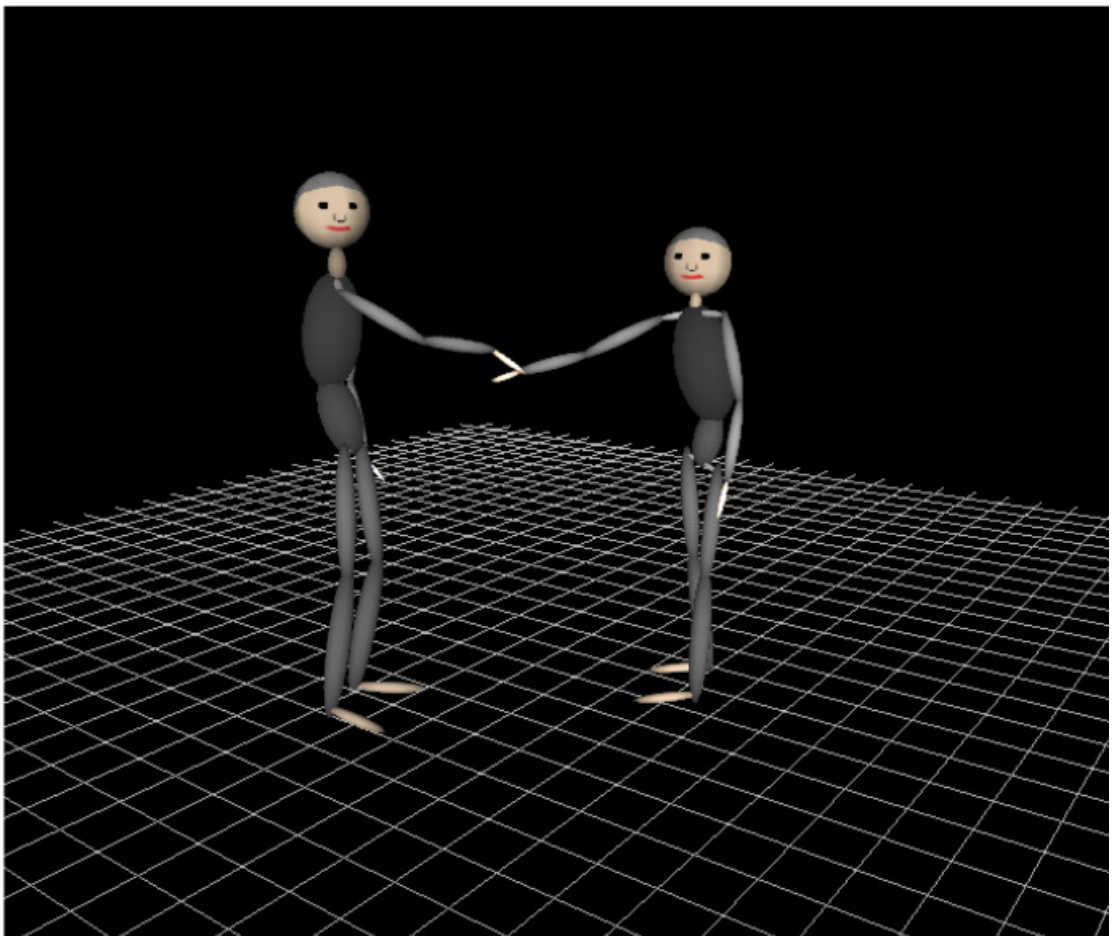
ART-Human Version1.1.0



Introduction

What is ART-Human?

ART-Human is an application which assists A.R.T. optical tracking system for Motion Capture.

What is the main function of ART-Human?

ART-Human can automatically calibrate the human body length in the accuracy level of 1cm and construct the human model in VR, visualize the 3D model in OpenGL viewer. When certain optical targets are missing in the optical tracking system, ART-Human can estimate the movements of limbs with inverse kinematics and the position of end effectors. ART-Human also calculate and output real-time joint data for further development like Autodesk MotionBuilder, Siemens Jack etc..

What is new in ART-Human V1.1.0?

In this release you will find several enhancements, including;

- Integration of finger tracking with one or two hands for each person
- New feature to send tools data to Jack with or without human model data
- New feature to send two human model data to Jack
- Fix the bug that communication with Jack is not stable and cause Jack crash
- Fix the bug of shaking elbow problem when sending data to Jack
- Add the feature that in bad tracking condition, the valid frame number for each pair of targets is counted to the calibration evaluation result
- Change the definition of joints data output from original calculated data to after fitting data, the quality is always positive. The limb end data is also changed from original dtrack output to model limb tip.
- Fix the bug of hand rotation not correct problem and leg shaking problem in Jack.

Interface

Main Interface

The main interface of the application has mainly five different parts.

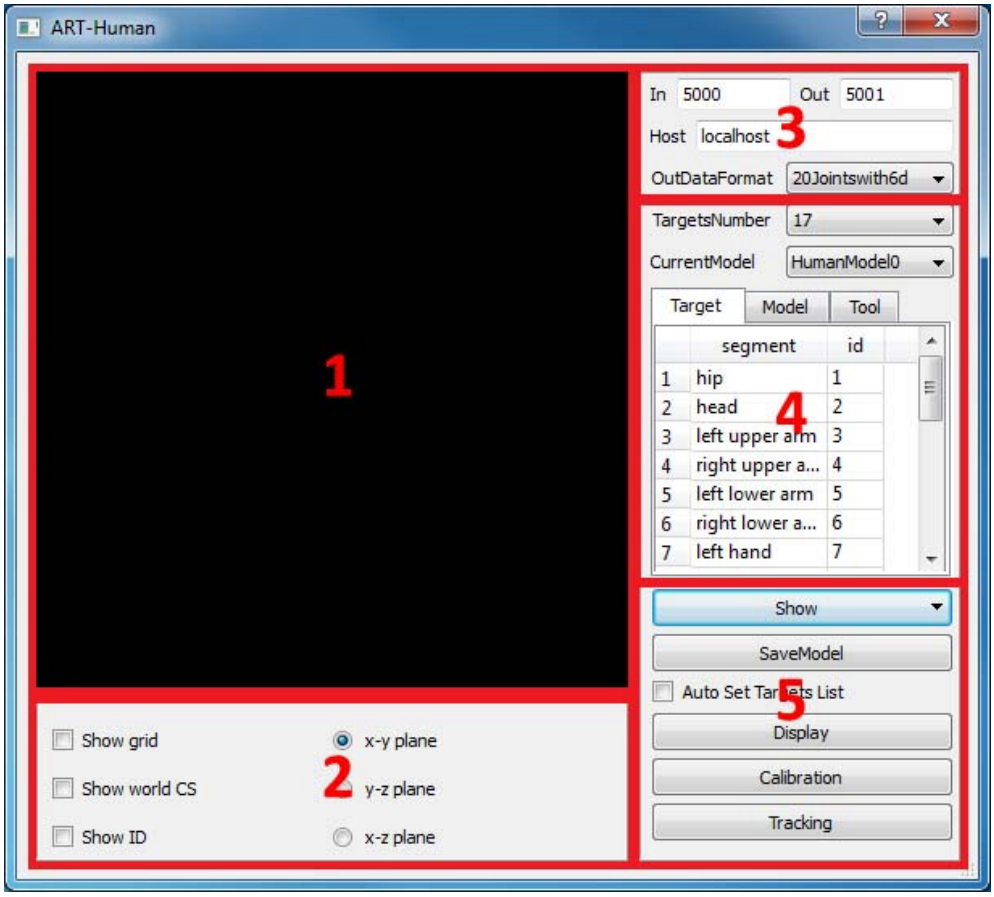
Part1. OpenGL Viewer;

Part2. Viewer Setup;

Part3. IO Setup

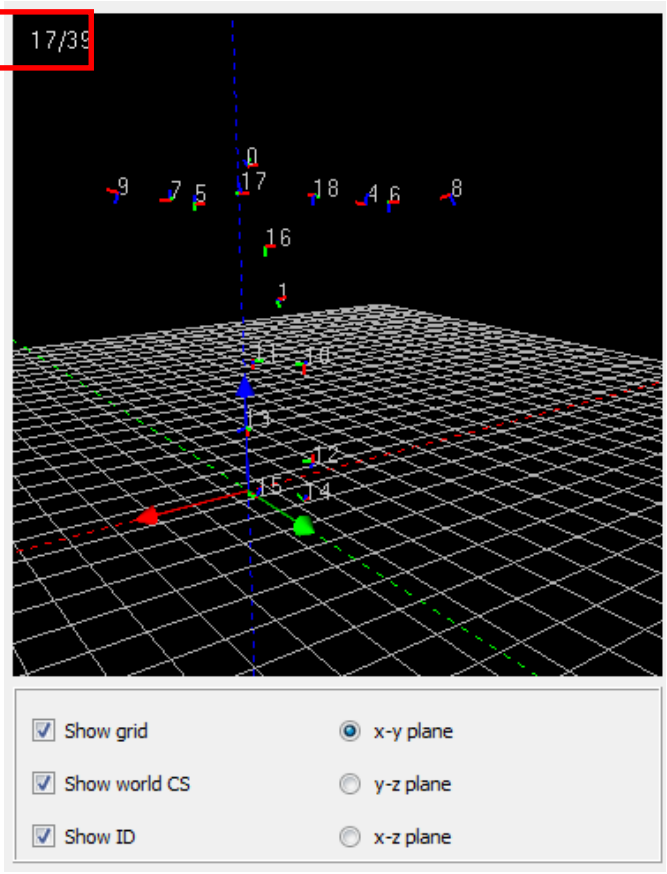
Part4. Targets list, Model list and Tool list

Part5. Button Group



Part1 OpenGL Viewer

The OpenGL viewer is built based on QGLWidget and provide 3D visualization of human model animation. In playing mode, the numbers shown on the left up corner indicates how many targets are tracked and how many targets are defined. <Ctrl> + mouse movements will let you move or rotate the viewer.



Part2 Viewer Setup

In the viewer setup, you can select *Show grid* checkbox to show grid as the ground of VR. When the room calibration in Dtrack2 is defined differently, the ground is shown at x-y plane, or y-z plane, or x-z plane by different settings. This room coordinate system setup also influences the later function as "Auto Set Targets List" and "Tpose taken".

When *Show world CS* is selected, the room coordinate system is shown as red arrow for x-axis, green for y-axis and blue for z-axis.

When *Show ID* is selected, in playing mode, the id of the targets are shown next to the markers and help you easily mapping the target list in right order.

Part3 IO Setup

In the IO setup, *In* and *Out* are set as the port number for data flow. Only valid port number from 0 to 32767 is allowed, other input will be automatically corrected. The 6d standard body data from Dtrack2 is taken from Port *In* and 6dj joint data is sending out from Port *Out* to *Host* computer. *Host* can be set as "localhost" or "127.0.0.1" if you want to send the data to local computer, otherwise set it as other valid IP address.

In the *OutDataFormat* combobox, select the output 6dj data format. "20Jointswith6d" means the output data is original Dtrack2 output plus 6dj joint data. The 20 joints are defined as same as standard dtrack data format. "20Jswithout6d" means the output data has only 6dj joint data. Both these output formats are sending via UDP socket. "20JointsForJack" means the output data has 6dj joint data with 20 joints defined as

Siemens Jack required format. In this situation, the output is sending via Tcp socket. The output data format is explained in detail in **File Management** part.

Part4 Target list, Model list and Tool list

In the list part, the combobox *TargetsNumber* is only necessary when you want to auto set the target list. When you select the appropriate targets number, the targets list will change correspondingly. Make sure that the number selected is the same with the targets that the model wears, otherwise the auto set function cannot work.

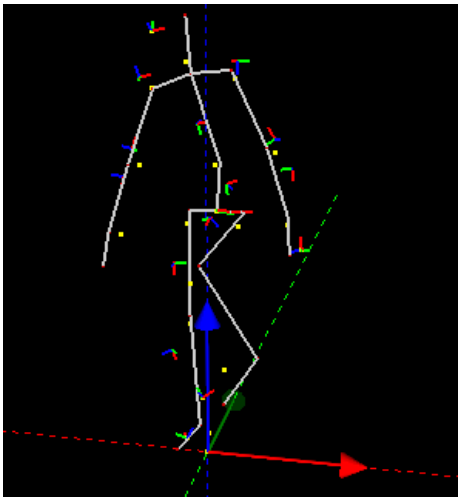
In the target list, you can also manually change the target id in the table list, the valid input is positive integer, from 1 to 50, other input will automatically set to "&&". If finger tracking is used, you will see h1-h4 if you use auto set targets function. You can also manually input h1-h4 for hand targets. Note that, once you attach one more target to the model, the human model need to be recalibrated. When single id is selected, this marker will be highlighted in the viewer to help you check whether the mapping is correct.

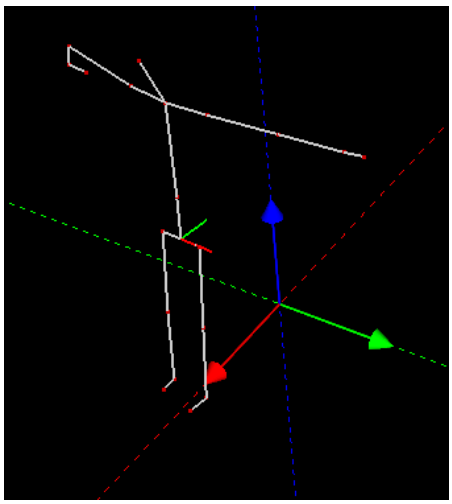
The combobox *CurrentModel* shows the current active model's name. During the calibration mode, this selected model is calculated. In the model list, you can change the models name by double click on the model's name; create, save, load or delete model by right click on the model. The *TPs* indicates whether the model's T Posture is set, *Cali* indicates whether the model is calibrated. In the tracking mode, the checkbox in front of the models need to be selected, then the selected models are activated for fitting and output. In this version, two models in maximum can be activated at the same time.

In the tool list, you can create or delete the tools ready to be send to Jack. Double click on the id position, and change the id number. If two tools have the same id, only one is valid. Select the checkbox in front, activate the tools to send to Jack. Standard tools data can be send alone to Jack without valid calibrated human model 's data.

Part5 Button Group

In the *Show* menu, you can choose the elements which are shown in Part 1. "Joints, Body, Skeleton" only valid for calibrated models. When the markers are shown, you can see the targets body in small colorful cross to present the local orientation. The yellow points show the joints position and is outputted in *Out-Port*. In the *Skeleton* shown mode, you can see the model offset which is defined as x-axis point from right hip to left hip, y-axis point to back side, z-axis point to up head.





In the *Body* shown mode, you can easily recognize the left and right side by the front face.

SaveModel button is to save the bone length of the model in .txt file after the model calibration.

If *Auto Set Targets List* checkbox is selected, the application will auto detect the targets mapping before calibration.

In *Display* mode, only the markers are animated.

In *Calibration* mode, the Dtrack data is recorded in the record buffer, when there are enough frames, the selected model is calibrated.

In *Tracking* mode, the active model is animated in the viewer. If the model is not calibrated yet, it is the same as display mode.

Working Routine

System setup

Set up the A.R.T Tracking systems with at lease 8 cameras.

Reference to

“DTrack2_User-Manual.pdf”.

Adjust the camera location to make sure that the whole body of track model is in the tracking volume (or the upper body in some cases). Continue to finish the room

calibration and body calibration. The body calibration should be “due to room” instead of “due to body”.

Put on the mocap suit

After calibrating all targets in good quality, wear the mocap suit in right order.

Notice:

The auto set targets list can only work when the head target is worn in front;

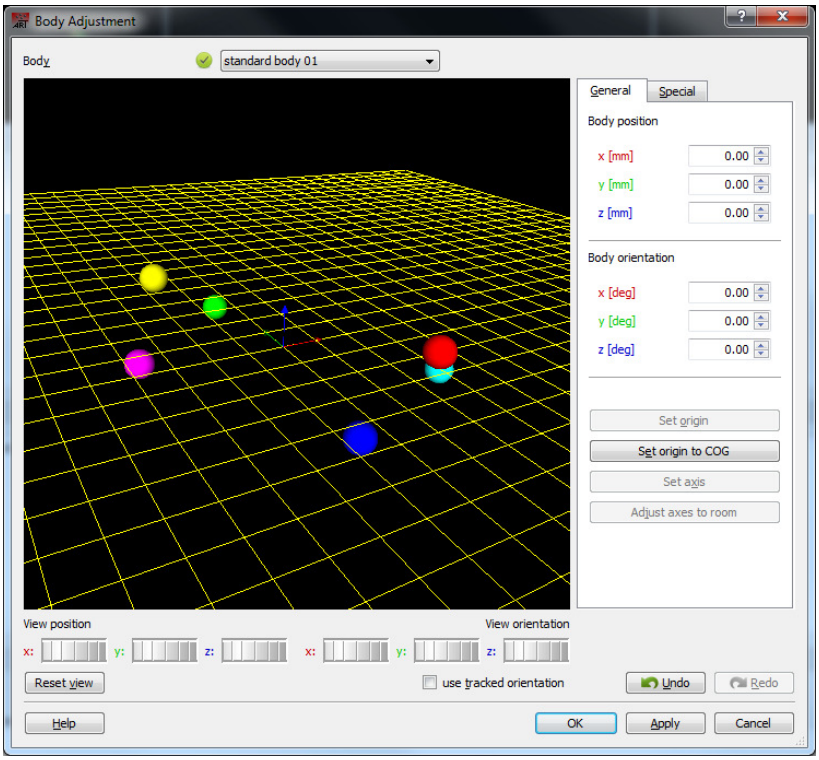
The chest and hip targets can be worn either in front or back of the body;

The hip target is best in the middle of waist, not on the left side nor the right side;

The targets on one limb should be worn on the same side;

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

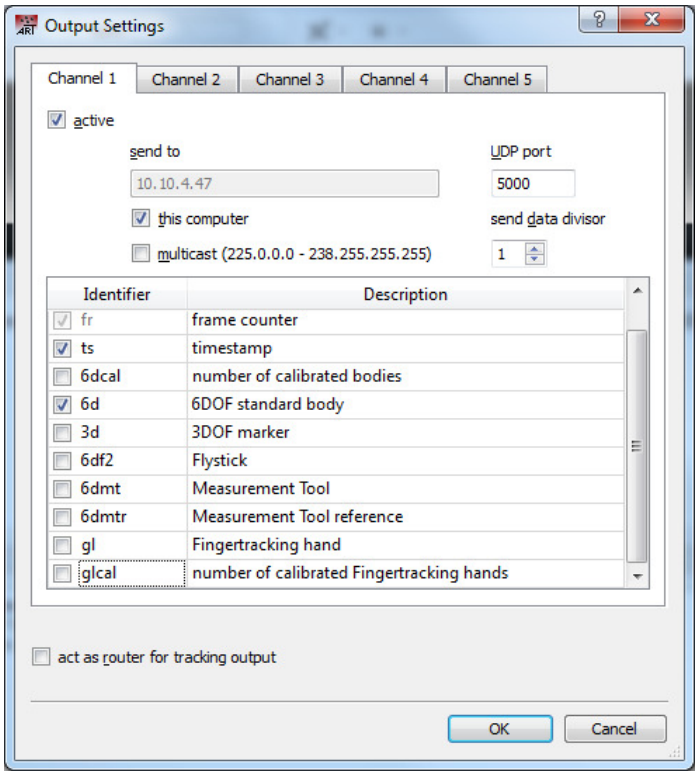
Notice: Do not change the target center to the actual joint position in Body Adjustment.



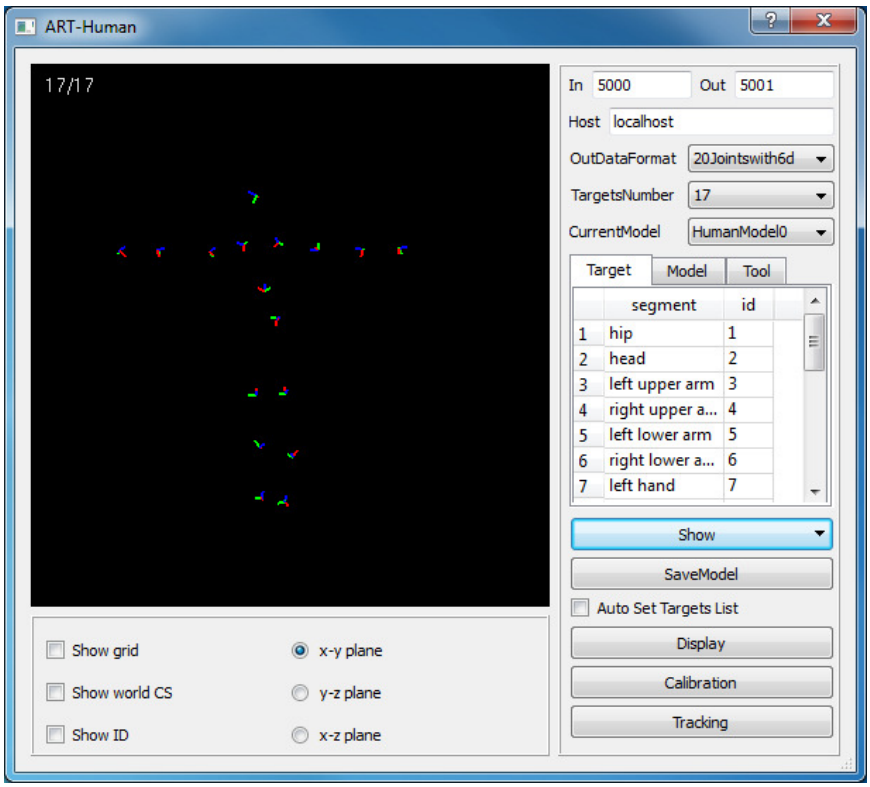
Walk around in the tracking volume, check if all the targets can be tracked.

Model calibration

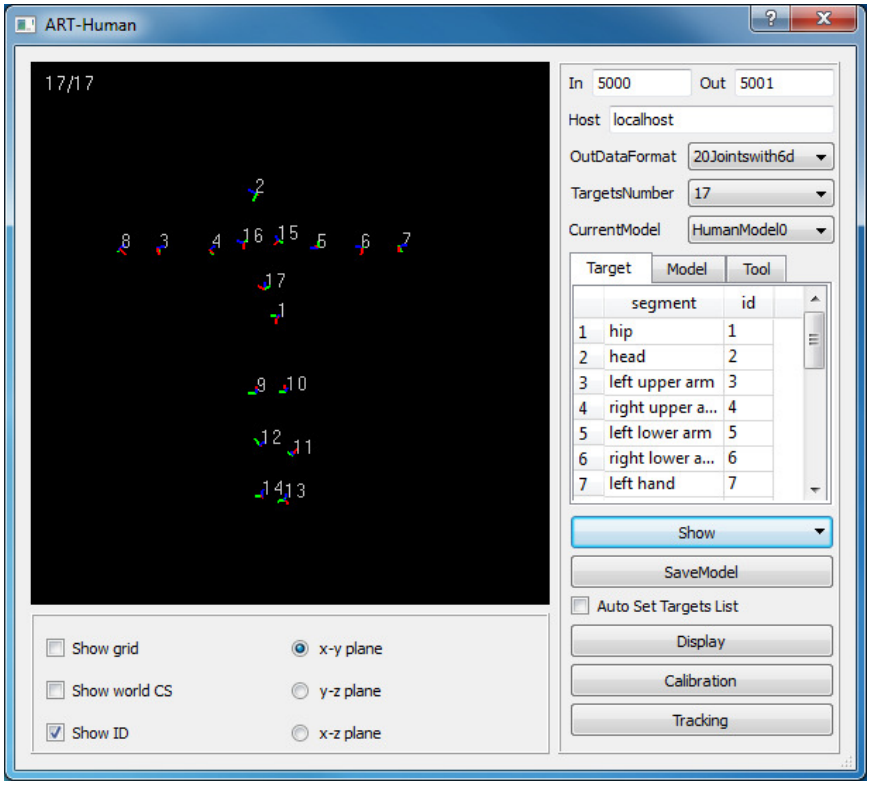
In the DTrack2 output settings, check the data output with fr, ts, 6d, and gl if finger tracking is used. Send data to the computer with ART-Human running in certain port number.



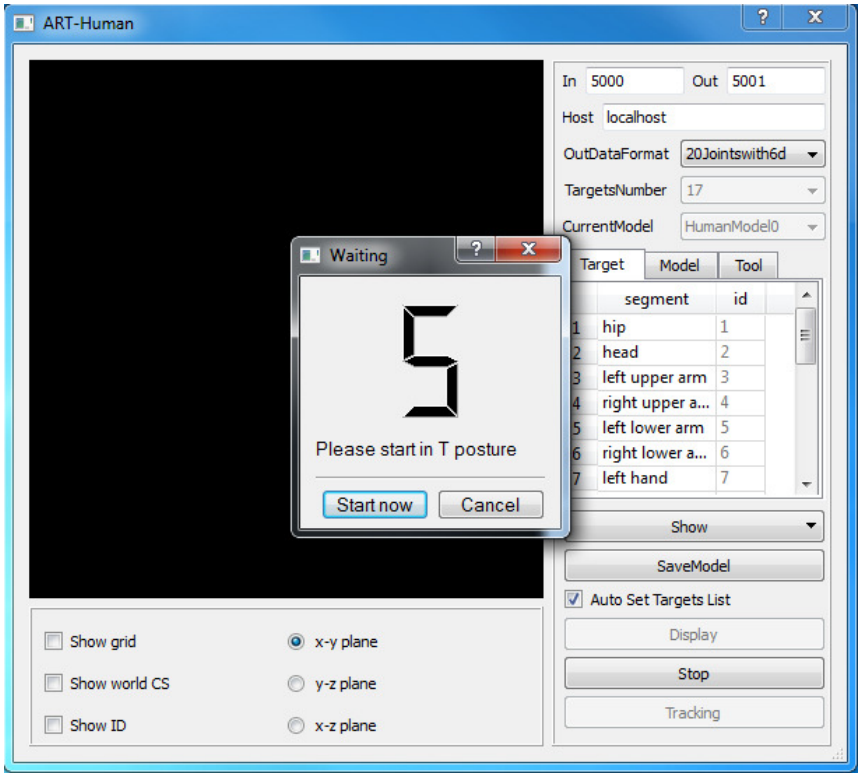
Start the ART-Human, press *Display* button, check if all the targets perform normally in the viewer.



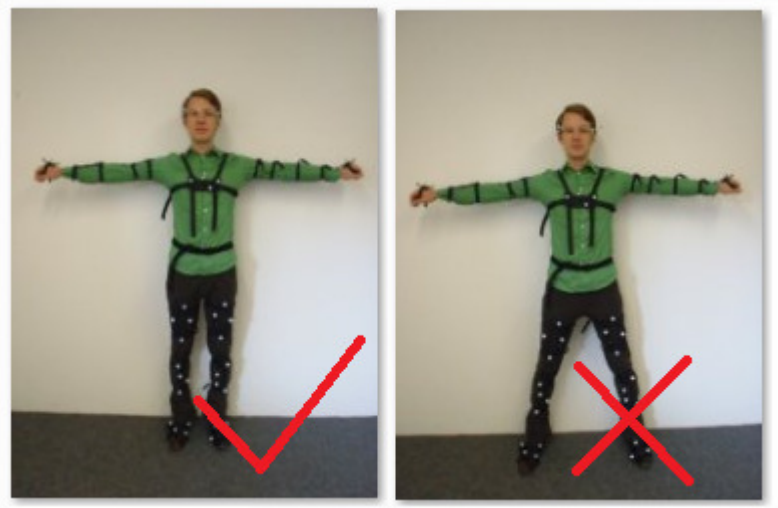
Keep the model stay in T posture, stop display mode. Check *Show ID* (Part2) function, input the target id in the target list in the right order.



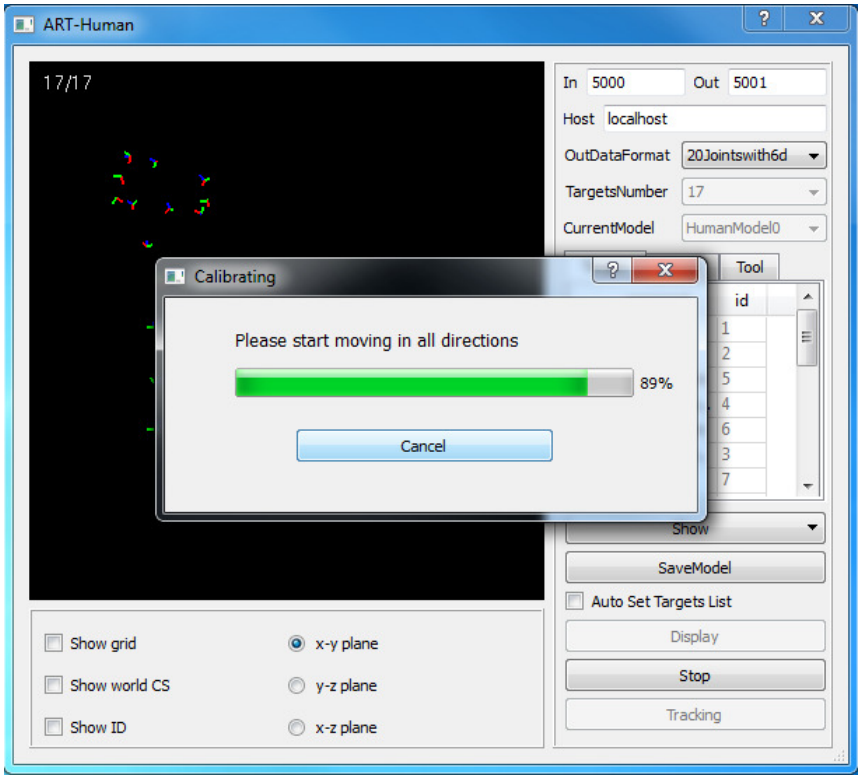
Or check the *Auto Set Targets List* (Part5), ask the model to stay in T posture, press *Calibration* button. If finger tracking is used in the mocap, the application support two human models each wears single or double hands finger tracking set and the auto set targets list function can work normally. The id for the finger tracking will be set to h1-h4. Maximum 4 finger tracking sets are supported.



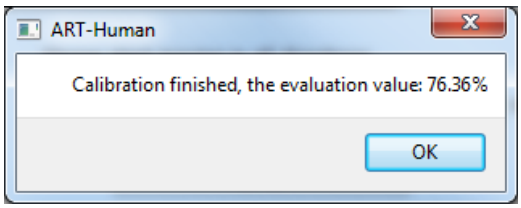
T posture frame is very important in the fitting of the human model, if the T posture is not set appropriately, there will be displacement between the animation of the human model and the real motion. Please stand in strict T pose to avoid shift error later.



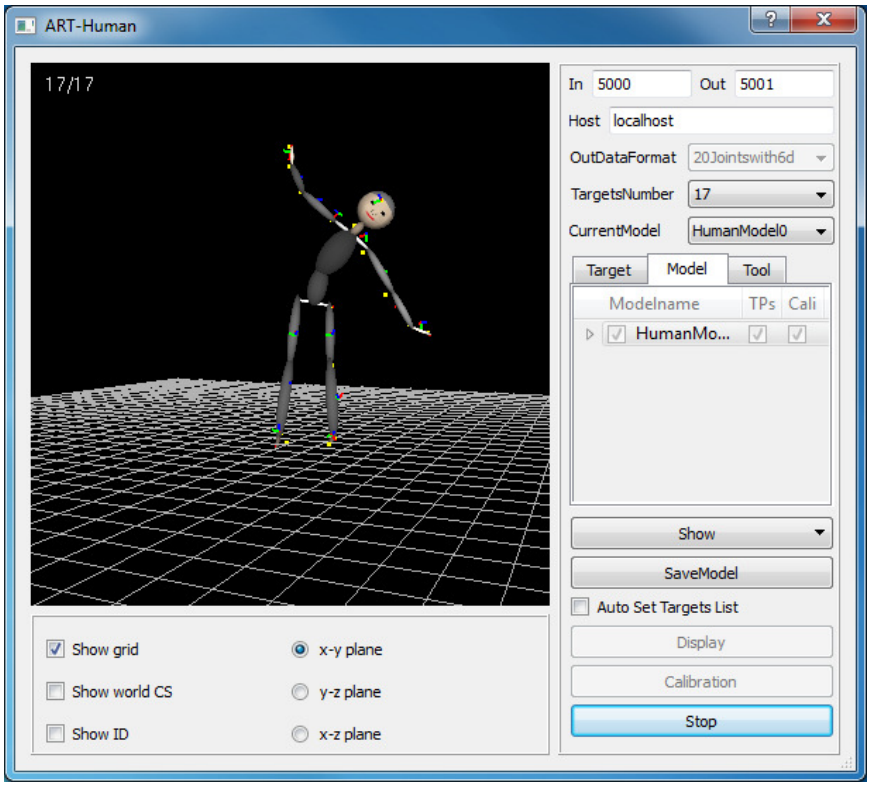
If the T posture has no problem, the target list will be set automatically. The T pose frame is taken and the calibration will start. The model should make random movement to make sure all the joints of the body are captured, especially the head and the torso.

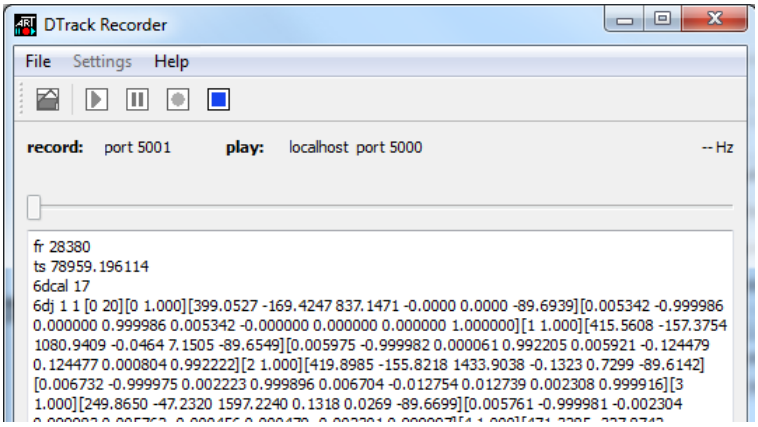


After enough valid frames are recorded, the human model is calculated. You can get the evaluation of the calibration from the dialog, the evaluation bigger than 60% is acceptable.



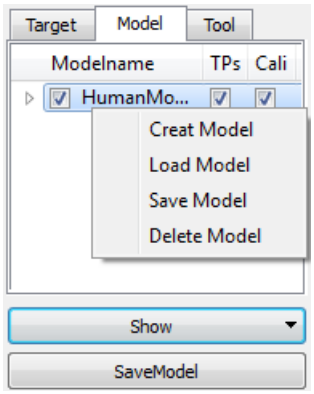
Now the human model is calibrated, you can save the limb length by pressing *SaveModel* button (Part5), or press *Tracking* button to see the animation of the model. In the tracking mode, the 6dj joint data is sending out.





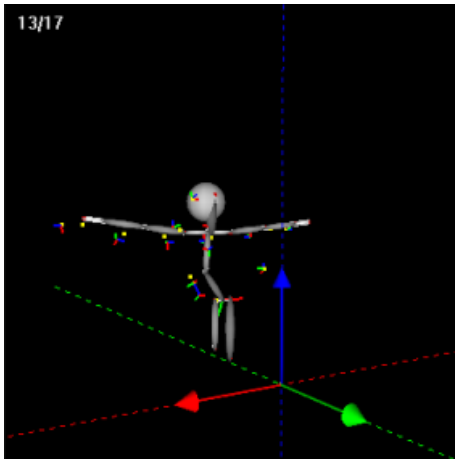
If you are not satisfy with the calibration result, press *Calibration* button to record more frames for calculation, or uncheck the *Cali* to clear the buffer and record the data again. If the targets position on the person is changed, you need to uncheck the *TPs* to clear the T posture frame and do the calibration again.

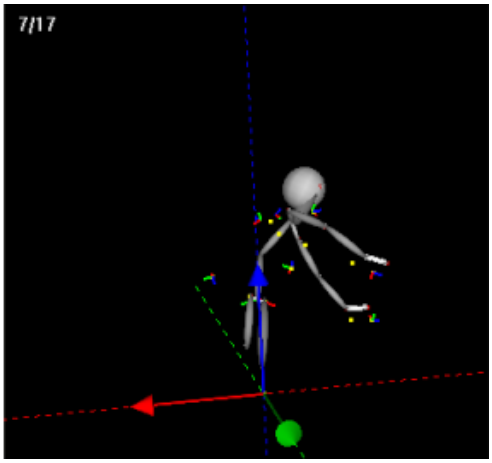
Notice: in the calibration mode, only one model moves in the tracking volume.



Change the model name in a memorizing way, right click on the model and save it in XML file. Later you can load the xml file to the model, the mapping and calibration result will be loaded at the same time, and tracking can start immediately. Note that if the mocap suit is not in the same position as when the XML is saved, you should uncheck the *TPs* and restart calibration, otherwise the fitting of the animation might not be right or have big displacement.

The application also support upper body tracking in sitting position. Make sure the calibration start with arms in T posture, and all the arm targets are tracked. When the Dtrack works in a CAVE condition, sometimes most of the targets are lost, the software can give an reasonable estimation of the model position.

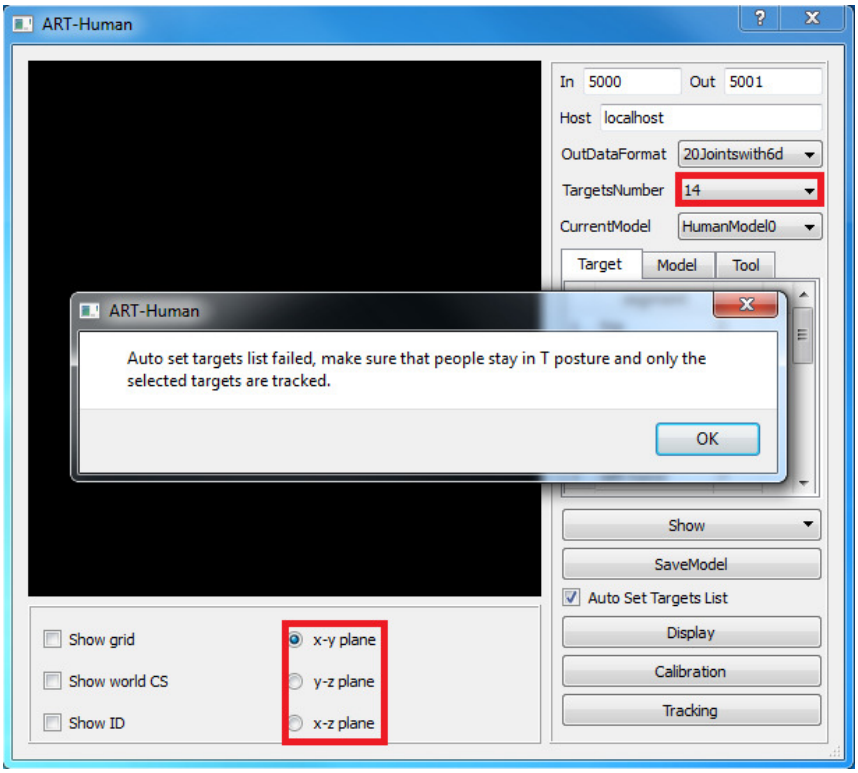




Trouble Shooting

Auto set targets list failed

When auto set the targets list function failed, please check first that if all the targets in the mocap suit are tracked, and no extra targets in the tracking volume, then check the application if *TargetsNumber* is set correctly and whether the room coordinate system is set correctly.

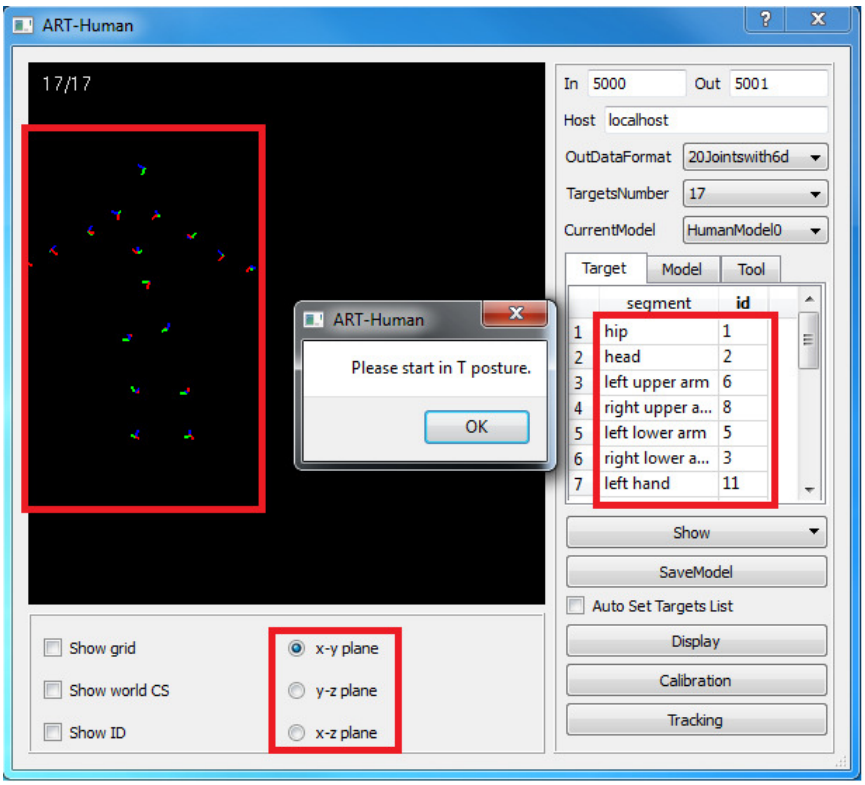


If all the set up is correct, examine whether the character wears the mocap suit in the right way, is head target in front of the face and character stays in the strict T pose.

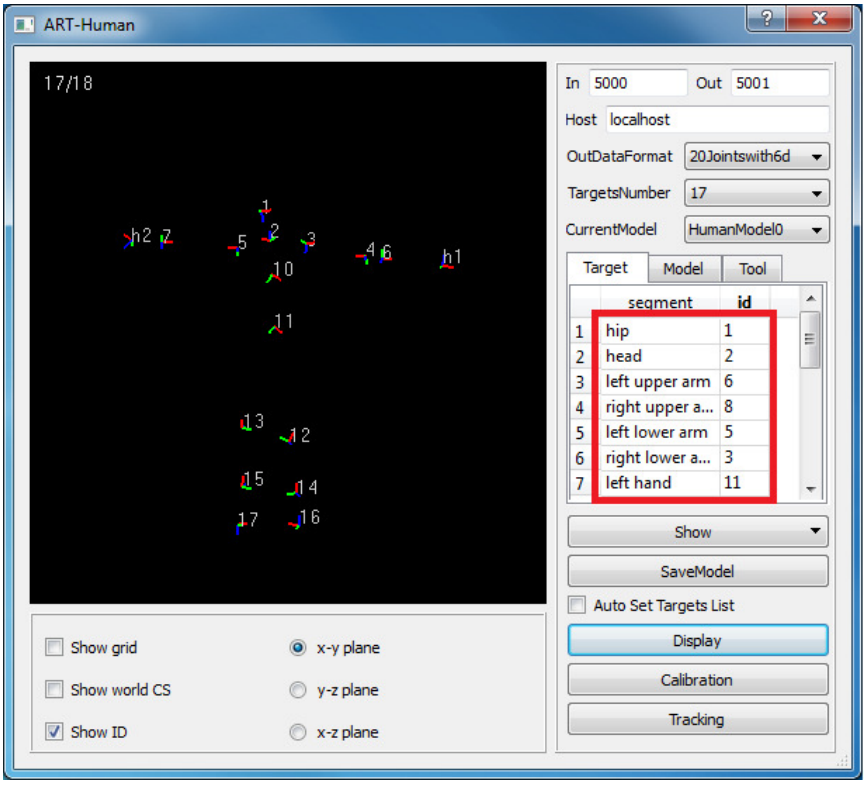
If the auto set function still doesn't work, please use *Show ID* to show the target id and change the mapping list manually.

Set T Posture failed

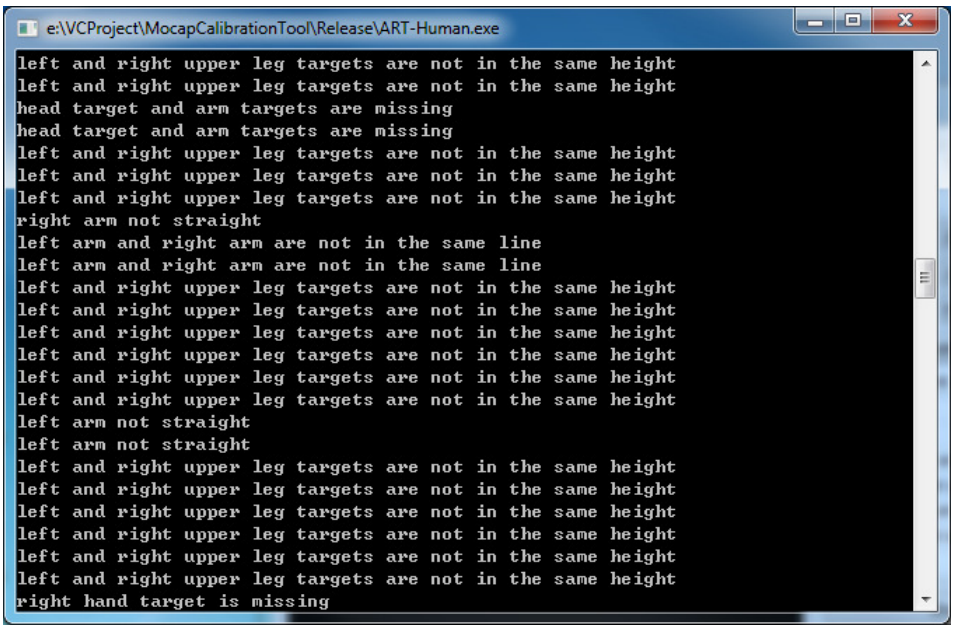
If the T posture is not accepted by the application, please check first that if all the targets are tracked, then check the application if the room coordinate system is set correctly.



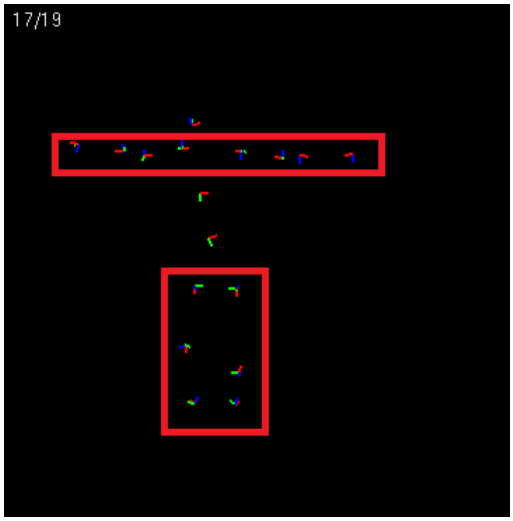
Note that sometimes if the person is not in T posture the auto set targets list could be accepted by the software, but the mapping is not correct. So always use *Show ID* function to check whether the mapping list is correct.

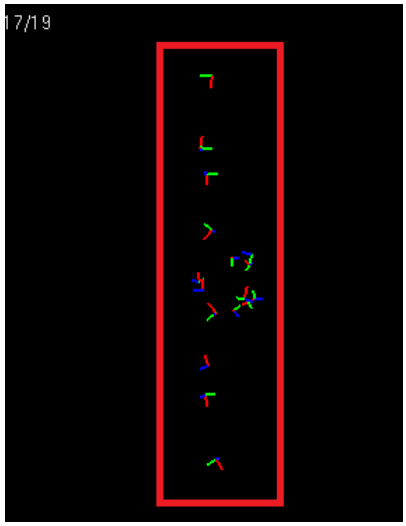


If all the set up is correct, examine whether the character wears the mocap suit in the right way. Check on **Put on the mocap suit** part whether the targets are on the same side of the limb and character stays in the strict T pose. Check whether the both feet stand on the floor, whether the leg targets are in the similar height; whether the arm targets are in a line. You can get the tips in the console to see what might be the problem.



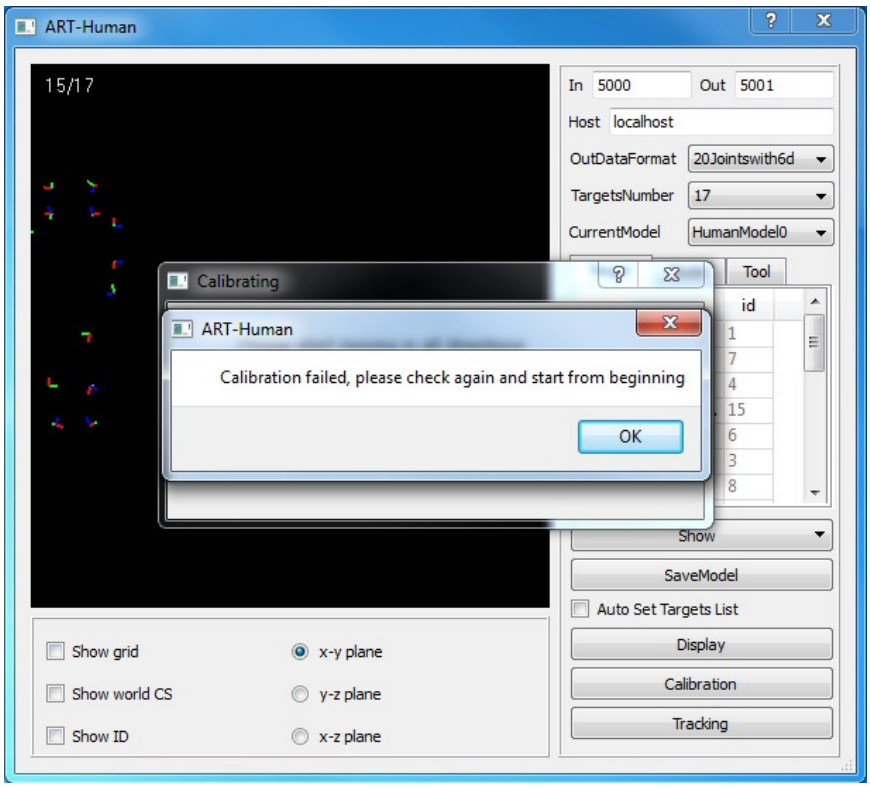
Or freeze the viewer at T posture to see what is the problem.

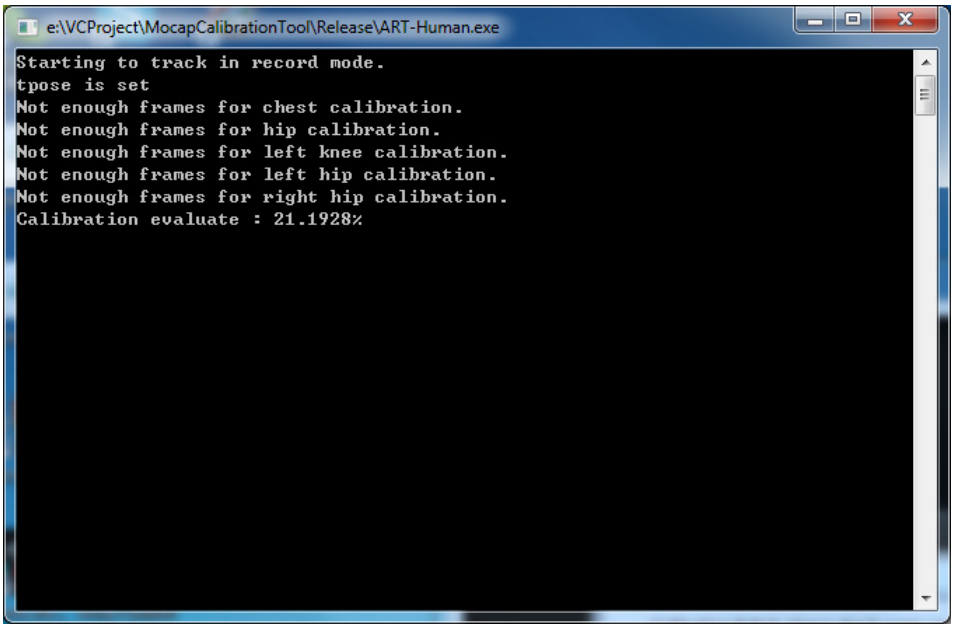




Human model calibration failed

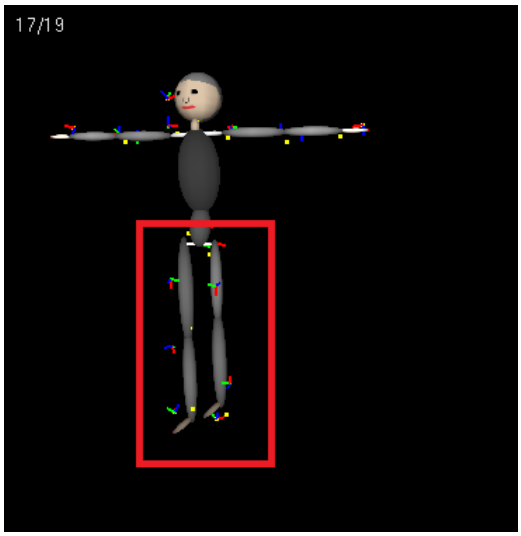
If the calibration evaluation is smaller than 0.6, calibration fails. The reason might be some targets are lost in the most recorded frames. You can see the tips in the console. Sometimes, the tracking condition is really limited, so the bad calibration is also taken by the software, but then the followed tracking cannot be guaranteed.





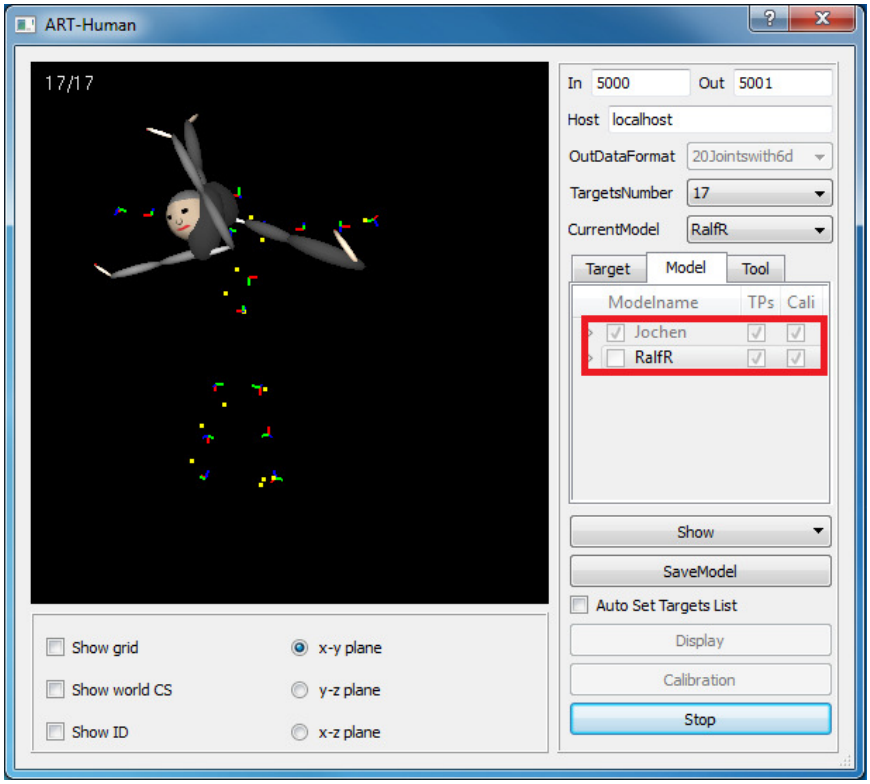
You may also find sometimes the human model has obvious failure. Please check that during the calibration, whether all the joints have sufficient movement. For example, if you move your legs in big circle, but barely rotate the ankles, then the lower leg and foot can not be calibrated correctly. You can start calibration again to record more frames, or uncheck *Cali* to record the frames from beginning.

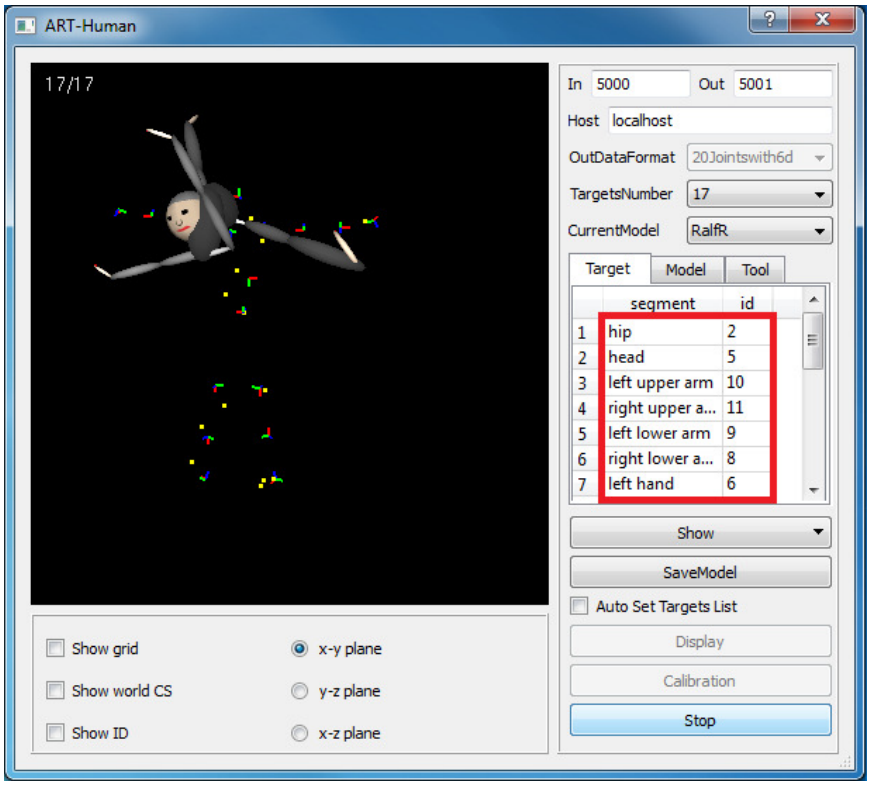
In the picture is an example, only one leg is calibrated correctly, the other one has not enough movement recorded.



Human model tracking failed

After the human model is calibrated successfully, start the *Tracking* mode. If the human model is not tracked correctly, first check in the model list, whether the model you selected is the right one. Then check if the targets mapping is correct. If everything seems normal but the tracking is still in disorder, please create a new model and start from the beginning.





File Management

XML model file

The xml file contains all the information to reconstruct the human model. Normally, do not change the content of the file. If the trouble shooting doesn't help when you have problems in calibrating the human model, you can go to the xml file for information.

In the xml files, you can see that the name of the human model, and it is constructed by five kinematic chains, each chain contains several segments. The local information and rotation limitation for each segment are listed and also the target id combined to it.

TXT bone length file

In the txt human bone length file, you can get the character's bone length in mm as calibrated results. For example:

Upper arm left: 304.354 Lower arm left: 284.641
Upper arm right: 310.603 Lower arm right: 287.366
Thigh left: 445.27 Lower leg left: 437.36
Thigh right: 435.711 Lower leg right: 432.524
Shoulders: 376.082 Hips: 190.049
Torso: 610.036

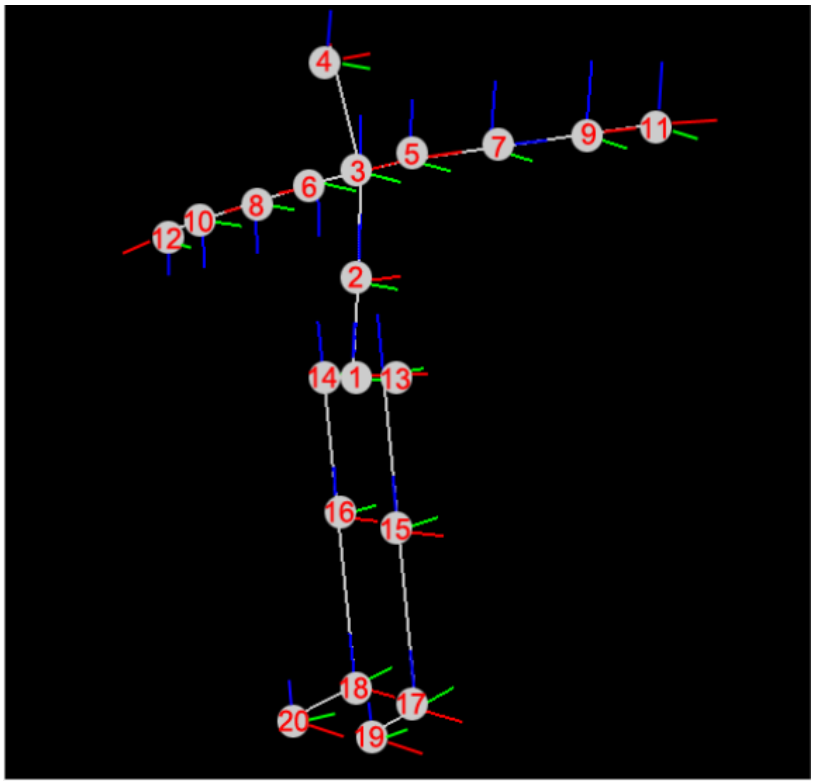
In this situation, the accuracy of bone length for the limbs are around 1cm, the accuracy of shoulder and hip breadth and torso length are not so accurate.

DRF data file

The output of the joint data is sending via UDP socket. The joints data output is in the format:

fr 34514
ts 64425.076492
6dcal 17
6d 15 [0 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 ….

fr: ---------- frame counter
ts: ---------- time stamp
6dj 3 1 ---------- ---- 6Dof joints data output, 3 human model calibrated, 1 human model data output
[0 20] ---------- ---- the first human model joints data, 20 joints data is defined as figure below.



The joints data is in the following order, and orientation at T-Pose:

J1: hip: x-axis point left; y-axis point backward; z-axis point up
J2: chest: x-axis point left; y-axis point backward; z-axis point up
J3: neck: x-axis point left; y-axis point backward; z-axis point up
J4: head: x-axis point left; y-axis point backward; z-axis point up
J5: left shoulder: x-axis point left; y-axis point backward; z-axis point up
J6: right shoulder: x-axis point right; y-axis point backward, z-axis to the ground
J7: left elbow: x-axis point left; y-axis point backward; z-axis point up
J8: right elbow: x-axis point right; y-axis point backward, z-axis to the ground
J9: left wrist: x-axis point left; y-axis point backward; z-axis point up
J10: right wrist: x-axis point right; y-axis point backward, z-axis to the ground
J11: left hand: x-axis point left; y-axis point backward; z-axis point up
J12: right hand: x-axis point right; y-axis point backward, z-axis to the ground
J13: left hip: x-axis point left; y-axis point backward; z-axis point up
J14: right hip: x-axis point left; y-axis point backward; z-axis point up
J15: left knee: x-axis point left; y-axis point backward; z-axis point up
J16: right knee: x-axis point left; y-axis point backward; z-axis point up
J17: left ankle: x-axis point left; y-axis point backward; z-axis point up
J18: right ankle: x-axis point left; y-axis point backward; z-axis point up
J19: left foot: x-axis point left; y-axis point backward; z-axis point up
J20: right foot: x-axis point left; y-axis point backward; z-axis point up

The global joint output means:

Dtrack joint body type J1 has the location of 1 which is the middle of J13 and J14, and the orientation is the offset when the first time T pose is captured. Once the T pose is set, this J1 matrix does not change. It shows the offset between human body CS in this T pose and the world CS.

Dtrack joint body type J2 has the location of the chest joint 2. The orientation is J1*(joint angle of segment S1 compared to offset J1), and actually J2 is the real time CS of the human body and also shown in small colorful cross at point 1.

Dtrack joint body type J3 has the location of the neck joint 3. The orientation is J2*(joint angle of segment S2 compared to segment S1) and is equal to the chest orientation compared to the world CS.

Dtrack joint body type J4 has the location of the head target. The orientation is J3*(joint angle of segment S3(head) compared to segment S2) and is equal to the head orientation compared to the world CS.

Dtrack body type J5 has the location of the left shoulder 5. The orientation is J3*(joint angle of left shoulder compared to segment S2) and is equal to the leftshoulder orientation compared to the world CS.

Dtrack body type J13 and J14 has the same orientation with the human model CS (J2), because the joint angle limits for left and right hip compared to waist are fixed to zero.

Integration for further development

Autodesk MotionBuilder

Please reference to

“MotionCapturingwithDtrack_v1.1.pdf”.

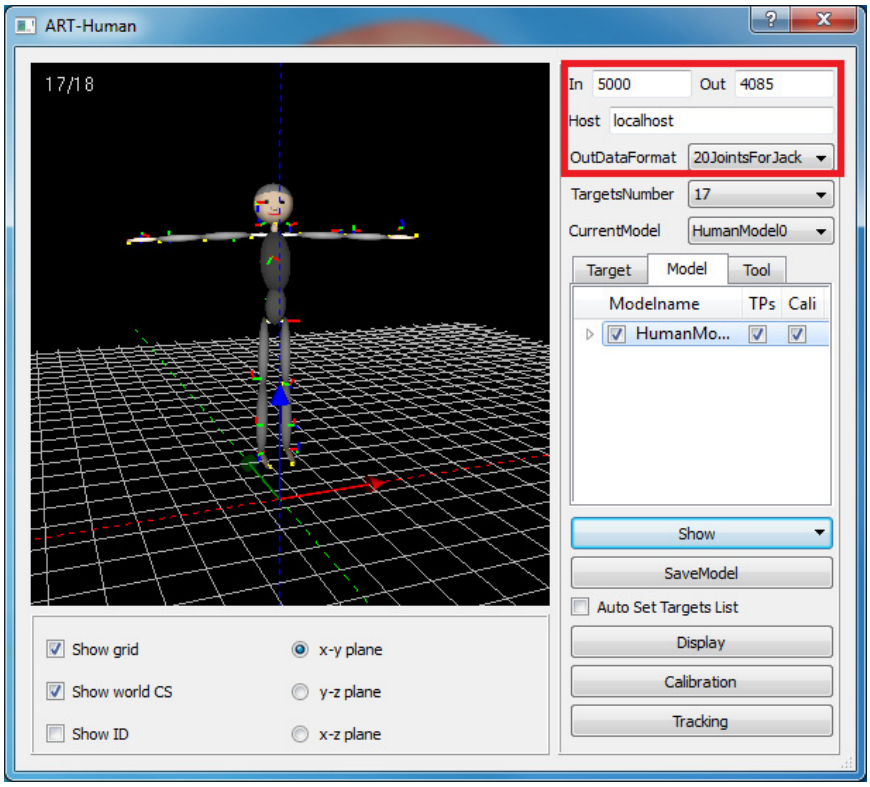
Siemens PLM software Jack

Please reference to

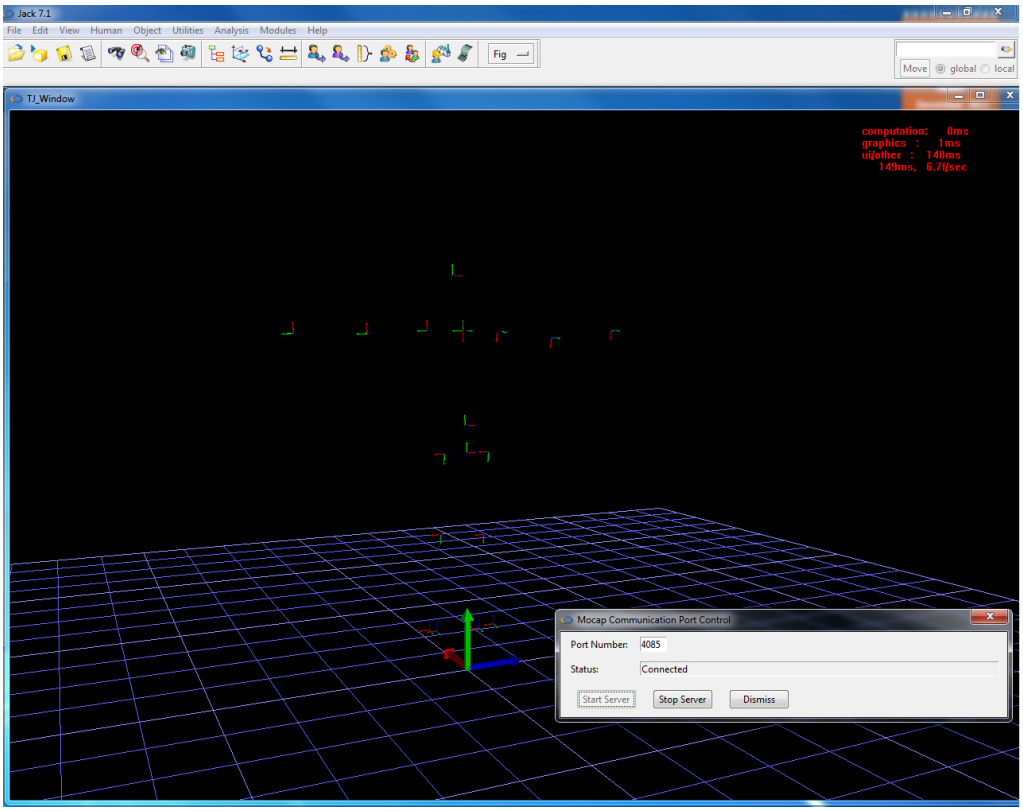
“TrackingJackFigures.pdf” provided by Siemens PLM.

First, follow the working routine to calibrate the human model until the tracking can work normally.

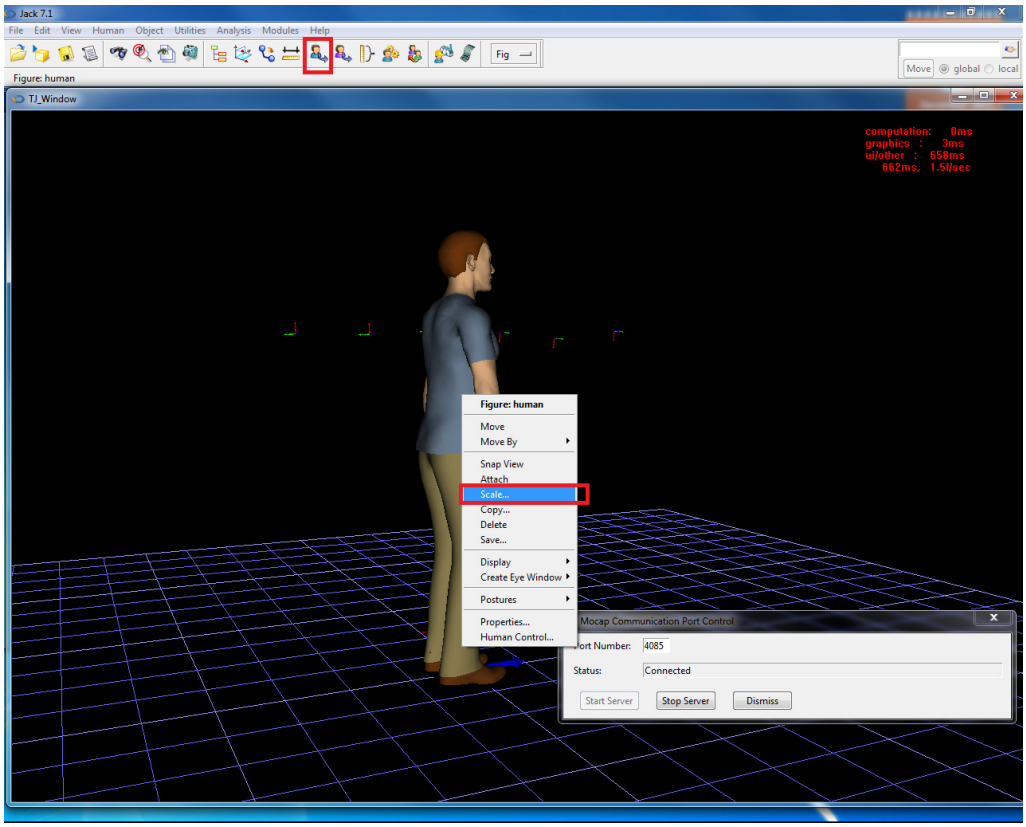
Set **the output port number** and the **host address** in Part 3 to the computer with Jack software. Select the output format to *20JointsForJack***.**

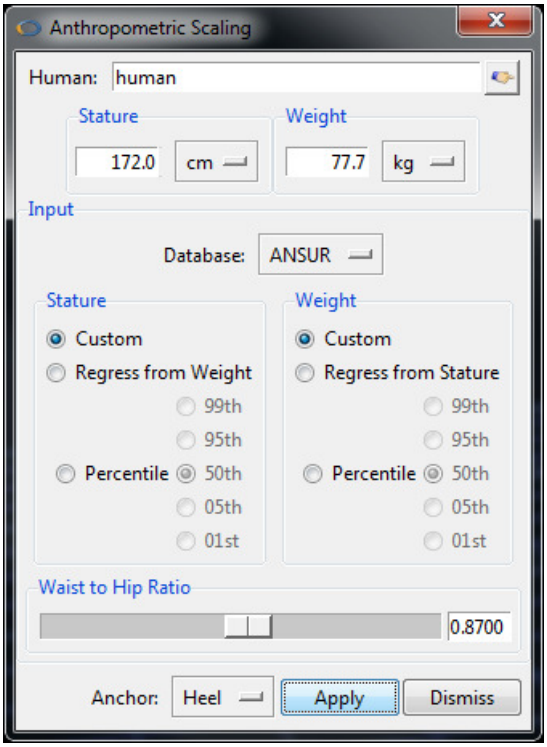


Start Jack7.1. Open **Mocap Communication Port Control** dialog from **Modules | Motion Capture | Communication Protocol | Server Setup**. Check the Port Number and then **Start Server.** Go back to ART-Human. Check the **Port Number, Host** and **OutDataFormat** again. Start **Tracking**. If all the settings are correct, you will see the joint angles update in Jack Window.



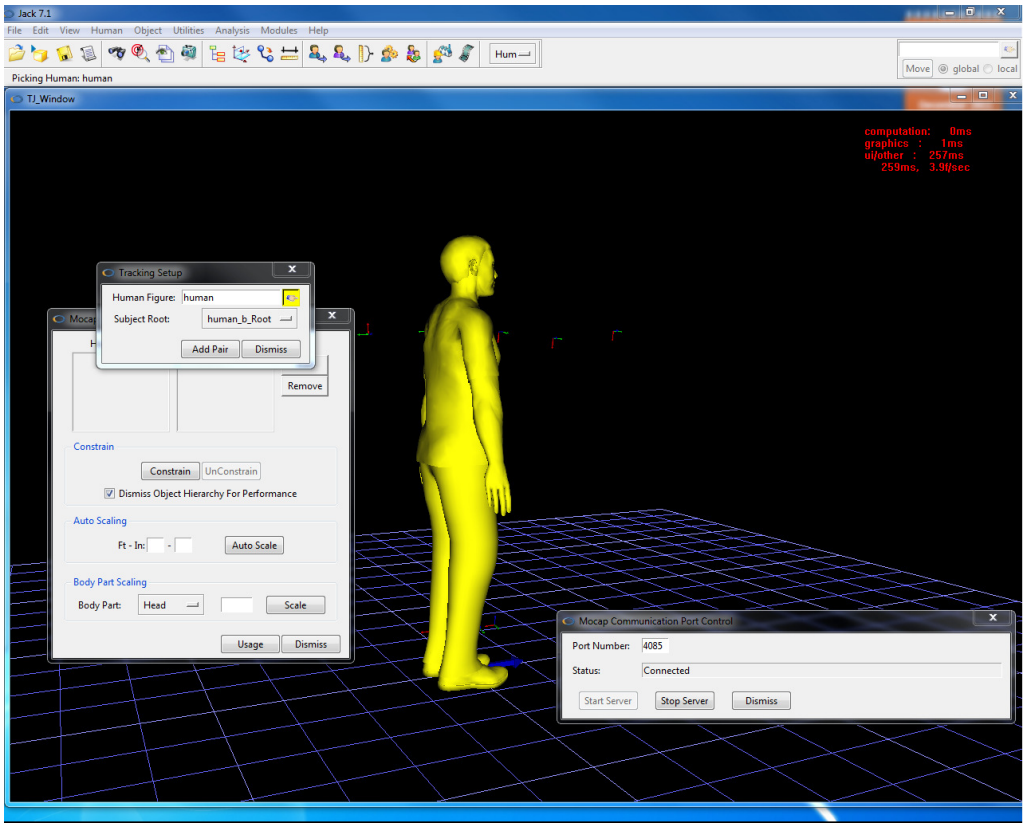
Now stop tracking in Dtrack2 or stop tracking in ART-Human, to freeze the data at **T Pose**. Create a Default Male Human in Jack. Right click on the human and scale it to the correct height.

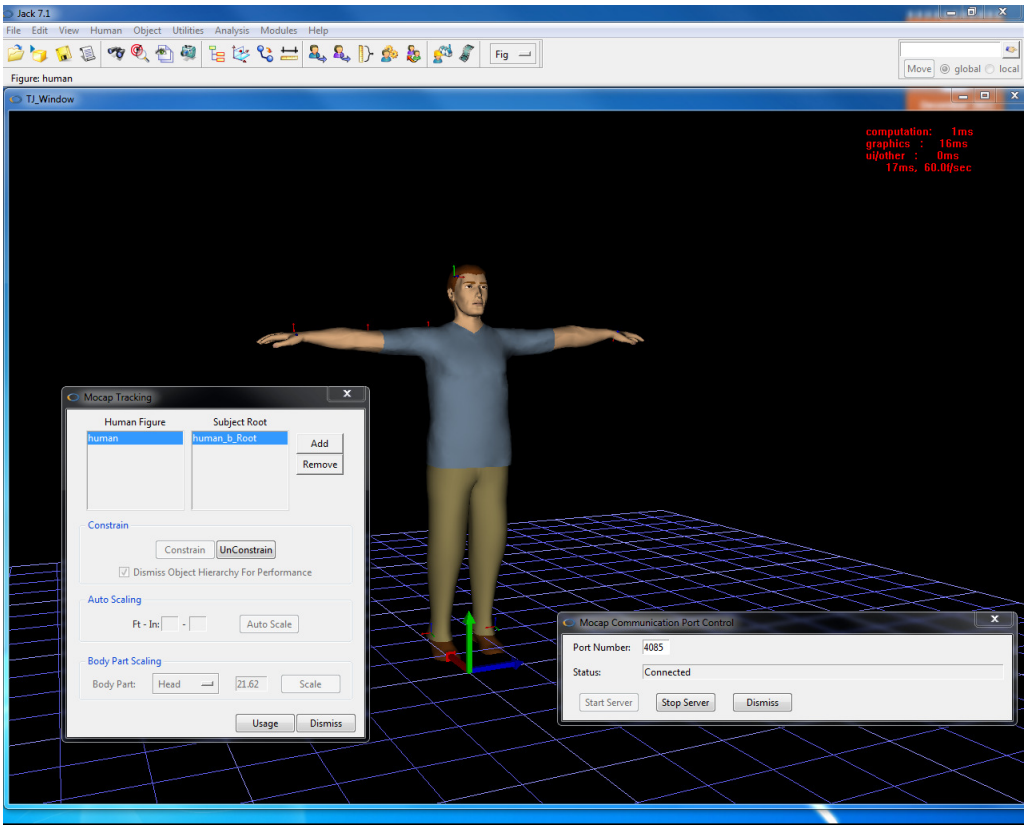

Jack 7.1
File Edit View Human Object Utilities Analysis Modules Help
Figure: human
TJ_Window
computation: 0ms
graphics : 3ms
ui/other : 658ms
662ms, 1.5f/sec
Figure: human
Move
Move By
Snap View
Attach
Scale...
Copy...
Delete
Save...
Display
Create Eye Window
Postures
Properties...
Human Control...
Mocap Communication Port Control
Port Number: 4085
Status: Connected
Start Server
Stop Server
Dismiss


Anthropometric Scaling
Human: human
Stature
172.0
cm
Weight
77.7
kg
Input
Database: ANSUR
Stature
Custom
Regress from Weight
99th
95th
Percentile 50th
05th
01st
Weight
Custom
Regress from Stature
99th
95th
Percentile 50th
05th
01st
Waist to Hip Ratio
0.8700
Anchor: Heel
Apply
Dismiss

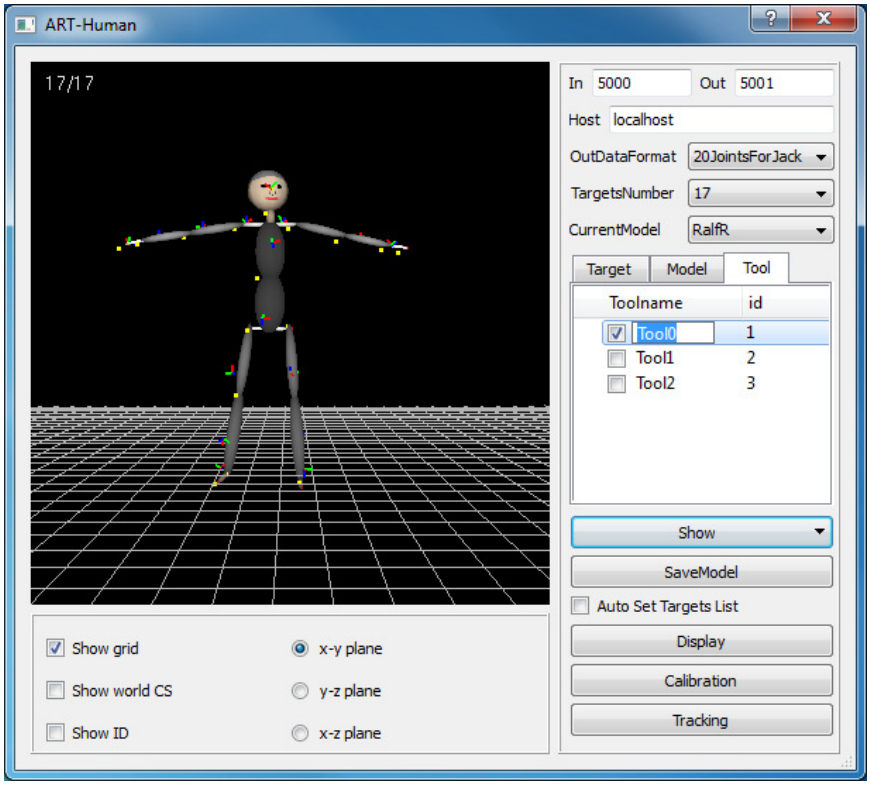
Open **Mocap Tracking** dialog from **Modules | Motion Capture | Communication Protocol | Tracking Setup**. Press **Add** to open **Tracking Setup** dialog. Pick up the Human Figure by pressing  and click the mouse on the Human. Press **Add Pair**.

Press **Constrain** in the **Mocap Tracking** dialog and now the human is constrained to the joints data.





In the tool list of ART-Human, create tool target to send to Jack. Set the 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 “z_b_**PO”.



Now start **Tracking** in Dtrack2 or ART-Human again. You will get real time animation of the human in Jack.

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 problem and cause crash of Jack.

For further questions please contact:

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