ART-Human
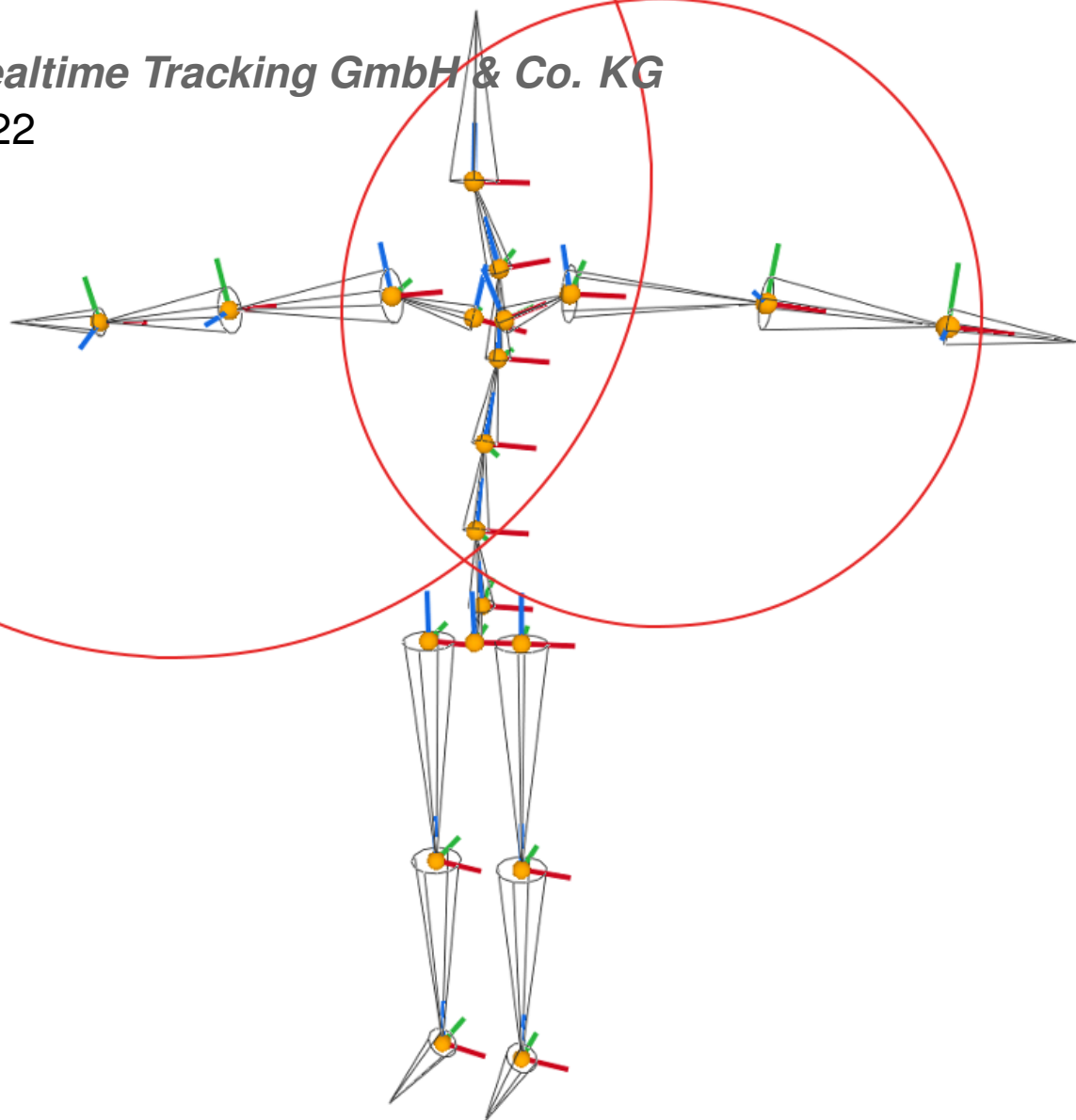**Motion Capture User's Guide**
Version 2.1.2

Advanced Realtime Tracking GmbH & Co. KG
November 2022

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What's new in version 2.1.2 ?

The following new features are available in ART-Human version 2.1.2:

- Improved and corrected BVH file output

- Revised and improved C3D file output, now entirely following the C3D file format specifications

- Support for Measurement Tool output format `6dmt2`

What's new in version 2.1.0 ?

The following new features are available in ART-Human version 2.1.0:

- Introduced output to a CSV file which can be used in RAMSIS software

- Several important bug fixes in `6dj` output

What's new in version 2.0.0 ?

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

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1 Introduction

1.1 What is ART-Human?

ART-Human allows an **ART** optical tracking system 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 one centimeter. 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, for example, *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

2 Main User Interface

The user interface of ART-Human consists of the views

- 3D Viewer

- Control Window

- Models Window

- Tools Window

- Display Settings
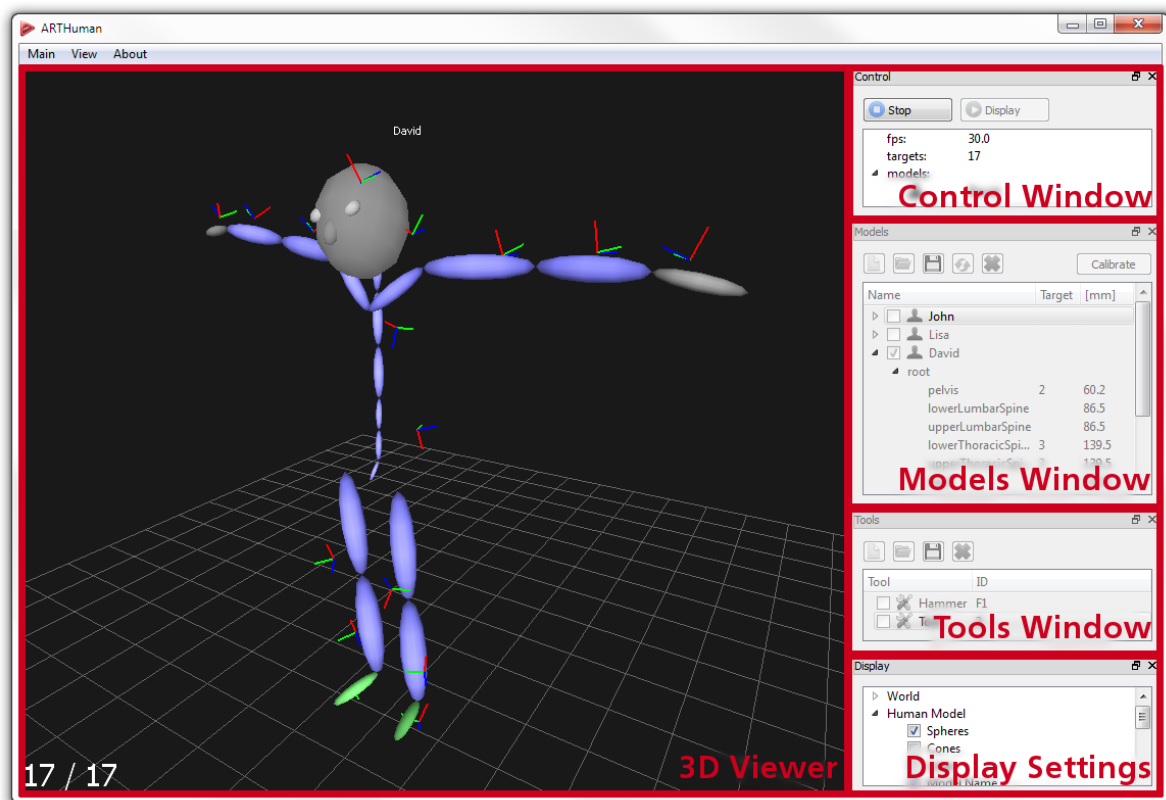
Figure 2.1: Main user interface

With the 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.

Options	Descriptions
Frames/Second	Frames per second of the output data
Number of Targets	Number of active tracking targets provided by *DTRACK*
Models	Shows the currently tracked models

Table 2.1: Displayed information in Control window.

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**. Additional displayed information is briefly described in Table 2.1.

Figure 2.2: Control window

2.3 Models Window

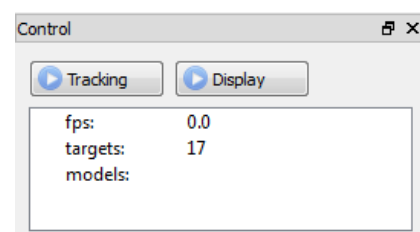The Models window shows the currently available models and allows basic operations on the model list. By clicking on the arrow left of the model name, it is possible to navigate through the bone hierarchy of each model and view the current target assignments and bone lengths for each calibrated bone.

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. How to create 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 calibra-

Figure 2.3: Models window

tion, see Section 3.4. Manual changes to the target assignment can be *reset* using the ↻ button.

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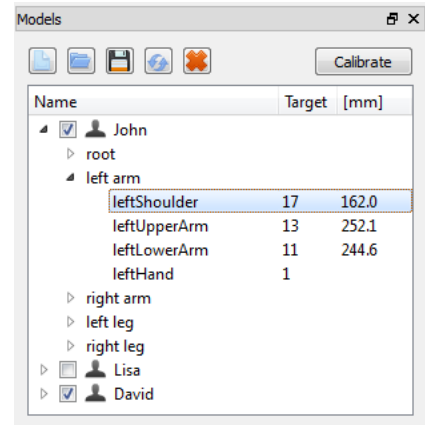
> **Remark** Normally it is not necessary to explicitly save models except for backup or transferring to another computer, because ART-Human automatically saves the models in the **Models Window** to its internal workspace and loads them on start of the application.

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

For *target assignment*, 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 naming scheme listed in Table 2.2.

> **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

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

Table 2.2: Naming scheme for targets

Figure 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.

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 Table 2.2 in Section 2.3. The buttons and 💾 and 📁 *save* and *load* the tool name and target assignment to and from a file on disk, respectively.
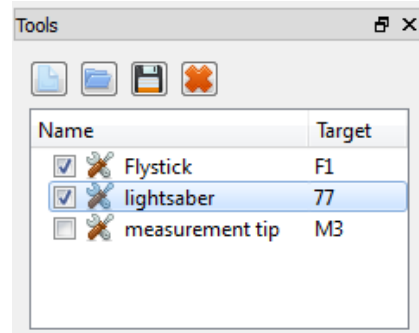
2.5 Display Settings

The contents displayed in the 3D viewer can be customized by activating and deactivating the various options in the Display Settings window. Available options are listed below.

Figure 2.5: Display settings

World Display

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

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

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Human Model Display

The options listed in Table 2.3 control the display of the tracked models.

Target IDs	Body Type
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.

Table 2.3: Model Display

Target Display

The options listed in Table 2.4 control the display of **DTRACK** tracking targets, i.e., ART-Human inputs.

Target IDs	Body Type
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.

Table 2.4: Target Display

3 Creating and calibrating models

Before a model can be tracked, the following steps have to be performed.

- 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 DTRACK3 User's Guide.

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 DTRACK3 User's Guide 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.
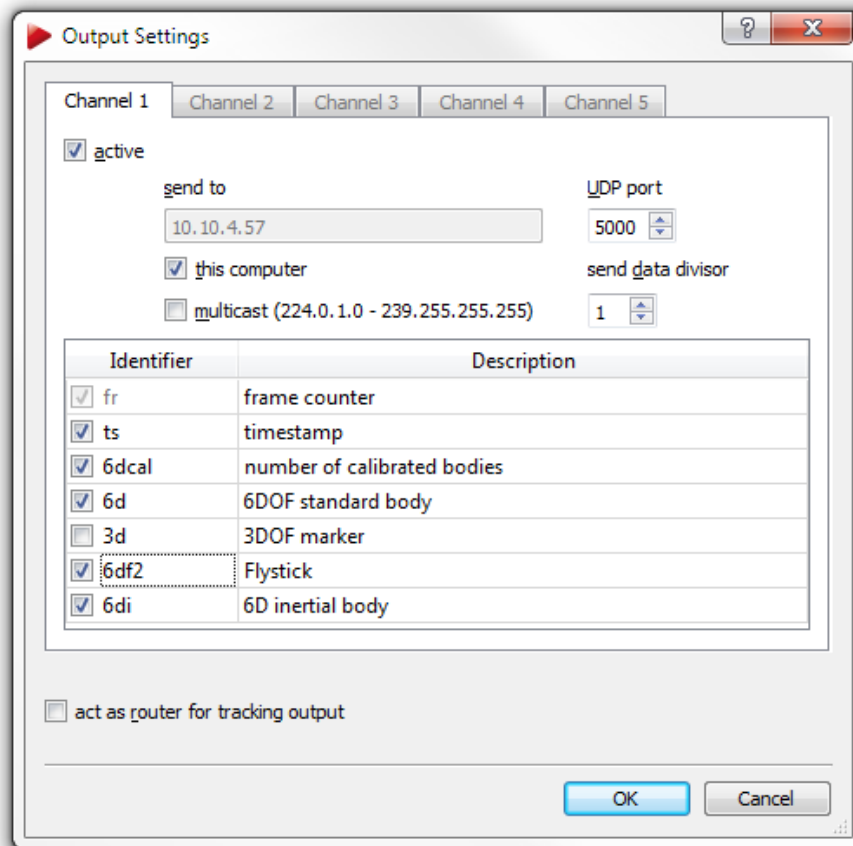
Figure 3.1: *DTRACK* output settings.

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* .
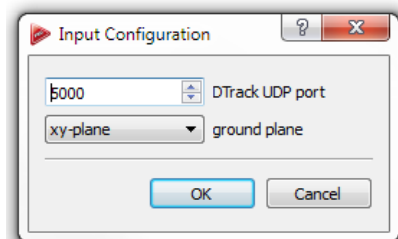
Figure 3.2: Display settings

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.
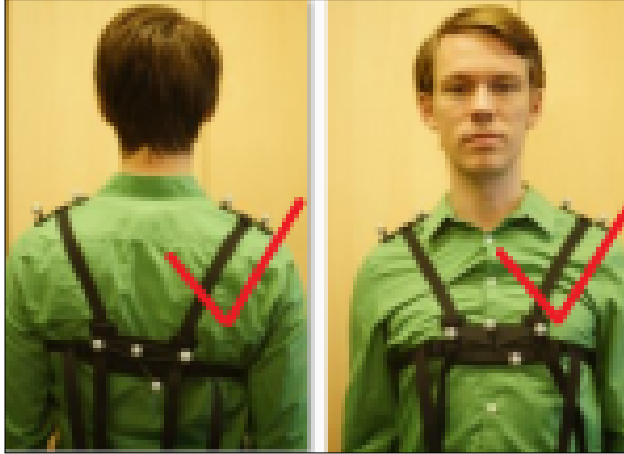
The chest and hip targets can be worn either in front or back of the body
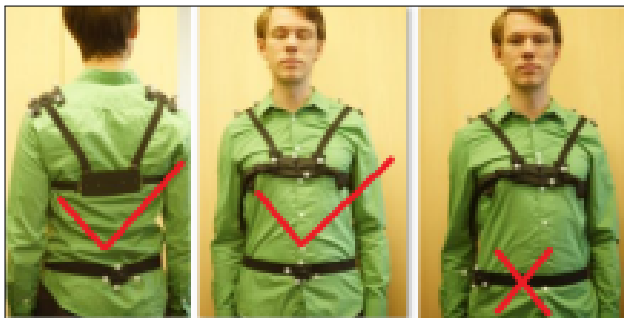
The hip target is best worn in the middle of waist, not on the left or the right side
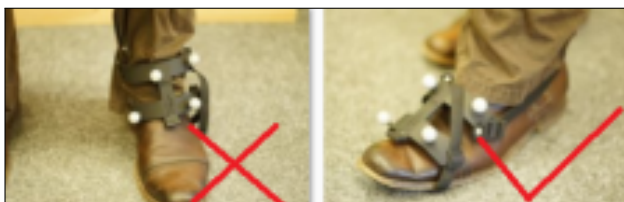
The foot targets should be near the tip instead of near the ankle

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.

Under **Type of MoCap set**, please choose the target set you want to use. Currently, the following target sets are supported.
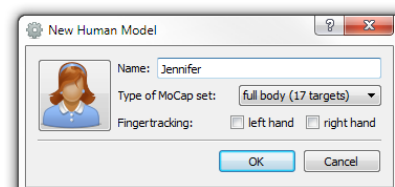
Figure 3.3: Creating new Human model

- **Full body (17 targets)**: A full body target set, consists 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.

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 figure 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

1. feet are parallel and standing firmly on the ground

2. hands are flat and oriented parallel to the ground

3. neck is stretched upwards
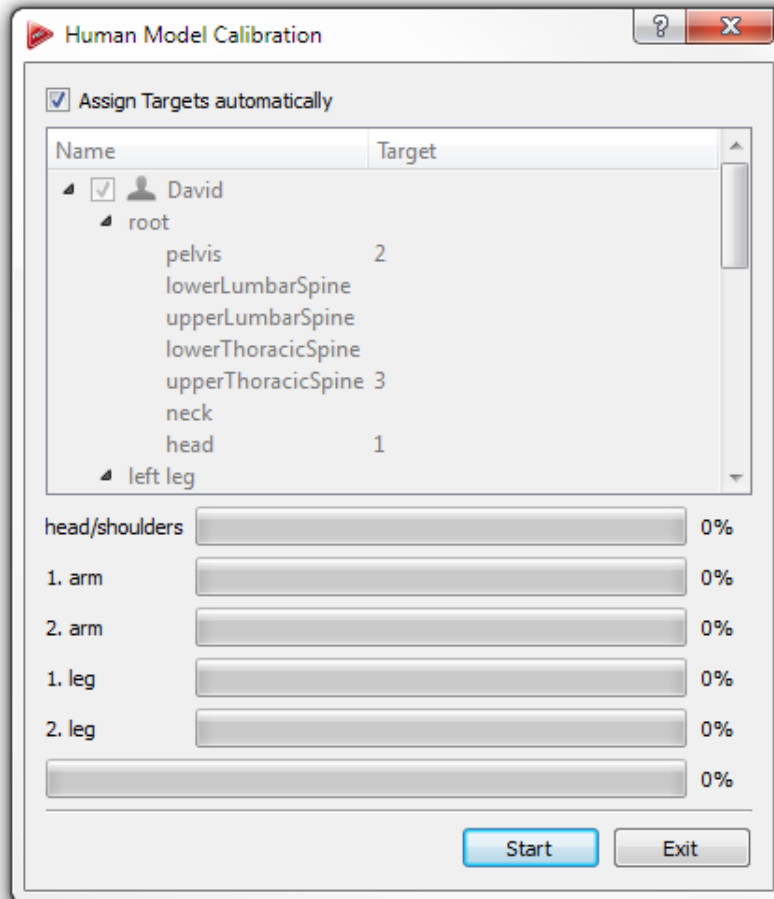
Figure 3.4: Human model calibration.

4. 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 positions. 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 configurations

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.
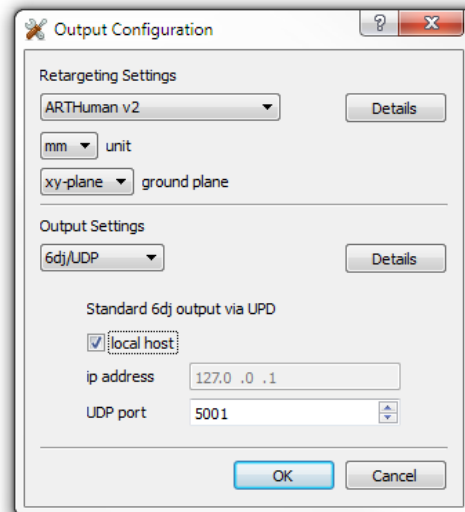
4.1 Retargeting Options

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.

4.1.1 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.1 for 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*** finger-tracking. When finger-tracking is activated, the orientations and positions of the finger bones are sent to the configured output channel along with the ART-Human bones. Please refer to Appendix A.1 for bone IDs and to Section 5.2 for general finger-tracking settings.

4.1.2 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 ART-Human 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.2 for details about the coordinate systems and bone IDs.

4.1.3 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.3 for details about the coordinate systems and bone IDs.

4.1.4 Dassault Systémes 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.4 for details about the coordinate systems and bone IDs.

4.1.5 General Retargeting Settings

ART-Human provides a number of general retargeting settings (see Table 4.1) which may be applied to all models.

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.

Options	Descriptions
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.

Table 4.1: General retargeting settings

4.2.1 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 "*DTrack2* User Manual, Technical Appendix" or "*DTRACK3* Programmer's Guide" for a general introduction to the format. The destination IP address and UDP port of the UDP packets can be specified in the dialog. See figure 4.1 for an example frame and table 4.2 for explanation.

```
fr 34514

ts 64425.076492

6d 17 [0 1.000][588.999 290.937 251.231 177.0007 -4.8196 -80.9044][0.157524
0.985378 -0.064929 0.983935 -0.162207 -0.074577 -0.084019 -0.052138 -0.995099]
 [1 1.000][876.623 96.167 1300.229 6.4727 -1.0685 -159.4684][-0.936316 -0.346520
-0.056889 0.350663 -0.931247 -0.099071 -0.018648 -0.112711 0.993453] [2 1.000]
[608.793 96.403 46.564 154.4344 44.2072 -58.8099][0.371228 0.927526 -0.043426
0.613209 -0.209772 0.761558 0.697255 -0.309341 -0.646641]...

6dj 1 1 [0 21][0 1.000][535.5939 210.3112 832.9551 0.0179 -0.0045 1.3798]
[0.189832 0.981644 0.018420 -0.981806 0.189882 -0.000978 -0.004457 -0.017899
0.999830][1 1.000][473.2766 221.5040 878.6974 0.0267 0.0323 1.3811][0.188488
0.981870 0.020107 -0.981544 0.187673 0.036758 0.032318 -0.026664 0.999122][2
1.000][478.2118 217.4322 1031.2696 0.0132 -0.0466 1.3825][0.187015 0.982118
0.021679 -0.981250 0.187806 -0.043321 -0.046618 -0.013171 0.998826][3 1.000]
[471.0929 215.4209 1183.7966 0.0779 0.2727 1.3775][0.184986 0.982428 0.024828
-0.945124 0.170925 0.278433 0.269296 -0.074972 0.960135]...
```

Figure 4.1: Example frame for 6dj output (shortened, four separate lines)

Note that ART-Human can also pass tracking data of Flysticks and Measurement Tools using `6df`, `6df2`, `6dmt`, and `6dmt2` frames. Do not forget to activate necessary formats in *DTRACK* output settings. Please refer to the "*DTrack2* User Manual" or "*DTRACK3* User's Guide" for details.

Line tag	Description
fr	Frame counter
ts	Timestamp in seconds
6d n_T	Number of tracked standard bodies n_T. For each body the ID number $I_T \in \{0, \ldots\}$, quality value $q \in [0,1]$, position $\mathbf{s} = (s_x, s_y, s_z)^T \in \mathbb{R}^3$, orientation angles $\eta, \theta, \varphi \in \mathbb{R}$ and rotation matrix $\mathbf{b} = (b_{ij})_{j=1,i=1}^{3,3} \in \mathbb{R}^{3\times3}$ is transmitted as $$[I_T\ q][s_x\ s_y\ s_z\ \eta\ \theta\ \varphi]\ [b_{11}, b_{21}, b_{31},\ b_{12}, b_{22}, b_{32},\ b_{13}, b_{23}, b_{33}]$$ Please refer to the "*DTrack2* User Manual, Technical Appendix" or "*DTRACK3* Programmer's Guide" for an exact definition of orientation angles and rotation matrices.
6dj $n_M\ n_O$	Number of calibrated models n_M and number of output models n_O. For each output model the ID number $I_M \in \{0, \ldots\}$ and number of retargeted bones $m \in \mathbb{N}$ is transmitted. In addition, for each retargeted bone its pose relative to the world coordinate system is transmitted equivalent to **6d**, such that the packet has the form $$[I_M\ m]<bones>\ldots$$ Please note that the orientation angles in **6dj** are given in unit `rad`.

Table 4.2: 6dj message content

ART provides free sample source code ('DTrackSDK', available in C++ and Java) to receive and parse the output data. Please contact *ART* to obtain it.

4.2.2 Siemens Jack

In order to communicate with Siemens PLM Jack software select this message format and transport channel. The Siemens Jack MCC output format opens a TCP network connection to deliver tracking data to Jack. The destination IP address and TCP port number of Jack can be specified. For Jack configuration details, see Section 5.3.

4.2.3 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 meter 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.

4.2.4 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 filename will include the date and time when the recording was stopped. In C3D, positions of all bones are recorded and labeled according to the settings of the retargeter. The orientation of bones is described using two additional "virtual markers" which are calculated as outlined in Table 4.3. Labels of these additional markers are suffixed with *Y* and *Z*, respectively. The output of orientation can optionally be enabled for all bones or just limbs. By ticking **Use 16bit integers for 3D data** the file created will store tracking data as signed words rather than floating point numbers. To convert such data to the physical reference system an appropriate scaling factor is calculated.

Marker-Suffix	Location	Example
none	At origin of bone coordinate system	LUAR
Y	20 mm along the y axis of the bone	LUARY
Z	20 mm along the z axis of the bone	LUARZ

Table 4.3: Markers and virtual markers written to C3D files. The example refers to the left upper arm.

Each model's marker is assigned a four letter unique abbreviation according to the bone name given by the retargeter. E.g., *LUAR* depicting the *Left Upper Arm*, with the long form being assigned to the marker description parameter. Each marker label uses the abbreviation prefixed with the model name assigned by the user, e.g., in the **Model Window** (cf. Section 2.3), such that the total marker label length *modelname:abbreviation* does not exceed a total of 16 characters. As a consequence, model names used with C3D output may be truncated and are required to be unique within the first 10 characters. Marker prefixes are managed within the *SUBJECTS* group.

For tools the capitalized and possibly truncated assigned name is used to label the markers. All tools are prefixed with the word *Tools*. There is no requirement that tool names must be unique, however, we encourage you to choose names that can easily be distinguished. Please acknowledge that the tools prefix is a reserved keyword and may no be used to name a model.

4.2.5 Biovision 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 filename will include the date and time when the recording was stopped. BVH files contain the full bone hierarchy of the retargeted models. The pose of the bones is then described

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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.

Remark As off ART-Human 2.1.2 the frame time was corrected to specify the time between two successive frames. In previous versions this entry incorrectly contained the frequency, i.e., the inverse of the intended meaning.

4.2.6 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 filename will include the date and time when the recording was stopped. CSV files provide positions of the bones for any chosen retargeting model. The file is structured as follows:

Frame,<*ModelName*>:<*BoneName*>,<*ModelName*>:<*BoneName*>,...

For example, a file containing N frames of coordinates X, Y, Z would look like this.

```
0,X,Y,Z,X,Y,Z,...
1,X,Y,Z,X,Y,Z,...
...
N-1,X,Y,Z,X,Y,Z,...
```

A bone can be represented using a single marker or three markers using two additional "virtual markers" similar to C3D output format, but instead of 20 mm the offset is 200 mm (see Table 4.4). If using three markers each bone appears three times that is, e.g., pelvis_0, pelvis_1, pelvis_2, according to Table 4.4.

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

Table 4.4: Virtual markers according to the CSV format

When the option **Use 3 markers only for limbs** is enabled, all the bones will be represented using a single marker, except for distal bones which do not have continuation. When the calibrated model has no Fingertracking enabled, the bones which will be represented using three "virtual markers" are *head*, *arms*, and *feet*. 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 three markers. We recommend activating this option as it greatly reduces file size and further computation time in RAMSIS. All the tools are represented using three markers and stored after human models in CSV file.

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

Chapter 4

5 Working with ART-Human clients

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 DTRACK3 User's Guide. 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 targets 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 DTRACK3 User's Guide. 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 do not 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, because previous versions do not support this feature.

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 select the retargeter *Siemens Jack* with unit *cm* and ground plane *Z-X* in the output configuration.

- Retargeting: Siemens Jack MCC

- Unit: cm

- Ground plane: Z-X

- Output channel: Siemens Jack MCC (TCP)

- IP address: IP address of computer running Jack

- Port: UDP or TCP port to send data to

Remark The following instructions apply to Siemens Jack software prior to version 9.

After the configuration in ART-Human, start Jack. 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 and click **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 **DTRACK** or stop tracking in ART-Human, to freeze the data at T-Posture. Create a Default Female or Male Human in Jack. Right click on the human and scale it to the correct height (Figures 5.1 and 5.2).
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).

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

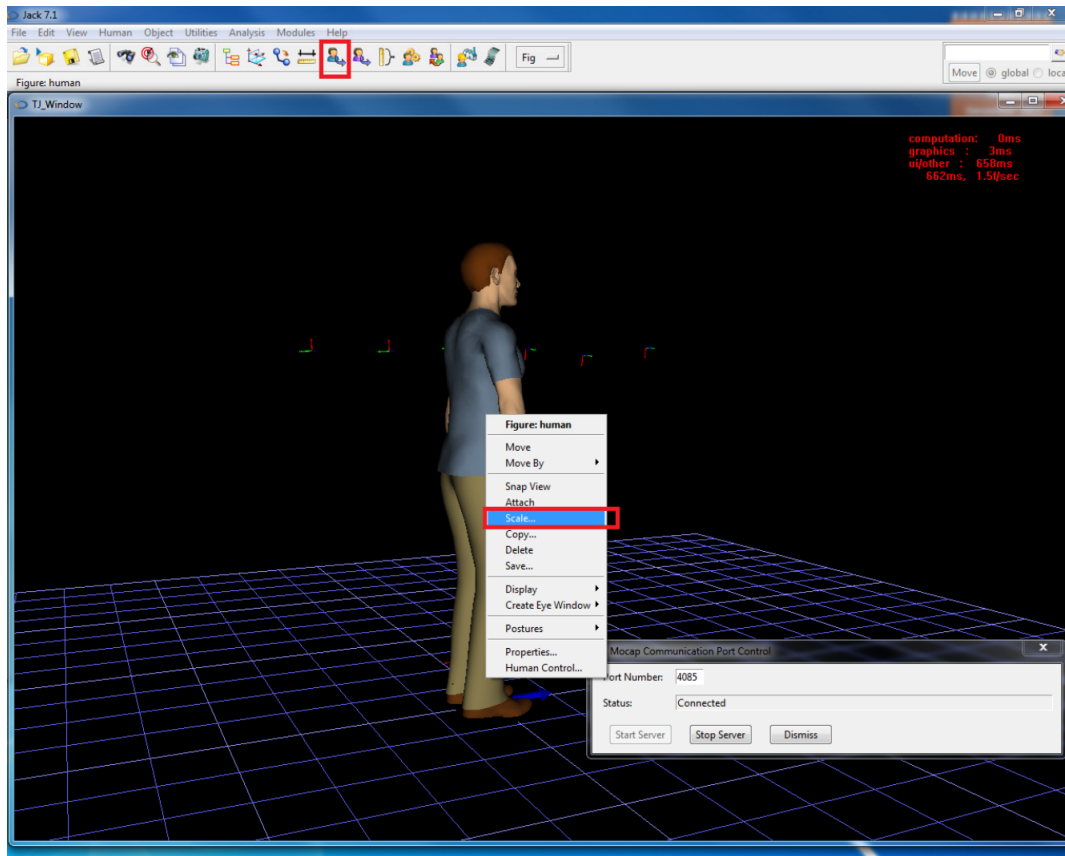The work routine to communicate with Jack should be:

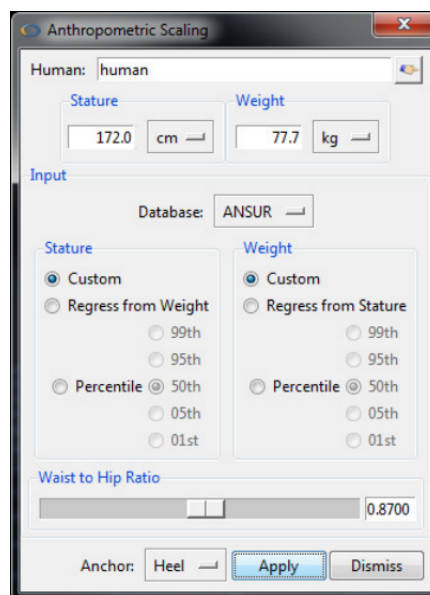Figure 5.1: Scaling of Jack manikin

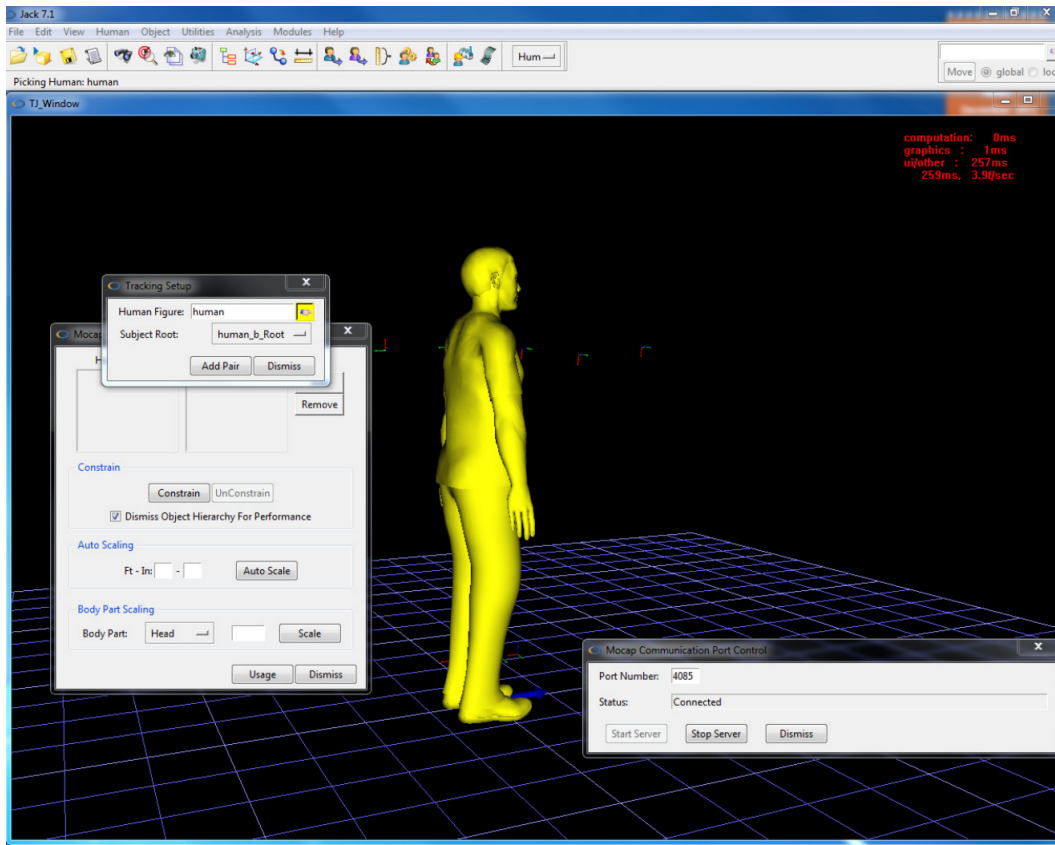
Figure 5.2: Scaling settings in Jack

Figure 5.3: Attaching Jack manikin to tracking data

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 Jack to crash.

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 Systémes Live Motion Standard v1

- Unit: m

- Ground plane: X-Y

- Output channel: VRPN

Chapter 5

3DVIA also requires the first tracked model to be named `User0`, the second `User1`, and so forth. To connect to ART-Human from 3DVIA Studio, please follow the instructions in the 3DVIA documentation.

5.5 RAMSIS Automotive

Please also refer to the RAMSIS handbook and BodyBuilder handbook provided with the 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.

Creating manikins

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.

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!
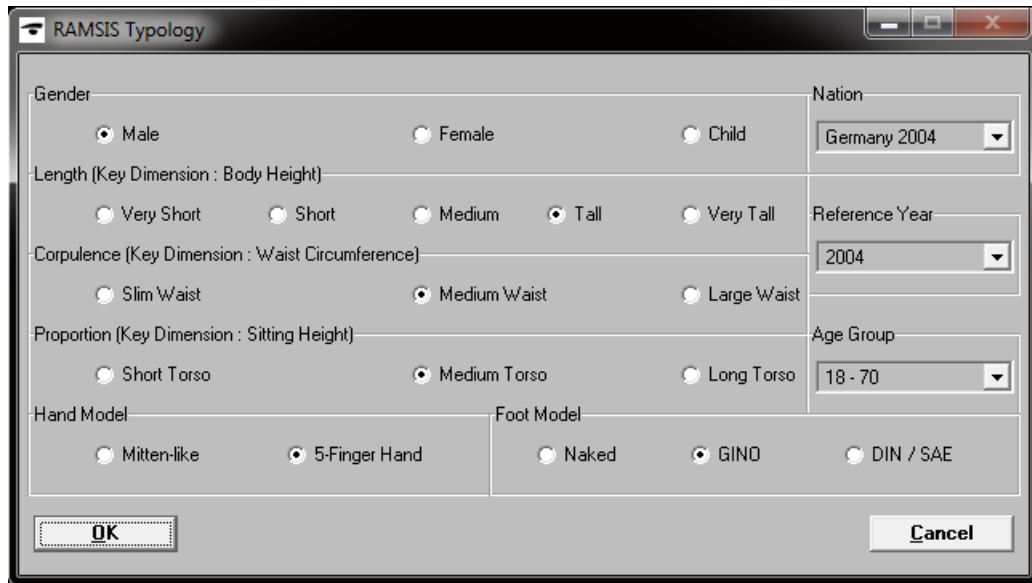
Figure 5.4: Create manikin in RAMSIS

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.
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, i.e., 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).
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 Fig-
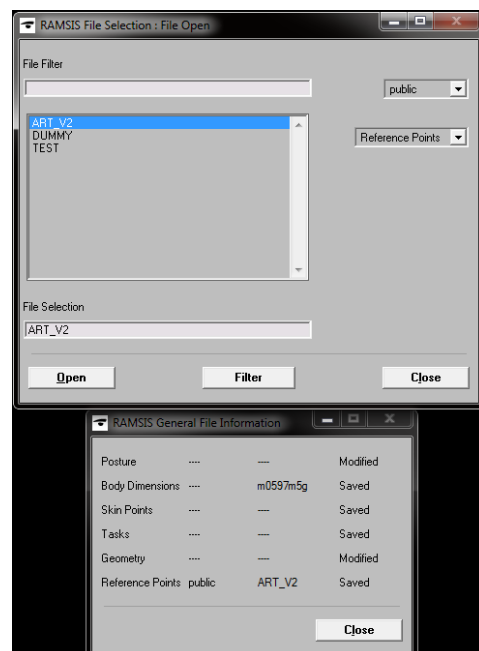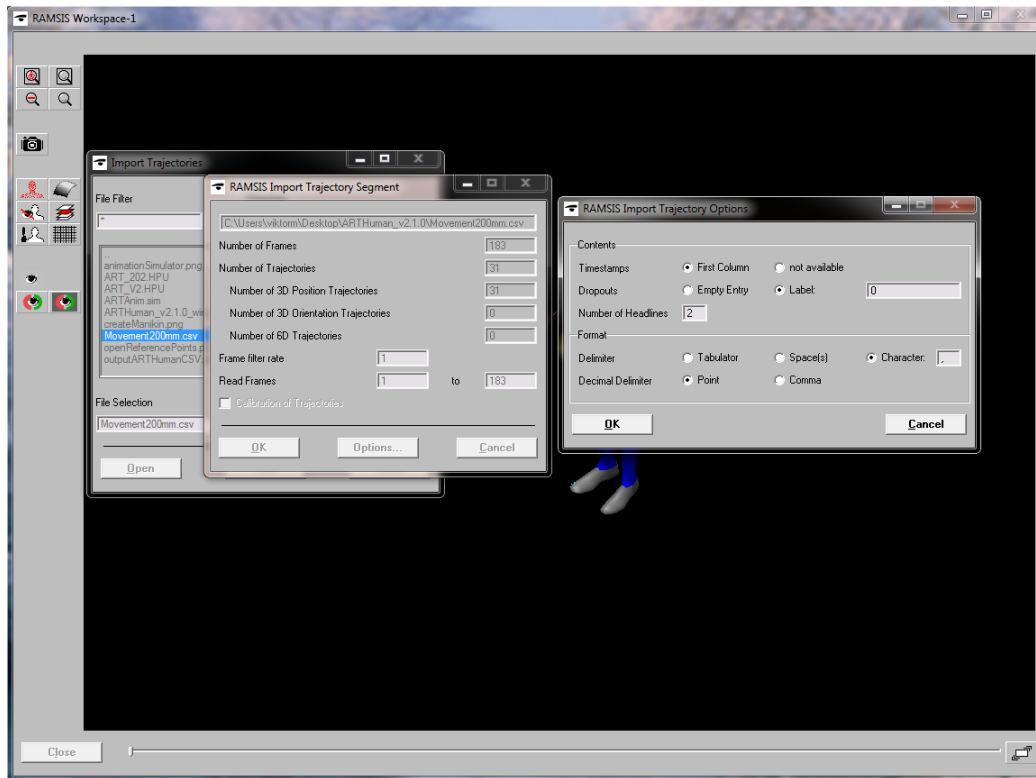

Figure 5.7: Importing reference points in RAMSIS

Figure 5.5: Import CSV file in RAMSIS

ure 5.7. This file maps bone positions of **ART-Human v2** model to corresponding joints of the RAMSIS manikin. See also Section 4.2.6 for exact CSV output specification.

Note, since ART-Human and RAMSIS have different

skeleton models, there is no 1:1 mapping defined. We use a 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 a mapping file `ARTAnim.sim` which maps 31 reference points from `ART_V2.HPU` file to 31 imported trajectories (see Figure 5.8).
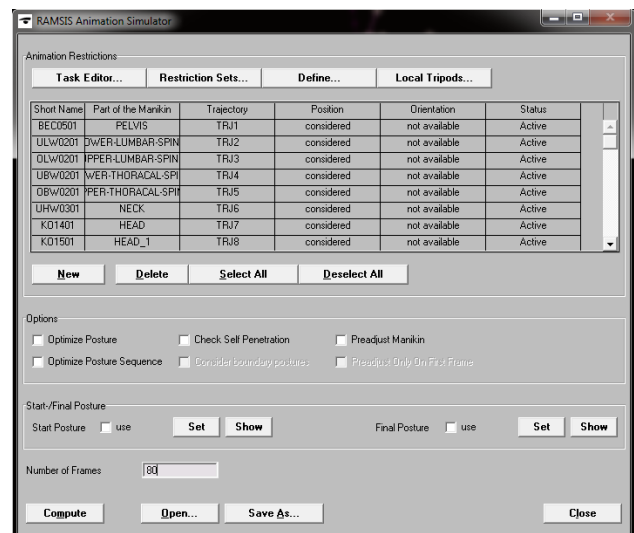
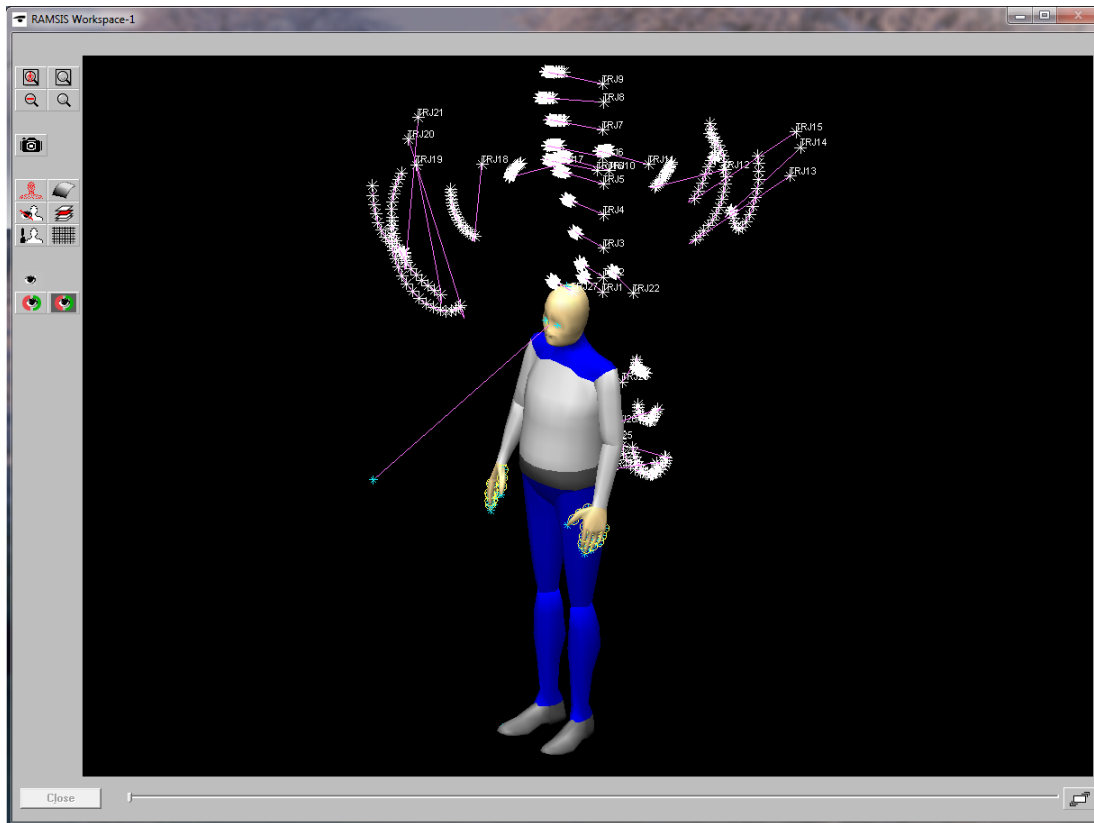Figure 5.8: Importing reference points to trajectories in RAMSIS

Figure 5.6: RAMSIS Workspace after successful CSV file import

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 (see Figure 5.8) first uncheck the options **Optimize Posture**, **Optimize Posture Sequence**, and **Preadjust Manikin** 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.

Chapter 5

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 Marx website[1].

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

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[1] https://www.marx.com/de/support/downloads

A Bone IDs and Coordinate System Specifications

A.1 ART-Human v2

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

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
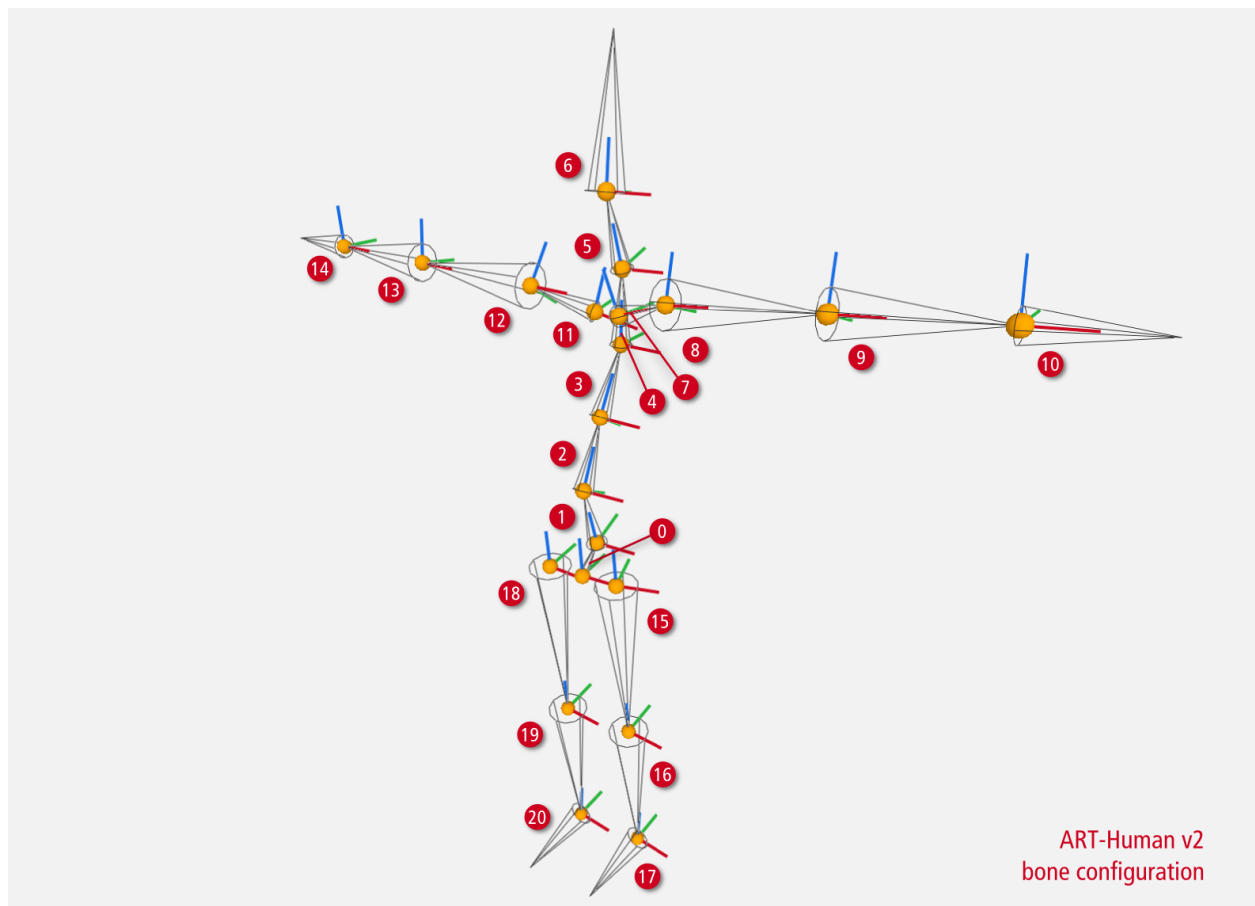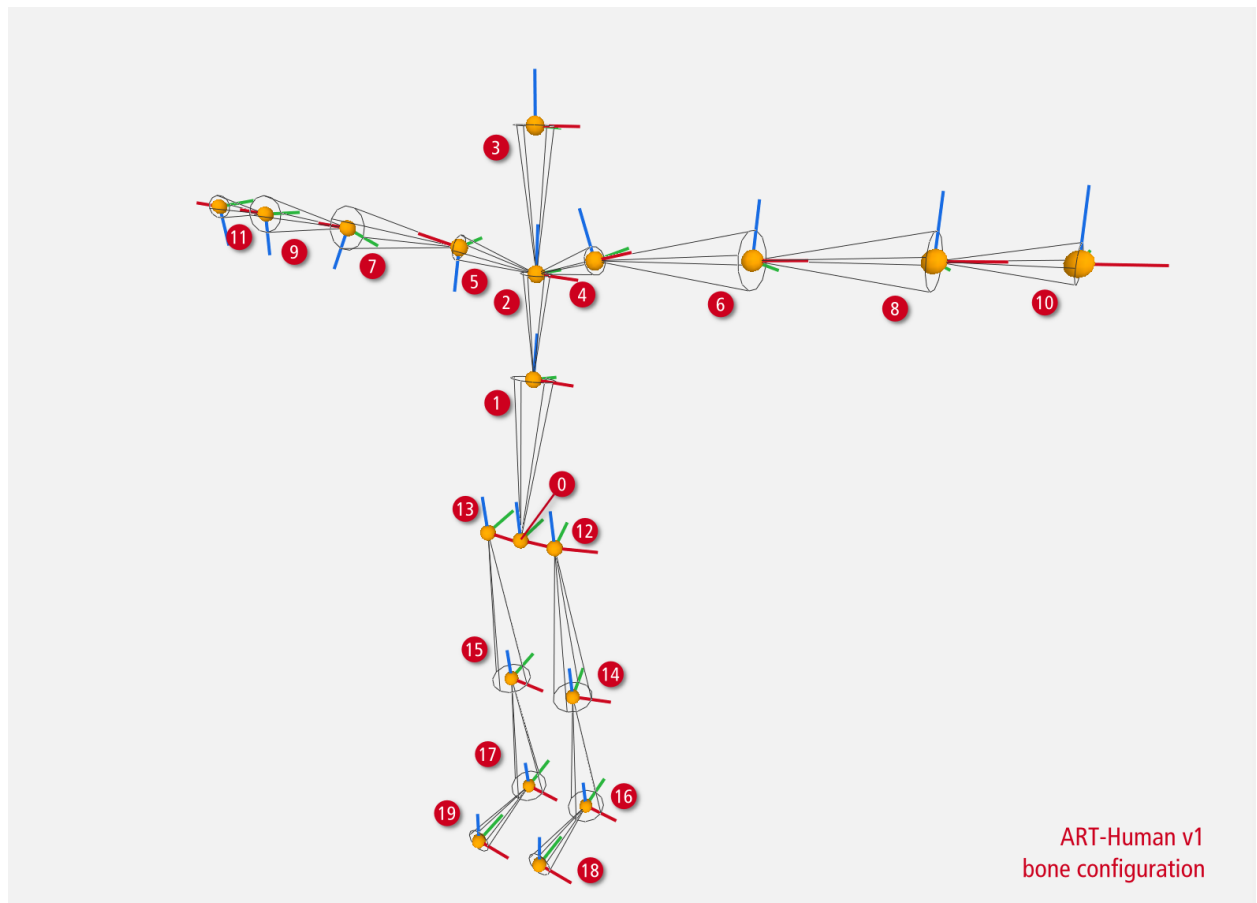
ART-Human v2 Fingertracking Assignment

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 DTRACK3 User's Guide. Note that the coordinate system orientation of the finger segments in ART-Human is the same as that of the corresponding hand.

ID (Left Hand)	Bone Assignment		ID (Right Hand)
21 – 24	Thumb	root, middle, outer, tip	41 – 44
25 – 28	Index finger	root, middle, outer, tip	45 – 48
29 – 32	Middle finger	root, middle, outer, tip	49 – 52
33 – 36	Ring finger	root, middle, outer, tip	53 – 56
37 – 40	Pinky	root, middle, outer, tip	57 – 60

Appendix A

A.2 ART-Human v1

ID	Bone Assignment		ID	Bone Assignment
0	Pelvis (hip)		10	Left hand
1	Lower spine (chest)		11	Right hand
2	Upper spine (neck)		12	Left hip
3	Head		13	Right hip
4	Left shoulder		14	Left upper leg (knee)
5	Right shoulder		15	Right upper leg (knee)
6	Left upper arm (elbow)		16	Left lower leg (ankle)
7	Right upper arm (elbow)		17	Right lower leg (ankle)
8	Left lower arm (wrist)		18	Left foot
9	Right lower arm (wrist)		19	Right foot

ART-Human v1
bone configuration

A.3 Siemens Jack (MCC)

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

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

Appendix A

Siemens Jack
bone configuration
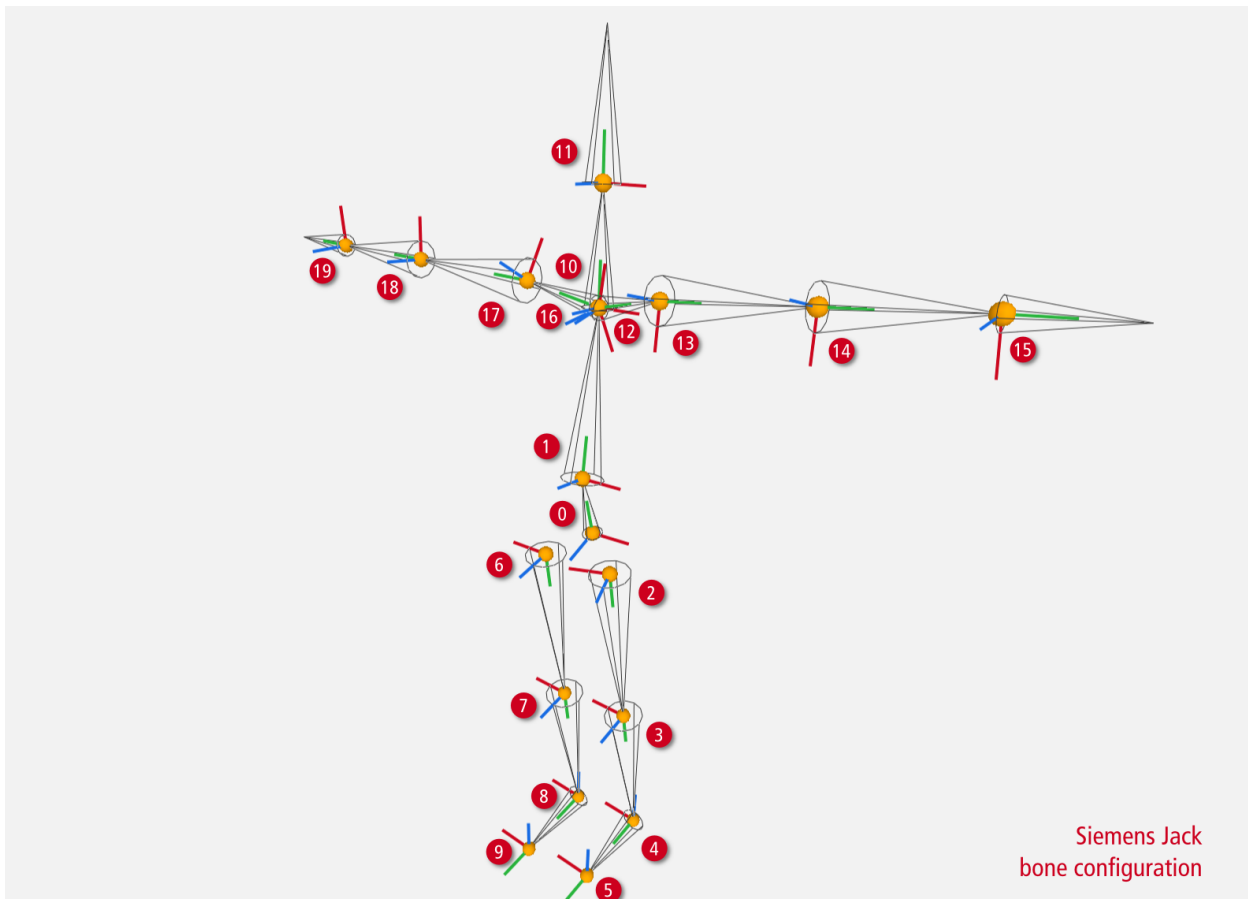
A.4 Dassault Systémes Live Motion Standard v1

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

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