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**Vicon Workstation
Quick Reference Guide**

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Vicon Workstation Quick Reference Guide

Introduction

This guide will familiarize the reader with how to collect human motion data with the Vicon motion analysis system. This system consists both hardware and software components. The hardware includes from 4 to 7 infrared MX cameras, an analog data acquisition module and an optional CCD video camera. The software includes Vicon Workstation that collects and partly processes the motion and analog data, the Eclipse database manager for keeping records of the data files their associated calibration files and the programs BodyBuilder and Polygon from constructing and processing the acquired data. Note that Visual3D, MatLab, BioProc3 can also be used to view and analyze these data file. This guide will not include how to process the data beyond the collection and reconstruction of the data into 3-D motion trajectories. Detailed information about the Vicon system may be obtained from the online Vicon manual or its hardcopy version.

Camera Setup

The first step to any motion capture session is decide on the number MX cameras and their appropriate positioning within the laboratory. Generally at least four cameras are necessary to obtain valid 3D motion but as few as two is possible, for complex whole body motions six or seven cameras may be needed. The cameras need to be aligned so that each sees as much of the total motion as possible and that at least two cameras can see all the markers throughout the duration of the analysis period of the motion investigated. Note that at times a marker may be blocked from one or more camera's view so other cameras will be needed to see the marker during these periods. Furthermore, all cameras will be to see the static calibration object (triangular plate with four markers, see Figure 4) so that its position relative to the laboratory reference system may be computed.

An optional "movie" camera for recording the subject and trial conditions may positioned, usually, to view motion in the sagittal plane. This camera is for presentation purposes and is not normally for collection of analyzable data. We use a Basler charge-coupled device (CCD) camera that collects digital images at the rate of 80 frames per second or a Panasonic digital video camera at the rate of 30 Hz. Use the **Live Movie** item in the **System** menu to align the movie camera appropriately.



Figure 1. Vicon MX infrared camera



Figure 2. Basler CCD camera

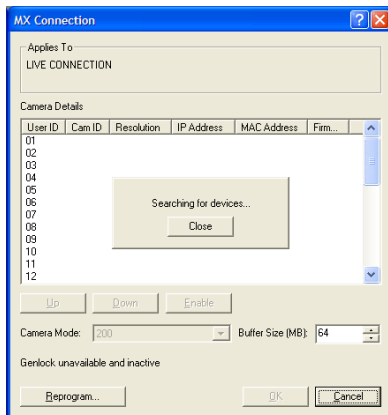


Figure 3. Searching for cameras and analog system

Start this step by turning on the Vicon system and from the **System** menu pressing the **System Configuration...** item to open an appropriate configuration file such as, *Gaitlab.car*. Configuration files tell the system what analog devices are available and how force platforms are aligned. These files can only be selected at the beginning of the session. If you pick the wrong one you may have to exit and restart Workstation. Next, select the **Start Link** item to have the Vicon system search for the connected cameras and determine whether the analog system is present (Figure 3). Finally, press the Eclipse button (👁) and then use the **Live Monitor** item to position the Vicon cameras optimally.

Subject Preparation and Marker Placement

The subject should wear the minimum amount of clothing and wear clothing that is skin tight if possible and acceptable to the subject. Footwear should have no reflective material but if this is not possible the reflective areas must be covered by nonreflective (cloth) tape.

The number and positioning of the markers is based on the type of motion being analyzed and the number of body segments needed to answer the research question. Usually a whole lower or extremity will be analyzed but sometimes the whole body will need to have appropriate markers attached to specific anatomical landmarks. The default system used by the Vicon system is called the Plug-In Gait marker set. This is similar to the Helen Hayes Marker system that was designed for clinical gait analysis. Another well-used system is the Cleveland Clinic Marker set; this set uses triads of markers attached as clusters to each segment analyzed. We prefer to use an enhanced version of the Plug-In Gait marker set (see appendix 1). Our system includes additional markers at the hip and medial aspects of the elbow, knee and ankle and additional foot markers. We also use a different markers locations at the proximal ends of the pelvis and around the head.

Note that, in general, each segment needs three noncollinear markers to identify the 3D motion of a segment. These markers, called **tracking markers**, do not have to be located over joint centres and in fact can be attached as triad clusters to the middle of a segment. The joint centres, however, **MUST** be identified during a static recording of the total marker set. During the static recording, the locations of both joint markers and tracking markers must be collected and visible to the Vicon camera system. This step is critical to the valid analysis of the data. No motion capture should be started until verification that all tracking markers and joint markers are visible during the static trial (not the same as the static camera calibration).

Camera Calibration

Camera calibration requires two recordings. The first recording, the static camera calibration, requires that the static calibration object (Figure 4) be the only reflective object visible to all cameras. The subject and calibration wand and any stray markers need to be covered or removed from the laboratory briefly during this recording. Place this object at a specific location on the floor of the laboratory and if using one or more force platforms over a specific corner and in a specific direction of one of the force platforms. Figure 5 shows the appropriate location for the static calibration object when using force platforms.



Figure 4. Static calibration object



Figure 5. Correct location of static calibration object over force platforms

Start this step by pressing the **Calibrate Cameras...** item in the **System** menu or the calibration icon (📷). Press the **Calibrate** (Figure 6) button to record the location of the static object on all cameras. Be sure the form shows the correct calibration object in the **Reference Object** area. The correct **Name** of the wand is “**2C) Ergocal 14mm mkr - 240mm Wand 14mm mkr**”. Press the **Start** button to record for a few seconds (Figure 7).

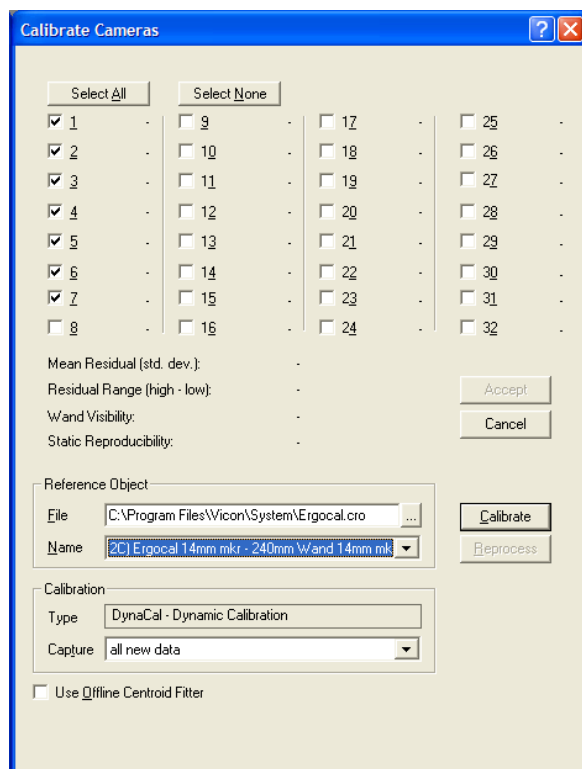


Figure 6. Camera calibration screen. Check the first seven boxes and select the correct calibration object used.

three-dimensional motion. This procedure may have to be done several times until a suitable accuracy is achieved. Press the **Start** button to record the wand’s trajectory for several minutes. Afterwards the system processes the calibration data and reports on the accuracy and precision of the calibrated volume. You should try to achieve an accuracy (Mean Residual) of less than 1.000 mm and a static reproducibility of less than 1.000% (Figure 8).



Figure 7. 240 mm and 120 mm camera calibration wands. Each has three reflective markers.

The second recording consists of moving a specific wand (Figure 7) with three markers and of a specific length. We use the intermediate sized wand of the calibration set. Waft this wand slowly for between 1 to 2 minutes throughout the entire volume to be calibrated moving the wand in with

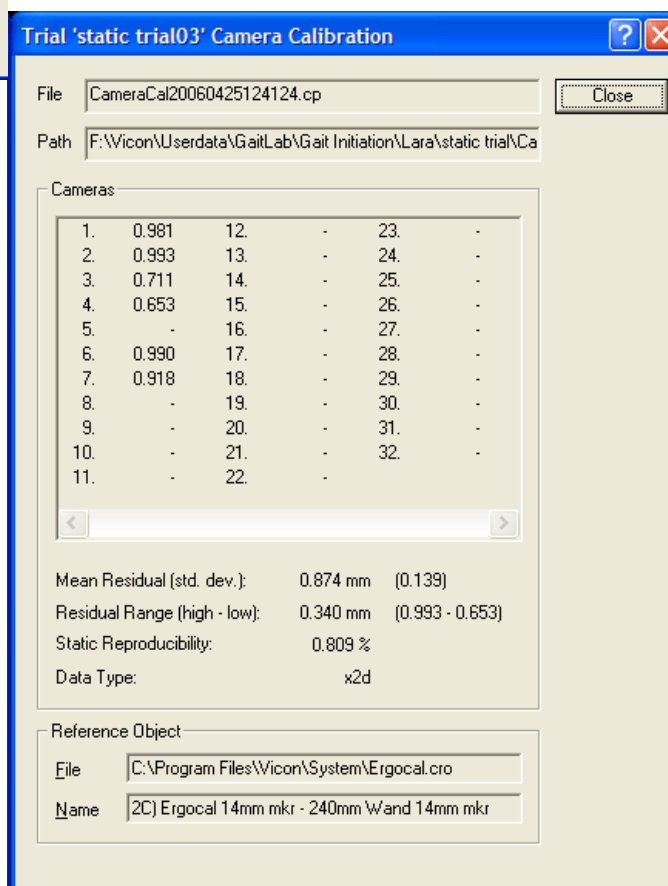







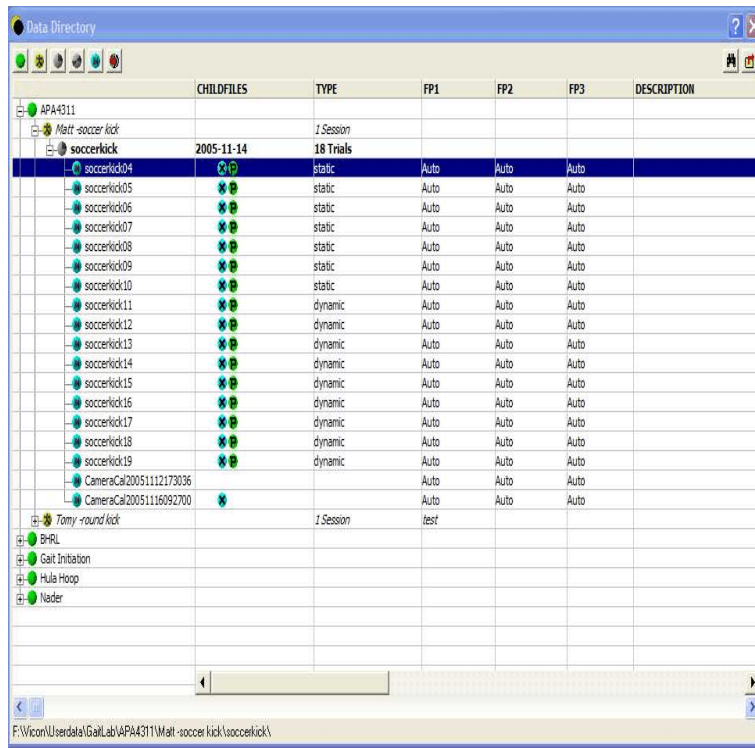
Figure 8. Results of a camera calibration

Force Platform Calibration

Check that your force platform(s) are zeroed correctly. Use the **Live Analog** button () in the **System** menu. Check the F_z channels then press Update and Stacked to verify that the vertical force channels are zeroed when the plates are in the *Reset* mode. Use **Calibrate Analog Zero Levels for System...** in the **System** menu to accurately zero each force platform. Set the plates to *Operate* before collecting any data. You should also have a person walk across the plates to ensure that all the plates are feeding information to the analog system correctly.

Capturing Static and Movement Trajectories

Open the Eclipse database manager (Figure 9) and create a *Project Name* () and associated subdirectory. Next create new *Subject* () and *Session* () folders. Press the *Trial* icon () to



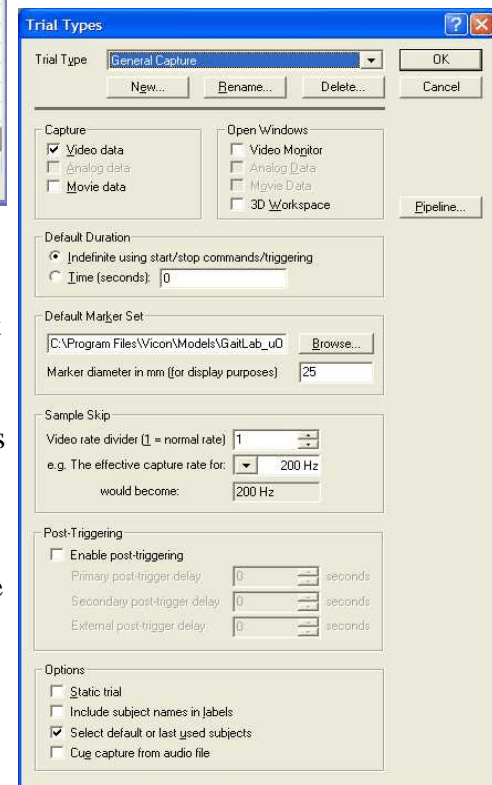
CHILDFILES	TYPE	FP1	FP2	FP3	DESCRIPTION
APA4311					
Matt -soccer kick	1 Session				
soccerkick	2005-11-14	18 Trials			
soccerkick04	static	Auto	Auto	Auto	
soccerkick05	static	Auto	Auto	Auto	
soccerkick06	static	Auto	Auto	Auto	
soccerkick07	static	Auto	Auto	Auto	
soccerkick08	static	Auto	Auto	Auto	
soccerkick09	static	Auto	Auto	Auto	
soccerkick10	static	Auto	Auto	Auto	
soccerkick11	dynamic	Auto	Auto	Auto	
soccerkick12	dynamic	Auto	Auto	Auto	
soccerkick13	dynamic	Auto	Auto	Auto	
soccerkick14	dynamic	Auto	Auto	Auto	
soccerkick15	dynamic	Auto	Auto	Auto	
soccerkick16	dynamic	Auto	Auto	Auto	
soccerkick17	dynamic	Auto	Auto	Auto	
soccerkick18	dynamic	Auto	Auto	Auto	
soccerkick19	dynamic	Auto	Auto	Auto	
CameraCal20051112173036		Auto	Auto	Auto	
CameraCal20051116092700		Auto	Auto	Auto	
Tommy -round kick	1 Session	test			
BHRL					
Gait Initiation					
Hula Hoop					
Nader					

Figure 9. Typical Eclipse database manager screen

Capture several static trials to ensure that you have a complete view of all markers. It is advisable to reconstruct and fully label one of these trials to make sure all markers are visible and motionless for a brief period. You should also check that the correct sampling rate, usually 200 Hz is selected in the Sample Skip area.

Next, begin capturing of your motion trials. Be sure to uncheck the box labelled **Static trial** in the Trial Types form. It may be possible to reconstruct and label the trials as they are collected. To minimize the duration that the subject has to be in the lab you may skip these steps until later.

begin a data collection trial. Press the **Types** button and check the type of data to be collected (Figure 10). Check the Video data, Analog data and optionally the Movie data boxes in the Capture area. In the Open Windows area, check the boxes labelled Video Monitor, Analog Data Movie Data and 3D Workspace boxes. The first data collected must be the subject standing motionless with the arms and legs in their neutral positions and slightly abducted. Check the box labelled **Static trial** then press OK.



Trial Types

Trial Type: General Capture [OK] [New...] [Rename...] [Delete...] [Cancel]

Capture

Video data
 Analog data
 Movie data

Open Windows

Video Monitor
 Analog Data
 Movie Data
 3D Workspace [Pipeline...]

Default Duration

Indefinite using start/stop commands/triggering
 Time (seconds): 0

Default Marker Set

[C:\Program Files\Wicon\Models\GaitLab_u0] [Browse...]
 Marker diameter in mm (for display purposes) 25

Sample Skip

Video rate divider (1 = normal rate) 1
 e.g. The effective capture rate for: 200 Hz
 would become: 200 Hz

Post-Triggering

Enable post-triggering
 Primary post-trigger delay 0 seconds
 Secondary post-trigger delay 0 seconds
 External post-trigger delay 0 seconds

Options

Static trial
 Include subject names in labels
 Select default or last used subjects
 Cue capture from audio file

Figure 10. Trial types and capture options screen

Reconstruction and Cropping

If the motion trials include the marker trajectories from each camera. These are 2D views. The 3D positions are computed by pressing the **Reconstruct** button of the **Trial** menu. It may take time to fully reconstruct the entire trial. Before labelling the trajectories in the motion trials it is advisable to crop unwanted data that are outside the duration of the analysis or outside the calibration volume. Use the 3D view and its cursor to locate the start and end of each trial. Move the upper markers of the cursor bar (bottom of the form) to mark the crop area (see Figure 12). Press the **Crop to Save Range** in the **File** menu. You should also select the **Reload Analog Data** in the **Trial** menu to be sure that the analog data is precisely synchronized with the motion capture data.

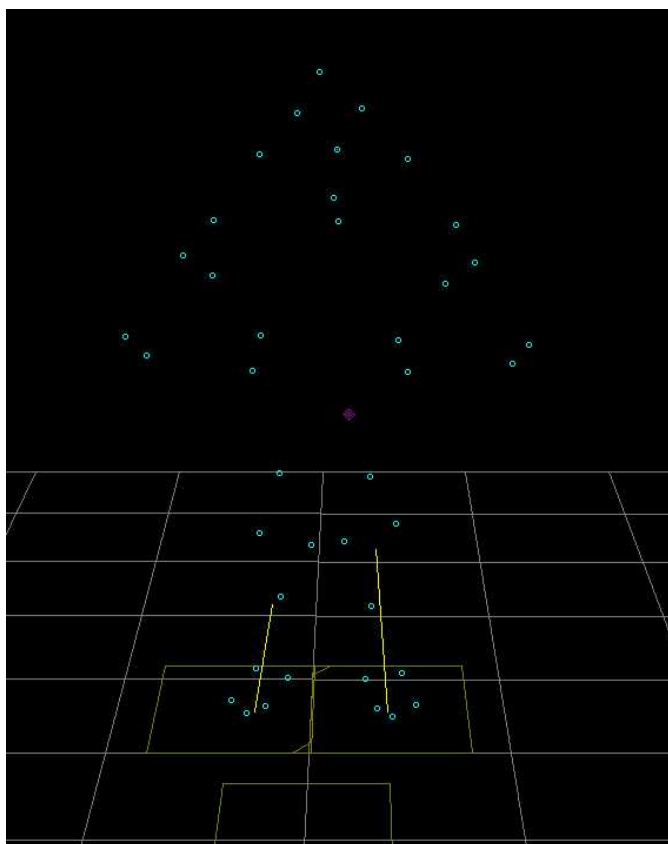


Figure 11. Example of unlabeled static trial

Trajectory Identification and Gap Removal

To label the trajectories you should start with the static view of the subject and identify each marker by clicking on a marker from the 3D view and then selecting its four letter name from the list on the left of the screen (Figures 11 and 12). For speed you can click on a series of markers and then selecting the markers names in the same order. As the markers are identified green lines are added automatically to joint markers that are part of the same “rigid-body” or segment. Once all markers have been identified you should check that all the trajectories are joined without any gaps. Do this by sliding the cursor backwards and forwards within the trial. If a marker turns white it needs to be manually labeled. Each label may have many trajectory paths.

To fill gaps press the **Fill All Gaps** item in the **Edit** menu. Next open each motion trial and press the **Autolabel** item in the **Trial** menu to have the program label all the trajectories automatically. As before check that all marker paths have been labelled and if not manually label them. Next fill all the gaps and delete any unlabeled trajectories using the **Delete Unlabeled Trajectories** item in the **Edit** menu. Lastly, save the trial data. You can now view and animate your 3D trajectories and attach a model to the data points with the *Visual3D* program. Read the document *Visual3D Quick Reference Guide* for information on this process.

Autolabelling

Once all paths have been labeled press the **Create Autolabel Calibration...** item in the **Trial** menu. Save the labeled trial before proceeding further. To use the autolabel function with other trials go to the **Trial** menu, select **Options...** and check the box that has the same name as the trial that was used to perform the autolabel calibration (Figure 13). Next, press the **Autolabel** item from the **Trial** menu. Usually the static trial is used to create the autolabel calibration.

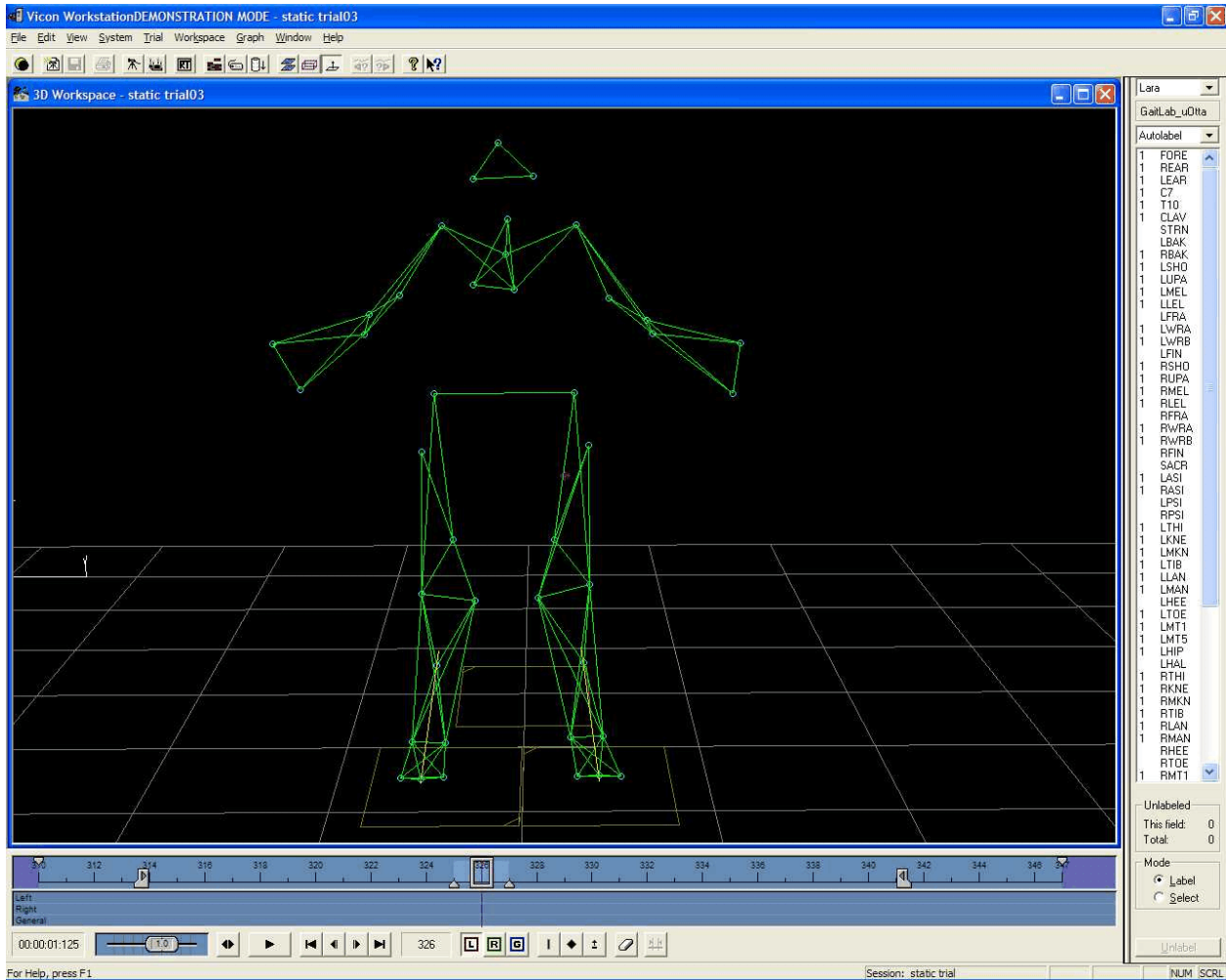


Figure 12. Fully labeled static trial. Right hand column show marker set labels. Items along bottom control the animation and permit the insertion of event codes. The area above shows locations of the event codes. The numbered area at the bottom includes a cursor for moving the image to a particular frame number. The upper triangles mark the “crop region,” the lower triangles mark the length of marker trails and the left and right sliders limit the animation region.

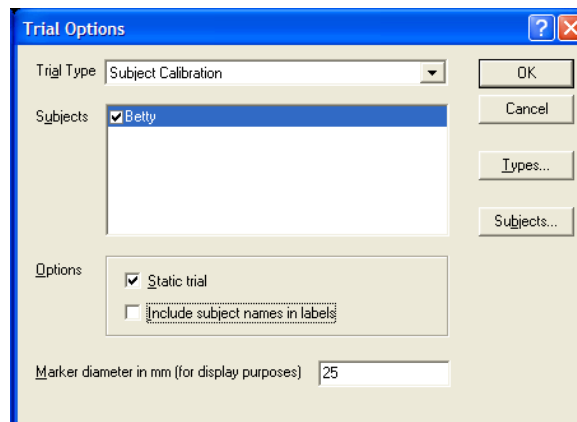
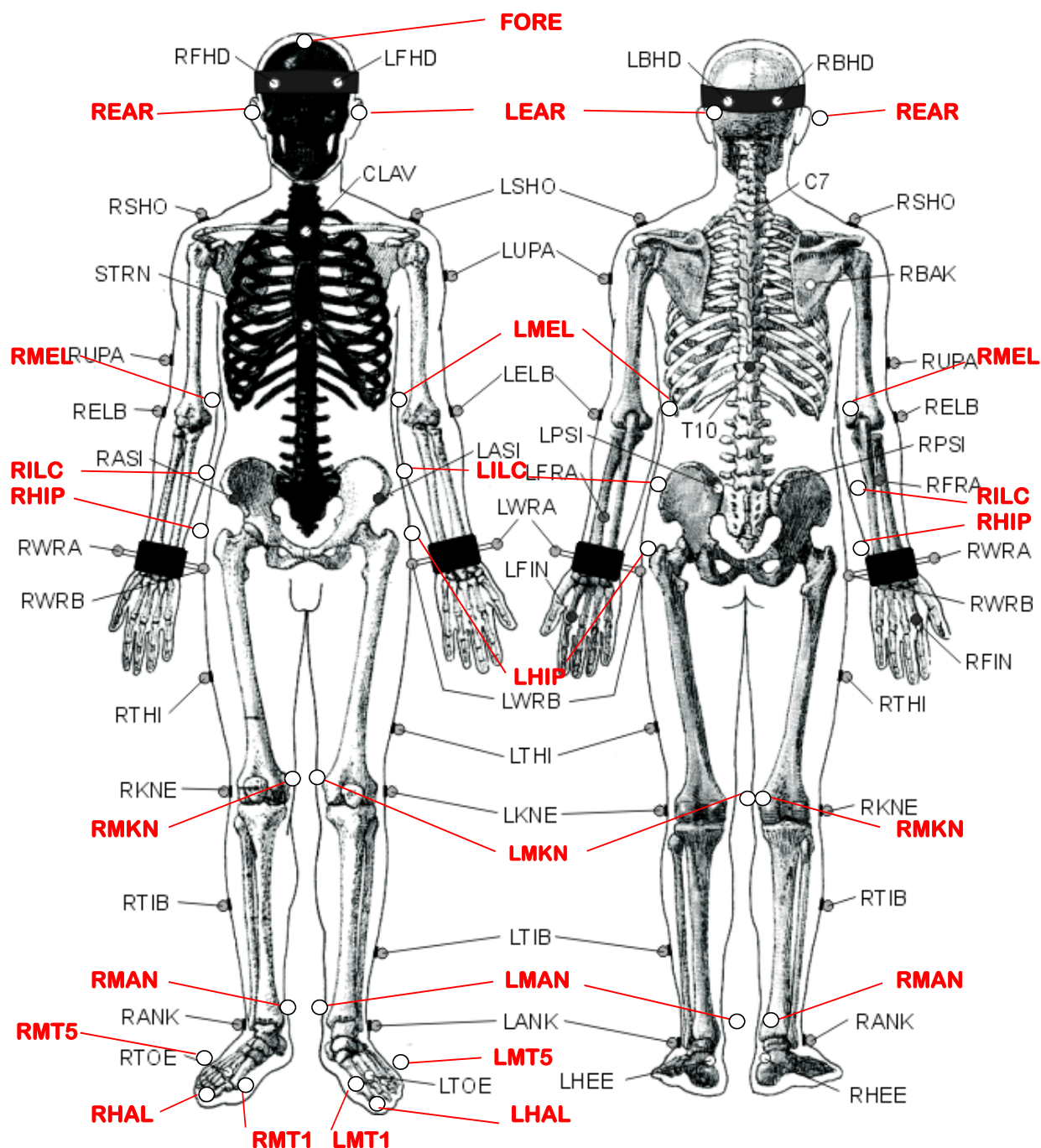


Figure 13. Use the Trial Options menu to enable autolabelling. Check the subject’s name in the **Subjects** box and uncheck the box: “**Include subject names in labels**”

Appendix A

uOttawa Marker Set



Red ○ markers are additional for use by uOttawa Gait lab.

The following describes in detail where the markers should be placed on the subject. Where left side markers only are listed, the positioning is identical for the right side. Markers defined in grey are not normally used.

Upper Body

Head Markers

LFHD	Left front head	Located approximately over the left temple
RFHD	Right front head	Located approximately over the right temple
LBHD	Left back head	Placed on the back of the head, roughly in a horizontal plane of the front head markers
RBHD	Right back head	Placed on the back of the head, roughly in a horizontal plane of the front head markers
FORE	Forehead	Middle anterior aspect of forehead
LEAR	Left ear	Left ear canal
REAR	Right ear	Right ear canal
BHED	Back of head	Opposite of forehead marker

The markers over the temples define the origin, and the scale of the head. The rear markers define its orientation. If they cannot be placed level with the front markers, and the head is level in the static trial, tick the “Head Level” check box under options on “Run static model” in the pipeline when processing the static trial. Many users buy a headband and permanently attach markers to it.

Torso Markers

C7	7 th Cervical vertebrae	Spinous process of the 7 th cervical vertebrae
T10	10 th thoracic vertebrae	Spinous Process of the 10 th thoracic vertebrae
CLAV	Clavicle	Jugular notch where the clavicles meet the sternum
STRN	Sternum	Xiphoid process of the sternum
RBAK, LBAK	Right back, Left back	Place in the middle of the right scapula. This marker has no symmetrical marker on the left side. This asymmetry helps the autolabeling routine determine right from left on the subject.

C7, T10, CLAV, STRN define a plane hence their lateral positioning is most important.

Arm Markers

LSHO	Left shoulder	Placed on the acromioclavicular joint
LUPA	Left upper arm marker	Place on the upper arm between the elbow and shoulder markers. Should be placed asymmetrically with RUPA
LLEL	Left elbow	Place on lateral epicondyle approximating elbow joint axis
LMEL	Left medial elbow	Place on medial epicondyle approximating elbow joint axis
LFRA	Left forearm marker	Place on the lower arm between the wrist and elbow markers. Should be placed asymmetrically with RFRA
LWRA	Left wrist marker A	Left wrist bar thumb side
LWRB	Left wrist marker B	Left wrist bar pinkie side

The wrist markers are placed at the ends of a bar attached symmetrically with a wristband on the posterior of the wrist, as close to the wrist joint center as possible.

LFIN	Left fingers	Actually placed on the dorsum of the hand just below the head of the second metacarpal
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Lower Body

Pelvis

LASI	Left ASIS	Place directly over the left anterior superior iliac spine
RASI	Right ASIS	Place directly over the right anterior superior iliac spine

The above markers may need to be placed medially to the ASIS to get the marker to the correct position due to the curvature of the abdomen. In some patients, especially those who are obese, the markers either cannot be placed exactly anterior to the ASIS, or are invisible in this position to cameras. In these cases, move each marker laterally by an equal amount, along the ASIS-ASIS axis. The true inter-ASIS distance must then be recorded and entered on the subject parameters form. These markers, together with the sacral marker or LPSI and RPSI markers, define the pelvic axes.

LPSI	Left PSIS	Place directly over the left posterior superior iliac spine
RPSI	Right PSIS	Place directly over the right posterior superior iliac spine

LPSI and RPSI markers are placed on the slight bony prominences that can be felt immediately below the dimples (sacroiliac joints), at the point where the spine joins the pelvis.

SACR	Sacral wand marker	Place on the skin mid-way between the posterior superior iliac spines (PSIS). An alternative to LPSI and RPSI.
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SACR may be used as an alternative to the LPSI and RPSI markers to overcome the problem of losing visibility of the sacral marker (if this occurs), the standard marker kit contains a base plate and selection of short “sticks” or “wands” to allow the marker to be extended away from the body, if necessary. In this case, it must be positioned to lie in the plane formed by the ASIS and PSIS points.

LILC	Left iliac crest	Place on the mid-superior aspect of the left iliac crest
RILC	Right iliac crest	Place on the mid-superior aspect of the right iliac crest

Use **LILC and RILC as alternative to the above-mentioned pelvic markers**. These markers require right and left hip markers to fully define the pelvis.

Leg Markers

LKNE	Left knee	Place on the lateral epicondyle of the left knee
LMKN	Left medial knee	Place on the medial epicondyle of the left knee

To locate the “precise” point for the knee marker placement, passively flex and extend the knee a little while watching the skin surface on the lateral aspect of the knee joint. Identify where knee joint axis passes through the lateral side of the knee by finding the lateral skin surface that comes closest to remaining fixed in the thigh. This landmark should also be the point about which the lower leg appears to rotate. Mark this point with a pen. With an adult patient standing, this pen mark should be about 1.5 cm above the joint line, mid-way between the front and back of the joint. Attach the marker at this point.

LTHI	Left thigh	Place the marker over the lower lateral 1/3 rd surface of the thigh, just below the swing of the hand, although the height is not critical.
LHIP	Left hip	Superior aspect of greater trochanter

The thigh markers are used to calculate the knee flexion axis location and orientation. Place the marker over the lower lateral 1/3rd surface of the thigh, just below the swing of the hand, although the height is not critical. The anteroposterior placement of the marker is critical for correct alignment of the knee flexion axis. Try to keep the thigh marker off the belly of the muscle, but place the thigh marker at least two marker diameters proximal of the knee marker. Adjust the position of the marker so that it is aligned in the plane that contains the hip and knee joint centers and the knee flexion/extension axis. There is also another method that uses a mirror to align this marker, allowing the operator to better judge the positioning.

LLAN	Left ankle	Place on the lateral malleolus along an imaginary line that passes through the transmalleolar axis
LMAN	Left medial ankle	Place on the medial malleolus
LTIB	Left tibial wand marker	Similar to the thigh markers, these are placed over the lower 1/3 rd of the shank to determine the alignment of the ankle flexion axis

The tibial marker should lie in the plane that contains the knee and ankle joint centers and the ankle flexion/extension axis. In a normal subject the ankle joint axis, between the medial and lateral malleoli, is externally rotated by between 5 and 15 degrees with respect to the knee flexion axis. The placements of the shank markers should reflect this.

Foot Markers

LTOE	Left toe	Place over the second metatarsal head, on the mid-foot side of the equinus break between forefoot and mid-foot
LHEE	Left heel	Place on the calcaneus at the same height above the plantar surface of the foot as the toe marker
LHAL	Left hallux	Anterior surface of left hallux (big toe)
LMT1	Left metatarsal 1	Medial aspect of head of left metatarsal one
LMT5	Left metatarsal 5	Lateral aspect of head of left metatarsal five

Extra Markers

Wand1, ... Wand4	Wand/Davis wand	Wand markers (Davis distal, proximal, far lateral, near lateral)
Bat1, Bat 2, BatR, BatL	Bat markers	Bat/racquet/stick handle, middle, right or left end
Ball	Ball marker	Ball/puck/point marker

Appendix B

Command Summary

1. **System | System Configuration...** then select the appropriate *.car* file.
2. **System | Start Link** to connect with cameras and analog system and set camera frame rate (e.g., 200 fps).
3. **System | Analog Setup** to set sampling rate of analog system (e.g., 200 Hz, 2000 Hz) and add/subtract additional analog channels (e.g., EMG channels, accelerometers, etc.).
4. **System | Force Plates Setup for System...** to modify force platform parameters and corners.
5. **System | Calibrate Analog Zero Levels for System...** to set zero levels of force platforms and other analog signals. Reset the force platforms and check the appropriate boxes before pressing *Calibrate*.
6. **File | Open Database** to open the *Gaitlab* or other database.
7. Open *Eclipse* (🔍) and then open an existing project or create a new *Project Name* (📁) and associated subdirectory. Next, create new *Subject* (👤) and *Session* (📅) folders.
8. **System | Calibrate Cameras...** if the cameras were moved or need recalibration.
9. Press the *Trial* icon (🎯) to collect one or more static trials.
10. Before proceeding to the dynamic trials check that the all markers are visible in the static trial. You can now save the autolabelling data (**Trial | Create Autolabel Calibration**).
11. Press the *Trial* icon (🎯) to collect dynamic trials. Check appropriate data *Types* (e.g., Video, Movie, Analog) and *Pipeline* items (e.g., Reconstruction, Labelling, Save Data, Next Trial).
12. After trials have been collected select trials from the database, complete reconstruction, then mark the start and end of the data with the upper markers in the 3D window. Then crop the data with the **File | Crop to Save Range** item.
13. Use **Trial | Options...** to select the autolabelling trial then press **Trial | Autolabel** to start the autolabelling procedure.
14. **Edit | Defragment Trajectories** to join marker trajectories.
15. **Edit | Fill All Gaps** to fill gaps in trajectories. For large gaps you may use *BodyBuilder* to fill the gap. After using *BodyBuilder* you may need to reattach the marker set with **Trial | Attach Marker Set...**
16. **Edit | Erase Unlabelled Trajectories** to remove any unlabelled trajectories.
17. Lastly use **File | Save** to save the data.