

Inertial Sensors Go Hollywood

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MEMS-based accelerometers and gyroscopes bring Marvel Studios' Iron Man to life.

A At the end of *Iron Man 2*, when the heroes and villains are flying, flipping, punching and rolling about in a Japanese garden, the real stars aren't the actors. They're a bunch of matchbox-sized sensor packs sewn into the lining of the so-called "mo-cap" suits, which enable stunt people to perform physical feats that ... well, even stunt people can't do.



The technology that allows actors to fly off tall buildings or run through walls has been available for several years, of course, but these new sensor-laden suits are taking moviemaking to new heights.

“With this technology, you can exaggerate everything,” says Harvey Weinberg, group leader of applications engi-

neering for Analog Devices Inc., maker of the sensors. “You can have an actor jump off a three-foot platform and with a motion-capture suit and computer graphics, the platform becomes a 10-story building.”

Actually, it does that and much more. The new breed of sensors and suits is transforming the process of “previsualization” (or “pre-vis,” as it’s known in Hollywood lingo). Instead of artist-rendered storyboards or black suits with luminous markers, directors can now use gyroscopes and accelerometers to visualize scenes before filming them. It’s a huge step forward for moviemakers, largely because it removes multiple cameras and sound stages from the previsualization process. Directors can now do the pre-vis step wherever they want — in a hallway, parking lot, or in someone’s backyard.

“We can go anywhere with this suit,” says Chris Edwards, chief executive officer of The Third Floor, the largest previsualization company in the world. “We don’t need any special rooms with lots of heavy gear. We can take it on a plane and go to a director’s house in Europe and set it up with a laptop. We can do a remote motion capture recording session there and get high fidelity data in real time.”

Moreover, the new MVN Motion Capture Suits, as they’re known, are bringing new capabilities to a broader swath of moviemakers. Until now, such digital capabilities were reserved for the likes of James Cameron and others with mammoth budgets.

“My hope is that we’re embarking on a golden age of cinematic content creation, where finally these technological tools will enable inspired directors with average budgets to create whatever their hearts desire,” Edwards says.

Beyond Optical

At first glance, the marriage of inertial sensors and Hollywood moviemaking would seem an unlikely one. Microelectromechanical systems-based (MEMS-based) inertial sensors debuted in the early 1990s, first in automotive air bags and stability control systems. Later, they began appearing in smart phones, laptop computers and video games, such as Nintendo’s Wii.

But as sensor performance improved over the years and costs dropped, engineers began finding new uses for the technology. The most popular of the inertial sensors —

Each tracker employs two dual-axis accelerometers from Analog Devices.

Source: Analog Devices

accelerometers — have become increasingly appealing to engineers designing medical and industrial equipment, as well as automotive systems.

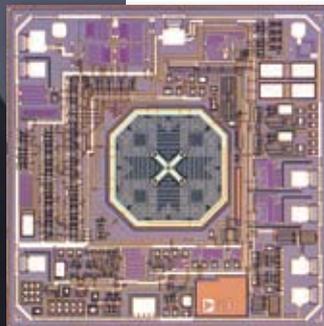
Tens of millions of the devices are now employed every year to measure motion in linear axes. At the same time, MEMS-based gyroscopes have added another

dimension to inertial measurement, enabling engineers to build products that can determine the rate of rotation about an axis.

Xbus Master controller synchronizes and powers suit’s trackers.



Trackers gather data and send it to master controller.





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Xsens Technologies B.V., a Netherlands-based supplier of 3-D motion-tracking products, began researching the concept of a sensor-based suit for biomechanical measurements in 2005. A 25-person research team, including about a dozen Ph.D.s, was assigned to the project of applying accelerometers, gyroscopes, digital processors and Bluetooth transmitters to the Lycra suit, and then tying the hardware together with a laptop-based software model. By August 2007, the company was demonstrating the technology at the Siggraph computer graphics conference.

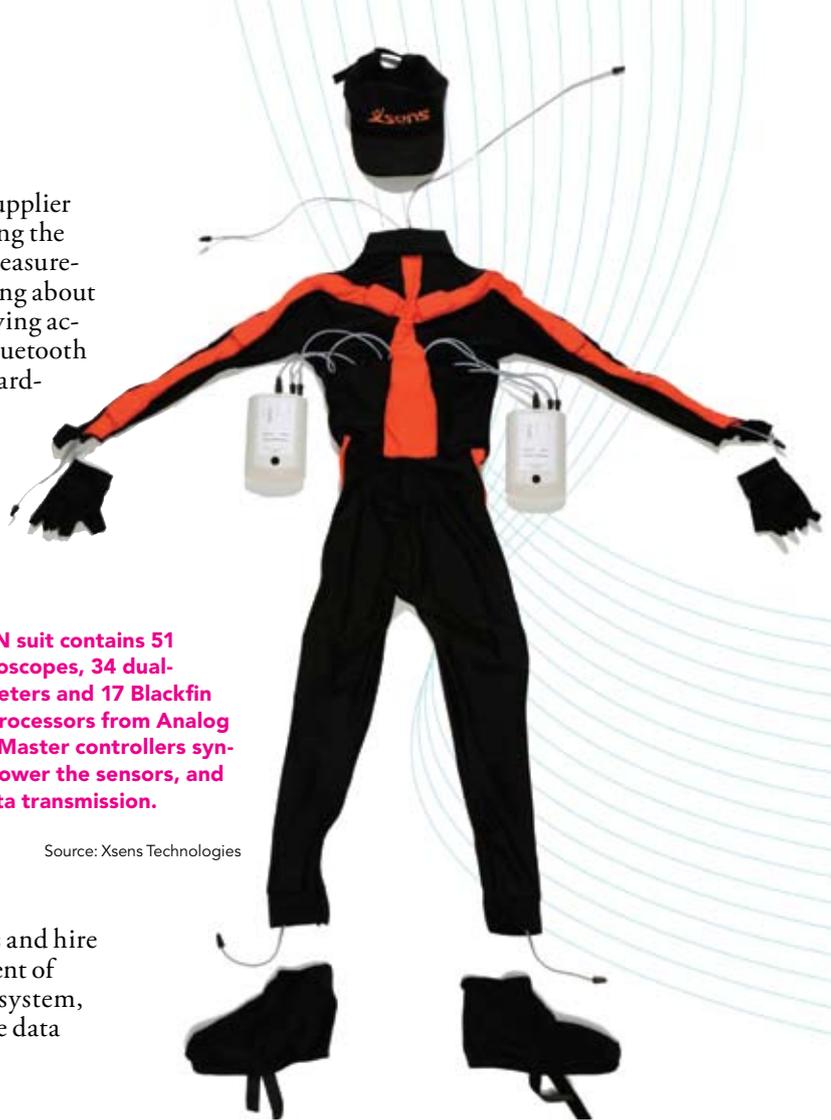
“I went to Siggraph and they were unveiling this killer app,” Edwards says. “It was a way to do mo-cap (motion capture) unlike anything I’d ever seen.”

Indeed, until that time, Edwards and others who did “pre-vis” thought the state-of-the-art was an optical method that involved suits with luminous markers. The optical technique, however, contained a level of complexity that was especially vexing for smaller companies.

“If you have an optical system, you have to rent more space, use expensive cameras and hire trained operators,” says Erik Wilbrink, vice president of sales and marketing for Xsens, “whereas with our system, people are motion-capturing and getting real-time data within 15 minutes.”

The Xsens MVN suit contains 51 single-axis gyroscopes, 34 dual-axis accelerometers and 17 Blackfin digital signal processors from Analog Devices. Xbus Master controllers synchronize and power the sensors, and do wireless data transmission.

Source: Xsens Technologies



Source: The Third Floor

The Third Floor, which specializes in film previsualization, takes data from the MVN suit and turns it into a scene full of characters, environments and props that can be re-arranged with a laptop computer.

Collecting the Data

But real-time feedback is just one of many advantages The Third Floor got from the MVN Motion Capture Suit.

The suit, which incorporates 17 matchbox-sized “trackers,” enables directors to take a set of data points and turn them into a scene full of characters, environments and props that can be re-arranged with a laptop computer. Containing three single-axis iMEMS gyroscopes, two dual-axis iMEMS accelerometers, and one Blackfin digital signal processor (DSP) from Analog Devices, each tracker is sewn into fabric tunnels within the suit. Wires in the tunnels connect the trackers in long daisy chains to an Xbus Master — a controller that synchronizes and powers them while simultaneously sending data to a laptop computer through a Bluetooth connection.

Essentially, the suit comprises a six-degree-of-freedom motion-sensing platform. The two dual-axis accelerometers collect acceleration data in the x, y and z planes, with one extra axis remaining for redundancy. The three gyroscopes measure rate of rotation about each of the axes.

During a movie shoot, pre-vis experts gather data from the inertial measurement units (IMUs), which are located in the middle of actors’ body segments, such as mid-calf, mid-forearm, mid-thigh and other spots around the body.



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Data from those points is sent to a biomechanical software model in the laptop, which tallies motion data at each point in real time. Computer graphics imagery (CGI) software then superimposes characters, objects and environments over the motion data.

“The sensors give us acceleration data and orientation data,” says Hein Beute, product manager for the entertainment market at Xsens. “When you feed that data into a biomechanical model, then you know the orientation of the upper arm and lower arm and legs. Within a millisecond, you can reconstruct an actor’s pose.”

During motion capture, the sensor-based suits offer two important advantages over optical techniques: They can gather data over huge areas and they eliminate the problem of “occlusion,” which occurs when one body part blocks another, preventing the transmission of data. Because the MVN suit transmits data by RF, rather than optically, occlusion is not an issue.

“When we tell people they don’t have to deal with occlusion anymore, there’s a big sigh of relief,” Wilbrink says. “With occlusion, there’s missing data. And the only solution to that is to add more cameras, which makes it more complex.”

Living Story Board

Engineers at The Third Floor employed the MVN suit for *Iron Man 2*’s action sequences and fight scenes. The sensor-based technology was especially important for a complex 20-minute scene known as the Japanese garden sequence near the end of the movie, which involved multiple characters, props and environments.

“We had bi-pedal humans and robotic characters, and they were supposed to be running around and punching and flipping each other,” Edwards says. “Within very little time, the actors got into their motion capture suits and did the fight choreography, punching and flipping to their hearts’ content.” The director’s team then compiled single elements of the battle into a larger scene that involved integration of multiple clips.

Seventeen of the matchbox-sized sensor packs are placed within the suit, as well as in the actors’ gloves and atop their shoes.

Source: Adam Nelson

The Third Floor used a similar approach in another recent movie, *Alice in Wonderland*. There, engineers used the MVN Motion Capture Suits on actors running on



Source: Xsens Technologies

Trackers containing accelerometers, gyroscopes and digital signal processors are placed at the mid-points of leg and arm segments, as well as elsewhere around the body. Acceleration and orientation data is sent wirelessly to a software model that tallies that data.

treadmills, then took the data and later “composited” the actors’ movements into a virtual world.

“If you can put a lot of detail into your pre-vis, which is what we always try to do, then directors treat it more seriously,” Edwards says. “All of a sudden, what you’ve built is more than a story board. It’s a living, breathing design document for each and every shot.”

Engineers from Xsens say they foresee the technology being employed in biomechanical research, movement science, ergonomics, human factors design, sports analysis and virtual-reality applications. Computer games are also a growing market for the technology. Gearbox Software employed it for character animation in the “Borderlands” video game, and Sony Computer Entertainment /Guerilla Games used it for “Killzone 2.” Moreover, the MVN suit is capturing the interest of a growing number of Hollywood studios. In addition to *Iron Man 2* and *Alice in Wonderland*, it’s been used in movies made by Industrial Light & Magic, Sony Pictures Imageworks and Double Negative.

“It’s amazing to see the directors’ and cinematographers’ eyes light up when they realize, ‘You mean we can get in the suits and act this out right now?’”

Equally important, though, is the effect the suit could have on smaller film companies with tighter budgets.

“That’s the most exciting part,” Edwards says. “With this, you don’t need to be a super-elite filmmaker to take advantage of the best tools.”

