

Maximizing Your Investment With Motion Capture Equipment

By Fritz Garrison

The birth of animation in every budding six-year-old cinematographer usually begins with a stick figure drawn on a note pad or the margins of a schoolbook. Flipping the pages with a controlled release is all that's needed to set the figure in motion as the pages fall in place.

Reduced to its simplest form, the animation of virtually any creature or inanimate object, for that matter, is an assemblage of stick figures who've been endowed with a bit



Imagine a cast of hundreds of soldiers and alien creatures, all running or flying around at the same time. The best way to get the 3D characters of Roughnecks: Starship Troopers to interact in this setting would be by using motion capture. Foundation Imaging uses MotionStar trackers to set these characters in motion and significantly reduce their production time. © 1999 Adelaide Productions, Inc.

of flesh (or perhaps steel) and costumed. Motion capture technology now endows those stick figures with human movement and a three-dimensional presence.

The heart of motion capture is driven by live-action performers outfitted with an array of sensors or markers that allow every motion to be tracked and recorded.

Combining the natural, fluid motions of people with the immense power of the

computer, animations are rendered in real time. Still in its adolescence, motion capture has already outgrown its need for huge computers, confidently requiring no more than an NT workstation. Magnetic systems have shed their tethers, and animation software such as FILMBOX puts versatile tools and filters right at the animator's fingertips.

By linking the best features of human performers and computers, motion capture is also capable of producing extraordinary dollar savings in animation costs.

According to one industry estimate, it costs \$10,000 a minute for traditional animation. A single 30-second commercial often takes eight weeks to produce with half the time

spent getting the animation right. At Lamb & Company in Minneapolis, where Ascension Technology's motion capture trackers have been used in several commercials, animation time was reduced so significantly that it was no longer a cost-driven concern. Said Larry Lamb, "Animation can be done in hours instead of weeks." Medialab also reduced their broadcast animation costs to as little as \$500 a minute with magnetic motion capture. For the popular television show *Roughnecks: Starship Troopers Chronicles*, Foundation Imaging captures in excess of 75 scenes per day. And for *The Dog and Dinosaur Show*, Protozoa produced 13 episodes requiring 15 minutes of animation per episode in two weeks. Time is money and motion capture saves time exponentially. It doesn't get more bottom line than that.

The Technologies

Within the realm of motion tracking, several distinct technologies are currently available, including optical, magnetic, inertial, and laser. Optical and magnetic dominate the motion capture animation field. Until now, however, optical and magnetic have come pre-loaded with a set of pros and cons.



Motion capture animation isn't just for people and animal characters. The performer wearing the MotionStar tracker uses his body to animate Jay Jay the Jet Plane for Discovery's Learning Channel, © 2000. Courtesy: Modern Cartoons

Optical sensors make use of reflective markers placed on strategic locations of the performer's body. Each marker is tracked by an array of high-resolution digital cameras that encircle the stage. The performer is thus free to move unencumbered by cables or harnesses typically associated with magnetic trackers. As the performer moves through the scene, the cameras record each reflector in a sequential scan at up to 240 times per second. Data is sent in a constant stream to the computer where it is post-processed to reconstruct a spatial rendering of the performer's location in space. Because of the relatively high number of frames per second captured by optical trackers, they are often used for faster-motions in high-end productions or are purchased from service bureaus.

But optical trackers have serious drawbacks, not the least of which is cost. With price tags for a fully outfitted optical tracking system in the range of \$200,000 and up, they're about five times the cost of a magnetic unit. Additionally, optical systems rely on a clear line-of-sight between at least one camera and each marker at all times. Significant amounts of motion data can be lost during a take when markers are blocked from view (occluded). The problem becomes more acute when two or more performers interact.



©2000 Ascension Technology Corporation,
Courtesy of Kaydara, Inc. "Plastic Man" is set in
motion in real-time by the movements of a
performer wearing Ascension's CyberSuit.

Adding more cameras helps alleviate this problem, but it further drives up cost and system complexity.

Perhaps the greatest disadvantage of most optical systems is the inability to display even rough data in real time. In fact, it usually takes the computer several minutes just to crunch all the numbers for localizing the performer in space. Motion Analysis and Vicon have introduced optical systems with real-time capability, but they still face the same cost and occlusion challenges. Game developers in particular are finding the occlusion problems make even real-time optical tracking of dancing figures, kick boxers, and other interactive performers impractical.

It's that Magnetism

Unlike its optical cousin, a magnetic-based tracker captures motion on the performer. An array of sensors, placed on the body, measures a magnetic field emitted by a nearby transmitter. As each sensor detects the magnetic field, it sends back data to a base computer, which calculates accurate position and orientation information. Outputs are then transmitted via a high speed Ethernet interface to a host computer running animation software from Alias, Softimage, Kaydara, DreamTeam, 3D Studio Max, and the like.

AC vs DC

Magnetic motion trackers are divided into two camps: AC (alternating current) and DC (direct current). AC trackers are available from Polhemus Inc., under the trademark Star Trak. DC trackers are available from Ascension under the trademarks MotionStar and MotionStar Wireless. AC Trackers generally have trouble obtaining good measurements whenever metals, like steel or aluminum, are present. Even building materials like rebar in a concrete floor or ductwork can cause major interference. In such cases, the AC transmitter itself actually sets up eddy currents (invisible electronic whirlpools) in the metal objects that distort the sensor readings. Attempts to work around this electronic interference involves time-consuming calibration procedures, commonly referred to as mapping and compensation.

DC models, with their inherently more stable magnetic fields (they do not continuously generate eddy currents) are much less sensitive to interference from metal objects. Ten-fold reductions in sensitivity to conductive metals are typical. They also experience one-fifth the distortion from permeable metals—such as steel—seen in AC systems. These factors make DC trackers easy to set up and highly portable. DC trackers do not require mapping and compensation prior to use. Speed-wise, DC magnetic sensors are always processed in parallel to ensure fastest possible display of motions.

A Little History

Both AC and DC trackers were originally developed for tactical military aircraft. The concept takes advantage of a pilot's natural head-pointing abilities to acquire targets by looking at them through a reticle (similar to a rifle boresight) on his visor. Pointing angles are measured by tracking a single sensor mounted on the pilot's helmet. Once the line-of-sight angles to a target are acquired, these data are passed to a fire-control computer for weapons delivery with pinpoint accuracy.

AC magnetic technology was first developed in the 1970s. Its initial patents date back to that time. On more than one occasion, its incorporation into the military inventory has been shelved by metallic distortion problems. Even today, each aircraft must be mapped and compensated prior to using an AC tracker.

DC magnetic technology was developed and patented in the late 1980s to mitigate the metallic limitation of AC trackers. Because of its overall insensitivity, it can be used in most tactical aircraft and simulators without mapping and compensation.

The first application of sensors and real-time sensor feedback to computer animation occurred in 1990. Mr. Film Studios debuted the character Silver Suzy, a project conceived by Steve E. Tice and Chris Walker, with the first commercial real-time face and body tracking performance animation conceived, designed and developed by Tice and Mike Fusco, founders of SimGraphics Engineering Corporation. Silver Suzy was animated in real time with just two sensors, one controlling the 3D model and one controlling the virtual camera. It was an auspicious beginning.

With entertainment industry encouragement, DC technology, starting with Ascension's Flock of Birds tracker, rapidly matured to meet animation requirements. Today Ascension's MotionStar models can track over 80 points simultaneously, make up to 100 measurements per second, and operate over room-sized areas.

Cutting the Ties that Bind

One of the latest advances in motion capture has been the shedding of bulky cables formerly needed for data communications between the sensors and the base computer. Cables ran from each sensor, with often 12 or more affixed to a performer. So weighted and tethered were the performers that they often found it difficult



Basil Basset from the popular television show Macaroni, on Tele-Quebec, is created using a MotionStar motion tracker. © 1999 Publivision, Inc. Courtesy: Modern Cartoons for Distractoon Formats.

or impossible to make some extreme movements. Tethering also interfered with smooth interaction among multiple performers.

Both Polhemus and Ascension introduced wireless models at SIGGRAPH '96. Ascension's offered real-time tracking from the start, while the Polhemus unit, called StarTrak, initially required post processing to the host computer via a wire. Polhemus has recently introduced a real-time wireless unit, but it faces the same calibration challenges as their wired model.

The Ascension wireless tracker, called MotionStar Wireless, captures and displays data in real time. It consists of up to 20 sensors mounted at key points on the performer's body. Four performers can be tracked simultaneously. The sensors are attached via small cables to a miniaturized electronics unit powered by a lead-acid battery that lasts up to an hour and a half. The battery is mounted in a backpack worn by the performer. In addition to a strap and harness kit for mounting sensors on performers, Ascension has also developed a CyberSuit, a skin-tight nylon unitard with snap-in sensor holders and channeled tubing that holds and guides the sensor cables on the performer's body. During a motion capture session, sensor data, as well as signals from other body-mounted peripherals, such as data gloves, are sent through the air to a base station for final processing. Outputs are transmitted to the host computer via serial or Ethernet interface.

The wireless models retain the essential advantages of their wired predecessors (affordable cost and absence of visual occlusion) while gaining the freedom of movement formerly associated exclusively with optical trackers.

Optimizing Performance of Magnetic Trackers

Like virtually any new computer-based technology, there is a learning curve to navigate before realizing a payback on your motion-capture investment. Users are learning that putting motion capture to work is not simply a matter of opening a box, plugging in a

computer, and capturing motion. In fact, the nature of motion capture is a lot more like a symphony than a solo. In the early days of motion capture, the user had to coordinate the workings of several products and technologies including 3D modeling software, motion-tracking sensors or special cameras, computer hardware, and in some cases, elaborate stage considerations.

The good news is that motion capture has come of age. Not only is the learning curve being shortened through the outreach efforts of companies now better at coordinating



These three hosts of the French children's program, Tribal X, are able to jump, dance, skate and interact with each other because Ascension's MotionStar motion tracker allows for 6 degrees-of-freedom tracking without restrictions. © 2000. Courtesy: Antefilms/TF1, Paris

their products, but accessibility to motion capture is expanding as well. Ascension's turn-key system combines MotionStar or MotionStar Wireless trackers with an Intergraph ZX1 workstation and Kaydara FiLMBOX animation software. This integrated package gives small production houses, independent game developers, and animation start-ups access to motion capture at a cost far less than most motion tracking systems.

Installing Magnetic Trackers

The process of installing AC systems is fairly involved. As previously mentioned, the stage area must be mapped. This requires gathering hundreds of data points throughout the performance stage. These are then plugged into a correction algorithm that compensates for the metal distortion. In addition to the time and cost involved, the process must be repeated if the AC transmitter is moved (even an inch) or if a new source of metal is introduced to the stage.

Fortunately for those who use DC magnetic trackers, adhering to the list of do's and don'ts is more or less a one-time procedure. Most pitfalls can be avoided with proper

installation. Getting the most out of a DC magnetic motion capture system is not a difficult undertaking provided a few relatively common-sense guidelines are followed.

Most importantly, large metal objects must be kept away from the performance stage. Metal items such as desks, bookcases, and structural building supports should not be any closer than the maximum separation between the transmitter or sensors. Ideally, unnecessary metallic objects should be removed from the area entirely.

While wooden structure buildings make ideal studios for motion capture, a few simple steps can help provide excellent results within conventional steel and concrete structures as well. For example, construction of a wooden stage that gets the performer above a concrete floor containing steel-reinforcing mesh is a low-tech solution to a potentially vexing problem. Placing the transmitter(s) on a pedestal in the center of the stage (not on the floor or against a wall) likewise avoids a slew of potential problems.

If you settle on an Ascension (DC) motion tracker, a number of helpful support options become available. You receive a tech note entitled *What You Need to do Before Your MotionStar Tracker Arrives*. It briefs you on Ethernet cabling, animation software, attaching the sensors, mounting the transmitter, etc. It discusses what you should do to find a suitable location for your motion-capture stage. Included is a checklist to complete. Among other things, the note is designed to ensure you are operating in a suitable environment to optimize performance. On-site MotionStar installation assistance and free telephone support are available as needed. Free installation of a MotionStar Wireless is available throughout North America, with on-site Wireless installation available worldwide for just the cost of travel. Ascension also has a trouble-shooting guide on their web site.

Additionally, Ascension has developed a number of installation tools that help ensure optimal performance. These include an “environmental analyzer”. It enables technicians to install a MotionStar in the best possible location to minimize metallic interference and to change operational frequencies to avoid noise disturbances.

Motion-Capture Software

Once you get a magnetic-based tracker properly installed, you can get even more assistance from a growing group of third-party software providers. These software packages are designed to provide the easy integration of complimentary hardware and software products. (As mentioned, magnetic trackers are supported by all the major animation software packages, including those by Kaydara, DreamTeam, 3D Studio Max and more.)

Kaydara's FiLMBOX and DreamTeam Ltd.'s Typhoon are two examples of motion capture software tools designed to smooth out the wrinkles in animation software programs. They allow you to correct and manipulate the data generated from magnetic or optical motion trackers. Sophisticated filtering algorithms let you remove the jitters to smooth out motion while keeping original data intact. Virtual sets, camera tracking, phoneme recognition, and other feature options are integrated through supporting plug-ins to enhance the end product.



The Pillsbury Doughboy – © The Pillsbury Company. Image courtesy of Windlight Studios. Windlight used MotionStar for animating the Pillsbury Doughboy in their latest TV ad campaign.

Lamb & Company provides Motion Viewer—another comprehensive system for capturing, viewing, key framing, and exporting motion capture data. The program includes functions such as automatically filling in missing data points that might have been lost during the capture process. An integral set of tools helps cut post-production time with features like the facial animator editor for lip-synching.

And beyond motion-capture software? You can outsource your entire project to groups like Modern Cartoons, Spectrum Studios, Foundation Imaging, Dotcomix, or Antefilms. In France, the current popular *Tribal X* television show stars three young virtual hosts. The show runs on TF1 and is produced entirely in-house by Antefilms, requiring three days of motion capture shooting per show. *Tribal X* relies on animation generated by MotionStar, Alias' Maya software add-ins, Kaydara FiLMBOX, and some of Antefilms' own software.

If you are not ready to jump into the technology with both feet, it is comforting to know there are companies that will provide not only the motion capture hardware and expertise, but also the creative artistry to develop characters from scratch and bring them to life using their own proprietary animation software.



3D model, animation and production by Protozoa, Inc., Copyright BBC Choice, 2000. Dinosaur is one half of The Dog and Dinosaur Show's television team hosting the popular children's show in Great Britain.

Faster, Cheaper, Truer to Life

Given the benefits of motion capture, it is not surprising to note the existence of a large and growing list of animators taking advantage of it. The credit roll for Ascension magnetic trackers is by far the largest and attests to the reliable performance of its products. In addition to credits noted elsewhere in this paper, prominent mention goes to the following: Sorceron for the New York Knicks TeckNick promotional character; R/Greenberg's award-winning Dancing Cars & Pumps commercials for Shell Oil; Modern Cartoons/Mr. Film for *Jay Jay the Jet Plane*, *Macaroni*, and *Top Cat* television shows; Foundation Imaging for special effects in the *Star Trek: Voyager* series; Dream Team for Shoni on the talk show *Yehiyeh Tov*; and Windlight for the Pillsbury Doughboy and Mattel's Barbie commercials.

On projects that lend themselves to motion capture, animators are reaping a significant competitive advantage. Yet despite the benefits, motion capture is not about to deep-six keyframing and 3D animation. Leading animators worldwide are reaching consensus that a combination of techniques often works best.

Capturing live-action human motions with magnetic trackers has a number of distinct advantages over reliance on key-framing alone. First and foremost, motion capture is

eminently faster and thus less expensive. According to Modern Cartoons' Chris Walker, magnetic motion capture is an unbelievable timesaver that lets you edit results before finishing a scene. With instant feedback on how a sequence will look, a director can order modification or retakes on the spot. "If your goal is a high quality character who moves like a human—not a robot—then you need to use motion capture," says Walker.

By capturing human motion, it's not uncommon to process 30-60 minutes of animation in a single day, which, as we have seen, can easily represent a savings of several weeks over working from scratch with conventional techniques. Extra time that would otherwise have been spent keyframing can now go to fine-tuning characters, enhancing sets, or working on the next project. At Modern Cartoons (Mr. Film), 100% of the background shots are done with motion capture. "With half the job done so economically," says Walker, "we can then focus resources creating special effects for foreground shots." The result again is earlier delivery dates well within or below budget.

Perhaps the culmination of the current use of motion capture is performance animation. Here, real actors on camera perform with animated characters generated in real-time. Live dialogue and interactive motion take place between the actor and the virtual co-star. For the 1999 Super Bowl, Medialab and actor Harry Shearer created a virtual version of talk show host Larry King. During the game, he appeared on the stadium jumbo screen interviewing celebrities and athletes. DreamTeam Ltd. has created Franky (a.k.a. Luigi), a game show host, who interacts with the crowd at conventions and shows. Another DreamTeam star was the three-inch tall sports commentator, Ponchito, who became an instant hit during the 1998 World Cup when he covered the games for Mexico's TV Azteca.

Courtesy of New York Knicks, with permission from Sorcerer. TecNick, seen here with motion capture performer creating his movements, is used by the Knicks basketball team in promotional materials and video displays.



Tracking the Future

Perhaps motion capture's greatest advantage lies in its sense of immediacy. With traditional animation, it is not uncommon for months to pass before seeing a rough animation. Motion capture lets us watch the motions as they happen, says Dotcomix's Ann Brilz, who initially produced the Moxie Pirate Show for the Cartoon Network. At Nelvana/Windlight where the Pillsbury Doughboy and Mattel Barbie commercials were animated, there is a solid commitment to magnetic motion capture. "We are strong believers in live interaction," says Scott Dyer. "It lets clients, directors, and performer put



Dancing Sports Car. Courtesy: Ogilvy & Mather's Shell Ad Campaign. To make sporty red cars dance with Shell Gas Pumps, R/Greenberg Associates turned to MotionStar for motion capture. The result: a series of award-winning TV commercials.

their heads together to get the best result in one session." Walker agrees: "No other art form allows you to see things as they are being done. If it accomplishes nothing else, it is an incredible preview device."

Having seen what motion capture can do for a variety of projects, most animators are coming to the conclusion that the technique is an important complement to other forms of animation. And in the right hands, motion capture is an animation art form unto itself. Modern Cartoon's Walker and Dotcomix's Mike Morasky both anticipate productions that are conceived on the capabilities of motion capture itself.

The immediate future of motion capture is the migration to the NT operating system. Next is the PC platform. Who knows, someday our budding cinematographer may be animating characters on a home PC just as he or she once did on notebook pads. Stay tuned.

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This article is an updated version of Mr. Garrison's paper.

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