Marker-Based Motion Capture Overview (Under Construction)

Marker-based motion capture systems can be split into passive and active systems.

Passive marker-based systems generally use retroreflective markers placed on the body in accordance with a particular marker set. Cameras are set up to record the near infrared light reflected by these markers and estimate the 3-dimensional position of these markers throughout the movement. A model, essentially a mapping from markers to the skeleton, providing these marker positions with biomechanical meaning is defined by the user and this model is applied to the recorded 3D marker positions during dynamic movements of interest to produce pose estimates.

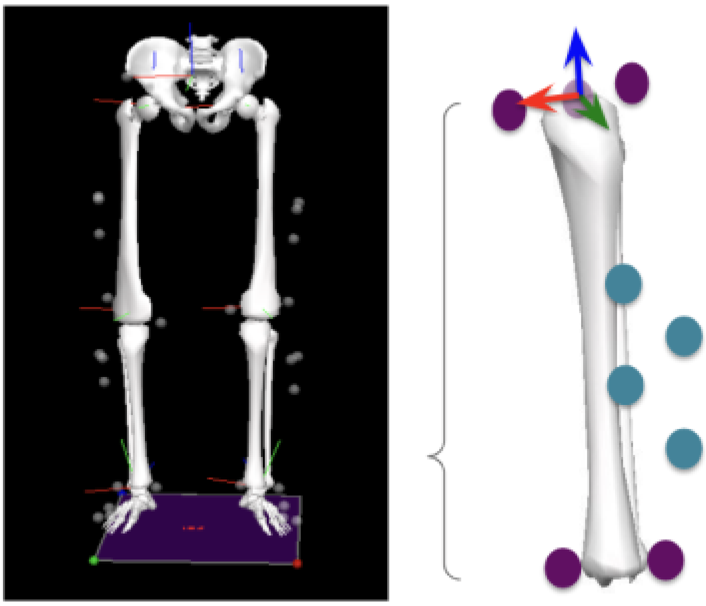
Active marker-based systems generally use markers that emit light, which are placed on the body. Cameras record the light emitted by these markers and estimate their 3-dimensional position throughout the movement.

Marker Sets

Before data collection using marker-based motion capture, you should decide on the appropriate Marker Set for your research question. See the Marker Set Guidelines and read more on the specific considerations of Marker Placement.

In general, the marker set will comprise of:

- Anatomical / calibration markers: used to define the segment (purple)
- Tracking markers: used to track the segment's motion (blue)



// Fig. 1. Visual of anatomical and tracking markers on a left tibia. The segment coordinate system is defined at the proximal end of the segment //

Marker sets commonly fall into three families:

1. Plug-in Gait (Plug-in Gait Original Marker Set, Plug-in Gait Clavicle Marker Set, Plug-in Gait Lower Limb)
2. IOR Gait (IOR Gait Overview)
3. OptiTrack (OptiTrack Biomech 57 Marker Set)

Data Collection

A static trial of the subject is required to define the segment coordinate system and build the model. The position of the subject will depend on the marker set you selected and the activity you want to look at. Subsequent Dynamic Trials should contain the movement of interest to be analyzed.

Model Building

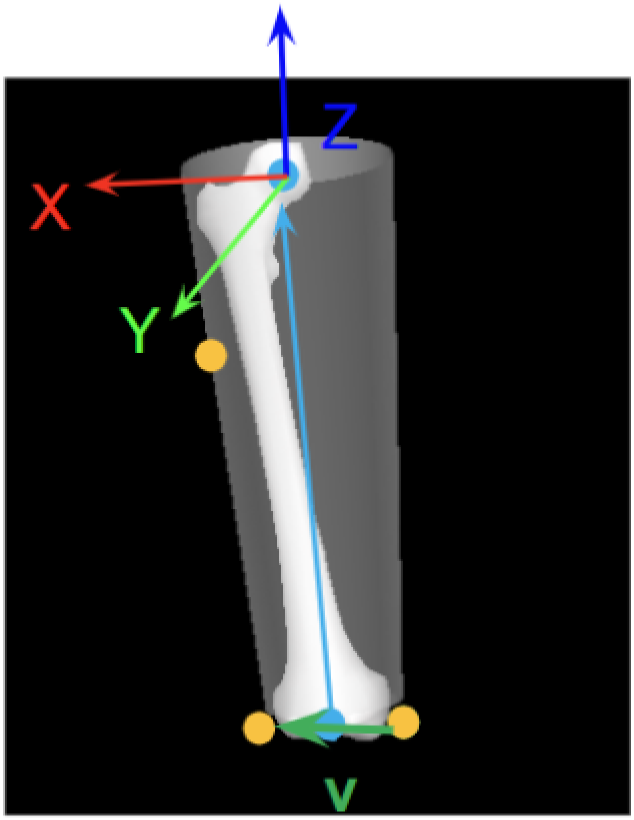
Why Define a Model?

The raw marker data - stored as TARGET Data in Visual3D - is used to define the rigid body segment it is attached to, and those body segments are tracked in the dynamic trials in order to extract biomechanical information from the body. Visual3D uses a least squares fit to solve for the position and orientation (pose) of the segment coordinate system with respect to the lab. But first, we must use the marker data to define the segments.

Segments

Segments are defined using 3 or more noncolinear markers attached to a rigid body. The longitudinal axis of the segment (default Z) runs from the distal to proximal end. The frontal plane is defined by 3 or 4 targets / landmarks (default XY plane). The segment ends are described by targets or landmarks. Due to the Right Hand Rule, the segment coordinate systems are not mirrored for right and left sides of the body. The segment coordinate system is always defined at the proximal end of the segment.

See the 4 methods to define a segment on the Segment Coordinate System page. See the Segment Overview for more information.



// Fig. 2: Right thigh segment in Visual3D. The Z-axis runs from the distal end (knee joint) to the proximal end (hip joint). Vector V (green) is defined from the medial to lateral knee markers, which, when crossed with the light blue vector going from the knee joint center to the hip joint center, creates the frontal plane. The Y-axis comes out from the frontal plane of the segment, and the X-axis runs along the frontal plane according to the right hand rule. //

Note that segment names must have a right or left side to resolve a singularity issue during subject calibration. By default, segments are 'right sided“ unless they start with the letter “L”. E.g., RPV is 'right pelvis', despite there only being one pelvis segment. Check out the Segment Default Names.

Landmarks

Sometimes we want to track or define locations of the body where we cannot place a marker, such as a knee joint center. Landmarks are like virtual markers, whose positions are computed automatically by Visual3D based on the positions of actual markers or segments. They can be used for: calibrating segments, tracking segments, etc. Check out the Creating Landmarks Tutorial.

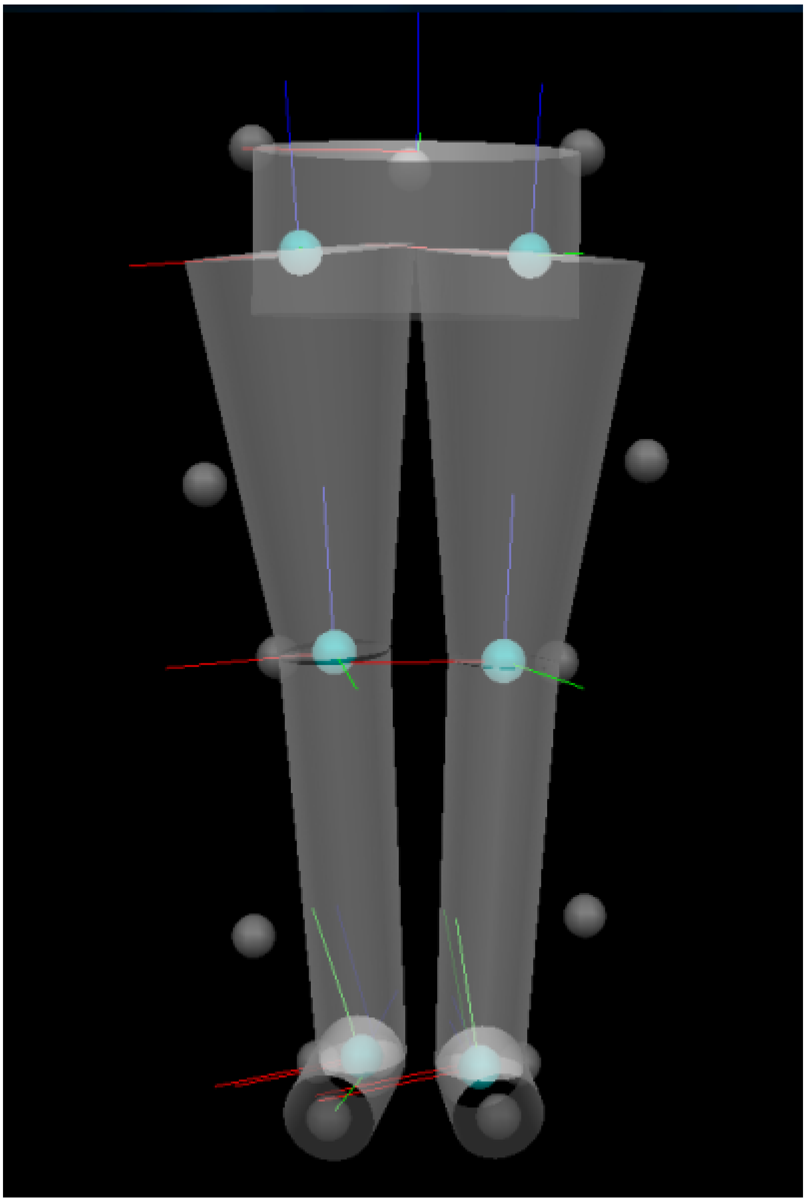


Fig. 3: The segments are represented by the grey volumes. Target markers shown in grey, and landmarks in teal.

For more guidance on model building, see the Model Building Playlist on the HasMotion youtube or check out the Modeling FAQ.

Pose

There are two ways to find the pose of your model:

The 6 DOF Model / Segment Optimization

This method of pose estimation tracks each segment independently. Here, we use 3 translational (X, Y, Z) and 3 rotational (qx, qy, qz) components to describe the rigid body (6 DOF) relative to the global coordinate system. One marker defines 3 DOF (X, Y, Z), the second marker adds two more DOF (qx, qy), and the third (non-colinear) marker adds 1 more DOF (qz). A fourth marker adds no additional information (the system is overdetermined). Learn about the 6 Degrees of Freedom pose estimation, or complete the Building a 6 DOF Model Tutorial.

IK Model

Inverse Kinematics (IK) offers an alternative approach to pose estimation from the 6 DOF. The IK method is also referred to as Global Optimization, since segment positions and orientations are solved in order to minimize a global loss function while respecting certain joint constraints. Learn about the theory of Inverse Kinematics, then check out the IK Model Building Tutorial.

What Next?

To visualize your motion data, check out the Visualizing Data tutorial.