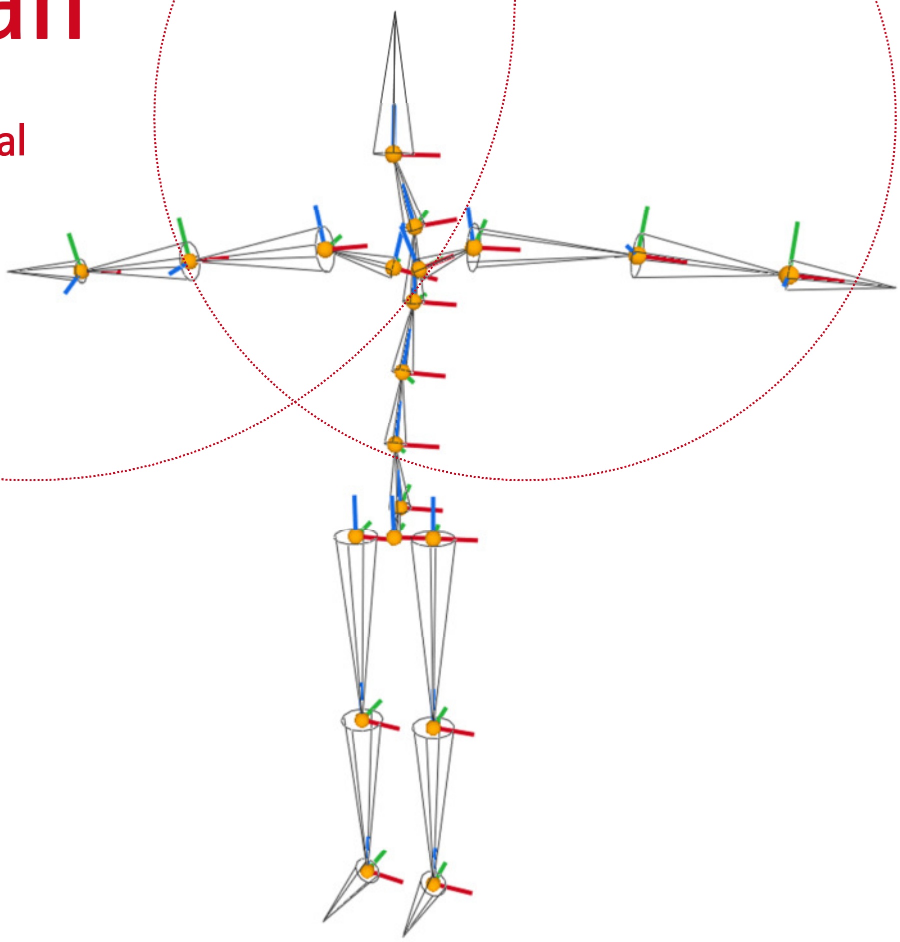


Table of Contents

1 Introduction

1.1 What is ART-Human?

ART-Human allows an ART optical tracking systems to be used for Motion Capture. ART-Human can automatically calibrate the bone lengths of a human body model in a simple calibration procedure to an accuracy level of 1cm. Using advanced inverse kinematics, the human body pose is reconstructed in real-time and visualized in 3D. The resulting bone positions can be sent in real-time to other applications using 6dj, VRPN or Siemens Jack interfaces or recorded to disk in C3D, BVH, and CSV formats.

1.2 Features

The most important features of ART-Human are:

- Real-time inverse kinematics solver
- Simple calibration procedure
- Support of hybrid optical-inertial tracking for better occlusion handling
- Full-body and upper-body tracking
- Full Fingertracking support
- Interfaces to RAMSIS Automotive, Siemens Jack and Dassault Systèmes Live Motion Standard v1
- Real-time output via VRPN, 6dj and Siemens Jack interfaces
- Output to C3D, BVH , and CSV files for animation and motion analysis

1.3 New in Version 2.1

Version 2.0 of ART-Human was rewritten from ground up and includes many new features and bug fixes. Compared to version 1.x, the most important new features are:

- New and more accurate inverse kinematics solver
- More detailed spine model
- Improved calibration process
- Reworked user interface
- Full Fingertracking integration
- Real-time VRPN output
- C3D and BVH file output
- Dassault Systèmes Live Motion Standard v1 support
- New license model

Version 2.1 introduced output to a CSV file which can be used in RAMSIS software. It also contains several important bug fixes in 6dj output.

2 Main User Interface

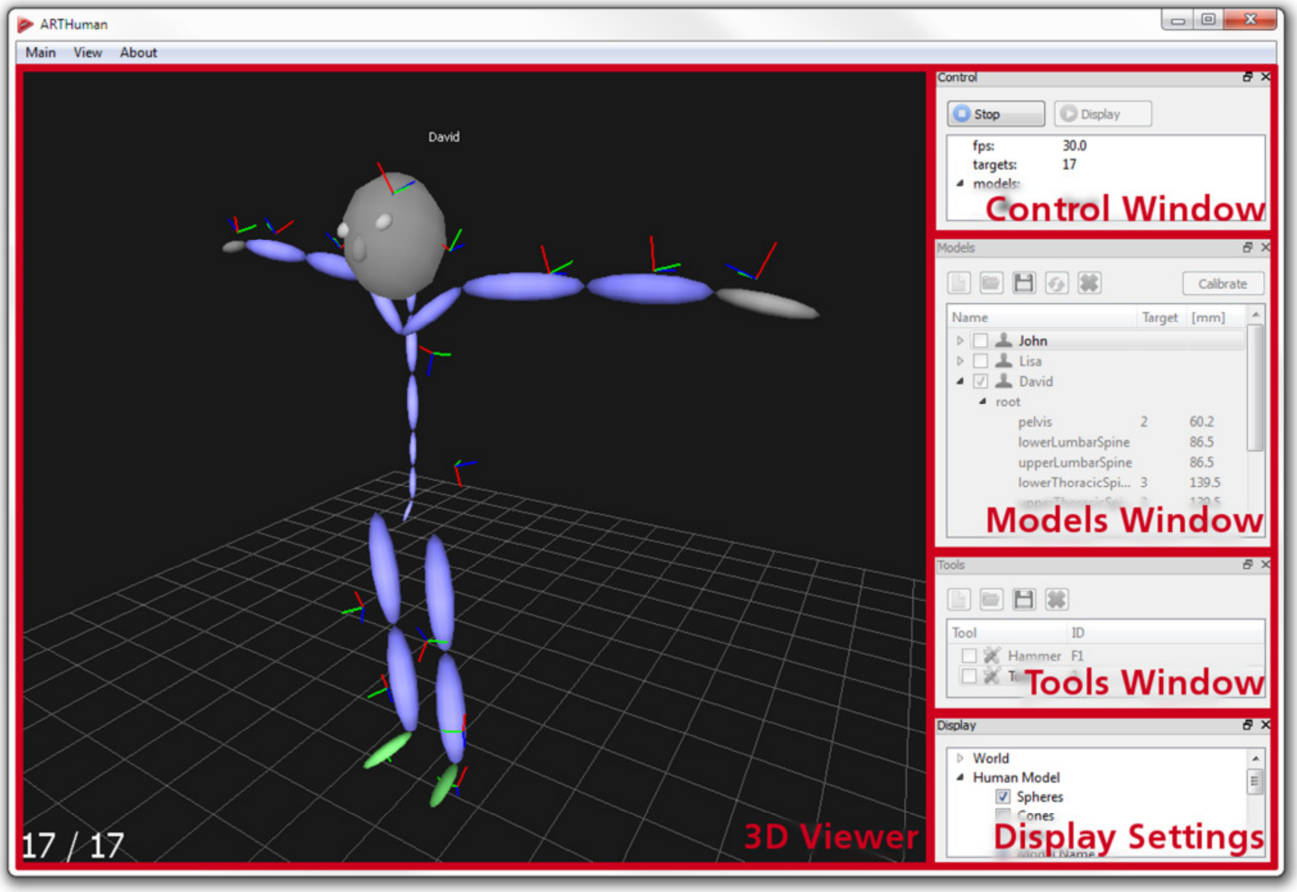


Figure 2.1: Main user interface

The user interface of ART-Human consists of the following views:

- 3D Viewer
- Control Window
- Models Window
- Tools Window
- Display Settings

With exception of the 3D Viewer, each view can be enabled or disabled from the *View* menu. The views can be placed freely on the screen by drag and drop operations.

2.1 3D Viewer

When the tracking or target display is active, the 3D Viewer shows a real-time 3D view of the tracked models, tools and targets. The viewpoint can be moved using the following operations:

- To *move left/right and up/down*, hold the left mouse button and move the mouse
- To *move forward/backward*, use the scroll wheel or hold both the shift key and the left mouse button while moving the mouse up or down
- To *rotate the viewing position* around the scene, hold the right mouse button and move the mouse

For a full screen view, choose *View→Full Screen* from the menu or press *F5*. If the viewing position was accidentally moved out of the tracking volume, the position can be reset using *View→Reset View* or by pressing the *ESC* key. The contents of the 3D Viewer can be changed in the *Display Settings* view (see section 2.5).

2.2 Control Window

The control window is used to start and stop the tracking process and provides some information about the current tracking state.

To start or stop the real-time *inverse kinematics tracking* and activate the configured output channel, push *Tracking*. When no models are calibrated, a real-time *display of the tracking targets* as provided by DTrack (with no inverse kinematics) can be activated by pressing *Display*.

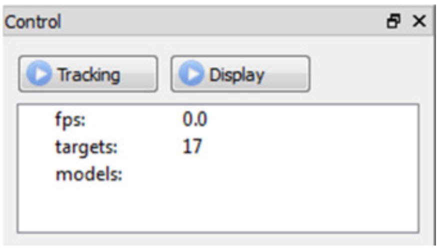


Figure 2.2: Control window

Additionally, the following information is provided:

Option	Description
fps	Frames per second of the output data.
Targets	Number of active tracking targets provided by DTrack.
Models	Shows the currently tracked models.

2.3 Models Window

The Models Window shows the currently available models and allows basic operations on the model list. By clicking on the arrow left of the model name, it is possible to navigate through the bone hierarchy of each model and view the current target assignments and bone lengths for each calibrated bone.

To *create a new model*, press the button, which will open the *New Human Model* dialog. You can assign the model a name, an icon and choose the MoCap target set to use. Creation of new models is described in more detail in section 3.3. To *delete a model*, select it and press the button.

The *model calibration* is started by selecting the model and clicking on *Calibrate*. For more details on calibration, see section 3.4. Manual changes to the target assignment can be *reset* using the button.

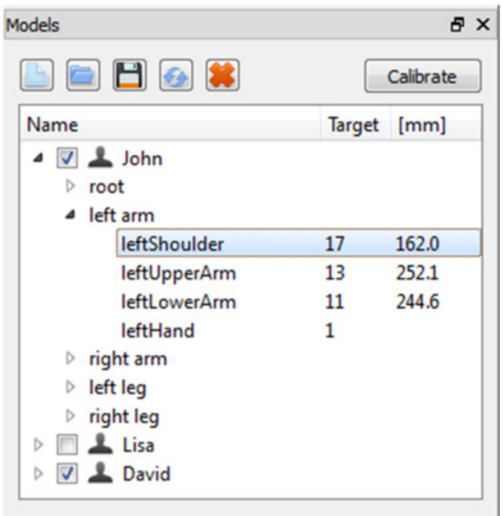


Figure 2.3: Models window

A calibrated model can be *saved to disk* using the button. ART-Human currently supports two formats, which can be chosen in the *Save Model* dialog: The *human models (*.hm)* format contains the whole hierarchy and calibration data for backup or transfer of calibration to another computer. The *segment descriptions (*.csv)* format provides a simple method to *export segment lengths* for use by other programs. Note that the segment descriptions do not contain the full hierarchy or calibration information, and thus cannot be loaded back into ART-Human. An exported human model can be *loaded from disk* using the button.

Remark: Normally it is not necessary to explicitly save models except for backup or transferring to another computer, as ART-Human automatically saves the models in the Models Window to its internal workspace and loads them on start of the application.

To *activate a model* for tracking, check the *check box* left of the model name. Only active models will be used for inverse kinematics and output.

For *target assignment*, the double click the *Target* field of the bone and enter the DTrack target ID. Special target types such as Flysticks or measurement tools can be specified using the following naming scheme:

Target IDs	Body Type
01, …, 99	DTrack standard bodies and inertial targets
H01, …, H99	Hand targets used by the finger tracking module
F01, …, F99	Flysticks
M01, …, M99	Measurement tools

Remark: Normally, targets are assigned to bones automatically during calibration. Manual assignment is only necessary when this does not work for some reason. Manual target assignment can also be done in the Calibration dialog.

2.4 Tools Window

Tools are additional tracking targets which are not used for inverse kinematics and passed through to the output channel by ART-Human. Among others, they can be used for prop tracking and interaction devices.

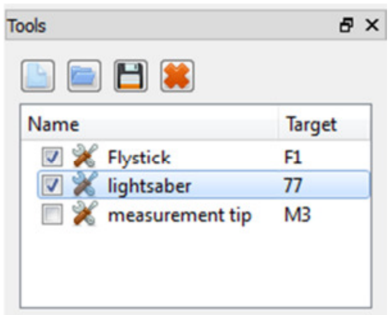


Figure 2.4: Tools window

Clicking on *creates a new tool*, while *deletes* the selected tool. By double-clicking on the tool Name, the name can be changed. To *assign a target*, double-click the Target field and enter the body id. For Flysticks, measurement tools, etc. use the same naming scheme as described in section 2.3.

The buttons and *save and load* the tool name and target assignment to and from a file on disk.

2.5 Display Settings

The contents displayed in the 3D viewer can be customized be activating and deactivating the various options in the Display Settings window. The following options are available:

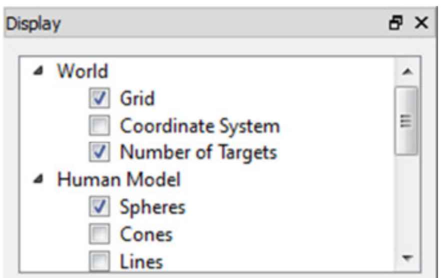


Figure 2.5: Display settings

World Display

The following options control the display of items which are always present in the scene:

Option	Description
Grid	Shows a grid on the floor.
Coordinate System	Shows the axes and the origin of the current room coordinate system.
Number of Targets	Shows the number of available and assigned targets.

Human Model Display

The following options control the display of the tracked models:

Option	Description
Spheres	Displays the bones of the tracked model using three-dimensional ellipsoids.
Cones	Displays the bones of the tracked model as cones. In contrast to the Spheres option, the orientation of bones can be recognized more easily
Lines	Draws straight lines between the joints of the tracked model.
Model Name	Shows the name of the model next to the model's head. Useful when multiple models are tracked.
Segment IDs	Draws the bone IDs next to each bone. Useful for debugging the output.
Joints	Draws the joint locations as spheres.
Coordinate Systems	Draws a coordinate system at the origin of each bone.
Retargeted Model	If activated, the retargeted model is shown, as sent to the output channel. Otherwise, the internal representation is shown.

Target Display

The following options control the display of DTrack tracking targets, i.e. of ART-Human's inputs:

Option	Description
Coordinate Systems	Draws a coordinate system at the origin of each target.
Target IDs	Draws the target ID next to each target's location. Useful for checking the target assignment.

Tool Display

The following options control the display of tools:

Option	Description
Name	Draws the name of the tool next to its location.
IDs	Draws the numeric ID of the target next to its location. Whether the ID or the name is output depends on the selected output channel (see section 4.2).
Coordinate System	Draws a coordinate system at the origin of each tracked tool.
Sphere	Draws a sphere at the origin of each tracked tool.

3 Creating and Calibrating Models

Before a model can be tracked, a number of steps have to be performed, which consist of:

- Setting up the DTrack system
- Putting on the MoCap Suit
- Creating a new model
- Calibrating the model

3.1 Preparing DTrack

For setting up the camera system and to perform an initial *room calibration*, please follow the instructions given in the DTrack user manual.

Calibrating the Tracking Targets

To track the targets of the MoCap suit with the camera system, a *body calibration* of all tracking targets must be performed in the DTrack software once. The simplest solution is to use the *Target Library* method which allows the simultaneous calibration of all MoCap targets, even when already worn on the body. Please refer to the DTrack2 user manual for details.

In cases where body calibration using the target library is not possible (e.g. when using an older target set or an older DTrack version), each target must be calibrated individually using the *Custom* Calibration method. We recommend calibrating using the *due to room* coordinate system setting.

Remark: There is no need to calibrate targets in any particular order or to assign particular body IDs. In most cases, the correct assignment is automatically computed during calibration.

Configuring DTrack Output

Finally, please configure DTrack to send the tracking data to the computer running ART-Human. The simplest method is to run the DTrack Frontend on the same computer as ART-Human, open *Settings→Output*, activate an output *Channel* and set the destination to *this computer*.

Please also make sure that at least the fields *ts* and *6d* are enabled. If you want to use additional target types such as Flysticks, measurement tools or inertial bodies, please enable the respective output fields as well.

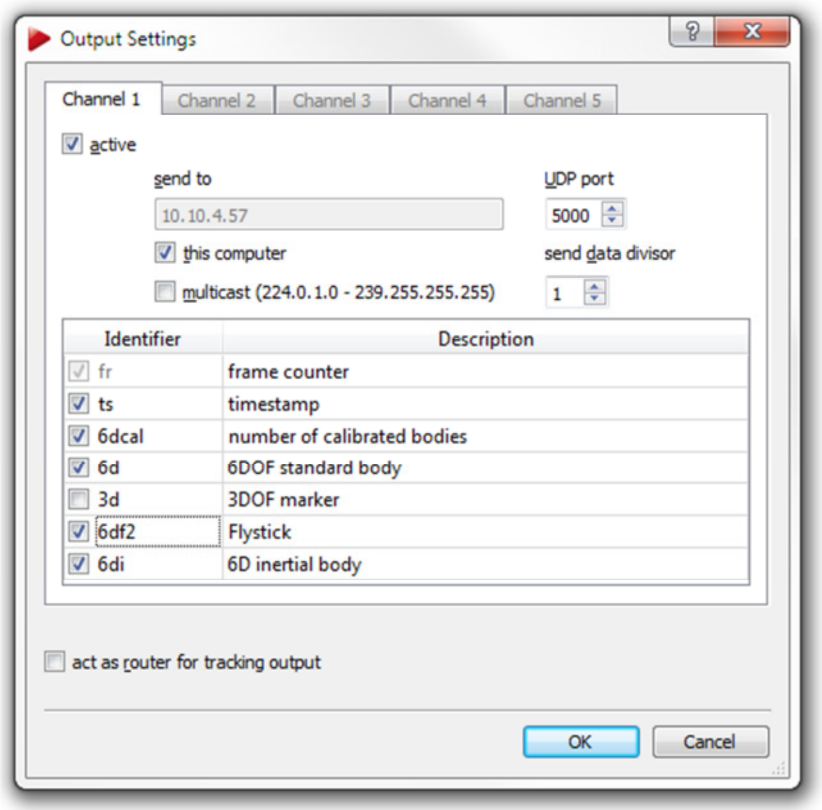


Figure 3.1: DTrack2 output settings

Remark: When using inertial targets, make sure to have the 6di field enabled. Otherwise, inertial targets may seem to track, but ART-Human will not behave correctly in occlusion situations.

Configuring ART-Human Input

After configuring the output channel in DTrack, go back to ART-Human and open *Main→Input Configuration* from the menu. Make sure that the *DTrack UDP port* number matches the one of the DTrack output channel and set the *ground plane* to correspond to the room calibration setting of DTrack.

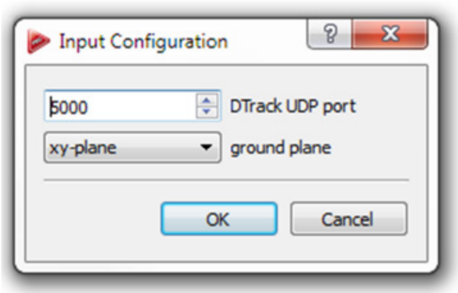


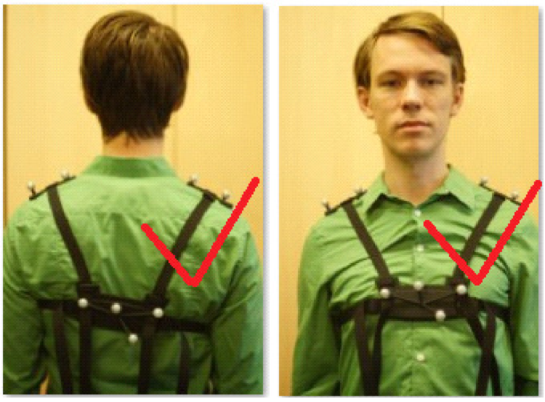
Figure 3.2: Input configuration

3.2 Putting on the MoCap Targets

After DTrack is configured appropriately, please put on the tracking targets. Each target contains a small symbol indicating where on the body it should be worn.

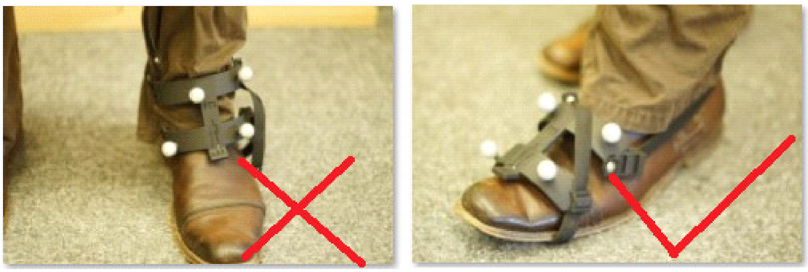
When putting on the target set, there are several important points to consider:

- The chest and hip targets can be worn either in front or back of the body



- The hip target is best worn in the middle of waist, not on the left or the right side

- The foot targets should be near the tip instead of near the ankle



Finally, walk around in the tracking volume and check if all the targets can be tracked well.

3.3 Creating a new Model

A new model is created by pressing the button in the *Models Window*, which opens the *New Human Model* dialog. Please enter a descriptive name and optionally choose an icon.

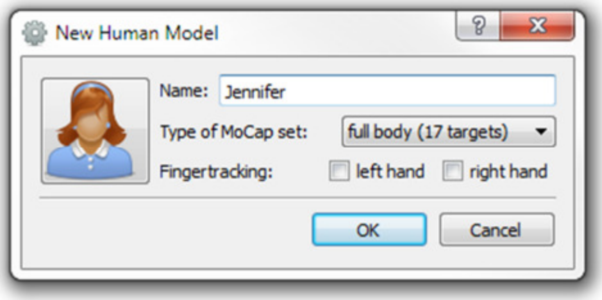


Figure 3.3: Creating new human model

Under *Type of MoCap set*, please choose the target set you want to use. Currently, the following target sets are supported.

- *Full body (17 targets):* A full body target set, consisting of the following targets: hip, chest, head, shoulders (2x), upper arms (2x), lower arms (2x), hands (2x), upper legs (2x), lower legs (2x) and feet (2x).
- *Upper body (7 targets):* A simplified target set for tracking arms and head only. It consists of the following targets: head, upper arms (2x), lower arms (2x) and hands (2x).
  Using this target set, tracking will start with the upper thoracic spine and bones below will not be part of the output stream. Also note that this target set does not allow tracking of the correct torso orientation and thus, the torso will always be standing upright.

If you want to use ART-Human together with *Fingertracking*, please also tick the *left hand* and/or *right hand* checkboxes. After clicking OK, the model will be created and can be calibrated.

3.4 Calibrating a Model

To calibrate a new or existing model, first click on the model in the *Models Window* and then click *Calibrate*. Now, the Human Model Calibration dialog should open.

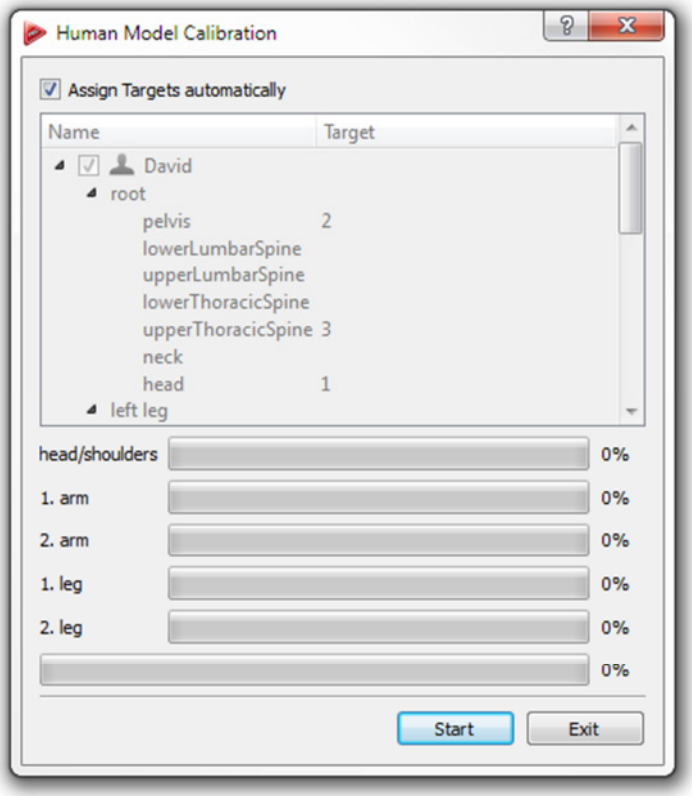


Figure 3.4: Human model calibration

Target Assignment

If you want to use the *automatic target assignment*, please check the box *Assign Targets automatically*. In this case, remove any tracking targets that do not belong to the model from the tracking volume, so that only targets on the person are tracked by DTrack during calibration. Any other targets in the volume may cause the automatic assignment to fail.

If you want to keep the current target assignment or override the assignment manually, disable the check box and enter target IDs manually. For targets other than standard bodies, follow the target naming scheme given in section 2.3.

Starting the Calibration in T Posture

To start the calibration, press *Start*. After a five seconds count-down, data recording will start. At the beginning of the calibration, the person must be standing in T posture, i.e. upright with arms pointing away from the body, as shown in the picture below. If the T posture is not set appropriately, there will be displacements between the calculated human model and the real motion. It is particularly important that

- the feet are parallel and standing firmly on the ground
- the hands are flat and oriented parallel to the ground
- the neck is stretched upwards
- the head is looking forward (and not to a screen standing on the side)

Joint Calibration Movement

After the data recording has started while standing in T posture, move all limbs until all progress bars reach 100% in order to calibrate the bone lengths and target position. The calibration will automatically finish when enough motion is recorded.

Remark: Please consider that most joints can be rotated in two or three axes and move the limbs accordingly. Rotating all possible axes may greatly improve calibration quality!

After the calibration has finished, push *Tracking* and move inside the tracking volume to test the motions of the calibrated model. If you are not satisfied with the results, try to calibrate again, putting extra emphasis on the motions of the body parts that did not look correct.

4 Output Configuration

In order to define the output of ART-Human, open *Main→Output Configuration* from the main menu. In the Output Configuration dialog, two separate aspects need to be configured:

- the retargeting of the model, defining the world units, the available bones and their orientations
- the actual output channel used to transmit data to an application

In general, ART-Human allows all available options to be combined freely; however, specific applications may require specific settings. More information about the settings required for certain applications are given in section 5.

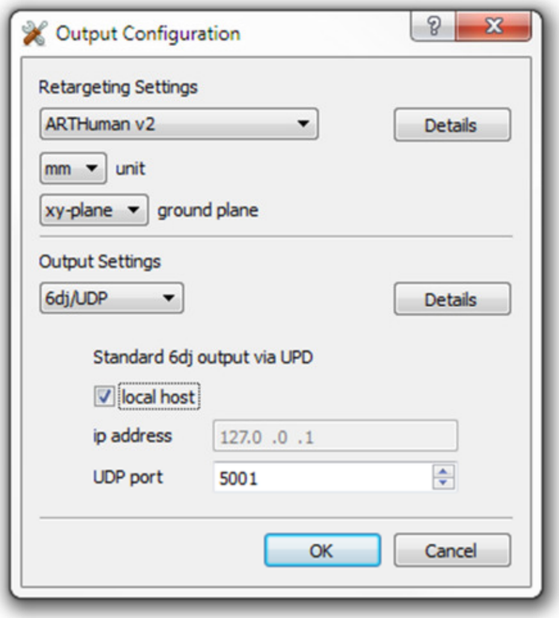


Figure 4.1: Output configuration

4.1 Retargeting Options

ART-Human provides a number of pre-defined retargeting settings which specify the following aspects of the model data sent to the application:

- number of bones
- orientation of the bones
- numeric IDs of the bones
- distal or proximal bone coordinates

By clicking on the *Details* button, a preview of each retargeted model with target IDs and bone orientations can be seen. The following retargeting settings are available:

ART-Human v2 (Default)

This default setting contains the new spine model with four spine segments. In T-pose, all bones are oriented such that X points left, Y points backwards and Z points up. The ART-Human v2 setting uses proximal bone coordinate systems, i.e. the origins are located at the bone end closer to the pelvis. Please refer to appendix A.1for details about the coordinate systems and bone IDs.

Unless required by some other application, we recommend using this setting as it most accurately describes the result of ART-Human's inverse kinematics.

The ART-Human v2 configuration also supports the ART Fingertracking. When Fingertracking is activated, the orientations and positions of the finger bones are sent to the configured output channel along the ART-Human bones. Please refer to appendix A.2 for bone IDs and to section 5.2 for general Fingertracking settings.

ART-Human v1

The ART-Human v1 retargeting setting is provided for compatibility with older versions of ART-Human. The setting uses a distal bone representation, i.e. the origin of the bone coordinate systems is at the end of the bone that is further away from the pelvis in T posture. Compared to v2, the spine contains fewer segments and the orientation of the right arm is changed such that the x axis points outwards. Please refer to appendix A.1 for details about the coordinate systems and bone IDs.

Siemens Jack

This retargeting setting is suitable for use with the Siemens PLM Jack software. It uses two spine and one neck segment. The y axis of each bone coordinate system points along the bone in an outward direction. The z axis points towards the front, with the exception of the feet where it points upwards. Please refer to appendix A.4 for details about the coordinate systems and bone IDs.

Dassault Systèmes Live Motion Standard v1

This retargeting setting is suitable for use with Dassault software such as 3DVIA Studio. It uses the same spine model as ART-Human v2 but adds additional coordinates systems for the toes (which are not tracked by ART-Human). The y axis of each bone coordinate system points along the bone in an outward direction. The z axis points towards the front, with the exception of the feet where it points upwards. Please refer to appendix A.5 for details about the coordinate systems and bone IDs.

General Retargeting Settings

ART-Human provides a number of general retargeting settings which may be applied to all models:

Option	Description
unit	Determines the unit in which the bone positions are given. Available choices are meters (m), centimeters (cm) and millimeters (mm).
ground plane	ART-Human can apply an extra rotation to the output data which is configured here. Output coordinate systems are always right-handed.

4.2 Output Channels

The output settings define the output channel that is used to send the retargeted bone coordinates to an application. Currently, the following choices are available:

6dj/UDP

This setting makes ART-Human send UDP packages to a client application. It extends the standard UDP format used by DTrack with a *6dj* line that contains the 6DoF pose of each bone in the retargeted models.

Please refer to the technical appendix of the DTrack User Manual for a general introduction to the format. The destination IP address and UDP port of the UDP packets can be specified in the dialog.

An example frame looks like this:

fr 34514
ts 64425.076492
6d 15 [0 1.000][522.1646 -141.5154 1347.3978 0.3947 0.2996 89.6321][0.006420 0.999956 0.006855 -0.999966 0.006384 0.005273 0.005229 -0.006889 0.999963][1 1.000]…
6dj 3 1 [0 20][0 1.000][562.7647 -128.7422 781.4459 -0.0000 0.0000 87.8071][0.038265 0.999268 0.000000 -0.999268 0.038265 0.000000 0.000000 0.000000 1.000000][1 1.000][564.9398 -128.8686 966.4164 1.1212 2.2889 88.7907][0.021088 0.999602 0.018721 -0.998980 0.020320 0.040335 0.039939 -0.019552 0.999011][2 1.000][522.1646 -141.5154 1347.3978 0.3947 0.2996 89.6321][0.006420 0.999956 0.006855 -0.999966 0.006384 0.005273 0.005229 -0.006889 0.999963][3 1.000][654.3460 -144.7520 1504.9670 -1.5249 1.7823 90.0123][-0.000215 0.999646 -0.026605 -0.999516 0.000613 0.031097 0.031102…

Where the meaning of each line is:

<table>
<tr><th>Line tag</th><th>Description</th></tr>
<tr><td>fr</td><td>DTrack frame counter</td></tr>
<tr><td>ts</td><td>Time stamp in seconds</td></tr>
<tr><td>6d</td><td>Number of tracked tools, for each tool followed by
<code>[id qu][sx sy sz η θ φ][b0 … b8]</code>
• Id number (<code>id</code>, starting with 0) of the tool
• quality value <code>qu</code> (not used)
• Position <code>sx sy sz</code> and euler angles <code>η θ φ</code>
• Rotation matrix <code>b0 … b8</code> of the tool’s orientation
Please refer to the DTrack User Manual for an exact definition of euler angles and rotation matrices.</td></tr>
<tr><td>6dj</td><td>Number of calibrated models, number of output models. For each output model, the following element appears:
<code>[id num]</code>
• Id number (<code>id</code>, starting with 0) of the model
• Number <code>num</code> of retargeted bones.
For each retargeted bone, the <code>[id num]</code> element is followed by <code>num</code> elements of the form
<code>[id qu][sx sy sz η θ φ][b0 … b8]</code>
These have the same definition as for the 6d field above and represent the retargeted bone pose relative to the world coordinate system.</td></tr>
</table>

Note that ART-Human can also pass tracking data of Flysticks and Measurement Tools using 6df, 6df2, 6dmt, and 6dmt2 lines. Do not forget to activate necessary formats in DTrack output settings. Please refer to DTrack manual for details.

Siemens Jack

In order to communicate with Siemens PLM Jack, use this output format, which opens a TCP network connection to Jack. The destination IP address and TCP port number of Jack can be specified. For Jack configuration, see section 5.3.

VRPN

When this output setting is activated, ART-Human opens a VRPN server to transmit retargeted bone poses. The local port number of the server can be specified. For each retargeted model, a tracker is created having the same name as the model. Each bone is represented by a sensor using the IDs specified in the retargeting settings. We recommend also setting the unit settings to *m* to conform to the VRPN conventions.

For each defined tool, a dedicated tracker is created having the same name as the tool. A single sensor with id 0 transmits tool position and orientation on each tracker.

C3D file

For offline storage of tracking data in C3D format, please use the *C3D file* output setting. Each time the tracking is started, a new file is created in the specified directory. The file name will consist of the current date and time. In C3D, each bone's position and orientation is described using three "virtual markers" which are distributed as follows:

Marker ID	Location
0	At origin of bone coordinate system
1	20 mm along the y axis of the bone
2	20 mm along the z axis of the bone

Each marker is named according to the following naming scheme:

`h<modelid>b<boneid>m<markerid>`

Where `modelid` is the number of the model, `boneid` is the id of the bone as specified by the retargeting setting and `markerid` is the id of the virtual marker as specified by the table above.

For tools, the naming is

`tool<toolid>m<markerid>`

Where `toolid` is the number of the tool and `markerid` is the id of the virtual marker as specified by the table above.

BVH file

For offline storage of tracking data in BVH format, please use the *BVH file* output setting. Each time the tracking is started, a new file is created in the specified directory. The file name will consist of the current date and time. BVH files contain the full bone hierarchy of the retargeted models. The pose of the bones is then described using relative angles. The generated file contains all tracked models and tools using the names specified in the Model/Tool Windows.

If the exact position of extremities matters (and not just the joint angles), we recommend to use the *ART-Human v2* retargeting setting.

RAMSIS CSV file

For offline storage of tracking data in CSV format, please use the *RAMSIS CSV file* output setting. Each time the tracking is started, a new file is created in the specified directory. The file name will consist of the current date and time. CSV files provide positions of the bones for any chosen retargeting model. The file is structured as follows:

```
Frame,<model_name>:<bone_name>[_0],<model_name>:<bone_name>[_1],...
,mm,mm,...
0,X,Y,Z,X,Y,Z,...
1,X,Y,Z,X,Y,Z,...
...
N-1,X,Y,Z,X,Y,Z,...
```

Where `N` is the number of frames, `X,Y,Z` are the respective coordinates, `[_0]` and `[_1]` are the ids of markers which represent the same bone (e.g., pelvis_0, pelvis_1, pelvis_2). A bone can be represented using a single marker, or using 3 "virtual markers" similar to C3D output format, but instead of 20 mm the offset is 200 mm:

Marker ID	Location
0	At origin of bone coordinate system
1	200 mm along the y axis of the bone
2	200 mm along the z axis of the bone

When the option **"Use 3 markers only for limbs"** is enabled, all the bones will be represented using a single marker, except the bones which do not have continuation. When the calibrated model has no *Fingertracking* enabled, the bones which will be represented using 3 "virtual markers" are: head, arms, and foots. When *Fingertracking* is enabled, the arms will be represented using a single marker, as well as all finger bones, except the finger tips which will be represented using 3 markers. We recommend activating this option as it greatly reduces file size and further computation time in RAMSIS.

All the tools are represented using 3 markers and stored after human models in CSV file.

Note that RAMSIS does not read any header information, so you have to ignore first 2 rows of CSV file when importing it to RAMSIS.

5 Working with…

The following section explains how to interface ART-Human with special ART tracking targets and with 3rd party software.

5.1 ART Hybrid Optical-Inertial Targets

The ART hybrid optical-inertial motion capture targets contain wireless inertial sensors that allow continuous motion capture even when a large part of the targets can no longer be seen by the optical tracking cameras.

To setup inertial targets in DTrack, follow the instructions in the DTrack2 user manual. Do *make sure that the 6di output format is enabled* in the DTrack output settings. When 6di is not enabled, the inertial targets may seem to work, but will not produce correct results in occlusion situations.

To use inertial target in ART-Human, simply treat them the same way as standard targets. ART-Human will automatically recognize the inertial functionality when the 6di output is active.

5.2 ART Fingertracking

As of version 2, ART-Human fully integrates the ART Fingertracking system, enabling live preview of the finger poses in the 3D viewer. Additionally, finger bone data can be sent with the normal output channels of ART-Human.

To *setup the Fingertracking* and *calibrate the hands* in DTrack, please follow the instructions provided by the DTrack2 user manual. Also make sure that the *gl* and *glcal* outputs are enabled in the DTrack output settings.

After calibrating the hands in DTrack, switch to ART-Human and create a new model. In the *New Model* dialog, check the *right hand* and/or *left hand* boxes, depending on which hands you want to use. The model can now be calibrated normally. If you don't want to use the automatic target assignment, please enter *H01*, *H02*, etc. as the target IDs for the hands.

In the ART-Human *Output Settings* dialog, choose the *ART-Human v2* retargeting, as this is the only setting that supports Fingertracking.

5.3 Siemens PLM Jack

Please also refer to the Motion Capture manual provided by Siemens PLM.

ART-Human Settings

First, follow the instructions given in section 3 to calibrate the human model until the tracking can work normally. Then configure the output settings as follows:

- Retargeting: Siemens Jack
- Unit: cm
- Ground plane: zx
- Output channel: Siemens Jack
- IP address: IP address of computer running Jack

- TCP port: port number to send data to

After the configuration in ART-Human, start Jack7.1. Open *Mocap Communication Port Control* dialog from *Modules→Motion Capture→ Communication Protocol→Server Setup*. Check the port number and then *Start Server*. Go back to ART-Human. Start *Tracking*. If all the settings are correct, you will see the bone positions update in the Jack Window.

Attaching Tracking Data to Jack Humans

Now stop tracking in Dtrack2 or stop tracking in ART-Human, to *freeze the data at T Pose*. Create a *Default Male or Female Human* in Jack. Right click on the human and *scale* it to the correct height.

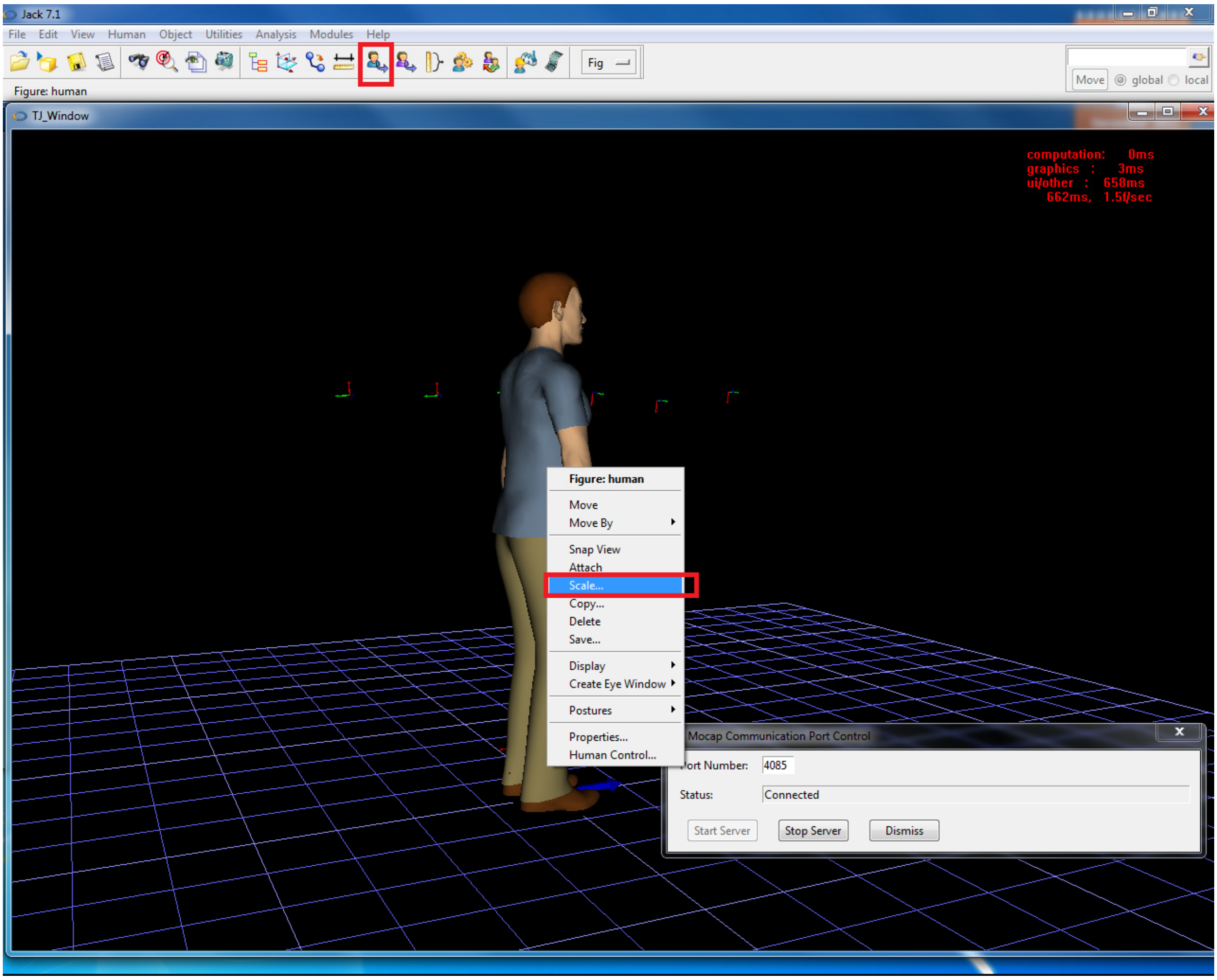


Figure 5.1: Scaling of Jack manikin

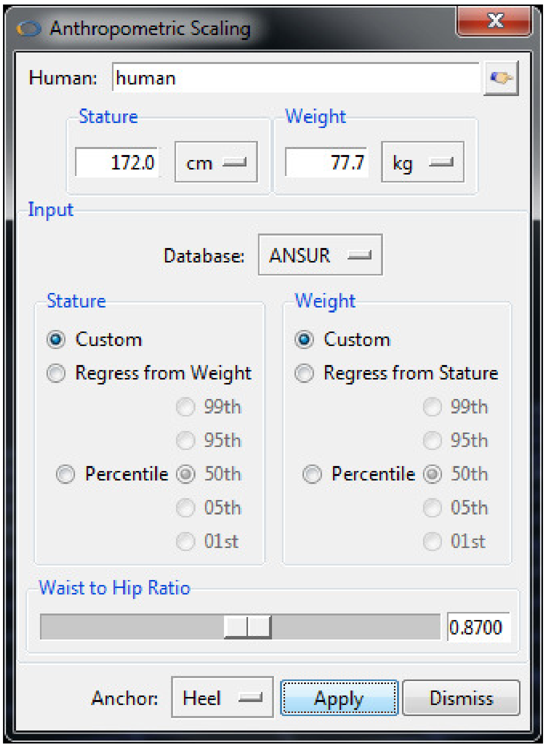


Figure 5.2: Scaling settings in Jack

Open *Mocap Tracking* dialog from *Modules→Motion Capture→Communication Protocol→Tracking Setup*. Press *Add* to open *Tracking Setup* dialog. Pick up the Human Figure by pressing and click the mouse on the Human. Press *Add Pair*. Press *Constrain* in the *Mocap Tracking* dialog and now the human is ***constrained*** to the joints data.

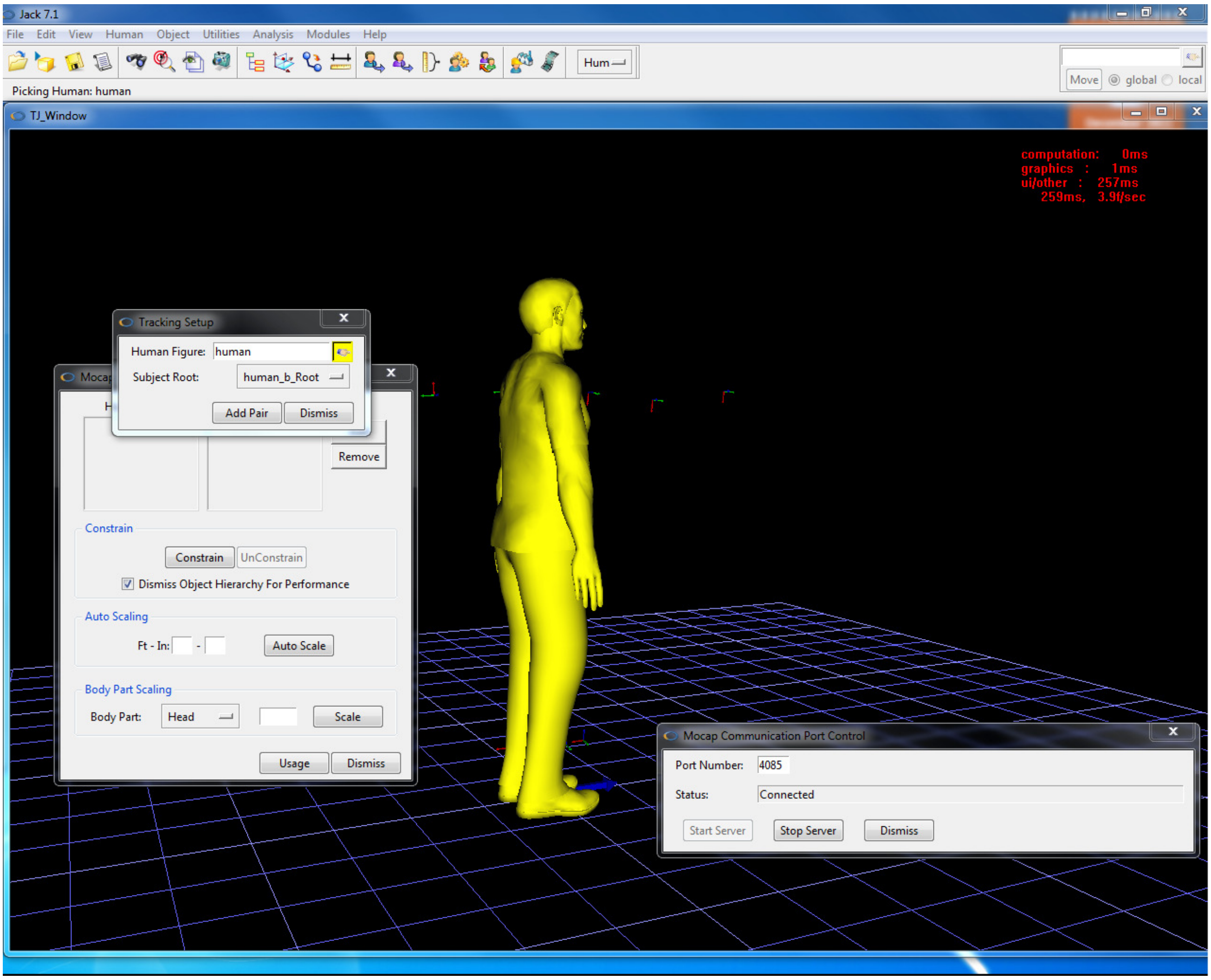


Figure 5.3: Attaching Jack manikin to tracking data

Tool Tracking

In the Tool Window of ART-Human, create tools to send to Jack. Set the target id and the name of the tool, check the checkbox in front. Then in the tracking mode, the tool target data will be send to Jack as the name “Tools_b_<toolname>”.

Starting and Stopping Tracking

The work routine to communicate with Jack should be:

1. Start Server in Mocap Communication Port Control
2. Start Tracking in ART-Human
3. Stop Tracking in ART-Human
4. Stop Server in Mocap Communication Port Control

Otherwise, the communication might have a problem and cause a crash of Jack.

5.4 Dassault 3DVIA Studio

First, follow the instructions given in section 3 to calibrate the human model until the tracking can work normally. Then configure the output settings as follows:

- Retargeting: Dassault Systèmes Live Motion Standard v1
- Unit: m
- Ground plane: xy
- Output channel: VRPN

3DVIA also requires the first tracked model to be named “User0”, the second “User1”, etc.

To connect to ART-Human from 3DVIA Studio, please follow the instructions in the 3DVIA documentation.

5.5 RAMSIS Automotive

Please also refer to **RAMSIS handbook** and **BodyBuilder handbook** provided by RAMSIS installation.

ART-Human Settings

First, follow the instructions given in section 3 to calibrate the human model until the tracking can work normally. Then configure the output settings as follows:

- Retargeting: ART-Human v2 (recommended)
- Unit: mm
- Ground plane: xy
- Output channel: RAMSIS CSV file
- Enable *“Use 3 markers only for limbs”* option (recommended)

The CSV file is created whenever a successful tracking is stopped. So, to work with RAMSIS, create a CSV file first by starting and stopping tracking when it's desired.

Note that RAMSIS processing of each animation frame takes considerable amount of time, so try to keep your CSV recordings as short as possible.

Creation of manikin

After the CSV file is prepared, start RAMSIS Automotive. Create a desired manikin using *“Manikin->Create...”* menu entry. A window *“RAMSIS Typology”* appears as illustrated on Figure 5.4. Specify the most appropriate settings for the person which was calibrated and tracked using ART-Human.

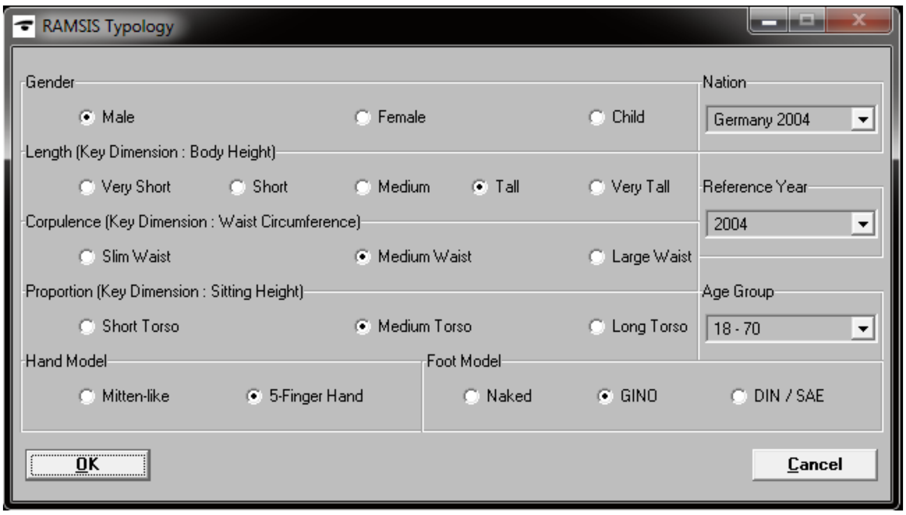


Figure 5.4: RAMSIS manikin creation

If you have prepared correct body dimensions, load it using *"File->Open..."* menu entry, specifying *"Body Dimensions"* as a type. Otherwise, you have to create *"Body Dimensions"* file with correct values. Please, refer to **BodyBuilder handbook** for further explanations on manikin adjustment.

Note that in principle, any RAMSIS manikin will work with our CSV output, but the less precise body dimensions are specified, the less precise the manikin is assigned to trajectories. Thus, incorrect manikin size can lead to highly imprecise results!

Import of CSV file

After the manikin is created and its dimensions correspond to actual person tracked in ART-Human, you can import your CSV file to RAMSIS using menu entry *"Animate->Trajectories->Import..."*. Specify the path to CSV file and press *"Open"*. In the next dialog (see Figure 5.5) Specify the number of frames to import and using *"Options..."* specify the number of header lines to ignore. ART-Human generates CSV files with two-line header: first line is the bone caption and second is the measurement unit, so 2 lines must be ignored.

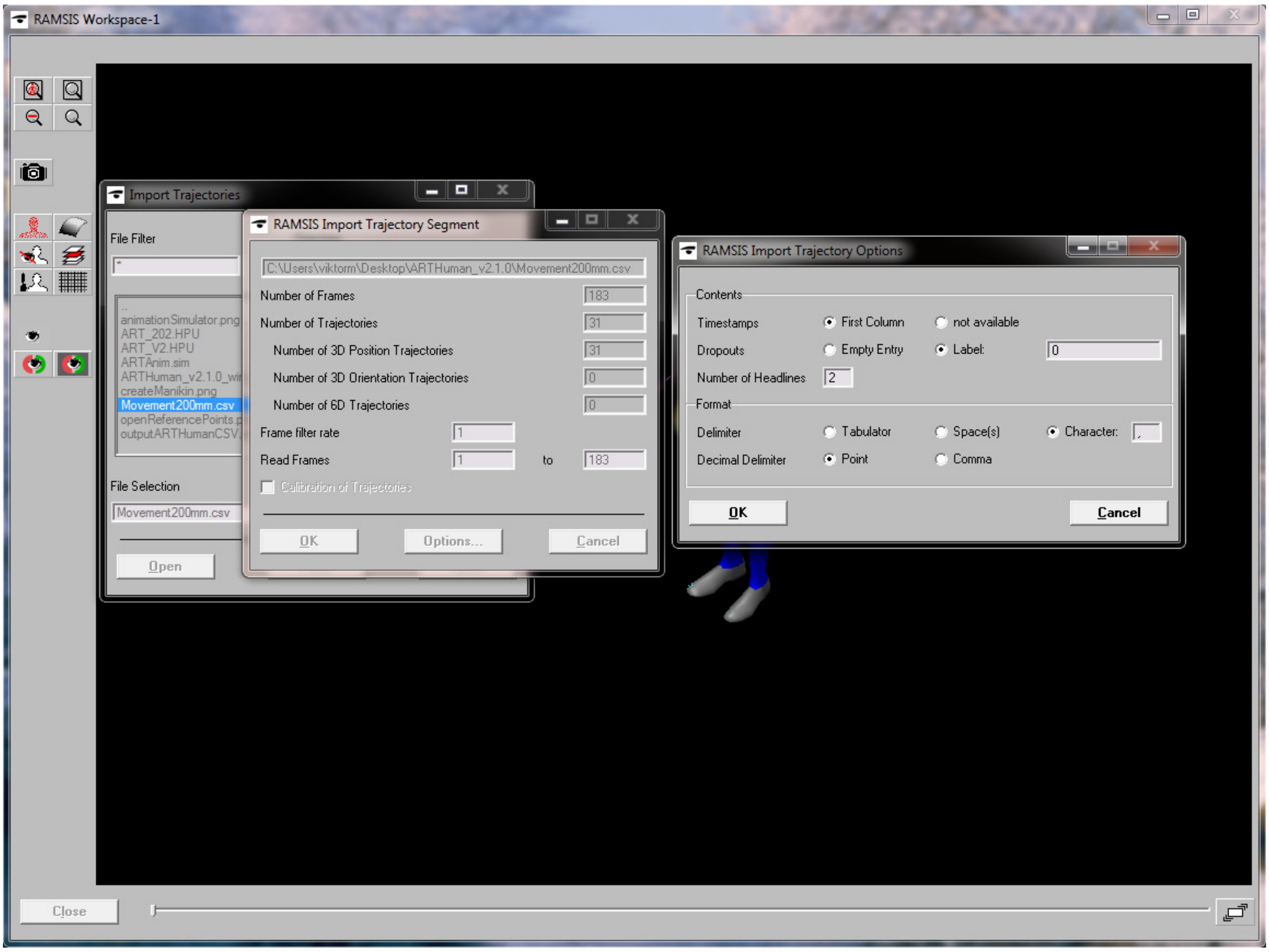


Figure 5.5: Import of CSV file

After the import of trajectories from CSV file, the RAMSIS workspace will look similarly to Figure 5.6.

Specification of reference points

Now, you have to specify reference points, namely – the points on RAMSIS manikin which correspond to the position of bones in the re-targeted model (see Appendix A for the list of supported models).

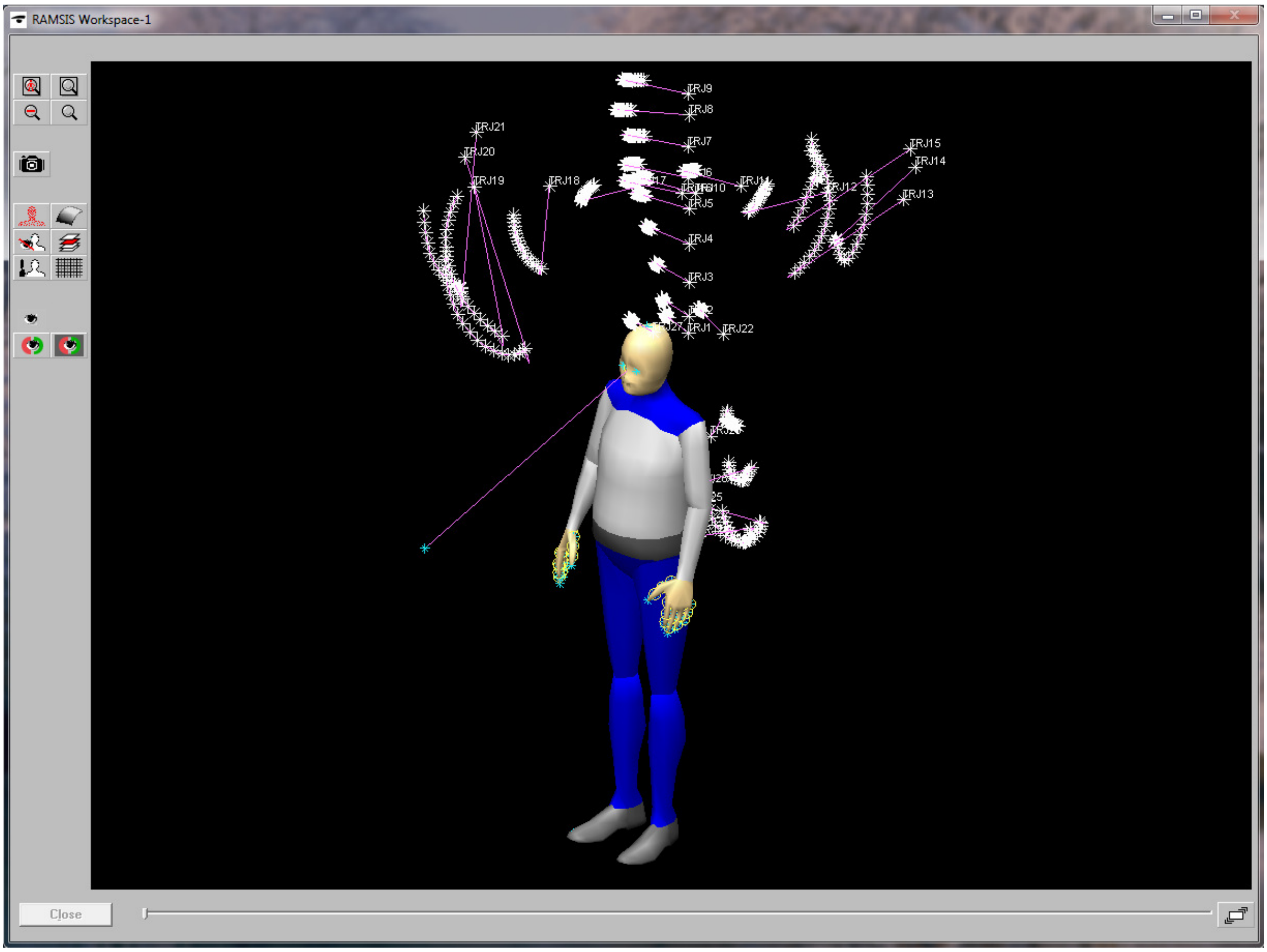


Figure 5.6: RAMSIS Workspace after CSV import

As an example, if *"ART-Human v2"* retargeting was used in the output, and *"Use 3 markers only for limbs"* option was enabled, we provide the reference points file *"ART_V2.HPU"* located in *"\examples\RAMSIS\"* directory of ART-Human installation folder. To load it, first copy provided ".HPU" file to RAMSIS reference-points directory. On Windows 7 it is usually: *"C:\ProgramData\RAMSIS\data\refpoints\"*. Then, use *"File ->Open..."* menu entry as shown on Figure 5.7. This file maps bone positions of *"ART-Human v2"* model to correspondent joints of RAMSIS manikin. See also section 4.2 for exact CSV output specification.

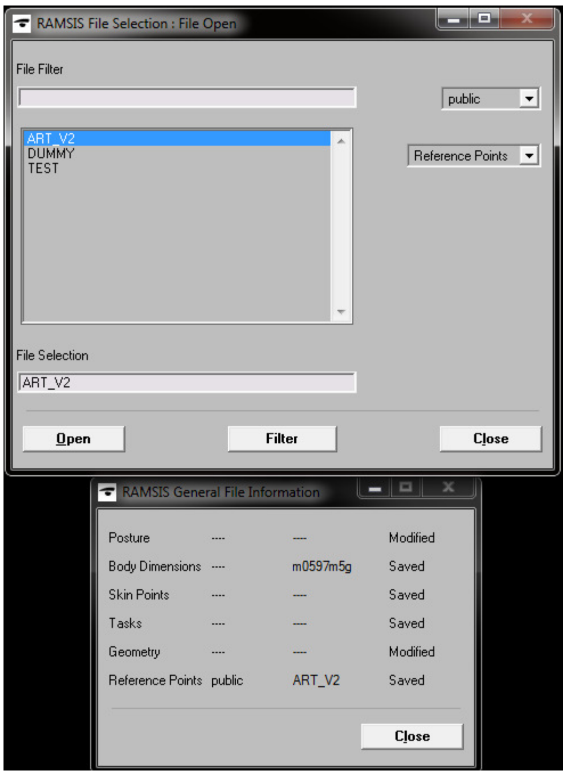


Figure 5.7: Import of reference points to RAMSIS

Note, since ART-Human and RAMSIS have different skeleton models, there is no 1:1 mapping defined, so we use quite straightforward mapping, which can introduce inaccuracies in the final animation. However, a user can always move reference points as desired. Please refer to **RAMSIS handbook** for details on reference points.

Mapping of reference points to trajectories

After the reference points were created, they can be mapped to imported trajectories using *"Animate->Animation Simulator..."* menu entry (see RAMSIS handbook). For your convenience we have prepared mapping file *"ARTAnim.sim"* which maps 31 reference points from *"ART_V2.HPU"* file to 31 imported trajectories (see Figure 5.8).

Note that you can disable the trajectories which are not needed by double-clicking on *"Active"* entry in *"Status"* field of animation simulator.

The final step is to compute the animation. In the *"Animation Simulator"* window (Figure 5.8) first uncheck *"Optimize Posture"*, *"Optimize Posture Sequence"*, and *"Preadjust Manikin"* options for better results as ART-Human already does the inverse kinematics. Then, specify *"Number of Frames"* to compute and press *"Compute"* button. For further details please refer to **RAMSIS handbook**.

There is also a sample CSV output file with a real measurement data in the examples directory of ART-Human which can be used for testing.

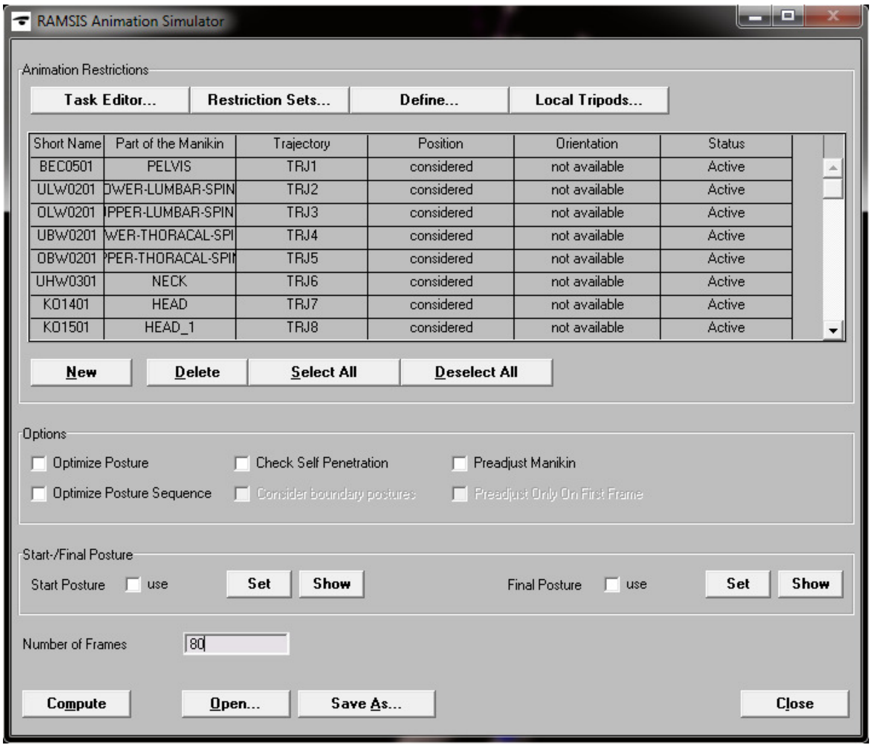


Figure 5.8: Mapping of reference points to trajectories

6 License Management

ART-Human is using USB dongles for copy protection and license storage. The USB dongle must be present on a USB port of the computer while ART-Human is running.

The USB dongles require special drivers which normally are installed by the ART-Human setup program. In case of problems, the latest version of the drivers *(CBUSetup)* can be downloaded from the following website:

> https://www.marx.com/de/support/downloads

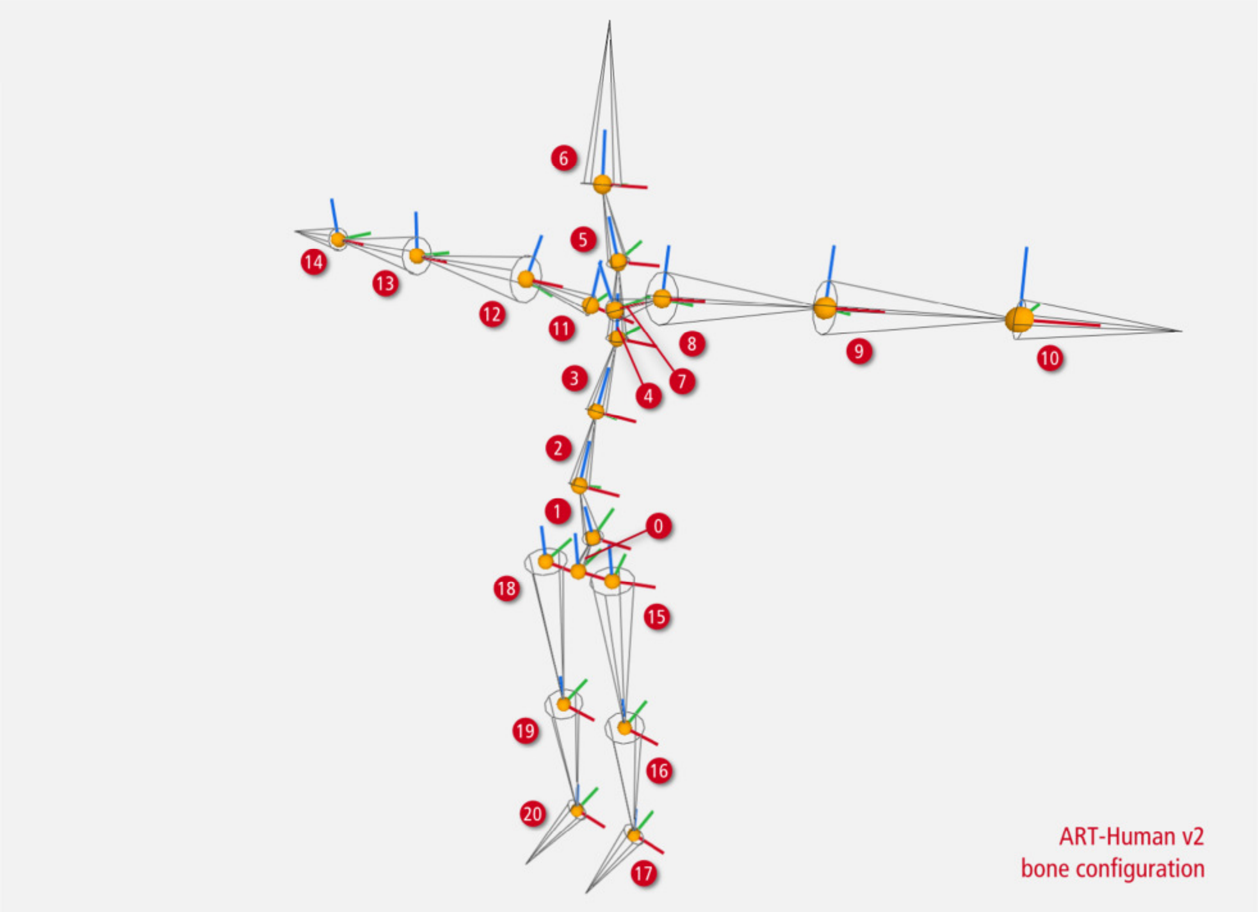
For licensing questions or to obtain additional licenses, please contact your ART sales representative.

A Bone IDs and Coordinate System Specifications

A.1 ART-Human v2

Bone ID	Bone Assignment
0	Pelvis
1	Lower lumbar spine
2	Upper lumbar spine
3	Lower thoracic spine
4	Upper thoracic spine
5	Neck
6	Head
7	Left shoulder
8	Left upper arm (humerus)
9	Left lower arm (radius/ula)
10	Left hand

Bone ID	Bone Assignment
11	Right shoulder
12	Right upper arm (humerus)
13	Right lower arm (radius/ula)
14	Right hand
15	Left upper leg (femur)
16	Left lower leg (fibula/tibia)
17	Left foot
18	Right upper leg (femur)
19	Right lower leg (fibula/tibia)
20	Right foot



ART-Human v2
bone configuration

A.2 ART-Human v2 Fingertracking Assignment

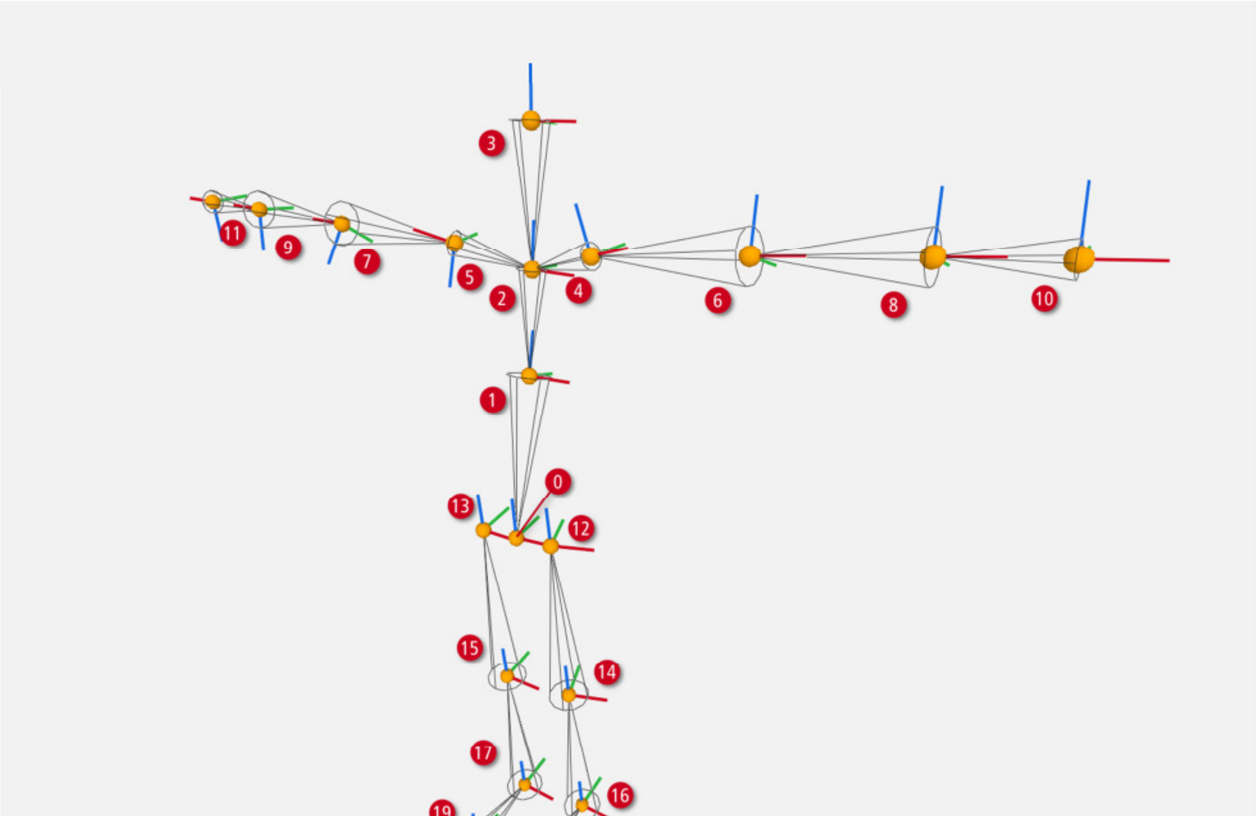
If Fingertracking is activated, additional bones will be used to represent the state of all finger segments. For the meaning of the segments, see the DTrack2 user manual. Note that the coordinate system orientation of the finger segments in ART-Human is the same as that of the corresponding hand.

Bone IDs	Fingertracking Bone Assignments
21-24	Left thumb: root, middle, outer, tip
25-28	Left index finger: root, middle, outer, tip
29-32	Left middle finger: root, middle, outer, tip
33-36	Left ring finger: root, middle, outer, tip
37-40	Left pinky: root, middle, outer, tip
41-44	Right thumb: root, middle, outer, tip
45-48	Right index finger: root, middle, outer, tip
49-52	Right middle finger: root, middle, outer, tip
53-56	Right ring finger: root, middle, outer, tip
57-60	Right pinky: root, middle, outer, tip

A.3 ART-Human v1

Bone ID	Bone Assignment
0	Pelvis (“hip”)
1	Lower spine (“chest”)
2	Upper spine (“neck”)
3	Head
4	Left shoulder
5	Right shoulder
6	Left upper arm (“elbow”)
7	Right upper arm (“elbow”)
8	Left lower arm (“wrist”)
9	Right lower arm (“wrist”)

Bone ID	Bone Assignment
10	Left hand
11	Right hand
12	Left hip
13	Right hip
14	Left upper leg (“knee”)
15	Right upper leg (“knee”)
16	Left lower leg (“ankle”)
17	Right lower leg (“ankle”)
18	Left foot
19	Right foot

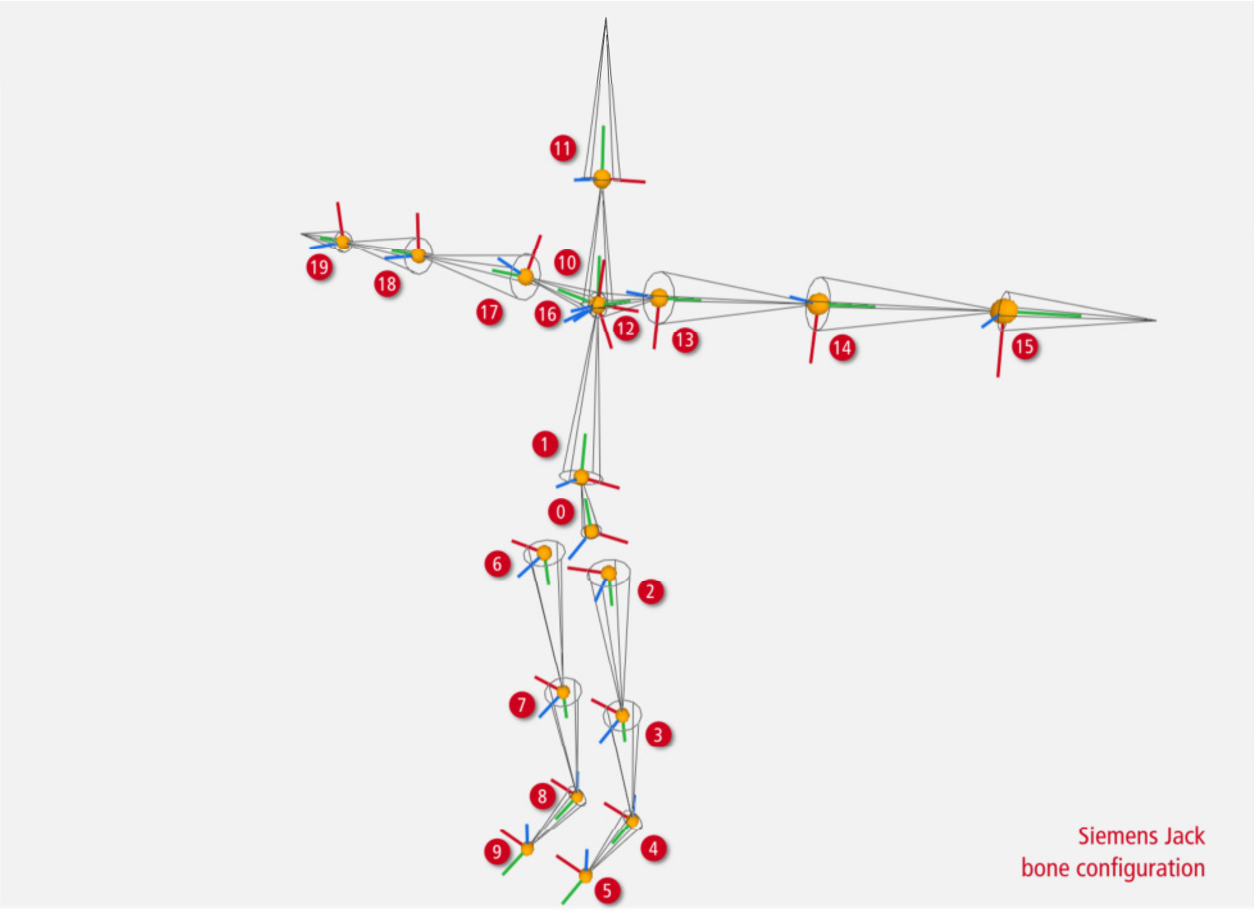


ART-Human v1
bone configuration

A.4 Siemens Jack

Bone ID	Bone Assignment
0	Pelvis/lower spine
1	Upper spine
2	Left upper leg
3	Left lower leg
4	Left foot
5	Left toes
6	Right upper leg
7	Right lower leg
8	Right foot
9	Right toes

Bone ID	Bone Assignment
10	Neck
11	Head
12	Left shoulder
13	Left upper arm
14	Left lower arm
15	Left hand
16	Right shoulder
17	Right upper arm
18	Right lower arm
19	Right hand

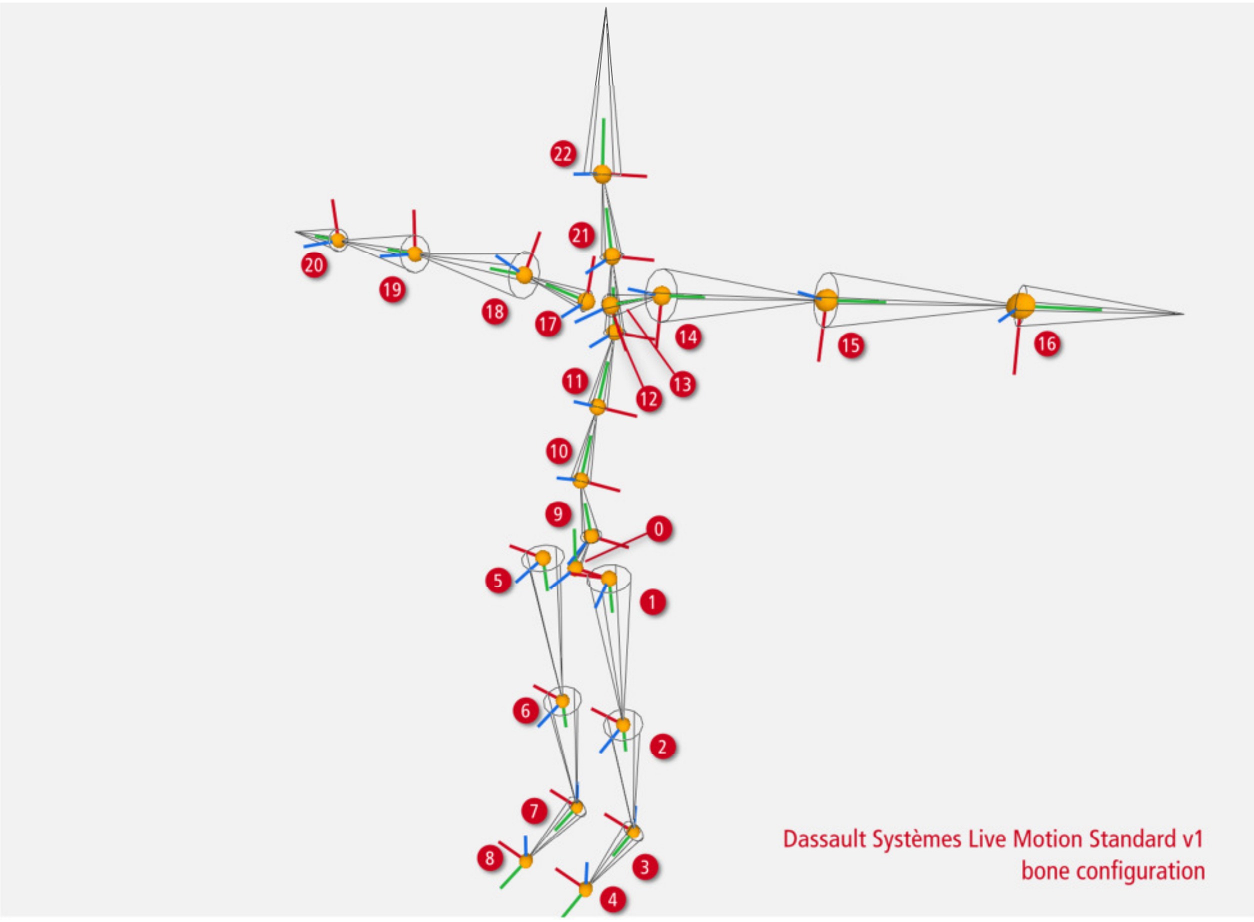


Siemens Jack
bone configuration

A.5 Dassault Systèmes Live Motion Standard v1

Bone ID	Bone Assignment
0	Pelvis
1	Left upper leg
2	Left lower leg
3	Left foot
4	Left toe
5	Right upper leg
6	Right lower leg
7	Right foot
8	Right toe
9	Spine1
10	Spine2
11	Spine3

Bone ID	Bone Assignment
12	Spine4
13	Left Shoulder
14	Left upper arm
15	Left lower arm
16	Left Hand
17	Right Shoulder
18	Right upper arm
19	Right lower arm
20	Right Hand
21	Neck
22	Head



Dassault Systèmes Live Motion Standard v1
bone configuration