MOTION ANALYSIS

THE ULTIMATE BUYER'S GUIDE FOR PURCHASING MOTION CAPTURE SOFTWARE

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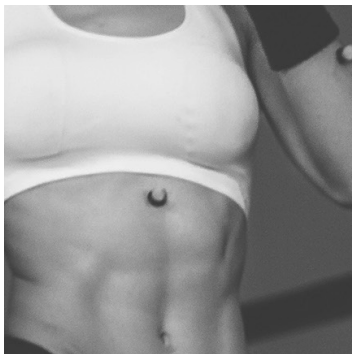
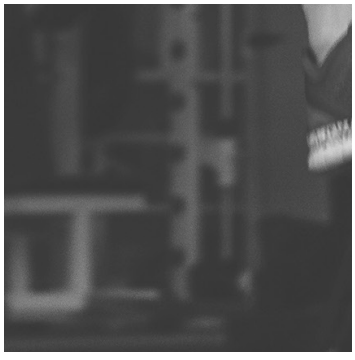
ABOUT THIS GUIDE





An increased adoption of 3D motion capture systems in the biomechanics, animation, and gaming industries is creating high demand, with the market expected to grow to USD 266 million by 2025. To satisfy this demand, motion capture developers are constantly innovating new systems and software to ensure buyers can get the best system to suit their needs. But, with so many options on the table, the process of choosing the right systems and software might be overwhelming.

If you're a researcher or a biomechanist, we've created this informative Buyer's Guide to help you when it comes to purchasing a motion tracking system.

In this guide, you'll:

- Gain a clearer understanding of what motion capture is, the common applications of it in biomechanics, and the challenges you might face when choosing the right system for your needs.
- Get an overview of the various system types and learn the difference between optical, non-optical, passive, and active systems.
- Be guided on how to select the right software, including what questions you should be asking and the top features you should be looking for.

Many of our findings are based on a survey undertaken with biomechanists who shared invaluable information about the buying process they've experienced, and hopefully their journey with motion capture tech can help you make the right buying decisions in the future.

WHAT IS MOTION CAPTURE?

Motion capture is what takes place when special software and hardware is used to record total body or object motion in three dimensions. Actions of the subject are tracked using a number of different technologies – in various combinations of active markers, passive markers, cameras, and sensors, with associated software programs - and the recorded or streamed data is used to animate the motion into a digital character or to analyze certain movements for research or clinical assessment.

MOTION CAPTURE AND BIOMECHANICS

Motion capture's connection to biomechanics dates back to the 1870s, where it was used as a photogrammetric analysis tool. In the late 20th century, digital technology expanded its use in sport and training analysis, and then computer, film, and video game animation. Some of the most common biomechanical applications of motion capture include:

- Gait analysis
- Human biomechanics rehabilitation
- Human biomechanics sports performance
- Robotics/humanoids
- Animal biomechanics
- Object tracking
- Virtual immersive environments

THE CHALLENGE WHEN IT COMES TO BUYING A NEW MOCAP SYSTEM

More than 60% of the biomechanists we surveyed have been using the same system for over 5 years but at least one third of them are wanting to change systems in the future. However, when it comes to buying a system, it's not a one-size-fits-all kind of process.

> ***More than 60%*** ***of biomechanists surveyed have used the same system for over 5 years but at least one third of them are wanting to change systems in the future***

Even within the field of 3D motion capture for biomechanics, there is a broad range of requirements. A simple clinical balance study may need minimal tracking devices but need kinetic data from force plates, whereas high-level gait analysis, with enhanced foot modeling, may need a hundred or more markers and simultaneous force plates, EMG and video vector overlays. Sports analysis could range from a single joint's angle measurement to an entire team of players, each with full body kinematics covering an entire sports field.

And although both optical and non-optical systems are designed to capture motion, the setup time, cost, and quality of the system needed is all dependent on the application it's going to be used for. Some entry level systems may work well for certain tests, but not be easily expandable. On the other hand, high-end systems can cover the full range of applications if cost is no barrier. This is why it's so important to be able to answer the "what's, why's and how's" of finding the perfect system for your needs before you make any buying decisions.

QUESTIONS TO ANSWER BEFORE YOU TALK TO VENDORS:

- [ ] **How would you summarize the application you need the system for?**
- [ ] **What is your goal with usage of this system? In detail, what items do you want to be able to observe, measure, and/or quantify?**
- [ ] **How many subjects do you need to record at any given time?**
- [ ] **What are the approximate capture volume dimensions?**
- [ ] **What is your preferred marker size, if you have one?**
- [ ] **Are you wanting a fixed setup (wall mounted or c-clamped to rail system) or mobile setup (tripods)?**
- [ ] **Are you in the pre-planning budgetary phase? Or do you already know how much you can afford to spend?**

Once you've got all your answers prepared, it's time to work out which system type is best suited to your needs.

CHOOSING BETWEEN OPTICAL VERSUS NON-OPTICAL SYSTEMS

TYPE OF SYSTEM	DESCRIPTION	MAIN COMPONENTS
Optical - passive markers	• Uses retroreflective markers and camera parameters to be altered so that only the markers are sampled, instead of skin and fabric or reflections and daylight. • System requires an absolute minimum of 2 cameras, although modern systems tend to start around 6-8 and typically have 12-24 for general use or 24-48 for greater flexibility. In high end labs/arenas, 100-150 or more is possible. • Subject does not need to wear wires or electronic equipment. • Hundreds of markers, either attached directly to the skin with hypoallergenic tape or to tight fitting suits (it's the markers that are important; the suit is just a way of holding them close to the skin). • Almost unlimited number of markers (100s or 1000s). • Tracking devices typically run at 100/120 to 200/250 frames per second.	• High-quality motion capture specific cameras • Spherical, retroreflective markers from 0.1mm to 50mm (typical) • Optionally flat disc or hemispherical for specialist applications • Rigid for ultimate centroid calculation • Deformable for comfort or impact sports • Calibration wand • Software
Optical - active markers	• Markers are powered to emit their own light instead of reflecting light. • Usually LED markers need power from a rechargeable battery and may need to be connected by wires. • Some systems need radio transmitters for synchronization. The better ones don't need this complication and are powered by a portable charger that the subject carries with them.	• High-quality cameras or other tracking devices • Markers • Portable power source transmitter for synchronization • Calibration wand • Software

Optical - markerless	• No special equipment is worn for tracking, but baggy, loose clothing needs to be avoided. May be sensitive to background colors, objects, and movement. • Special computer algorithms are used to identify movement and analyze data.	• High-quality cameras • Computers • Software
Non-optical-inertial	• Uses miniature inertial sensors, biomechanical models, and sensor fusion algorithms. • Data is captured by gyroscopes and accelerometers and then sent to the computer software to form a skeleton.	• Accelerometers • Transmitter cables • Software

More than half of the respondents in our survey use motion capture for human biomechanics in the form of gait analysis, sports performance, and rehabilitation, making precision and reproducibility crucial for detecting high-speed and subtle movements as accurately as possible.

> ***Over 50%*** ***of respondents surveyed use motion capture for human biomechanics***

Optical motion capture has the ability to pick up the slightest movement, because the position of each marker can be captured, and is reported in a known global reference frame. Whereas non-optical inertial motion capture cannot provide absolute positioning, due to the mathematical limitations of integration and therefore cannot guarantee positional accuracy even if they make some allowance for this "drift".

For animation, inertial systems were once the way to go as they were more affordable than optical, but if you're working in biomechanics, fidelity of data is key and should be one of the top features you look for in a system.

Speaking of features, in our survey, over 80% of respondents use their system's post-process analysis mode, and having auto-labeled marker data is a very beneficial feature they like in the system they purchase. But for the 20% of our respondents who use real-time streaming mode, by far the most important software feature to consider is real-time labeled marker data.

REAL-TIME STREAMING MODE AND POST-PROCESS ANALYSIS MODE

Many biomechanists record data and then look at it afterwards. This may include further biomechanical modeling; picking out events for time-normalizing over recurring cycles to compare to other subjects; or exporting in a selection of formats to analyze in other software packages, such as Matlab or Labview.

But some need the data to be generated instantly, in real time. If the application is tracking robots or drones to confirm they are moving as their algorithm intended, it may be a simple marker or rigid body (position, pitch, yaw, and roll) that is needed, while other users may be giving instant feedback for a rehabilitation patient. In all these disparate real-time experiments, there are a few factors you should consider:

- **The frame rate.** Closed-loop feedback for a fast-moving robot may need high speed, and humans can't visualize or process information this fast, so you can save on camera and computing costs.

- **Latency.** This is the delay between the action taken and the system's response to that action. For a motion capture system, this is typically measured from triggering the recording of an image frame in all the synchronized cameras, to data from that frame being presented to an ethernet network interface card (NIC), ready to be passed on. It includes the time to get the image from the sensors, calculating 2D centroids, reconstructing 3D coordinates, labeling the markers and optionally calculating 6DoF of one or more segments.

- **Calculation and graphics rendering.** When considering the required latency and frame rate for your application, it is worth considering the modeling and display capacity. Nowadays, vector algebra for segmental modeling requires very little computing power and therefore will only be significant if there are multiple subjects. But, if the feedback method requires highly detailed animation, then that step is likely to demand the greatest processor power. Ask the vendor about distributed computing - whether modeling, analysis, and rendering tasks can be easily sent to different computers so they can be undertaken in parallel.

- **Data cleanup.** In post-process analysis there are many methods for filling gaps, either by interpolation or rigid-body subset back calculation. Ask your vendor which of these methods can be used in real-time and how easy they are to instigate.

- **Time normalization/cyclical display.** For example, you may be doing treadmill running analysis and want to train your subject to attain a certain maximum or minimum joint ankle at a specific event. Many of the tools used in post-process should be able to also be applied in real time. Ask your vendor if all the built in graphing functions are available in Post-Process and Live Mode.

- **Data Streaming Formats**: Questions to ask include:
  - What data streaming formats are supplied?
  - Is there a software developer's kit and plug-ins?
  - Is it restricted to certain operating systems?

> **80%** *of respondents use post-process analysis mode*

Depending on which group you're a part of, here are the top features to look out for, as ranked by our survey respondents, according to whether they use real-time streaming mode or post-process analysis mode.

REAL-TIME STREAMING PRIORITY FEATURES

1	**Real-time labeled marker data**
2	**Streaming to third-party software**
3	**Real-time 2D viewing**
4	**Real-time segment data kinematic**

POST-PROCESS ANALYSIS PRIORITY FEATURES

1	**Export data to third-party software**
2	**Auto-labeled marker data**
3	**Real-time force plate and/or analogue data**
4	**Calculated segment data**

MARKER PLACEMENT AND ANATOMICAL MODELING

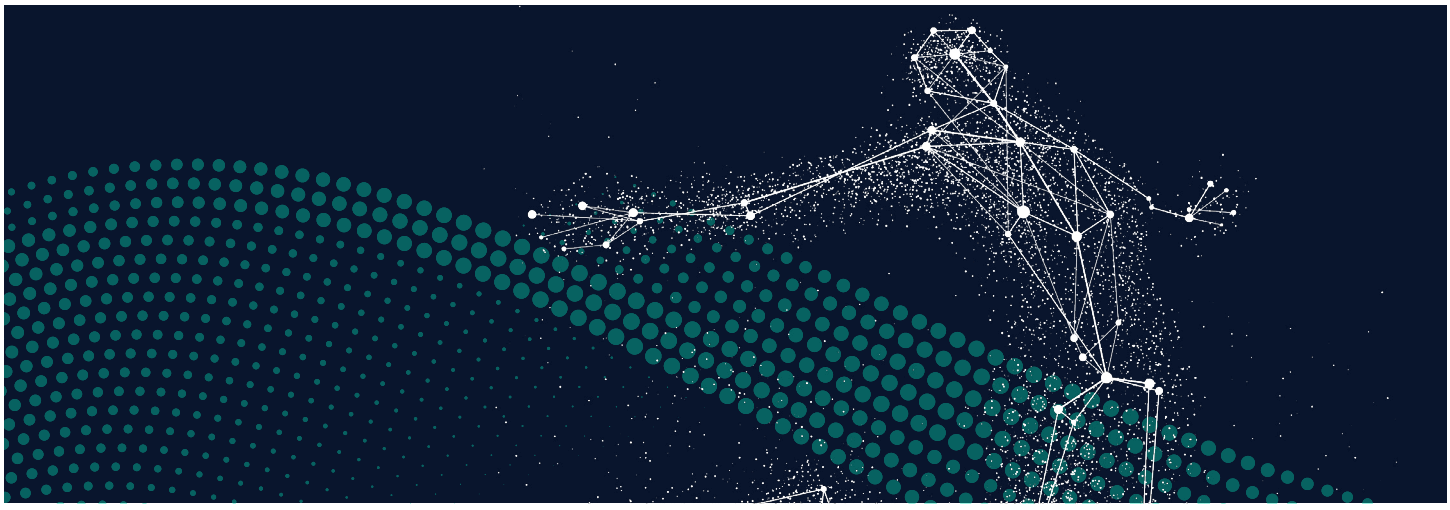
Following on from the report highlighting the desire for auto-labeled markers, either in recorded data or streaming, there are various considerations around how readily this can be achieved and how well the process is integrated with clean up and modeling. Here are the questions you should be asking to the vendors:

Marker sets:

- Does the vendor supply industry-standard samples?
- How easy is it to create new marker sets from scratch?
  [Do you use a simple graphical user interface (GUI) or do you need to deal with separate text files? Simple things like the choice of multiple colors can make using the system so much easier.]
- How easy is it to go from a newly created marker set to a "golden" template that will recognize and label any subject with that marker set?
- For those awkward captures, when the data is not perfect, do you have a full suite of easy-to-use clean up tools?
- Can some of those tools, such as pseudo-rigid subsets, be implemented in real-time streaming?

Segmental modeling:

- Are there samples that match accepted protocols (for example, the ISB Shoulder model)?
- Is there a simple GUI to click-and-create segments based on rigorous vector algebra or will I need to learn to code?
- Can these tools be used in real-time streaming as well as offline?



SUMMARY OF THE STEPS FOR SELECTING A SYSTEM

STEP 1:

Determine what your objectives are for motion capture and what type of system is required in order to achieve this.

STEP 2:

Understand what you need your mocap software to do.

STEP 3:

Analyze the top features you would need in a system.

STEP 4:

Reach out to a sales team for support in choosing the right system.

MOTION ANALYSIS

Learn more about our powerful Cortex software

Motion Analysis is a global leader in motion capture technology. Our systems are used by some of the most famous animators, researchers, and engineers in the world.

Cortex, our highest quality and most powerful software yet, offers the most complete set of visualization tools for constructing precise calibration. The software includes embedded modules for licensed users which offer an intuitive interface for a variety of applications, such as skeleton creation, model creation for monitoring movements and kinetics, and camera calibration.

Our motion capture cameras offer compact design, high accuracy, and robust performance. Our camera models are all "plug and play," field upgradeable, and compatible with our other cameras.

Interested in finding out more about the solutions Motion Analysis offers?

To learn more about Cortex and our camera hardware, visit:
https://www.motionanalysis.com/industries/movement-analysis/

For help building your own mocap system, visit:
https://www.motionanalysis.com/request-a-demo/

Book a demo with one of our customer support staff today and find the best system for your needs.

BOOK A DEMO