



TheStandard

2022 Edition

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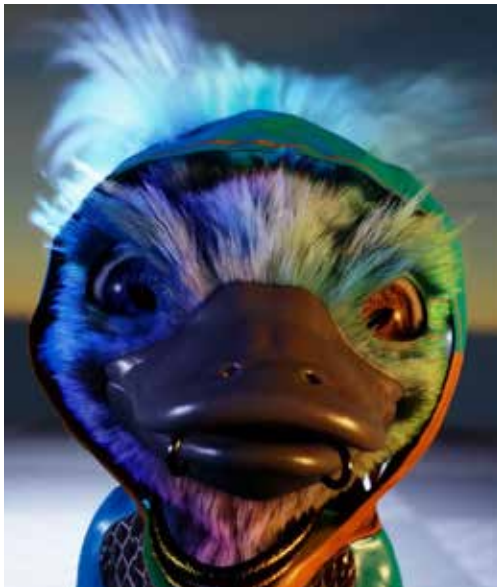
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Exploring Strange New Worlds





# INNOVATION



IMOGEN MOORHOUSE  
VICON CEO

Welcome to the 2022 edition of The Standard with “Customer Driven Innovation” as its theme. A big thank you to our customers who have contributed to this edition. As always, we are fascinated to read about the many diverse applications of our products.

The technology behind the making of Disney+ series *The Mandalorian* is showcased in an article with Industrial Light & Magic. This is ILM's latest project using Vicon technology, a technical partnership of over 25 years. Adoption of this pioneering tracking and production technique – virtual production – is growing, as content being generated this way is proving to save a lot of time over previous working practices.

The Virtual Reality market has grown in the last year, despite the pandemic, and two articles in this edition showcase some novel VR research cases. At the University of Strathclyde, UK the Bioengineering team are using their Vicon Origin system to explore the benefits of VR in stroke rehabilitation, whereas at The University of Portsmouth, UK, Centre for Creative and Immersive Extended Reality (CCIXR) is the UK's first integrated facility to support innovation in the creative and digital technologies of virtual, augmented and extended realities.

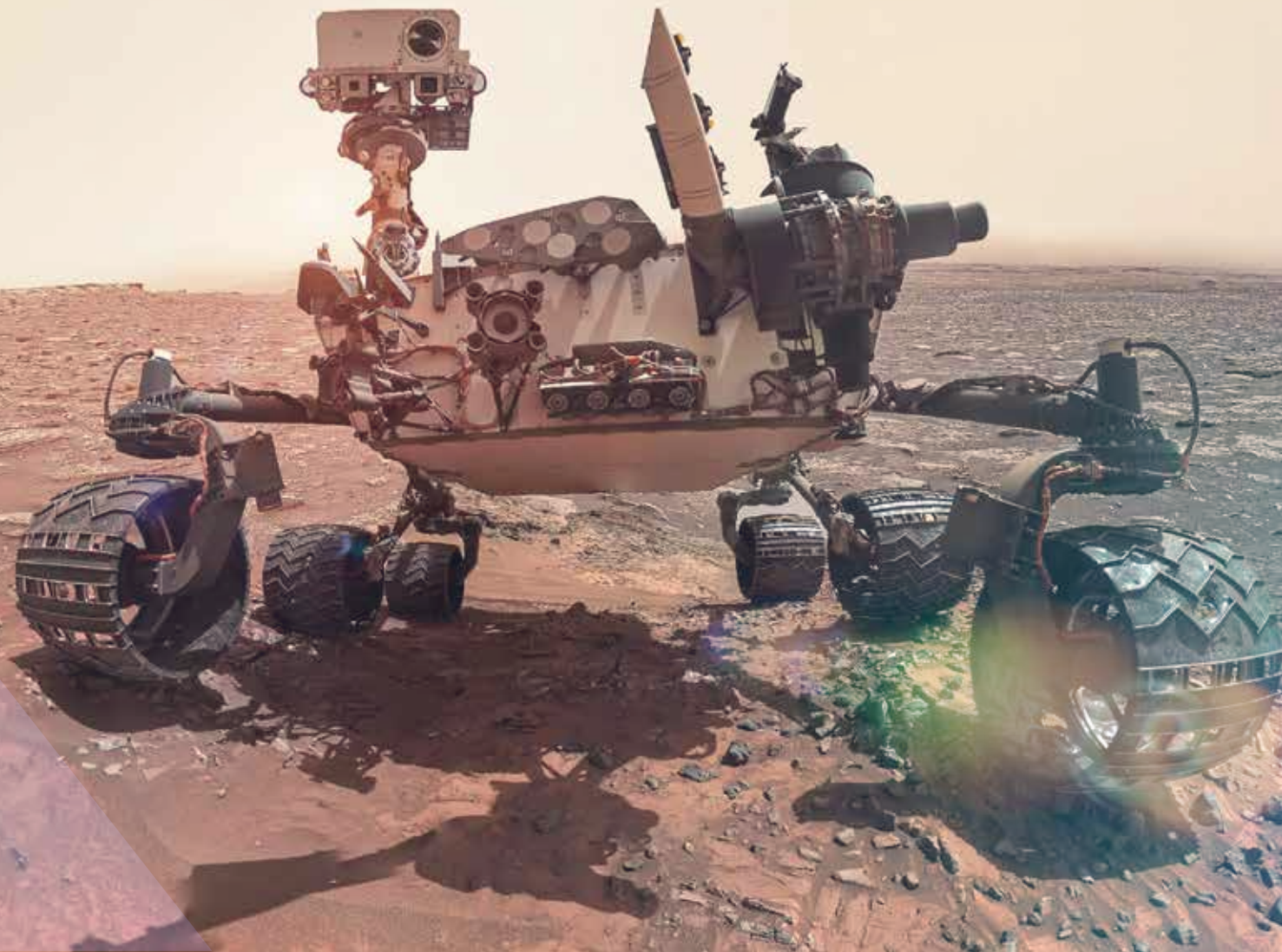
The adoption of emerging motion capture modalities, such as inertial and markerless in biomechanics, is discussed by an expert panel with some important considerations if you are considering adding these into your research program.

In September we welcomed CONTEMPLAS GmbH to the Vicon family. The CONTEMPLAS team bring over 15 years' experience working with video technology and images. With the growing use of video, not only to provide reference images, but to derive meaningful measurements, we are exploring ways to bring the benefits of these combined technologies to our mutual customer base.

As we move into 2022, all of us here at Vicon are looking forward to being able to meet up again in person whether at your lab, studio or conference venue.



# EXPLORING STRANGE NEW WORLDS



*Frances Zhu, PhD,  
Assistant Researcher  
and Deputy Director  
at University of  
Hawai'i Institute  
of Geophysics and  
Planetology*

"How do we build robots that can optimally explore space?" is the core question behind Dr. Frances' research at the University of Hawai'i. One part of the answer is 'with motion capture'.

"It is my hope that my research contributes to the way extraterrestrial robots move and make decisions on other planets," Zhu, an Assistant Researcher and Deputy Director at the University's Hawai'i Institute of Geophysics and Planetology, explains. That research is in its early stages, but NASA has seen the value in it and awarded Zhu an EPSCoR grant by the name "Autonomous Rover Operations for Planetary Surface Exploration using Machine Learning Algorithms."

Specifically, Zhu's project focuses on robots that explore extreme terrain on lunar and planetary surfaces.

"There are a few questions that I want to answer," she says. "For example, the lunar South Pole has a lot of water ice, we just don't know exactly how much. It's important for when we go to the moon and establish some kind of habitat; we need to have a large water

reserve. So imagine a little rover just landing, waking up and measuring how much ice is right beneath it, and then figuring out the same thing at the next location. And imagine doing that sequentially, iteratively, until you map out the entire ice distribution of a crater."

"Another question, which is explicitly using the Vicon system, is identifying what the dynamics model of a rover is in terrain that you've never seen before. So, a rover wakes up on a planetary surface, but it has no idea what it's like. It's unlike any kind of Earth terrain. Can you take measurements of its states, like position and orientation, and then over time come up with a model that predicts the robot's next state? This is a method called system identification. We're going to use the Vicon motion data to conduct this research."

MOTION CAPTURE IS GUIDING  
THE NEXT GENERATION OF  
EXTRATERRESTRIAL ROBOTS





## UNKNOWN TERRAIN

The challenges that these questions present are, of course, manifold. "Humans haven't been to the surface of Mars," says Zhu. "Only a few humans have been to the surface of the moon, and they've brought moon rocks back, but just from certain locations. So that terrain isn't well characterized."

Zhu notes that even here on Earth, terrain underfoot can vary hugely. Humans intuitively deal with different conditions in a way that feels like second nature but is, by the standards of most robots, highly advanced.

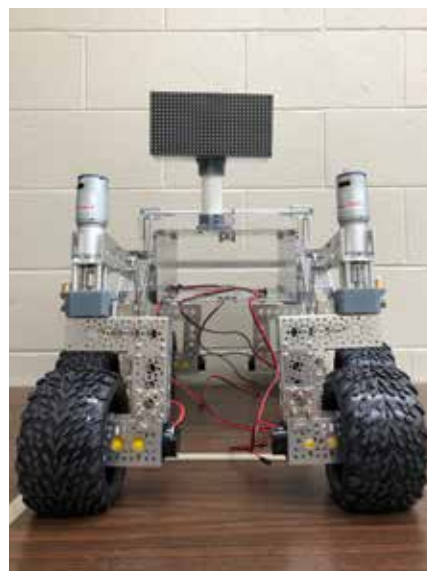
"The question, then, is if you don't have human intuition, can you formalize these environmental inputs, and then create some kind of control in the way that you locomote, all in an algorithm without human intuition and intelligence in the loop?" says Zhu.

## HOW MOTION CAPTURE CAN BOOST ROBOT INTELLIGENCE

Zhu hopes that the work she's doing with her Vicon system can inform future rover designs.

"Motion capture is the center of everything that I do," she says. "A little bit of context — right now, NASA's rover missions have extremely limited motion prediction based on a robot's dynamics model. It primarily has something called open-loop control, where you think of the path that you're going to take and you just implement that control without high-level feedback. There's some low-level feedback where there's a little bit of course correction, but there's not really that much prediction for something like a slippage. There's not any high level of intelligence."

"My dream is to someday use this data and these modeling techniques to upload an autonomy algorithm to future rover missions. This is going to be especially important for missions that are farther away than the moon and Mars, because that communication delay is going to prohibit any kind of real-time feedback."



To gather the data she needs, Zhu has procured six Vantage V5s and is running her setup using Tracker. Zhu previously worked with a competitor system, but says that she needed technology that had been subjected to greater levels of testing for this project. "There's this level of academic rigor to Vicon technology that was really compelling for me, and which is what convinced me to buy this system versus one of the competitors," she says.

"Vicon will enable me to take my rover outside and take precise vehicle state for my dynamic modeling work."

Before Zhu even begins extrapolating her findings to extraterrestrial environments, however, outdoor capture presents its own set of challenges. "The terrain might be quite uneven and extreme when it comes to the slope or the iciness. Because the research is based around characterizing ice I imagine that, as experiment operators, we're also going to have to set up this camera system on an icy slope."

"The cameras will need to be capable enough that if we are just stuck with

putting cameras far away from each other then we can cover a large enough capture volume with enough precision. We also have to make sure that we maintain constant tracking through various lighting conditions. And we're not sure how the ice might affect the reflection, or whether it will create more noise."

## ALL THE DIFFERENT ROBOTS

For now, these are problems for the future. That doesn't stop Zhu from jumping to potential future research ideas when the subject of markerless capture and Vicon's recent acquisition of Contemphas comes up, however.

"I'm just thinking about the applications for a lunar base," she muses. "It might make sense to set up these markerless cameras so that you are always monitoring the motion of the different robots that you're operating. That way, you don't have to force all of the sensing to be on the robot itself and could instead have some kind of environment-sensing that's external to the machine."

"It would be very cool to also work with amphibious vehicles," Zhu says, jumping delightedly back to Earth and the variety her field offers her. "So going from land to water, or land to air. Just all the different robots, all their fun shapes and types of movement."





# SMALL VOLUME HUGE CHALLENGES

CAPTURING FINE HAND-MOTION IN  
TIGHT SPACES WITH THE VERO

"

By far the largest part of the setup, however, is the substantial mechanism below the arm that loads/winds cables attached to the hand to simulate muscle force and wrist motion."



*Dr. David Ackland, PhD, Head of the Biomechanics Research group, Department of Biomedical Engineering, University of Melbourne*

While the largest motion capture projects might pick up the biggest headlines, some of the most challenging work done using Vicon technology happens at the smallest scale.

Dr. David Ackland, head of the Biomechanics Research group in the Department of Biomedical Engineering at the University of Melbourne, has been working with hand and wrist surgeons from the O'Brien Institute to better understand the inner workings of the human wrist.

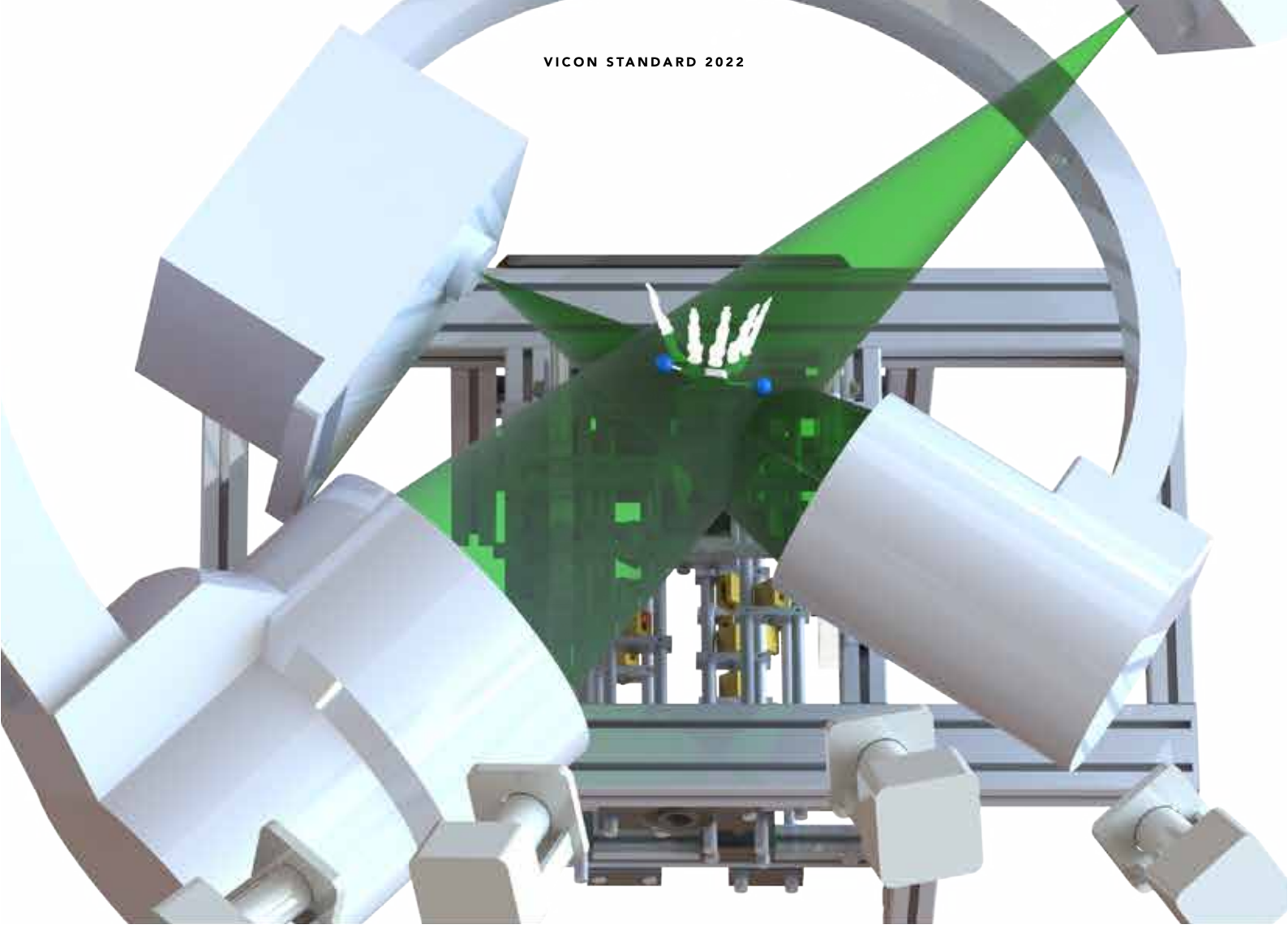
Associate Professor Ackland's study has an extremely focused goal: examining the function of a specific, easily damaged ligament that controls the scaphoid and lunate bones in the wrist, and how injury and surgical interventions affect that function.

"Firstly, the aim of our study was to evaluate normal carpal bone motion," says Ackland. "Secondly, motion of the carpal bones when the ligament is torn. Then we wanted to look at the effectiveness of surgical reconstruction of the ligament, taking a look at a couple of different techniques for repairing it, as well as a novel surgical approach that has not been reported previously. And the way that we assessed this was using a custom-built wrist simulator."

The wrist simulator sits in a dedicated wet tissue lab at the university. This highly compact setup comprises a novel rig for reproducing wrist motion by way of simulated force application to the wrist muscles. Two C-arm fluoroscopes are used for X-ray imaging the carpal bones, and a set of Vicon Vero cameras surrounding the hand and arm of a cadaver are used for wrist joint motion analysis. A motion capture marker cluster is placed on the forearm and another on one of the metacarpal bones in a finger, and these are used to track the overall wrist motion in real time, which is required for controlling the muscle forces correctly. By far the largest part of the setup is the substantial mechanism below the arm that loads cables attached to the hand to simulate muscle force and wrist motion.

"What we wanted to do was to create a rig with a control method that produced highly repeatable motion of the wrist in normal, pathological and surgically-repaired states. We could then use X-rays to measure motion at the individual carpal bone level," says Ackland.





“The Veros were able to capture the positions of markers very accurately, and we had the positions of the markers transformed into a local anatomical coordinate system.”

He and his team implanted metal beads into the bones and pressure sensitive film between them, then used biplane X-ray fluoroscopy to record moving 3D images of the bones and tissues inside the hand. This information was then combined with his motion capture data so that he and his team could understand what was happening broadly with respect to the wrist joint motion, as well as internally in relation to the individual carpal bones and the way they move and contact each other.

#### WORKING IN A TIGHT VOLUME

The limited space between the X-ray systems created a challenging environment for motion capture, however.

“It was really, really tight,” says Ackland. “It was incredibly difficult to get everything in the field of view without creating occlusions and it took quite some time to set up. It took PhD student Xin Zhang three years to

design the rig, build it and to plan and develop all the algorithms for tracking the motion.”

The challenges of the small volume meant that getting the right camera was essential. “The conversation with Vicon about what sort of camera would fit our needs made the Vero very appealing, because it suits a lab environment with a small capture volume while offering high accuracy. The price point was also really good for us. So it was an easy decision for us to make.”

The cameras have proven equal to the task. “The Veros were able to capture the positions of markers very accurately, and we had the positions of the markers transformed into a local anatomical coordinate system,” explains Ackland.

“The result was that we were able to reproduce wrist joint angles like flexion to 20 degrees, extension to 30 degrees, and so forth, meaning

“The result was that we were able to reproduce wrist joint angles like flexion to 20 degrees.”



we’re able to quantify the overall wrist motion with high precision and repeatability. The repeatability ultimately came from the control mechanism, which gave us the ability to control muscle forces accurately and in real time.

“The advantage of using this system was that we were able to get the data in real time and update the motors with a control pulse, and then receive new information on the updated position of the wrist instantly and change the muscle forces accordingly. We did all this seamlessly, achieving these smooth waves of muscle forces and motion trajectories all in a closed loop and in real time in order to achieve the desired wrist motion.”

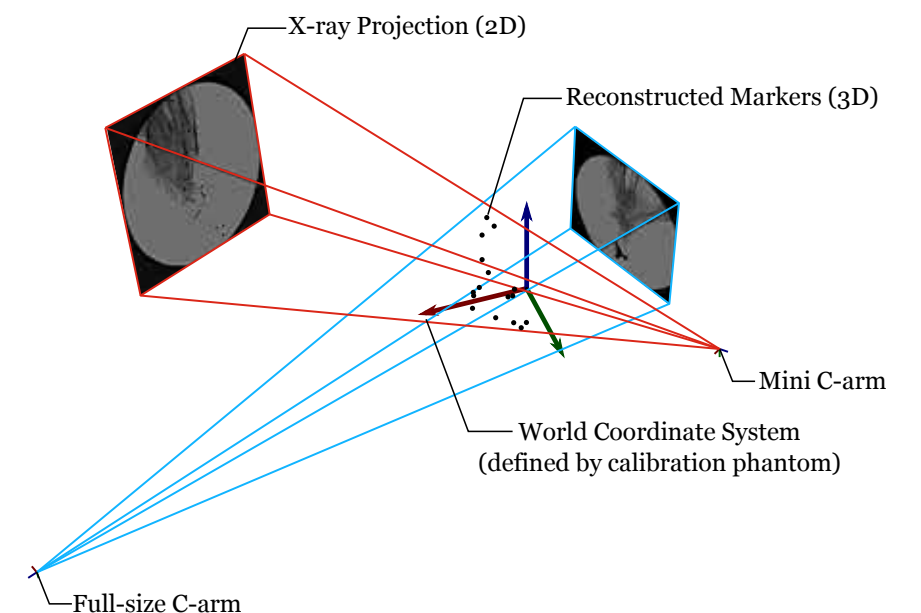
#### GOING DEEPER

Looking ahead, Ackland wants to build predictive models. “Where we want to go from here is to take our setup

and our simulations, and then take the motion of the bones that we get, and feed that into detailed finite element models of the joints so that we can then simulate the actual contact and the deformation of the hard and soft tissues. This is critical for understanding injury and joint disease such as osteoarthritis.

“We can do that by CT scanning the specimen and building anatomical models, then feeding all the data that we get from these experiments, such as force and motion, into the models to predict contact patterns in more detail. A finite element model allows us to interrogate different model elements, such as bone and cartilage, allowing us to explore contact behavior with unprecedented detail.

“Also,” Ackland adds, almost as an afterthought, “we want to do the same in a live subject.”





# SMOKE, MIRRORS AND THE REAL MAGIC OF MOTION CAPTURE IN SPACE JAM 2

“  
Any sufficiently  
advanced technology  
is indistinguishable  
from magic.”

Arthur C. Clarke,  
'Profiles of The Future', 1961  
(Clarke's third law)

HOUSE OF MOVES DISCUSSES  
THE PROBLEM OF TRACKING  
THAT LOOKS 'TOO EASY'

House of Moves has become renowned in the VFX and games sectors for its deep focus on quality, resulting in a client list that includes the likes of Marvel Studios, Industrial Light & Magic and Rockstar Games. The quality of their output, however, can sometimes belie the complexity of the work they do.

That complexity presented challenge after challenge on the set of **Space Jam: A New Legacy**, which puts stars including **LeBron James** and **Don Cheadle** on a basketball court alongside the likes of Bugs Bunny, Daffy Duck and Marvin the Martian.





“We set up a system around a professional-size court,” says Jimmy Corvan, Business Development Manager at House of Moves. A professional court is 94 x 50 feet and it took 96 Vicon T-Series cameras to cover it, but the setup was relatively straightforward despite the volume’s size. It was a series of additional hurdles that made the project technically difficult.



Jimmy Corvan,  
Business  
Development  
Manager at House  
of Moves

“We shot for 47 days on the lot at Warner Brothers. It was a serious challenge because, like many movies, motion capture was a late consideration in planning and we needed to adjust to decisions and requirements that were already in place.”

The variables stacked up. “The first week of shooting, the director shot with a fog machine in an enclosed stage. This entire stage was wrapped in green. It was like a giant, light-bending, green cocoon that was filled with fog,” says Corvan.

And beneath the fog was another motion capture issue. “The floor was super shiny, every single day,” Corvan says. “They wax it every single day, which was like shooting into a giant mirror...”

The biggest challenge, however, came in the form of Don Cheadle’s wardrobe. His character, Al-G Rhythm, wears what Corvan refers to as a reflective suit. “And by a reflective suit,” he goes on, “I mean it’s like a disco ball in suit form. And they needed us to track markers on the upper body.”

## POWERFUL TECHNOLOGY ENABLES CREATIVE SOLUTIONS

For House of Moves to be able to problem-solve in such dynamic circumstances, the studio needs technology that’s equal to its abilities. “With Vicon,” Corvan says, “we know exactly what we’re getting. And what we’re getting is the highest quality available on the market. The T160 or V16s are just the best practical motion capture cameras on the planet.

“Quite frankly, when we shoot with 4 mm markers on the face, fingers or even skateboard wheels, we get a higher resolution than an HD camera because we get 16 megapixels on those T-Series. On the post side, how many people only buy Blade or Shōgun after owning non-Vicon hardware? The answer is ‘a lot’. I’ll tell you that from hearing how many people want to solve in Shōgun, because the software is vastly superior to whatever else is out there. However, I simply don’t know why you wouldn’t pair Shōgun with Vicon cameras. When we were able to deploy the real-time subject calibrator, we were able to regain 7–12 minutes per actor every morning. When studios are paying millions per day in talent and overhead, regaining 7–12 minutes per actor is... I literally can’t think of a word to describe how huge this is.”

## KEEPING HUMANS IN THE LOOP

While House of Moves relies on the power and accuracy of its Vicon setup, however, the studio’s process is still grounded in its human talent.

At many motion capture studios, software such as Shōgun can do the heavy lifting and the resulting data will meet a client’s needs, says Corvan. “That’s definitely good enough for a lot of people. Shōgun is getting better and better at figuring this stuff out, even in real time.”



However, that’s not how House of Moves operates. “We have consistently had animators who are working on the data on the back end,” Corvan says.

“What we’re delivering back to our clients is data that animators actually want to receive, because animators are the ones who are working on that data [at House of Moves]. It’s not ‘we’ve got a bunch of data, we’ll put it into a system, spit it out, and you get what you get and your animators can fix what they need fixing’. A human touches every portion of it, a human cleans it, a human solves it and a human retargets it.”

It could be argued, in other words, that when House of Moves is asked ‘can’t you just...?’, the studio is a victim of its own success.

## THE KNOWLEDGE GAP

As Corvan sees it, challenges like the Space Jam court, which face many teams doing capture for the entertainment industry, are the product of a knowledge gap.

“The phrase ‘can’t you just...?’ comes up a lot,” says Corvan.

“Like, ‘can’t you just do this thing? It’s just as easy’. Motion capture is regularly looked at as: you press a button then Tom Holland crawls around on all fours and Spider-Man pops out the back end. And that’s not the way it works.”

While most people know what motion capture is, they don’t necessarily know how it works. “These cameras don’t see things like traditional cameras. We aren’t analyzing pictures, we’re analyzing pixels.

“And if light gets distorted because it’s being bounced around by fog, then we don’t know what’s a real marker and what’s not. We’re not looking through the eye of the camera: we’re looking through the algorithm that is telling us what the camera is saying about where these markers are. I think that, more than anything, it’s because they believe motion capture has gotten so easy, we don’t have any special technical needs.”

## A PROCESS THAT WORKS

Thanks to the combination of Vicon technology and the talent that House of Moves has in operating it, the studio will retain its reputation for technical wizardry a while longer. The Space Jam shoot, for all its technical hurdles, proved a success.

“I keep going back to that suit, because it’s so ingrained in my memory. I thought, ‘There’s no way this is going to work’. But we put markers across the top of Don Cheadle to track him. And we actually tracked him! The data is insane. There are three markers that are stable the entire time. And the rest is just flashing lights all over.

“It was a sight to behold, but those three little markers were enough. It was just one of those moments where I was so certain of something and so thrilled to be wrong.”



# OPENING NEW FRONTIERS IN CHILD DEVELOPMENT RESEARCH

BIRKBECK BABYLAB IS USING VICON TECHNOLOGY TO DIVE DEEPER THAN EVER INTO INFANT BEHAVIOUR

Although there's an old adage that you should never work with children or animals, there are Vicon users who do both. The work being done in the BabyLab and ToddlerLab at the Centre for Brain and Cognitive Development at Birkbeck, University of London, should be incredibly difficult, but the accuracy of Vicon motion capture combined with increasingly immersive lab environments is allowing researchers to gain fascinating insights into infant development.



*Leslie Tucker,  
Centre Coordinator,  
Centre for Brain  
and Cognitive  
Development,  
Birkbeck College*

"The unique thing about our research center is that it brings so many developmentalists together," says Leslie Tucker, Centre Coordinator. "We use all these different methods to try to understand very basic science questions about the brain and behavior."

The BabyLab includes a table that the toddlers can sit around, with six Vicon cameras providing complete coverage. The team wanted a more natural setting in which to observe the toddlers, however, and recently added a larger space modeled on a nursery setting, with 16 Vero cameras running with Nexus and two video cameras. The hope is that babies will behave more normally in a more familiar setting.

The new setup enhances the utility of the BabyLab's studies, says Lianne Schroer, one of the first PhD researchers to use the new volume. "The studies are more ecologically valid. They're environments that they

could also encounter in preschool, in nursery or in school.

"Generally, a lot of studies in developmental research are very lab-based," she goes on. "They show a movie, they follow their eyes with the eye tracker. But now we're trying to move to studies that show a richness of behavior that infants would also display in real life. And with these kinds of wireless techniques, we're able to very deeply track movements alongside brain activation, while kids act more like they would at home or at school."

## MAKING PLANS

The current phase of Schroer's research is acting as a pilot project for the new setup, combining motion capture with near-infrared spectroscopy brain-imaging.

"I'm interested to see how kids learn to plan complicated action sequences," Schroer says. She explains that actions which feel very easy to an adult are deceptively complex. "Even something



*Lianne Schroer,  
PhD Researcher,  
Centre for Brain  
and Cognitive  
Development,  
Birkbeck College*



“  
I’m interested to  
see how kids learn  
to plan complicated  
action sequences.”



as simple as making a cup of coffee in the morning requires you to keep track of a kind of goal hierarchy.”

“The main goal consists of several sub-goals that we have to keep track of. And each of the sub-goals consists of several action steps, which often have to be executed in a certain order. Like if we’re pouring milk, we first have to move the package towards the cup before we start pouring; you have to remember that you’re making coffee and not tea; you want to remember whether you already added sugar; and you have to keep track of each of the steps.

“In my PhD research, we’re trying to find out how kids learn to plan these kinds of actions. We know that very young babies can plan easy actions: they can grasp a toy, they can throw it away. But that does not cover the things we do as adults without even thinking about it.

“In a previous study, we asked children to build a house which had a goal hierarchy. It had a main goal of building a house, then it had several sub-goals and each of the sub-goals had several action steps. We asked the children to wear cycling gloves where there’s a plate of markers on each, so we can keep track of the hand movement.”

### FEWER MARKERS, EXTREME PRECISION

This minimal approach to tracking is the key to working with the children in the study. Tucker notes that if a child feels uncomfortable with any part of the process they simply won’t cooperate and the study will have to be redesigned. Full motion capture suits are not a plausible option, which is why the tracking is focused on the subjects’ hands.

Fortunately, in her study Schroer is able to get the quality of data she needs from just four markers on each glove, making it much easier to get buy-in from her subjects. “I tell them, they’re very cool magic gloves and they make them better builders. And actually, they just put them on. They might say ‘it’s a bit weird’, but generally they keep them on throughout the experiment,” she says.

The first phase of the research has already yielded interesting results, says Schroer. “We see an improvement in children’s planning ability over the preschool years between three and five. But we also see that children who are better planners and follow the so-called structure show a kind of freezing of their movement in the hand that they don’t use for building.

“So for example, if they’re building a wall with their right hand, they freeze their left hand while they’re building. Then at branch points when they have to switch from one sub-goal to another, that requires some planning and they unfreeze the hand. And we can really see that in the motion capture data.”

### NO MOTION CAPTURE, NO RESULTS

The findings are only possible thanks to tracking. “Without it,” Schroer says, “we would have never seen these results. This is about really small hand movements, maybe even just a tiny tremble. It’s something you would never be able to capture on a regular camera.”

“In the olden days,” says Leslie Tucker, “we used to do studies where you’re just videotaping, and you have coders looking for small facial expression changes and that kind of stuff. All that is very, very labor-intensive. You’re looking at these things frame by frame; it took hours and hours. Now we can do contingent studies, so what the child does determines what happens next in the experiment. So this new kit that we have has really changed developmental research over the last 20 years.”

Schroer hopes that her research will have practical applications beyond the world of academia.

“We hope that it helps our understanding of how kids develop. If we know that three-year-old kids can’t plan action sequences there’s no point in telling them, ‘We’re going outside now, so prepare for the whole outside sequence’. Instead, it’s better to say, ‘Put your coat on, put on your shoes,’ and so on.

“We also hope it will help with research for children with developmental disorders, such as autism and ADHD. It’s well-known that they show difficulties and impairments in action planning. But it’s generally the easier tasks that are the focus of research, such as grabbing an object, where we know that they show slightly different kinematics. But I hope that this research will also be useful in showing how they plan these more complex actions, and that we can help them with planning in daily life.”

While the new volume Schroer has been using has already increased the level of naturalism that the Centre can bring to its studies, there are more plans in the works. By the end of 2021 the Centre for Brain and Cognitive Development will have a Cave Automatic Virtual Environment (CAVE) facility installed.

“People have ideas for changing the environment that a child is in,” explains Tucker. “You could have street scenes and look at attentional learning, you could throw kids into a farmyard environment. Anything you can program, we can put them into these scenarios.”

In the CAVE, the Centre’s researchers plan to tie together the motion capture and near-infrared spectroscopy used in Schroer’s study with further measurements such as eye-tracking and EEG.

“With that in mind,” says Tucker, “a lot of the stuff we’re working on right now is technology development. What we’re going to be doing is figuring out ways to time-lock events in these naturalistic environments so that we know what we’re looking at, basically.”

That combination of imaginative study design with powerful, linked up technology will mean more immersive studies, broader datasets and, most importantly, even deeper insights into this crucial stage of human development.

“  
We see an improvement  
in children’s  
planning ability  
over the preschool  
years between  
three and five.”





# TAILS OF KITTY CAPTURE

WITH PATIENCE, EVEN THE MOST DIFFICULT ANIMALS CAN PRODUCE GOOD DATA

"

Despite that deep bank of experience and a powerful motion capture system, however, capturing cats came with its own set of challenges."



DIGIC has been providing motion capture services to its clients for around 12 years, using its data to produce VFX for film and TV as well as animation for video games. Mostly, that involves capturing stunt performers and vehicles. DIGIC also has a very specialist sideline, tracking animals.

To date, much of this work has focused on horses and dogs. More recently, though, the studio has been tracking animals that are notorious for their unwillingness to do what they're told – cats.

Doing animal capture in-house wasn't DIGIC's first choice. "We purchased horse mocap data from several places for earlier projects," György Tóth, Managing Director of DIGIC Services, says, "but we weren't satisfied with the quality, so we decided to try to record the horses' movements ourselves.

"During our first horse shoot, it was difficult to get the markers to stay on the horse, so for the next shoot we had a cloth sewn to make the markers stick better. There were also some problems with that: the cloth on the legs would get tangled, and if the horse got too sweaty the cloth would stretch, for example. After three or four shoots we got to the point where we could extract good data from the sessions,

and the current marker set was developed based on that experience."

DIGIC has banked almost 10,000 shooting hours in the dozen years since it established its volume, amassing 60TB of data and nearly 40,000 takes, so experience isn't something the studio is short of.

Those takes have been done in a steadily evolving setup that currently includes 40 16MP Vicon T160 cameras. "The team that designed the system had experience with optical motion capture and inertial sensing," says Tóth. "Based on this knowledge, we decided to go with the most advanced Vicon camera solution at the time, which was the T160 series. Over the last 12 years, after a few thousand hours of shooting, we think we made the right decision!"

Despite that deep bank of experience and a powerful motion capture system, however, capturing cats came with its own set of challenges.

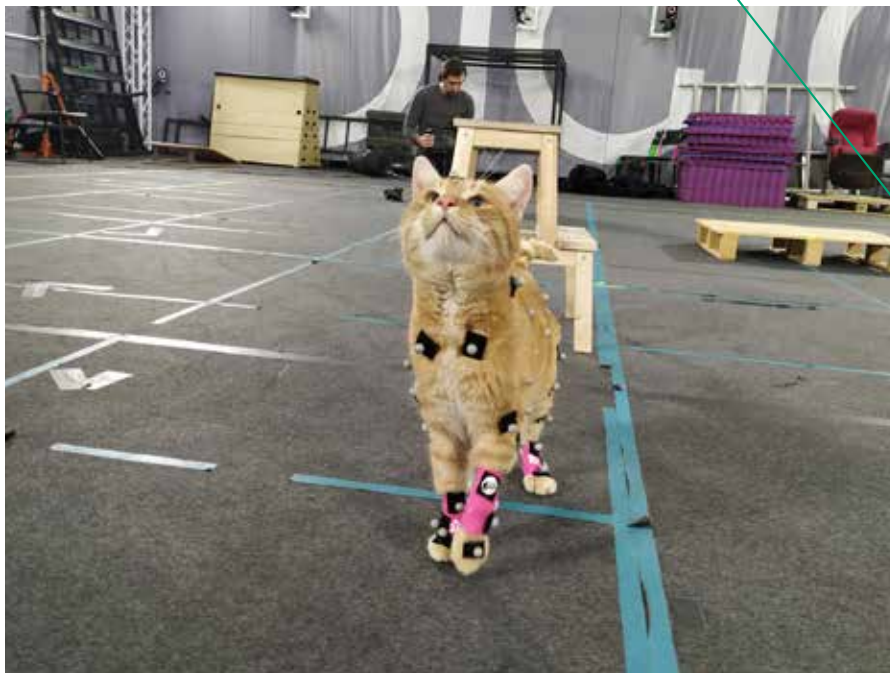


György Tóth,  
Managing Director  
of DIGIC Services





“Although the cats were trained and had been in films many times, it was a challenge to get them to move naturally.”



### MOCATS

The mocat project began at the request of a Korean client looking for a library of mocap data and scans of dogs, horses and cats to be integrated into their game engine as full navigation movements. While DIGIC was working with the cats, the studio decided that it would also use some of the data for “some more interesting ideas both for internal use and to put it on the market,” says Tóth.

For all of DIGIC’s work with horses, turning their expertise to cats wasn’t as straightforward as swapping one animal for another.

On a practical level, Csaba Kovári, Mocap Division Lead, says that, “We couldn’t dress the cats, so the marker placement had to be done differently. And you couldn’t put markers on the tails, either; it would have made natural movement impossible.”

Then there was the issue of getting the desired performance from the cats.

“Although the cats were trained and had been in films many times, it was a challenge to get them to move naturally despite the markers that were placed on them,” says Kovári. “The solution was a relatively long acclimatization process. First, placing one or two markers on the cat’s body for a few minutes, then gradually working up to the full marker set.

“Also, it’s important to note that it took approximately one month to train the cats – with the help of a professional animal trainer – and prepare them for the mocap shooting session.

“Another thing to mention is that, unlike humans, cats, horses and dogs can work for much shorter periods of time. Therefore we had to take a break after one or two hours or replace the animal with another one.”

After the performances were captured, processing the data presented its own problem.

“The other challenge was that for the cats, as for the dogs and horses, we had to develop a bespoke solver that could transfer the marker data to a skeleton that’s as lifelike as possible, while also taking into account the anatomical features,” says Kovári.

The cats’ much more mobile spines were a particular factor when it came to designing for cats rather than horses, too. “It took a lot of fine-tuning, and the marker set changed a lot after the first tests,” says Kovári.

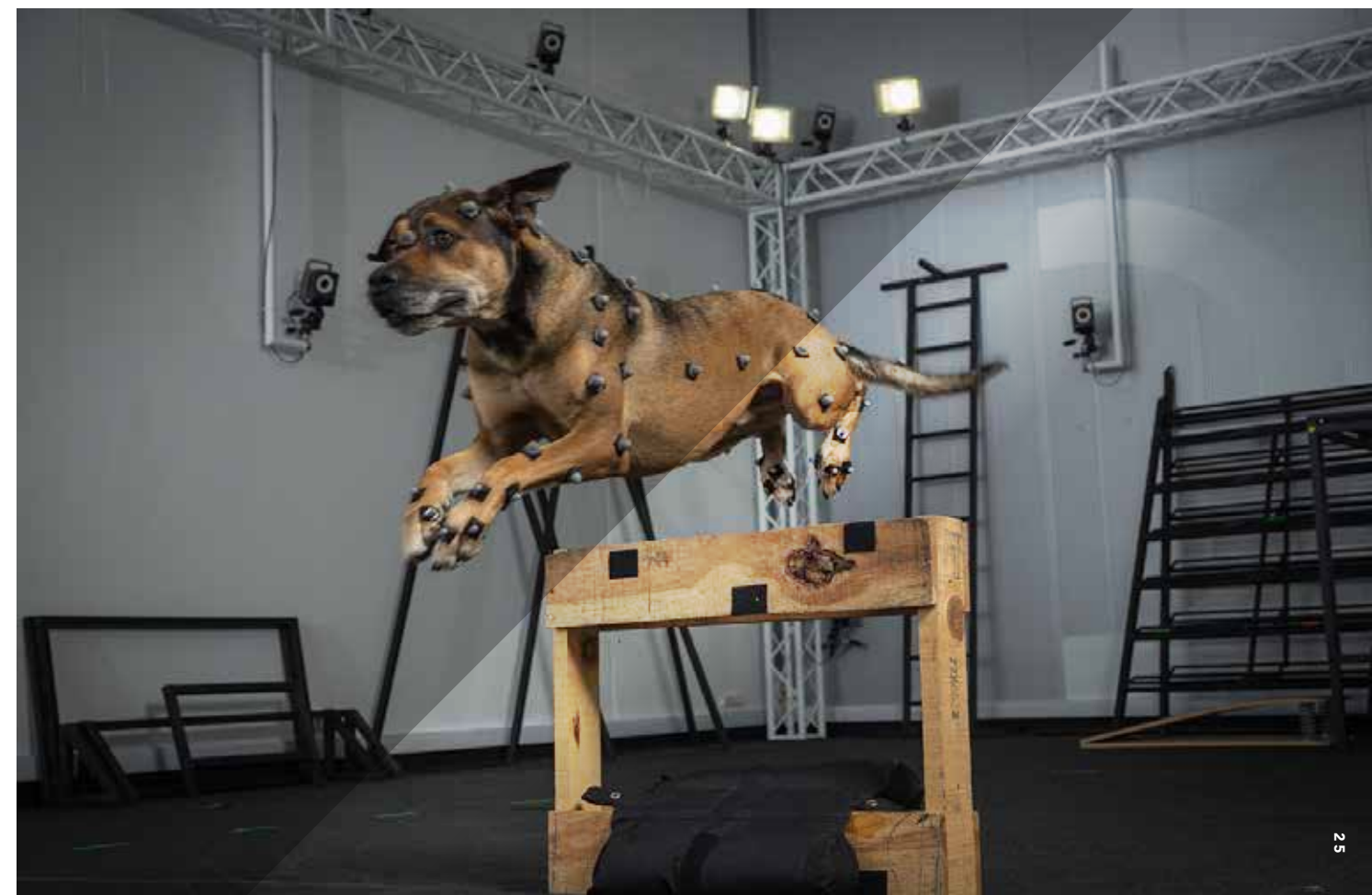
### PEOPLE POWER

Having the right technology in place is only one piece of the puzzle, however. The other is having people in the loop who can problem-solve during a difficult shoot.

“Working with animals is a completely different field from working with human performers,” says Tóth. “It’s very important to find the right trainer team, to work closely with them, to assess what is feasible, what is not, or when the shoot might become unpredictable. Also, it’s crucial to be prepared for the possibility of a complete redesign of the shooting schedule.”

While working with animals might require a loose approach to planning, DIGIC doesn’t intend to be put off. Looking ahead, the company plans to deepen its library of cat and dog animations. The studio is also, Tóth says, working on a new IP of its own, funded by the Epic MegaGrants program, involving a range of different animals.

“Working with animals is a completely different field from working with human performers, it’s very important to find the right trainer team.”





# CREATIVITY IN FLIGHT

SIX GEORGIA TECH MOTION  
CAPTURE PROJECTS THAT ARE  
PUSHING THE BOUNDARIES OF  
AUTONOMOUS FLIGHT

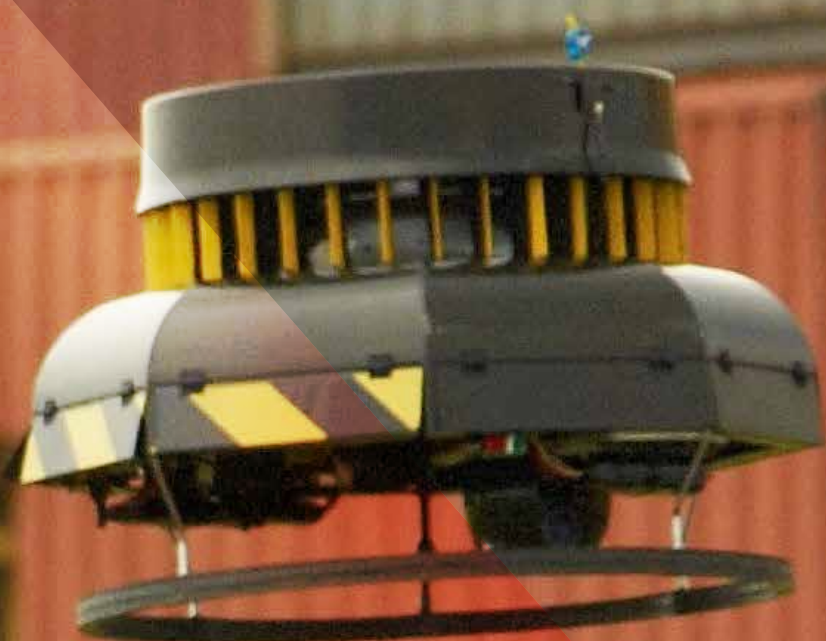


Photo: Steve Potter



Across the Georgia Tech School of Aerospace Engineering's three motion capture volumes, faculty and students alike are finding new tracking applications for creative projects that explore flight both on and off Earth.



Lee Whitcher,  
Lab Manager,  
Georgia Tech School  
of Aerospace  
Engineering

The newest of the three spaces, the Indoor Flight Laboratory, boasts 56 cameras alongside a projection system and wind simulation equipment across its 2000 square foot volume, though all three house their own state-of-the-art technologies. The facilities are home to projects that range from the playful to the potentially groundbreaking, and lab manager Lee Whitcher has a front row seat for all of them. Whitcher spoke with Vicon about six of the most interesting projects using motion capture in his labs.

## AGGRESSIVE FLYING

"Zhiyuan (Nick) Zhang, a student in Professor Panos Tsotras's Dynamics and Control Systems Laboratory, has been working on trajectory control, which is where you define a trajectory in space," says Whitcher. "It's a large series of coordinates that define a line, maybe through three-dimensional space, and then you control your

aircraft to match that trajectory. You also control not only your position on that line, but your orientation. So at certain points, you could actually be upside down on that trajectory."

The goal is to improve drone control. Whitcher notes that for 20 years, designers of autonomous drones have been working on basic problems such as keeping their vehicles level and ensuring consistent location tracking, but that developments such as drone racing are making new demands of the technology.

"Trajectory control is one way to do aggressive flying," he says, "and it's actually quite a mathematical problem because you can't define a trajectory that the aircraft can't follow. So you have to have a good model of the aircraft, so that you can actually come up with a good trajectory that meets your maneuverability requirements, but also one that the aircraft can achieve."



“Essentially it’s one giant quadrotor made out of four small quadrotors. Each of them is controlling its own angle on the frame, which is then giving you flight control of the whole aircraft.”



#### UNORTHODOX DESIGN

“This is a really strange and interesting aircraft,” says Whitcher. The drone in question, designed by student Kevin Webb in Professor Jon Rogers’ Aerial Robotics and Experimental Autonomy Lab, isn’t actually a single aircraft.

“It’s four cooperative transportation drones,” says Whitcher, “which are basically four quadrotors that are all attached to a rigid frame, and those four quadrotors can pivot on the frame. So, essentially it’s one giant quadrotor made out of four small quadrotors. Each of them is controlling its own angle on the frame, which is then giving you flight control of the whole aircraft.”

Another unconventional piece of aircraft design in the Georgia Tech flight labs is the work of Whitcher himself.

“It’s the flight control development for a drone called CEMAV (Coanda Effect Micro Aerial Vehicle) manufactured by a UK company named Aesir. This is my thesis research aircraft,” says Whitcher.

The drone, which resembles a flying saucer, usually flies outdoors with a gasoline engine. “But I converted it to electric and both free-fly it and run it mounted on a three degree of freedom gimbal rig so it can ‘fly on the spot’ in the Vicon room,” says

Whitcher. “This enables the control algorithms to be dialed in without risking crashing, or reliance on GPS.”

#### DIFFICULT MEASUREMENTS

“We have a student, Emily Glover, whose advisor is department chair Prof Mark Costello, who basically inflated a parafoil in the lab and then used markers all over it to measure it,” says Whitcher. “That enables her to do computational fluid dynamics on the parafoil, which in turn enables her to basically do wind tunnel testing without the wind tunnel.”

“You can do it in the computer, but for that you need accurate geometry,” he adds, “and how on Earth do you measure a parafoil if it’s not without a system like this?”

#### OFF-EARTH TECHNOLOGY

Whitcher’s next project is based in a lab that addresses the challenge of mimicking extraterrestrial conditions from firmly within Earth’s gravity well.

In the Autonomous Spacecraft Testing of Robotic Operations in Space (ASTROS) lab the School of Aerospace Engineering has a surface that Whitcher jokingly refers to as “a glorified air hockey table”. It’s actually a very sophisticated piece of engineering that enables equipment to move in two dimensions

without friction, helping users to simulate the motion of spacecraft.

The ASTROS test platform is a robot that consists of two stages. The lower stage creates the compressed air cushion that the device moves on, while the upper section is attached by a three-axis air bearing that enables it to roll, pitch and yaw. Between them, they can simulate very low-gravity conditions, enabling users to test algorithms for autonomous proximity operations such as the refueling of satellites.

“They use the lab’s Vicon system to know what their orbit is, effectively,” says Whitcher. “Right now, they’re doing a photogrammetry project. They have a fake asteroid in there that is mounted to another robot arm, and that asteroid rotates and moves around the space. The satellite tracks it and moves around it, taking lots of photographs which are then stitched together to make a 3D model of the asteroid.”

#### GRACEFUL LANDINGS

The final project Whitcher demonstrates is in the Computational Solid Mechanics Lab run by

Professor Julian J. Rimoli. “He has a Vicon system that looks at morphing bodies,” Whitcher says.

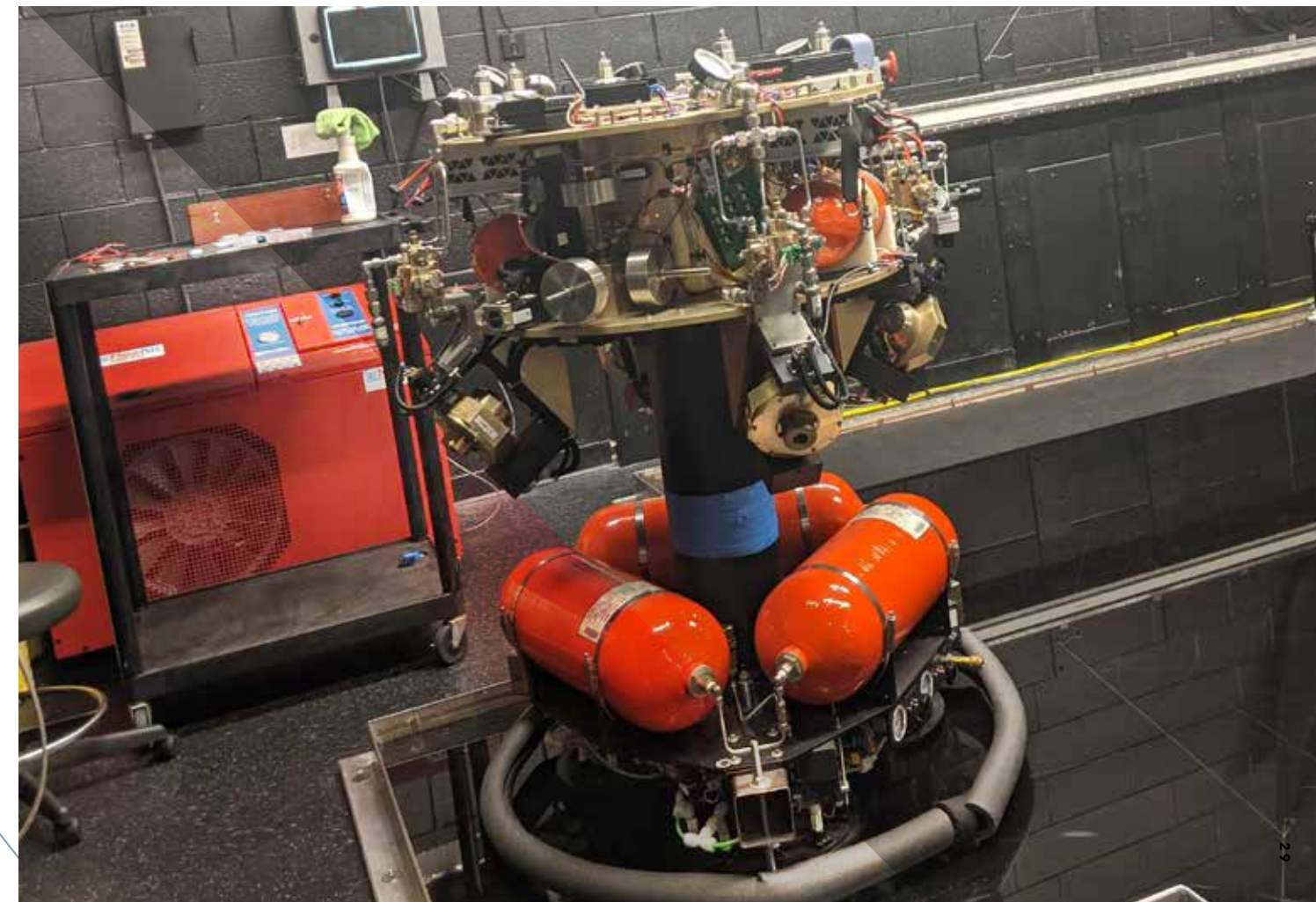
He gestures to a simulation of a tensegrity planetary lander, funded by C-STAR and NASA. “It’s a series of carbon fiber rods that are interconnected, and the whole body morphs. It can absorb landing impact and it also enables you to roll with very low energy usage,” says Whitcher.

The lander could be used to drop objects such as sensors onto other worlds. Whitcher says that it could even house a rover that would shed the structure to continue its journey.

“They have Vicon markers on every joint,” says Whitcher, “and that enables them to actually see the deceleration, and therefore how much energy is getting dissipated throughout the impact.”

For more on how Vicon systems are facilitating extraterrestrial travel, see our feature on Frances Zhu’s project applying machine learning to autonomous rover operations. For more on Georgia Tech’s innovative uses of motion capture, see our piece in The Standard 2020.

“Right now, they’re doing a photogrammetry project. They have a fake asteroid in there that is mounted to another robot arm, and that asteroid rotates and moves around the space.”





# A NEW LANGUAGE OF MOTION CAPTURE

KARA IS CREATING SIGN LANGUAGE AVATARS THAT COULD SAVE LIVES

Photo credits: Alingo Loh



Arash Tayebi,  
Co-Founder and  
CEO of Kara

"Kara started with a core vision to improve the access of the Deaf community to the incredibly broad range of information, content and services around the world," says Arash Tayebi, Co-Founder and CEO of Kara.

That vision was born after Tayebi was diagnosed with Menieres, a condition that caused him partial hearing loss, and he became aware of the access barriers faced by deaf people in education and across other walks of life.

"Sign language is the primary language of the Deaf people, and it is a moral and sometimes legal obligation to provide access to signed content," Tayebi says. "Our team's focus is to change the perspective of how avatars are used in movies, dancing, sports, gaming, and advertisements.

"We use the world's leading software and hardware technologies, combined with our in-house capabilities, to deliver high-demand, broadcast-quality translations in any signed language using digital avatars."

Kara operates Vicon Vero cameras with Shōgun, using the data to animate

avatars created with Epic's MetaHuman technology. "The input to our system is sign language gloss text. The output consists of individual motion-captured animations of each word that are smoothly blended together using Kara's proprietary algorithms," Tayebi explains.

## SUBTLETIES OF EXPRESSION

It's important that sign language avatars are not only functional, but expressive and fluid. Failing to capture the nuances of human sign language interpreters in Kara's avatars would result in animations equivalent to the flat delivery of early text-to-speech software for those with hearing.

"To be able to provide our services effectively, the most viable solution is using motion capture instead of hand animation," says Tayebi. "Most importantly, to capture the nuances of sign languages, motion capture is of the utmost importance. It's essential that it's reliable and extremely accurate.

"However, quite early on in our work, we realized the limitations of many off-

The coronavirus pandemic has shown how important it is for governments to be able to communicate quickly and clearly in an emergency. Tech startup Kara is using motion capture to make that communication faster and more accessible for the Deaf community.





the-shelf systems around the capture of nuanced body- and finger-movements. Vicon is the best motion capture technology for our requirements. It helps us capture the smallest motions of a signer with minimal animation cleanup needed."

The advantage of using motion capture isn't only the fidelity it offers. "Vicon provides us with the ability to produce content at a much faster rate and much more cost-effectively," says Tayebi. "With Vicon Vero cameras and Shōgun software, our process of animating our digital avatars is much more automatic.

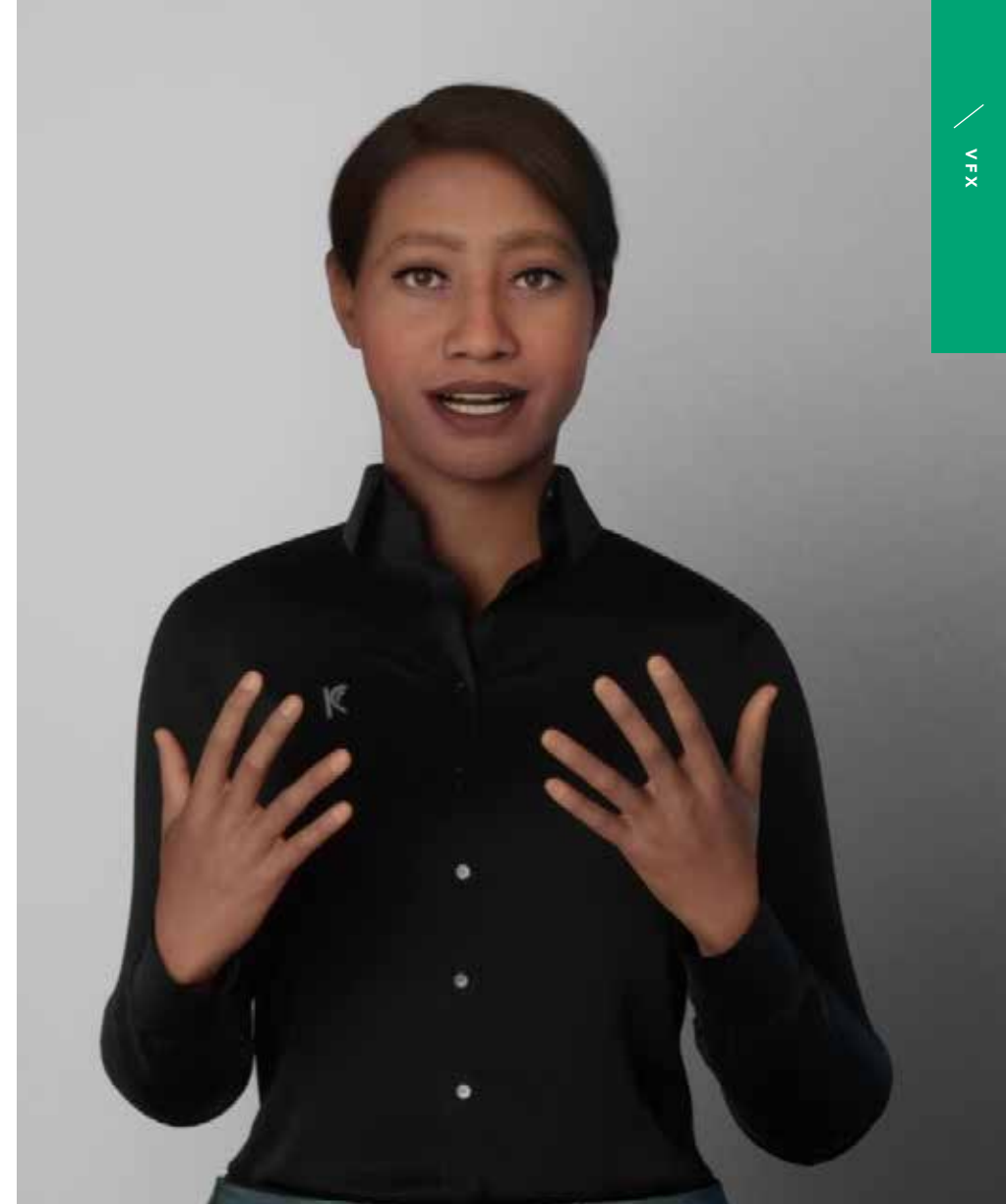
"We now rely much more on motion capture, whether for long pieces of content or individual words, and much

less on artistic interpretation to drive our avatars. This means that our avatars will be much more true-to-life and the sign language content produced will be of a higher quality. We can most definitely stand by the statement that these are hyper-realistic digital avatars/humans."

#### PRACTICAL APPLICATIONS

At the moment Kara has two main applications for its technology: producing signed versions of children's books such as a New Zealand Sign Language (NZSL) translated version of *The Very Hungry Caterpillar*, and sign language emergency notification messaging systems in the US and New Zealand.

"Vicon is the best motion capture technology for our requirements. It helps us capture the smallest motions of a signer with minimal animation cleanup needed."



"In an emergency situation, whether it is a natural disaster such as a tsunami, or a police alert, it's very important to send the messages out to all receivers in a timely manner," explains Tayebi. "Most emergency notification systems currently heavily focus on audio alerts. In some instances they involve text-based alert systems, which incorrectly assume a certain level of text-based comprehension by the Deaf.

"In the case of emergency situations, speed is of the utmost importance. We have worked alongside the Deaf community and have developed a system where a sign language avatar is able to deliver an emergency text alert accurately in sign language in a matter of minutes, without having to rely on the delayed availability of interpreters in the crucial moments after a disaster occurs.

"For scenarios such as emergency alerts, a message in a signed language can be sent out in a matter of minutes."

Kara is currently in talks with a number of governments at both local and national levels, working with them to integrate their technology into pre-existing emergency alert systems. Soon, it could be saving lives.

While Kara needs government buy-in, however, the company's most meaningful conversations are with its most important stakeholders: the Deaf community.

"Sign language belongs to the Deaf community and they have the right to create and work with the technology to ensure accurate translations," says Tayebi. "The best way to do something for a group of people is to have them be involved at every point in the process, and the Deaf community is no exception to that. Co-creation is an important part of creating something that will make an impact."



# WIZARDS AND UNICORNS, THE WONDERFUL NEW WORLD OF XR

CCIXR BRINGS TOGETHER A  
HIGH-TECH PLAYGROUND FOR  
IMAGINING THE FUTURE OF VR  
AND AR



Courtesy of RSC

In the world of education, motion capture is increasingly breaking out of animation, VFX and game design departments and being put to work in an ever-growing raft of other disciplines. At the University of Portsmouth, the Centre for Creative and Immersive Extended Reality (CCIXR) is getting several steps ahead of the trend by incorporating a dizzying array of technologies into a single facility for exploring the future of XR.



Trevor Keeble,  
Executive Dean  
of Creative and  
Cultural Industries,  
University of  
Portsmouth

Trevor Keeble, Executive Dean of Creative and Cultural Industries at the university, says that when he joined his department several years ago, it was already clear that the school of creative technologies had a deep specialism in motion capture and other departments were taking notice. He began having conversations about how his team could focus that growing connectivity into a bigger project.

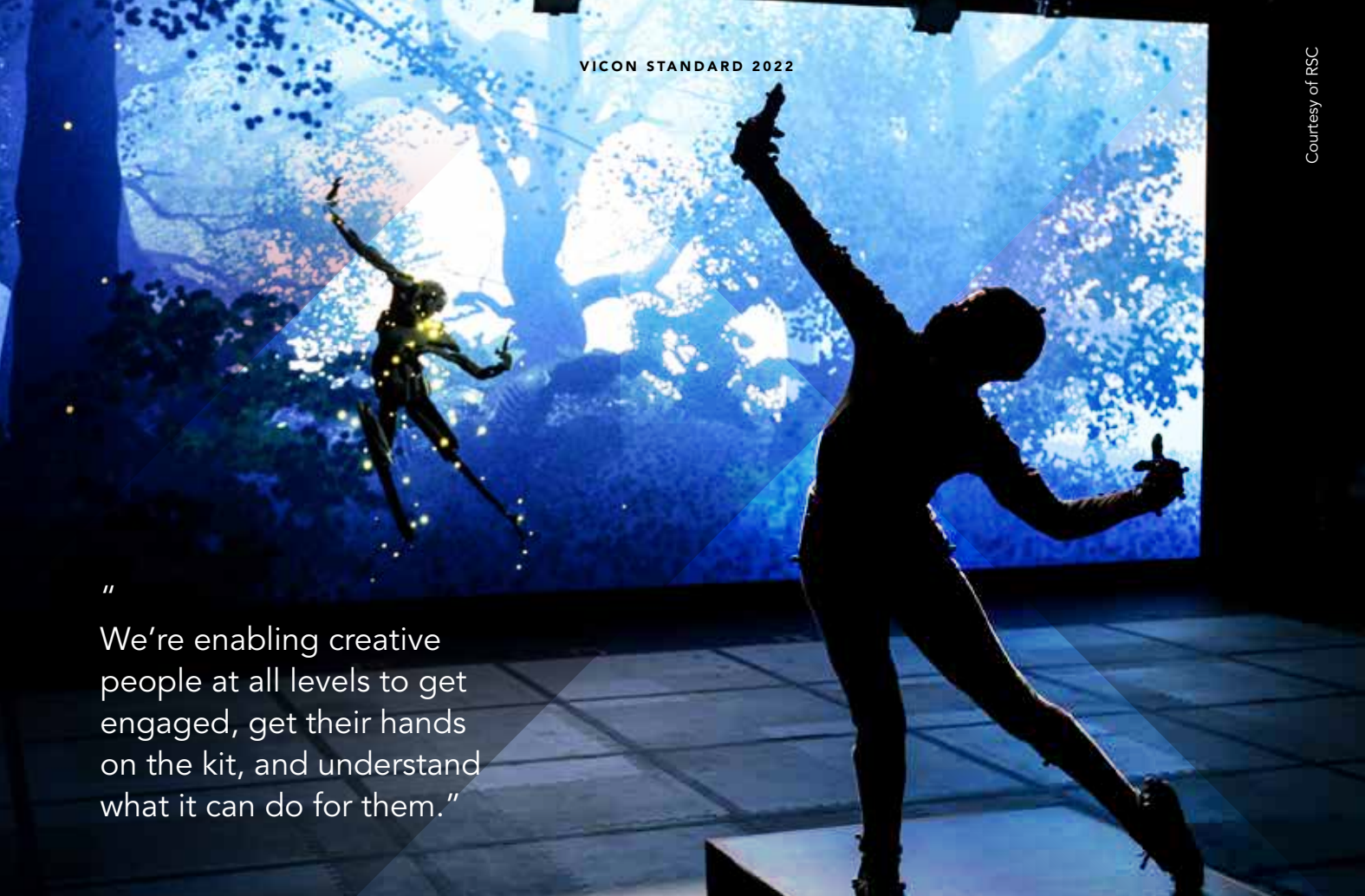
"The really key thing for me about CCIXR, and I think it's key to the nature of the faculty as a whole, is that we're at our best when we're working in partnership with industry," says Keeble. "Although we emerged from the creative and media industries and that's where our technical expertise has come from, we actually have real skills in taking it cross-sector."

That thinking ultimately led to the creation of a new facility, opening in early 2022, that houses a war chest of technologies associated with virtual and augmented reality or, as they're increasingly being referred to, extended reality.

The center will act as both a teaching facility for students and an XR R&D resource for industry, establishing the Solent region as a hub for immersive media.

The backbone of the center will be the technology that ties all the other disciplines to each other and to the physical world — its Vicon motion capture system.





Courtesy of RSC

“We’re enabling creative people at all levels to get engaged, get their hands on the kit, and understand what it can do for them.”



Alex Counsell,  
Faculty Technical  
Adviser for Creative  
and Cultural  
Industries,  
University of  
Portsmouth



Pippa Bostock,  
Business Director  
for CCIXR

## THE TECHNOLOGY

“It’s an extension of what I’ve been doing in the mocap studio for years,” says Alex Counsell, Faculty Technical Adviser for Creative and Cultural Industries and the man responsible for designing the center.

“It all started with the widening use of our Vicon system, especially real-time technology. We were doing more and more virtual production within the mocap studio, and we were using VR to enable that. And all of a sudden, all of this cross-pollination with different technologies was happening. We’ve always been aware of the wider pipeline of technology outside motion capture to feed content in and drive content with motion capture.

“So that was really the thought process behind it, building this end-to-end pipeline. We can capture people and performances, we can scan, we can do it live or pre-recorded in various formats, we can then explore how people interact with that through headsets, through screens, through LED walls. We can examine how you interact with that as a user, then how you realistically deliver that technology to a performance and a usable space.”

To that end, CCIXR has acquired a set of Vicon’s Vantage cameras for its main volume, with additional sets of Veros for smaller pop-up stages, and two Origin systems for location-based VR.

Alongside the tracking systems will be an impressive set of related technologies, including systems for volumetric capture, photogrammetry and spatial computing, a VR lab, development bays, simulation facilities, a mixed reality tech lab, and an immersive communication space.

“It really is the Swiss Army knife of kit that we’ve got,” says Counsell. “Mocap is a key tool, but it has so many crossovers. It’s like the thing you couldn’t do without in your toolbox. If you want to move something within an XR space, you need to track it.”

While motion capture might be the key tool, it’s the way it will interact with the other technology that will make CCIXR special.

“You don’t find studios that have all of that kit together,” says Counsell. “You go to a scanning company to scan your actors, you go to a volumetric company for that, you go to mocap studio to do this. So to have that huge selection of

tools in order to explore what they can do in combination is a really exciting prospect.”

## BRINGING CCIXR TO NEW USERS

While CCIXR won’t officially open until next year, the Creative and Cultural Industries department has already begun applying the center’s tools to a range of different challenges. The most high profile was the Royal Shakespeare Company’s production of *Dream*, a live event inspired by *A Midsummer Night’s Dream* that blended performance capture with a computer-generated environment.

Other projects have included immersive street art; scanning, LIDAR and 360 degree videos of sculpture by *My Dog Sighs* for the production of a VR version of an exhibition; and even an immersive simulation with a motion platform that the Royal Navy is using for training sailors to pilot one of its ships.

One of the themes that runs through the entire project is cross-pollination, whether that’s from bringing together technologies in new ways or from introducing different people and organizations to the world of XR.

“The fact that we’re working cross-sector is really important because we can take the learnings from the theater world and apply them into, for example, the medical world, and vice-versa,” says Pippa Bostock, Business Director for CCIXR.

“Everyone from the Royal Navy through to a local startup SME in the health sector can come to us and say,



‘Can you explain to me more what this technology is, or how I could use this?’ We’re enabling creative people at all levels to get engaged, get their hands on the kit, and understand what it can do for them.

“We all forget, because we work and live in this wonderful world of XR technology, that there’s a huge percentage of the business market that has no concept of what this technology is, what it can do for them, and how it can help them. The key to CCIXR is that we want businesses and organizations to give us actual challenges. And then we can show how these technologies can be applied to have real-world impact.”

## AN OPEN-ENDED APPROACH

Counsell emphasizes another core aspect of the center’s philosophy: play. “Having that chance to play and experiment is really important,” he says, “because that’s when these

happy accidents happen. You didn’t realize by doing one thing with a bit of technology that, all of a sudden, something magical happens. And it spawns a whole new direction of exploration.”

CCIXR’s leaders hope that the center will be able to bridge the perceived gap between creative and technical disciplines. “Our work is creative and technical,” says Keeble. “From an educational perspective, it’s very important for us to make that point, because the debates currently in the education sector are all about this kind of polarization of STEM and creative courses. Our experience, and the proposition at the center, is that actually, creative industries will bring value to anything in any industry. The creative and the technical are fundamentally linked.

“Historically, there’s a bit of a tendency for the modes of technology to dominate creative processes, but I think we try at all times to be really respectful of other people’s practices. When you’re walking into the RSC, you’re really not allowed to dominate their practice because they’re the RSC!”

It’s a point that comes up more and more often among Vicon customers — motion capture technology has become user-friendly enough that using it is now less about deep technical knowledge than it is about creative and innovative outputs.

Or, as Bostock puts it, “The best technology disappears. It just gets lost in the magic. I’m very lucky, I get to work with wizards.”







Dr Jacqueline Alderson,  
University of Western  
Australia



Dr Stuart McErlain-  
Naylor, University of  
Suffolk, UK



Dr Laura-Anne Furlong  
University of Limerick,  
Ireland



Dr Helen Bayne  
University of Pretoria,  
South Africa



Dr Lanie Gutierrez-Farewik,  
KTH Royal Institute of  
Technology, Stockholm

New motion capture technologies such as inertial and markerless tracking are opening new frontiers in biomechanics, while core optical solutions are evolving rapidly and consumer-grade devices are bringing big tech into the field. Vicon convened a panel of leading biomechanists to discuss how these changes are affecting their work, and the importance of lab-based, research-backed optical capture to ground new developments.

For some of the panelists, recent leaps forward in motion capture have been transformational. "We're very heavily reliant on some new developments in high-speed motion analysis systems," said Dr Laura-Anne Furlong of University of Limerick, Ireland, who is currently studying plantar flexor mechanics and the mechanics of the lower limb.

"You simply couldn't do that work manually. Even using older camera systems or older software processing, you couldn't do that type of work. So our work is very dependent on the technology we've developed in-house or procured from the likes of Vicon."

There was a consensus among the panel, however, that researchers shouldn't pursue a route of inquiry simply because technology enables it. "It was trained into us by Professor Bruce Elliot and others that we should only ever use tech to inform research questions, never to drive them," said Professor Jacqueline Alderson of the University of Western Australia.

"Most of the uses of machine learning at the moment in terms of motion capture are pose estimation techniques that essentially reinvent what we



did 30, 40, even 50 years ago. So what we are doing right now is creating tools that reduce our labor," Alderson added.

Rather than dictating research routes, says Dr Helen Bayne of the University of Pretoria, South Africa, technology is allowing researchers to approach existing routes from new angles. "The starting point is still asking good research questions, but the advances in technology are definitely enabling us to approach those research questions in different ways.

"Especially changing the things that we can measure accurately, and I think, changing the different environments that we can measure those things in, and how we can assimilate different data sources," said Bayne, who is researching sports performance and injury mechanisms.

# LAB-BASED OPTICAL MOTION CAPTURE IS OUR GROUND TRUTH

Biomechanists discuss how new  
technologies are changing their field



## THE ENTRY OF BIG TECH

While the panelists enthused about the possibilities offered by new technology from established motion capture companies such as Vicon, they expressed trepidation about the increasing encroachment of big, non-specialist tech companies into biomechanics.

"Researchers are under increasing pressure to collaborate with industry," said Alderson, whose current main focus is on using machine learning to enable lab-grade insights in the field. "I hear a lot of them saying 'that's good enough. That's close enough'. And unfortunately, it's not close enough. Because a commercial entity has different drivers and needs to monetize their data, they might be happy with data that's 60% accurate. It's a long way from what our profession should be looking to give back to someone, especially when we're talking about clinical and sports populations.

"It's not about just sending out smartwatches to the general consumer health and fitness sector. It's about dealing with real populations that

have marginal degrees of sensitivities that we need to be able to inform, because the real importance of our discipline is the people, and how we talk to people, how we translate the meaningfulness of that data, how we contextualize it. Technology can't replace that."

"From a public perspective, it increases the importance of our science communication," agreed Dr Stuart McErlain-Naylor of the University of Suffolk, UK. "It's not that this tech is good and this type is bad. It's asking what are the positives and negatives? What are the limits?"

Professor Lanie Gutierrez-Farewik, of KTH Royal Institute of Technology, Stockholm, said that biomechanists should take the lead on how such tech is used.

"We as scientists can help determine precisely under what conditions data is accurate or valid enough," said Gutierrez-Farewik, whose work examines the link between underlying function and motor performance in walking. "The consumer technology companies aren't going to draw that line for us."

"The panelists enthused about the possibilities offered by new technology from established motion capture companies such as Vicon."

McErlain-Naylor, who is currently exploring sporting technique in his research, added a note of optimism about possibilities opened up by the sheer volume of wearable activity monitors out in general populations. "In terms of big data, so many people all over the world are wearing these devices 24/7, and so there are now these huge datasets of physical activity from people in various populations. If researchers are able to tap into that, I think that could open up some interesting avenues for research."

"As long as we can accept that there's a pretty big margin of error, as long as the right question allows for that, the possibilities are huge. But the question needs to be relevant," said Gutierrez-Farewik.

### 'GROUND TRUTH'

The panelists stressed that each new development, whether it comes from an established motion capture company or a consumer brand, needs to be grounded in clinically-validated data gathered in a lab setting.

McErlain-Naylor warned of a potential rift in the field of biomechanics. "Your theoretical computational biomechanics will become more and more computationally advanced and more theoretical, but then you could have another branch of biomechanics moving in the opposite direction and getting quick and easy results in the field," he speculated.

"I think the challenge becomes bridging the two, and taking the theoretical advances and making sure they're actually applied out in the field; essentially that the two sides are still linked together and informing each other as one field," said McErlain-Naylor.

"There's always going to be a place for lab measurements," Gutierrez-Farewik agreed. "But there are, of course, more and more questions and applications for outside the lab, whether it's with wearables or markerless. That's just exploded over these past few years. It's tempting to hope that that's a holy grail, and you won't need labs anymore. But it's really important that we analyze and understand how much we can trust this data. And that's a huge technical challenge."



Alderson went a step further, saying that it's important to consider not only the validity of data collected with new technologies, but also whether the measurements are the ones biomechanists really want.

"I think there will always be a place for lab-grade data because it's our ground truth," Alderson said. "What I'd love to see is tools to bridge that lab/field nexus. But that doesn't mean that we create tools that just allow us to collect surrogate measures to stand in for what we really want to collect in the lab."

Alderson said that she wants to see measurements taken in the field that truly replicate those that can be taken with an optical system, but that for the moment that data remains locked in the lab.

In other words, while new technologies continue to open up new possibilities for study in biomechanics, they can't replace the power of lab-based solutions, which remain essential as the gold standard in motion capture.

I think there's always going to be that place for lab-grade data collection," concluded Furlong. "I think that you're always going to have to have a lab-based setting to compare new technologies back to."

**For more on the current state of biomechanics, see Vicon's panel discussion on our YouTube channel.**

"While new technologies continue to open up new possibilities for study in biomechanics, they can't replace the power of lab-based solutions, which remain essential as the gold standard in motion capture".





VICON

# ICONS

MEET THE NEW FACES ON  
THE VICON TEAM

2021 saw a number of exciting additions to the Vicon team, get to know them...



**Marisa Loo**  
VFX Applications Engineer

**Where are you from?**

I am from Thousand Oaks, California, just north of our LA office. I am very happy to be back in Southern California after stints on the East Coast and Midwest for school.

**Background before Vicon**

My educational background has been primarily in the life science side of motion capture – I became interested in sports biomechanics during my undergrad which propelled me to pursue a master's in biomechanics. Since then, I've worked as a movement specialist using the Functional Movement Screen and most recently as an adjunct professor in biomechanics at Pepperdine University. Throughout the last fifteen years, I've also been a head field hockey coach at Chaminade High School, for the Moorpark Coyotes Hockey Club, and for the US Field Hockey Futures program.

**Favorite part of your new role?**

I absolutely love the people I get to work with at Vicon – each and every one a stone cold nerd. I truly feel like I've found my people and am so grateful for everyone's willingness to help me learn and transition to motion capture on the entertainment side of things. I have also had a massively fun and confusing time learning all of the things that go with the entertainment side of mocap – 3D software and all things virtual production. It has been amazing to visit some of our customers on-site who have massive LED wall volumes – it's been an eye opening experience to see the magic behind the scenes first hand.

**Interesting fact**

Although my most recent education has been in sports biomechanics, I originally started with an aim to pursue graphic design. I never in a million years would have thought that I would find myself in a position that unites my interests in the arts along with my fascination with motion capture.



**Connor Shellis**  
Game Engine Specialist

**Where are you from?**

I'm from Plymouth! I've spent most of my life in Devon so moving to Oxford has been a great adventure.

**Background before Vicon**

I'm a recent graduate from University of Portsmouth and I studied Computer Games Technology. During my time at University of Portsmouth I worked in their motion capture studio where I first fell in love with motion capture and learnt a lot in a short period of time!

**Favorite part of your new role?**

My role involves working with all the departments within Vicon, the team really know their stuff and it's been great to learn from them and work together. I love that each day I get to work on new and exciting technology and help to create content for showing off these technologies.

**Interesting fact**

As a graduate I feel very lucky to be in this role and have found a place within the team here where I feel I can apply my knowledge and help to improve our work here. In my spare time I enjoy my original passion that led me to this point, which is playing video games!



**Pablo Callejo**  
Strategic Business  
Development Director

**Where are you from?**

I'm from Pamplona, Spain. I completed my MSc in Telecommunications Engineering at the University of Navarra, where I wrote a Masters' Thesis on wireless communication protocols and completed several internships on computer graphics.

**Background before Vicon**

After gaining managerial experience both in Spain and Singapore I joined motion analysis company STT Systems in 2012, taking on the roles of Sales Manager, Motion Capture Division Manager and finally Managing Director, conceptualizing and commercializing several innovative solutions for motion analysis.

**Favorite part of your new role?**

Being part of the sensational family at Vicon. The more I get to know my new colleagues, the in-house expertise and existing solutions, the more excited I become about the endless possibilities of this great project.

Motion Capture is fascinating and one of those rare technologies that enables the creation of stunning, visual contents, but at the same time helps improve people's lives through research and biomechanical analysis. And my fascination has grown over the years - Motion Capture is to me a magical blend between cutting-edge tech and powerful, practical applications.

**Interesting fact**

Despite a purely technical education, I love creating products, coordinating teams and coming up with cool, genuine solutions, digital painting, graphic design and hand drawing.





**Carlie Ede**  
Customer Support Engineer

**Where are you from?**  
I am from Sydney, Australia! I moved to the UK in 2014 to begin my university study.

**Background before Vicon**  
Before joining Vicon I completed my MSc in Sports Biomechanics at Loughborough University. I am also currently writing up my PhD (in Sports Biomechanics also at Loughborough) titled the Mechanics of Hamstring Function in Sprinting, where I am building a musculoskeletal computer model in OpenSim to investigate hamstring injury and sprinting performance.

**Favorite part of your new role?**  
Everyone I've spoken with has been incredibly supportive and made me feel welcome straight away into the Vicon family! I have learnt so many new things, even in this short period of time and the opportunity to visit new places in the UK and (hopefully) further afield is a definite highlight.

**Interesting fact**  
I went to a performing arts high school and have a background in dance and artistic gymnastics, I almost became a pastry chef (bit out of practice though) but broke my foot and ended up at university instead.



**David Edwards**  
VFX Product Manager

**Where are you from?**  
Born and raised in Staffordshire, UK where I also attended University. I graduated with a First Class BA(Hons) in Multimedia Graphics in 2006, with a focus on visual design and immersive environments.

**Background before Vicon**  
In the years following University I worked in online retail before moving to South Africa to focus on white shark research. In both positions I was balancing a mix of creative design, product/service development and team management. I maintained a freelance design business during this time so I could undertake more varied challenges on the side, keeping my skills and knowledge of the industry up to date. A couple of years after moving back to the UK a position at the University where I studied became available, providing technical support to the games art and design courses. Before establishing their suite of laser scanning and 3D photogrammetry facilities, I renovated their motion capture stage which introduced me to the Vicon family. In early 2021 I felt the need for a fresh challenge, Vicon was one of the first places I looked at and fortunately for me, the role of VFX Product Manager was being actively recruited for.

**Favorite part of your new role?**  
There are various aspects I enjoy, such as seeing software features grow from ideas into tangible products, connecting with customers to learn about their challenges and then having direct input on work that will ultimately address those challenges. Above all though, my favourite part has been the exposure to the raw competency of the team here. Every single person I've engaged with has demonstrated a consistently high standard of expertise and expectation. This was quite daunting initially, but as I've gotten to grips with the role it's given me a great deal of confidence and incentive to ensure I deliver on my responsibilities to the same standard.

**Interesting fact**  
When I'm not at work, irritating my other half, researching marine predators or experimenting with visual design, I play drums in a band that I like to think have given audiences an entirely new appreciation for the value of silence.



**Andrea Rivera**  
Application/Test Engineer

**Where are you from?**  
I'm from the surf city! San Salvador, El Salvador.

**Background before Vicon**  
It is through dance that I became interested in Biomechanics (Kinesiology). I was a Research and Teacher Assistant at the University of Illinois at Urbana-Champaign. There, I received an M.S. in Kinesiology. Before that, I worked as an Operations Manager in Chicago and taught dance and yoga.

**Favorite part of your new role?**  
There are many things I like about this job but if I only need to name one: the team.

**An interesting fact.**  
I enjoy drinking coffee with good company and I love playing tennis and bouldering.



**Howard Abrahall**  
Senior Product Manager

**Where are you from?**  
I'm from Wantage, in South Oxfordshire. I completed a BA (Hons) in Computer Games Art at the University of Teesside in 2008. I wrote my dissertation on the use of reactionary animation in real-time gameplay scenarios - making heavy use of MoCap and considerations of where the future of game AI would go. I specialised in both motion capture animation and 3D environment art for games.

**Background before Vicon**  
Substantial and varied. I worked in each area of the games industry as an artist, designer and animator – AAA, Indie, Edutainment/Serious games, research projects, and my own mobile apps. I moved to Belgium in 2010, progressed into multimedia work, and picked up roles as a product specialist and project manager in my own lab that I planned, built and operated. I also founded my first business whilst there. On returning to the UK I started a new company, and contracted for major media and VFX groups with a lot of work on app based VR, as well as developing my own content creation projects. I progressed through roles of technical project management, product ownership and finally product management.

**Favorite part of your new role?**  
There's several. Vicon has been a place on my professional radar for a long time, and I'm delighted to have finally landed here. Just being here at the company who are the byword for MoCap quality is great. All my new colleagues have been extremely welcoming; I feel right at home and enjoy coming to work. I've always loved MoCap since I first started working with it in 2006, so getting to work on its integration with Virtual Reality is amazing. The field of VR is growing exponentially, and is full of possibilities, risks and creative potential. Being in a position to shape how Vicon will approach these opportunities and challenges is really fulfilling.

**Interesting fact**  
When I'm not navigating the market of cutting edge technical products, I enjoy a good bit gaming and making online content. I periodically try and fail to snowboard competently. I still keep up with doing traditional and digital art, and am a keen – though currently lapsed – guitarist and gym rat.



**Louis Cicchino**  
Life Science Support Engineer

**Where are you from?**  
I am originally from Pittsburgh and have now lived in Denver for more than half of my life.

**Background before Vicon**  
Before joining the Vicon team I spent time training/racing on the Team USA Triathlon team, which led me to run an endurance coaching business. I pursued my Masters in Biomechanics to advance my understanding of human movement as a coach. During my studies I initiated a collaborative project with the athletic department to provide biomechanical analysis, using Vicon MoCap technology, of the volleyball team which successfully lowered the prevalence of lower extremity injuries during the season. This project has since been adapted to include the mens and womens basketball team, with the ultimate goal of leading to a longitudinal study of multiple cohorts of student athletes. I have also worked with the Ultimate Fighting Championship (UFC) as a Sport Scientist using their Vicon system among other technologies to analyze and assess fighters for their preparedness & readiness in/ out of fight camps in preparation for upcoming bouts. I continue to be passionate about sports, and improving athletes by continuing online coaching while in my position at Vicon.

**Favorite part of your new role?**  
I love to hear about the unique projects each customer is researching and how they are using Vicon MoCap technology.

**Interesting fact**  
I am a National Strength and Conditioning Association (NSCA) Certified Strength & Conditioning Specialist (CSCS) and am currently studying to become a NSCA-Certified Performance & Sport Scientist (CPSS).



**Haley Muller**  
IMeasureU Business Development Manager

**Where are you from?**  
I grew up in Windermere, FL (near Orlando) and lived in Texas and Mississippi before moving to Colorado a couple years ago.

**Background before Vicon**  
I was a collegiate athlete at Mississippi College before going on to get my M.S. in Biomechanics from University of Northern Colorado. I worked at a sports recovery facility for a couple years where I helped people from all backgrounds -- high schoolers to weekend warriors to professional athletes -- with rehab from minor injuries and use of recovery equipment usually only available to elite athletes. I also spent a couple years working in sports research where I was involved in projects like the biomechanics of alpine skiing and the development a markerless motion analysis system to analyze a golf swing.

**Favorite part of your new role?**  
My favorite part of my new role is that I get to meet and build relationships with all types of cool people and get to build awareness for the amazing products. I am confident that technology is the way forward for human health and performance and I enjoy getting to share that passion with others.

**Interesting fact**  
When I'm not working, you can find me playing slowpitch softball (or any other sport, I like to pretend like I'm not a washed up athlete), paddleboarding, or hiking in the summer months and snowboarding or missing the warm weather and beaches of Florida in the winter.



# PLEASE MEET

## OUR NEW LIFE SCIENCES PRODUCT MANAGER FOR THE AMERICAS



Dr. Felix Tsui,  
Life Sciences Product  
Manager for the  
Americas

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One day, I got a call because James May (formerly of Top Gear) was wanting to film an episode of his then-show called ‘Man Lab’ in our sports hall.”

After 8 years on the Vicon Support team working directly with our customers, Dr. Felix Tsui transitioned in 2021 to a new role as Life Sciences Product Manager for the Americas. We caught up with Felix to learn more about his background and next steps as Product Manager.

### 1. Where did your interest in biomechanics and motion capture begin?

Midway through my undergraduate mechanical engineering degree, I saw a short video clip of a baseball pitcher wearing reflective markers and being tracked by cameras. Researchers were trying to explain what made this pitcher so unique and effective. From that point forward, I knew I wanted to be involved in this field. I finished that degree and the rest is, as they say, history.

### 2. What did you do before joining the team at Vicon?

I had just finished a Post Doc at Loughborough University in the UK where I had also completed my Masters and Ph.D.

When I was doing my Ph.D., I considered myself the “Vicon guy” in my department. One day, I got a call because James May (formerly of Top Gear) was wanting to film an episode of his then-show called “Man Lab” in our sports hall. James wanted to do an analysis of the soccer/football penalty kick and called upon our biomechanics and sports technology expertise to help. I went down to the sports hall, set up our Vicon system and tracked James as he attempted his penalty kicks. I got about 3 seconds of TV time as it showed me processing his data. It’s funny, I still get random messages from friends new and old who view that episode for the first time and ask “Was that you?”.

### 3. What are you looking forward to in your new role?

I look forward to continuing to guide our products and help create applications that are not only extremely useful and powerful, but intuitive and efficient. On a personal level, I am eager to learn how to bring a product to market and be a part of all the nuanced conversations that go

along with it – whether it be with our own teams or with our customers. I come from a research background, so I am also eager to use that curiosity to help drive our products forward.

### 4. How has your role on the support team affected your approach to the new Product Management position?

I think a critical component of Product Management is knowing the users and understanding their use cases and pain points. Having completed roughly 200 site visits in my 8.5 years on the support team, I have seen my fair share of labs – from capture volumes as small as a closet to ones spanning an entire basketball court, from rats to UAVs. When it comes time to curate a product for our customers, having this first-hand knowledge and experience is invaluable.

### 5. What does a typical day look like for you?

The Vicon Head Office is located in the UK, so this means a lot of early starts to make sure we can fit in our cross-team meetings and coordination. As those wrap up by mid-morning, I’ll start tackling my personal tasks. Depending on where we are in a product cycle, I’ll either be writing or reviewing requirements for a feature/product, feature testing, or creating/reviewing product documentation (e.g. user guides). We’ve been producing quite a few webinars and virtual conference presentations recently so I’m often busy preparing, recording or editing those materials. What I find most invigorating about being in Product Management is that on a daily basis, there are multiple opportunities to put on a different professional hat. Some days, I’ll be speaking to customers or meeting with our marketing team to strategize our next launch, while others are spent sitting down with our lead developer to review our backlog of bugs and feature requests.



# ARMOR LAB IS USING MOTION CAPTURE DATA TO DEVELOP NEXT-GEN WEARABLES

VICON'S LOCK LAB IS THE  
NETWORKING TOOL MAKING  
IT POSSIBLE

Photo credits: Alingo Loh



Professor Ken Loh,  
Director of ARMOR Lab

Sometimes the challenge inherent in a motion capture project isn't the tracking itself – it's integrating every other data source into your digital ecosystem. The ARMOR Lab at UC San Diego is currently working on a new, potentially life-saving sensor technology that might not be possible without the use of Vicon Lock Lab to synchronize the project's complex data streams.

The ARMOR Lab at UC San Diego was founded by Professor Ken Loh with a mission to develop materials, technologies and algorithms that can be used to protect and enhance the performance of both physical structures and the human body. The Lab acquired its Vicon system using funding provided by the Defense University Research Instrumentation Program (DURIP) and the Office of Naval Research (ONR) in early 2021. It had a very specific purpose in mind – to develop a low-cost, wearable sensor that can measure human performance over long periods of time.

"I've been working closely with the Office of Naval Research on various topics related to how to better protect and monitor the health of the warfighter, the soldier, in all sorts of scenarios, especially when they're deployed," explains Loh.

"We're developing these sensors based on fabric that could be affixed onto different portions of your body to measure how your muscles engage during different types of movements or training activities."

While the current main focus of the research is soldiers, ARMOR Lab is also working on other applications for the technology, for athletes and the general public.

The benefit of such a system is twofold, says Loh. "By knowing how people move, you can begin to assess their physical health and set up a performance baseline. That information can then be used to understand how people are performing those certain activities to help them increase their performance, so that they become more capable at whatever skill they're trying to develop, whether it be throwing a baseball, shooting a rifle, running faster, etc."

Furthermore, having that baseline data will enable users to pick up on any changes that could indicate an injury. "You can now potentially intervene in a timely fashion to prevent something catastrophic from happening," says Loh. From there, he anticipates being able to use data gathered during recovery to assess how well rehab exercises are being performed and potentially find improvements that could speed up recuperation.

"You can now potentially intervene in a timely fashion to prevent something catastrophic from happening."



Photo credits: Alingo Loh



## AN EVERYDAY SENSOR

A key aspect of these wearable sensors is their relatively low cost and unobtrusiveness. "Our hope is that these sensors will become standard issue," says Loh. They would be used not only in specialized environments or for time-limited assessments in the field, but as a matter of course during everyday operations throughout a deployment.

To keep the sensors both durable and affordable, ARMOR Lab, through funding support from ONR, had to find the right materials as well as measurements that they could take with relatively simple sensors. "The sensors, called Motion Tape, use elastic fabric tape, based on kinesiology tape that a lot of our athletes and tactical athletes wear from the injury prevention and pain mitigation standpoint," says Loh.

"We've built our sensing materials directly onto this tape. We're measuring skin deformation on the surface, and we're relying on those measurements to back-calculate what's happening."

The skin deformation, Loh says, indicates what's happening below the surface at the muscular level. Linking those measurements to global movements backed by trusted data is where ARMOR Lab's Vicon system, comprising 12 Vero 2.2s and a Vue camera, comes in.

"The Vicon motion capture plays a critical role in helping us understand how people move during those types of activities, but it also serves as a great reference and gold standard for us to compare our measurements to, and for verification and validation purposes," says Loh.

"We have these pieces of tape mounted at different positions such as the shoulders, the legs, the neck. We're collecting data from our tape sensors, and we stream the data through the Vicon Lock Lab. At the same time, we have markers all over the body and the camera is picking up the 3D positions of each of those markers to tell us how people are moving."

"We've built our sensing materials directly onto this tape. We're measuring skin deformation on the surface, and we're relying on those measurements to back-calculate what's happening."

## FILLING A GAP

The data from ARMOR Lab's sensors isn't just functioning as a stand-in for the sort of information you could get from optical tracking or an IMU, however.

"Technologies like motion capture give you very detailed information about how the body is moving in the sense of where your different limbs are, and where you are in 3D space," says Loh. "But what it doesn't tell you is how your body and specifically how your muscles are engaging to do the things that you're doing. Our goal is to fill that gap. So we're putting these sensors directly over major muscle groups, like your biceps, for instance, to see if your biceps are engaging and, more importantly, how much they're engaging to perform functional tasks."

To create a context for that data, ARMOR Lab needed a platform that could bring together a broad range of data sources. "I think one of the great things about Vicon is its versatility - not only being able to do what it's meant to do to capture the positions of the markers, but also being able to bring in a lot of different sensing streams, from all sorts of sensors," says Loh.

"Part of that challenge is learning how to do that. Especially if you're working with new prototype sensors, like we are. We have the IMUs from Vicon, but then we have EMGs that we're trying to stream at the same time, our own sensors, force plates — the list goes on and on. It becomes a little bit challenging to synchronize everything to make sure that the data that we're getting is not only high quality, but does not have any errors that are caused by the user."

That challenge made one feature of Vicon's ecosystem, in particular, a draw for Loh. "I think the biggest selling point is really the Vicon Lock Lab being able to connect with all sorts of different sensors, since our goal with using motion capture is not necessarily to do an in-depth study of the human body, but rather to look at what my other sensors are telling me combined with motion capture. That gives me a holistic view of the person's physical health or physical performance."

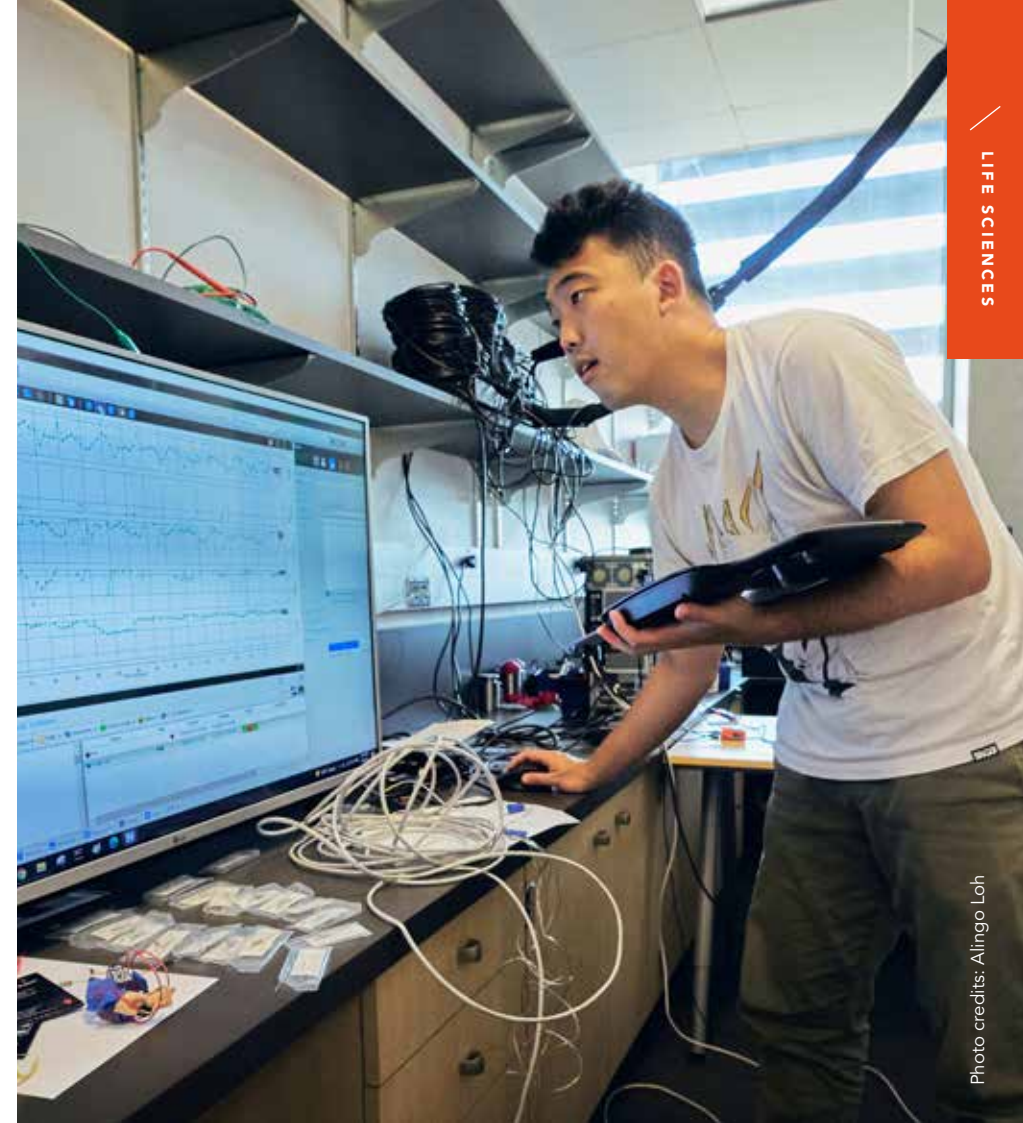


Photo credits: Alingo Loh

## PROOF OF CONCEPT

It's still very early days for the project, but Loh says that ARMOR Lab is already gathering valuable data. "It's been very insightful in terms of capturing the differences between untrained movement versus a trained athletic movement. They're pretty stark, and it begins to allow us to classify whether a person has been trained effectively just from the data. And what's kind of cool, too, is that we've been able to show that the sensors do in fact pick up how much your muscles engage, which I think adds another layer of depth in terms of the richness of information that you can capture."

Despite being in the early stages of the sensor project, Loh already has one eye on the future.

"I think, moving forward, we are looking to expand our lab. My vision from a research perspective is, we're getting all this great data on the human body. But really, how do you take all these different data streams and be able to holistically assess the person, and then take it further? And say, 'How do I predict performance?'"

"One of the bigger visions that we're working towards is creating a human digital twin. That's where I think motion capture and some of the new sensors we're developing, and what our collaborators are developing, will play a huge role."

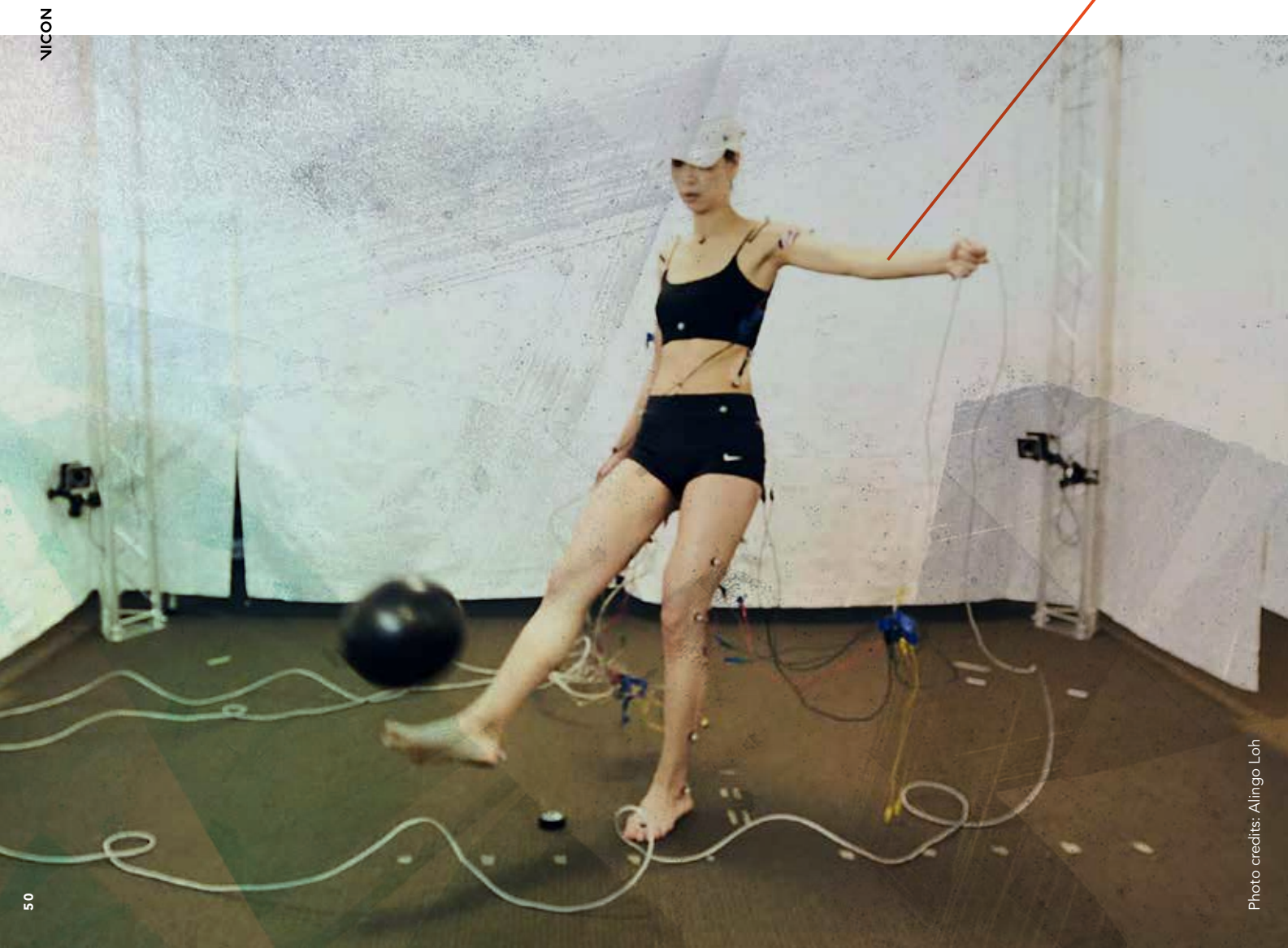


Photo credits: Alingo Loh



# THE ART OF DIGITAL PUPPETEERING

AMGI WANTS TO MAKE  
DISNEY-QUALITY ANIMATION  
IN REAL TIME



In the world of VFX, motion capture is conventionally viewed as a tool that's best suited for making live action film and TV. AMGI plans to turn that perception on its head by using digital puppeteering to drastically reduce production times in animation.



Colin Brady,  
Chief Creative  
Officer, AMGI

"I always joke that we try to be the SpaceX of animation," says Colin Brady, AMGI's Chief Creative Officer. "We want to just break whatever the system is, we want to fail as fast as possible so that we get our mistakes out of the way. We want to try something new every day."

Brady cut his teeth as an animator on the first Toy Story film for Pixar, going on to work closely with Steve Jobs and teams at Lucasfilm and Jim Henson's Creature Shop.

"In the early days I always found myself acting everything out with my body, using my video camera. I would sneak off to the bathroom because it had the largest mirror and I would plan out my shot. Even back then I thought, 'There's got to be a better way to do this,'" Brady says.

Brady's solution was motion capture, though the idea is not without its detractors. "They'd say, 'Motion capture, that's cheating'. Or, 'That's not for animation. That's more for live action'. And I think nothing could be further from the truth."

He found kindred spirits when he met Luke and Roger Paglia, now COO and CEO of AMGI, and the trio began the work of disrupting the way animation is created.

## DIGITAL PUPPETEERING

"What we're doing that's unique is focusing on puppeteering with non-human characters, retargeting human proportions to cartoon character proportions," says Brady.

The process uses Vicon-powered motion capture mixed with keyframe





“  
Technology  
inspires art, and  
art challenges  
technology.”

*John Lasseter,  
Chief Creative Officer,  
Pixar*

animation and processed using the render speed of Unreal Engine. The result is animated characters puppeteered by tracked human actors, dramatically reducing production times.

The bedrock of the process is AMGI's Vicon setup. “We have a beautiful stage that's about 20 ft by 25 ft with 16 Vero cameras,” says Brady. “They're great, we love the precision and they keep the calibration really well. I think it's my favorite stage I've ever worked with.

“Vicon, working hand in hand with some smart programming, really gets this process to stick together. If there are two lungs in the body of what we're doing, they're Vicon and Unreal.”

“What's so great about this system,” adds Luke Paglia, “is that you can put markers on anything and if you translate the data accurately in a creative way, you can do so much with it.”

## PUTTING THE SYSTEM TO WORK

AMGI has used this process to do work-for-hire for the likes of Coldplay and to rapidly produce a portfolio of its own IP, including a property coming soon to Netflix as a feature film.

AMGI also has an app, set to launch in 2022, that uses phone cameras to capture facial movements and then animates characters based on the data it produces. “Our goal is to create Disney-style, high quality characters that can work on an iPhone,” says Brady. “Essentially we pre-record a lot of motion using dancers on stage and we trigger that in a very smart way. I think we have the highest quality animation that's ever been put on an iPhone. We think it could be the TikTok of animation apps.”

While the technology is interesting in and of itself, it's the way that AMGI sees it impacting the animation

production pipeline and facilitates creativity that really excites Brady.

“Going back to Pixar days, we were lucky if we could animate four seconds a week by hand,” he says. “I've worked on shots for three weeks that were less than one second. I always look at that as a benchmark. Probably the largest portion of an animated feature film budget is how many seconds can be produced per week, per person. If you can turn those four seconds into 10 seconds, to 20 seconds, a minute, that changes everything.

“For live animation, a live TV show or an improv show, an animator could potentially do four minutes a week, and then you're animating an entire show in a week with five animators. It's crazy.”

AMGI even envisages using the process to sidestep platform holders such as the streaming services to reach audiences directly. “You could do a live show that streams on YouTube and reach 100 million people without having to worry about any distributors,” says Brady. “So we're really starting to get excited about bringing actors on stage and essentially doing live, SNL-style improv sketch comedy with our puppeteered characters.”

## HUMAN HURDLES

For all the technical challenges that AMGI has already overcome, it's the misperception of motion capture in the animation world that remains the sticking point.

“The biggest hurdle, to be honest, is that motion capture has always



been viewed as an icky technical thing by most traditional animators,” says Brady. “What it really takes is for the artists to embrace this. The scientists will never win by pushing this technology without the artists. But once animators actually get on stage themselves and they try it out, they get it. They see the efficiencies. They're hooked.”

Internally, AMGI already has an experimental culture that encourages animators to follow their curiosity. “We treat it like a big playground where, if you want to pick up a box and you want to start playing around with how you can capture and animate it, go play around! What's beautiful about it is the motion is high quality enough to be used for final production, but it's also inexpensive enough to experiment with,” says Brady.

For all the technical wizardry behind AMGI's production pipeline, everything comes back to that playful approach.

“Ultimately, what we're creating is memorable characters. All this is in the service of storytelling. What's exciting is that the more efficient you make the process, the more courageous you can be with the stories you tell. You don't have to wait for a studio to greenlight your show. You could say, ‘You know what, let's all come in on a Saturday and just do the movie.’”

Looking ahead, Brady has his eye on extended reality. “Of course, people talk about the metaverse. And yes, we're very interested in that. There's a lot of excitement there.”

It's telling stories that comes first, however. “Ultimately, I do think narrative is what drives culture,” says Brady. “I'm very excited about live cartoon animation, because I feel that we relate to it in a very basic way. I really do have a goal of making nothing less than Pixar- or Disney-quality animation that's done live, that no-one knows is motion capture. And I think we're getting there pretty rapidly.”





2021 marked yet another milestone in the Vicon story — the acquisition of CONTEMPLAS, bringing video-based movement analysis to the Vicon ecosystem. The move strengthened Vicon's core offering, extending market reach into Europe and opening up new possibilities and applications, such as swimming, thanks to markerless tracking.

CONTEMPLAS began life with a vision that runs parallel to that of Vicon, albeit with a slightly different target market. "The company was founded in 2005, by Thomas Seeholzer and myself," explains Stefan Klippel, Managing Director of CONTEMPLAS.

"The idea was to develop a piece of software that would provide a solution for applications such as running analysis, functional screening, posture analysis, gait analysis, bike fitting, and more. The market was users with limited time for the analysis and as such, needed software that guided them straight through the process," Klippel says.

Users in CONTEMPLAS's early days might have been gait analysts at a running store or a physiotherapist needing to do a quick analysis of a client's posture. More often than not, they had a business use for the software and needed a clear picture of what they could charge for it and how it would fit into their daily operations.

#### A FLEXIBLE SOLUTION

The result was TEMPLO. The software records and analyzes motion across a range of activities ranging from team sports, individual sports to swimming and beyond. It doesn't require specialist hardware and can run using a wide range of cameras.



## CONTEMPLAS BRINGS MARKERLESS TRACKING TO THE VICON ECOSYSTEM

INTRODUCING VICON'S NEWEST  
FAMILY MEMBER TO THE MOTION  
CAPTURE COMMUNITY





Stefan Klippel,  
Managing Director,  
CONTEMPLAS

## SPORT THERAPY

"We have a very strong expertise in video analysis and video technology itself," explains Klippel. "We can integrate with almost any kind of camera you find on the market, including those with either high resolution, high frame rate, or both; and record as many cameras as possible, with the emphasis on live streaming, live playback and delayed playback and delayed recording."

"In addition, alongside the camera data we can record third-party systems such as force plates, EMG, pressure plates — any analog or digital devices synchronized to the video cameras. So we see TEMPLO as a platform for gathering data and streamlining it towards an application-based protocol."

CONTEMPLAS has a strong presence in the sports and health markets, working with almost 4,000 partners/customers across 35 countries, but the

applications of its software go beyond that. CONTEMPLAS technology has also been used to analyze motion in challenging environments, tracking subjects such as lizards, underwater robots and astronauts, and its new partnership with Vicon will extend that reach even further.

## ATHLETICS



"We will be able to extend the company's reach to completely new markets such as sports performance testing, coaching for individual/team sports, such as swimming."

## JOINING THE VICON COMMUNITY

"I always saw Vicon as being the company that provides the gold standard of motion analysis," says Klippel. He adds that he has always admired Vicon's community-driven culture, appreciating the way it encompasses the company's wide user base as well as its own staff.

Klippel says that the move will extend CONTEMPLAS's reach and accelerate its growth, while allowing the company to enhance its technology and offer a wider array of solutions to its existing customer base.

Similarly, Klippel says that CONTEMPLAS will enable Vicon to serve customers with needs that are different from those of its existing base. "We will be able to extend the company's reach to completely new markets such as sports performance testing, coaching for individual/team sports, such as swimming. There's a huge variety of applications in practical analysis in addition to the more research-focused Vicon customer base."

"I think CONTEMPLAS contributes a lot, with applications for customers who don't have the time or money for an optical system or, on the other hand, are simply not able to put

sensors on subjects because they're in a live competition or in a prohibitive environment," says Klippel.

Adding an in-house 2D markerless solution to Vicon's optical and inertial offerings will also enable customers to explore this exciting new branch of motion capture from within the ecosystem they already know and trust.

## DRIVING GROWTH

Joining Vicon is already paying dividends for CONTEMPLAS. "Already in the last two months, I'm seeing CONTEMPLAS's growth accelerate in every direction," says Klippel. "Every employee is really happy with the solution and sees that there is a huge potential. They're highly motivated to push that forward in every division, be that development, support or marketing."

With the resources of Vicon behind CONTEMPLAS, Klippel anticipates a rapid expansion into new markets that were out of reach before the acquisition.

"This growth is all possible thanks to Vicon's support," he says. "Working together, we've created a new business plan for the next four years that will definitely lead to more revenue, a wider audience and presence in the market, and an even stronger product line."





## THE RISE IN MULTI-MODAL DATA FUSION IN MOTION CAPTURE

Historically, Vicon has been a company that focuses on one technology: optical motion capture.



Dr Kim Duffy,  
Senior Product  
Manager –  
Life Sciences

Now, like many others within biomechanics, we have shifted away from a focus on a single technology/tracking modality towards multi-modal fused data. Multi-modal in this case means more than one modality, so more than one technology to track motion, and data fusion is combining different data to produce a result.

### Why is this important and where is motion capture technology heading?

Before answering this question, we should look back at the history of motion capture. Eadweard Muybridge is not only considered a founder of biomechanics, but also of the technology used to capture and analyze human movement. The classic moving pictures that Muybridge captured, *The horse in motion* for example, is

a perfect representation of a single modality; the single technology in this case is photography being used to capture human movement. The work conducted by Muybridge is where we can say human movement technology began.

Over the years, motion capture technology (optical, video and inertial sensors) assessing human movement has developed and expanded. I like to think that technology evolves in two different ways. First, it can evolve linearly, making a single technology better. For years, Vicon and other technology companies have worked to improve the technology and the modality to help the biomechanics community get better and better results.

“  
There is value and exciting possibility when you start combining different modalities together and that is where we can see the industry moving.”

One of the natural results in the linear evolution of technology is that if you continue for long enough, the improvements that you can make start to plateau and you don't see big leaps as you did in the beginning. Rather than adopting a linear evolution approach, you can instead combine different technologies.

Mobile phones are a fantastic example of both linear and multi-modal data fusion evolution. Firstly, progressing linearly, mobile phones were originally solely about wireless voice communication, using one technology, and the manufacturers worked to make them easier to use, smaller and lighter. Eventually they started to combine other types of technology, more powerful processing, cameras within mobile phones and the use of inertial sensors for interactions between device and user. By combining these different technologies, designers evolved mobile phones into smart phones.

Biomechanics technology is no different to the evolution of the mobile phone. While optical motion capture is the tool of choice for many use-cases within life sciences, inertial and markerless technology allow users to expand their applications, moving away from the lab for example. These technologies have advantages and disadvantages and there is a lot of exciting potential in combining them.

At Vicon, we have been combining different technology for a long time. In the past, we focused on combining technologies that were sensing different things. For example, full-body optical motion capture combined with force plates to calculate joint forces. This allowed for synchronized collection of separate data (e.g. optical and EMG) in the same software.

Now, we are starting to use different technologies together to maximize their pros and balance out their cons by using multiple sources together to quantify the same movement. Several years ago, we acquired a company in New Zealand, IMeasureU that specialize in inertial sensing. We saw the advantages of inertial sensing and combined them with optical. Today we are moving past simply synchronizing

capture, and taking two different sensing technologies measuring the same movement and using them together. Emerging techniques such as markerless add the ability to compare Apple's AR Kit with the IMU Capture.U App. We also launched a partnership with Theia Markerless in 2020 to offer a combination of optical and markerless data. Today, rather than just having different synchronized data types, you are able to collect the same data. If you have inertial and optical measurement, and the optical marker gets covered, you could fill the data in with inertial. So, frame by frame you can use one or the other modality and you shouldn't lose data. We see this as a big advantage. Video user-needs and developments are also expanding, and we are excited to welcome CONTEMPLAS, a well known video system solution provider, to the Vicon Family this year to help address the need for quick, reliable video analysis.

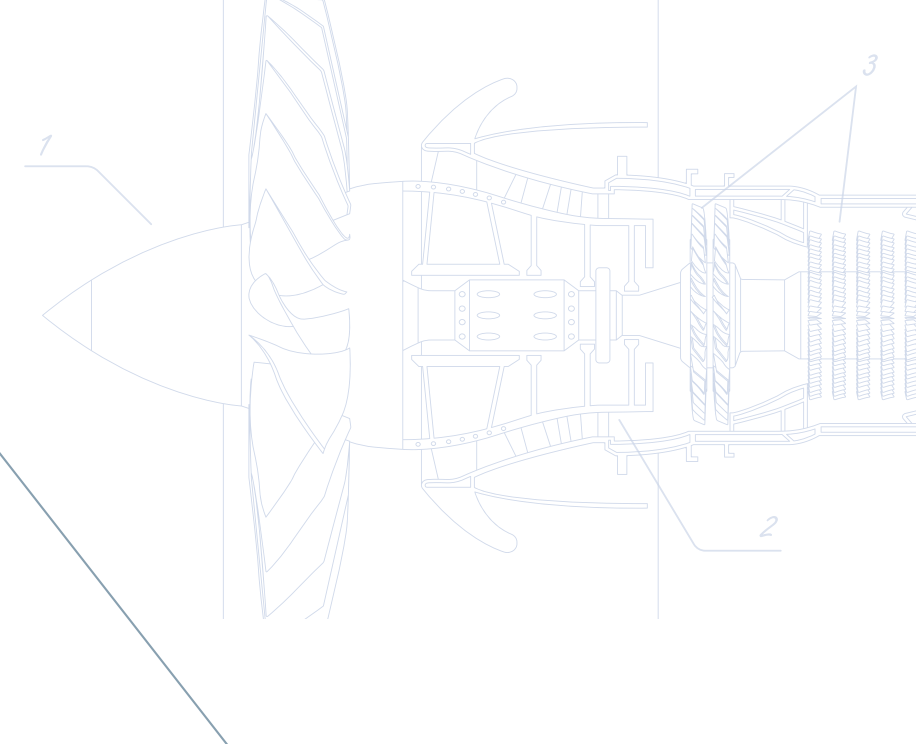
Vicon has a longstanding history within Life Sciences, and we will continue to work with the scientific community to expand multi-modal data capture and derive outcomes that are based on validated and published methods. Although this ultimately takes more time, our belief is that there must always be science behind our products.

There is value and exciting possibility when you start combining different modalities together, and that is where we can see the industry moving.

Nowhere is that more obvious than among our community of users. Every conversation we've had for The Standard has come down to one of our customers pushing the boundaries of what motion capture can do. We're seeing incredible strides in the applications Vicon technology is used for and we, in turn, are inspired to expand our offering to fit. The result is a virtuous cycle that continues to push motion capture in exciting new directions.



# MOTION CAPTURE, VIRTUAL REALITY AND IMMERSIVE AEROSPACE DESIGN



‘Digital transformation’, the process of recreating every last component of a physical product as a digital object, is the newest frontier for industrial production. At aerospace company Northrop Grumman, Sibio Chou is using motion capture technology to bring a human touch to that process.

In a given year the cost to operate and maintain a military aircraft can be astronomically high, sometimes leading the operators to cannibalize working components from multiple aircraft to keep a single plane in use. Meanwhile, aerospace hardware and the process of designing it continues to grow in complexity. That complexity breeds opportunities for design flaws, and each issue at the design stage can generate a cascade of unforeseen production and maintenance costs.

HIVE (Highly Immersive Virtual Environment), a virtual hardware testing system that uses motion capture to allow Northrop Grumman engineers to interact with designs, is

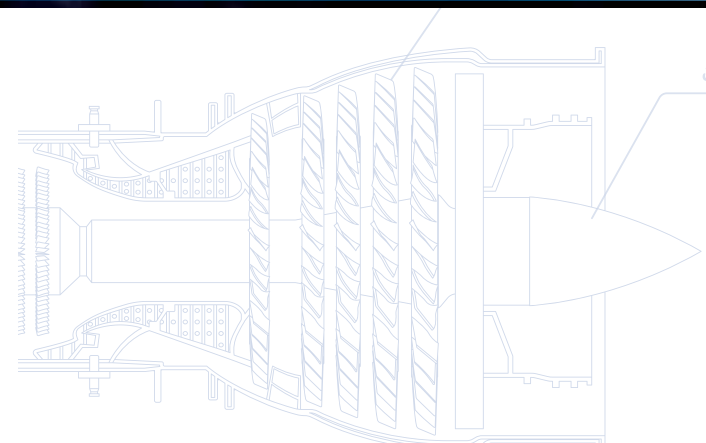
built to enable the early discovery of those flaws, unlocking exponential cost and resource savings across the lifespan of an aircraft.

## ASSEMBLING VIRTUAL AIRCRAFT

The overall concept isn’t dissimilar to gaming-focused, location-based VR, but the process and the application differ significantly.

“We stream motion data directly into a piece of digital manufacturing software,” explains Chou, who is lead Virtual Reality Engineer on HIVE. “Using that software, we’re able to bring in the engineering 3D models. With motion capture and a virtual

HOW MOTION CAPTURE  
CAN MAKE THE DIFFERENCE  
BETWEEN A DESIGN TWEAK AND  
GROUNDING 400 AIRCRAFT





Chou and his team estimate that for every 30 assessments they save around \$4 million.



Sibio Chou,  
Lead Virtual Reality  
Engineer at Northrop  
Grumman

reality environment, now we can assemble and maintain the airplane way in advance, even before we go and buy the parts. This allows us to simulate the manufacturing and maintenance sequences of our product.

While the exact cost savings are difficult to calculate, Chou and his team estimate that for every 30 assessments they save around \$4 million. "This estimate only accounts for labor and is extremely conservative," adds Chou, noting that every issue that the assessment catches could, unchecked, have led to numerous associated costs.

HIVE operates across various sites, utilizing more than 30 optical motion capture cameras in 20 ft x 20 ft x 10 ft volumes. It was a substantial investment up front, but Chou notes that the first two HIVEs recouped their initial costs after their first assessments.

"You always need 3D models," says Chou, "because without models we can't really analyze anything. But the thing is that a lot of the 3D models already exist. So when you use the HIVE, you're really reusing something that you already have."

#### A FIX IN TIME

Chou stresses that the ROI figures he provides are very loose estimates, but as he unpacks the potential cascading

production challenges that can come from not using HIVE early in the design phase, the benefits become very clear.

He gives the example of an access panel that might be too small for the majority of technicians, but is only discovered once production has begun. "If you find a problem in the production line and you've already made 50 of these access panels, you're talking about scrapping all 50 access panels that are on the dock. Or maybe you've got to go in and retrofit, drilling additional holes. That's more money now, but that's just for those 50 that have already been made."

Chou said that this would have to be followed with new engineering drawings and approval, and parts and labor costs that could reach into the millions. And it doesn't stop there. "Now you've got to flow that change down to your suppliers," Chou goes on.

"That's probably a month. So for that month, you told the supplier, 'stop making this item, because we're going to give you a newer version'. But what if that item's lead time is six months? Potentially, now you're impacting your delivery schedule, because you tell the supplier to stop for three months, in order to do manual design. Now, it's going to take them an additional three

months, and maybe they shut down the factory, and it costs money to restart the factory. So the supplier is going to come back to ask for more money, because shutting down and restarting is going to cost them as well."

It could be an order of magnitude worse if a fleet of planes has already been delivered. "Now you're talking about everything I just mentioned: design change, supplier redesign, but you have to figure out how to go out to the customer's fleet and retrofit all 400 planes. They could be all over the world. If they're on an aircraft carrier in the Middle East, how do I deal with that? And if it's a safety issue, now you've grounded the whole fleet."

#### MOTION CAPTURE AS A PLATFORM FOR COLLABORATION

Effectively, HIVE is enabling engineers to frontload the design process, surfacing issues that might previously have only come to light at the physical prototyping stage or, worse still, when aircraft are already in use. Crucially, it allows multiple engineers from different parts of the business to collaborate in an effective way.

"When we identify a problem, we always find the best solution with the correct stakeholders in the room," says Chou. "As programs and aircraft

"...we've been doing digital transformation for a while now. And obviously, they're finally catching on. But with HIVE, we've already done it."

A lot of times, when we're in the competition phase to win a program, we already have draft models. And by then we can use the HIVE to engage the customer, to show the customer that we are really 100% on board with this digital transformation our company is pushing."

As well as rolling HIVE out to other parts of Northrop Grumman, Chou hopes to improve the level of immersion that HIVE offers, bringing more users into a session.

Currently, the person performing an assessment wears a capture suit and headset while onlookers get that person's view through a TV screen. "I'm thinking that in the future, I would have either VR or augmented reality headsets for everybody. They will see the product in the room in 3D. The cameras will track the orientation of each headset, so that any guests with a headset can walk around the product and get their own perspective."

While there might always be ways to improve, HIVE is already on the leading edge of aerospace design. "I always tell people they're late to digital transformation," says Chou. "We've been doing digital transformation for a while now. And obviously, they're finally catching on. But with HIVE, we've already done it."

get more complicated, you're not just designing an aircraft with 400 people in the same building. You're talking about 5000 people all across the world. And a lot of times, a simple phone call is not good enough – you need to show the person what you're talking about in 3D space, along with movement."

Chou says that there are five questions his team asks at the beginning of any process assessment, and some of them can only be answered with a high-spec optical motion capture setup: "Can my hand reach? Do I need both my hands to reach? Can I see what I'm doing? Does my body fit? And what size maintainer fits into this access zone?"

"That's what is different between the HIVE and other motion capture technologies. A lot of people think that [a commercial VR] headset and two controllers is motion capture. Well, it's quite limited. I don't know if my elbow is crashing through the bulkhead. I don't know if my hips or my legs are fitting through this access panel."

The accuracy provided by a gold standard tracking solution removes that doubt, Chou says.

#### BEYOND MAINTENANCE

HIVE is increasingly being used in other parts of the company. "We want to use the HIVE to win programs.



Left & below: Still from  
Hannah the videogame  
Bottom right: New short  
film, 10:35

When Spaceboy wanted to take its digital effects work to the next level with a new short film, 10:35, and its first videogame, Hannah, the studio approached Vicon for a motion capture solution. The learning curve for the Mexico-based digital production house was steep, so we caught up with the Innovation Department from Spaceboy to find out what it has learned from working with its new system.

## THREE QUESTIONS WITH SPACEBOY ABOUT LEARNING MOTION CAPTURE ON THE JOB



SPACEBOY.MX







### What were the biggest challenges for the two projects, given that you were learning on the job?

The main challenge was to achieve realistic captures that corresponded to the physical characteristics of our characters, whether they were humans or insects, as we were looking to animate some unusual body shapes.



Another big challenge was obtaining the optimal capture with a reduced number of cameras, which made us look for different ways to set up our Veros. Finally, another challenge that we faced was planning the position of props and the actor on stage, given our modest setup.



With the number of cameras that Spaceboy has, the final result was breathtaking!

### What advice would you give to anyone attempting their first motion capture project?

Make your studio and capture session reflect the final result you're hoping to achieve as closely as possible.

So, make sure you have good illumination in your capture space. If you can, look for an actor who has a physical body constitution similar to your 3D character. Experiment with different camera rigs until you have the best capture. Finally, look for a real stage and props that resemble your digital scene and character.

**10:35 will be out in early 2022, with Hannah coming soon.**  
Build From Inside, S.A. de C.V.

### 10:35 was your first project using your Vicon system - how did you find the process of learning to use the technology and integrating it into your existing workflow?

We needed to create more realistic animations while speeding up the execution time, which is why we began by carrying out motion capture tests with our eight Veros and Shōgun before we did anything else on the project. The entire Spaceboy team was involved, because for us it was important that all the departments, including pre-production, production, post-production and the programming team understand the motion capture workflow. Once we were satisfied with the result we continued with the rest of our scenes.

We also know that given the short time we have been learning mocap, we have a long way to go. The animations will be better and we'll be able to capture much more complex movements and scenes.

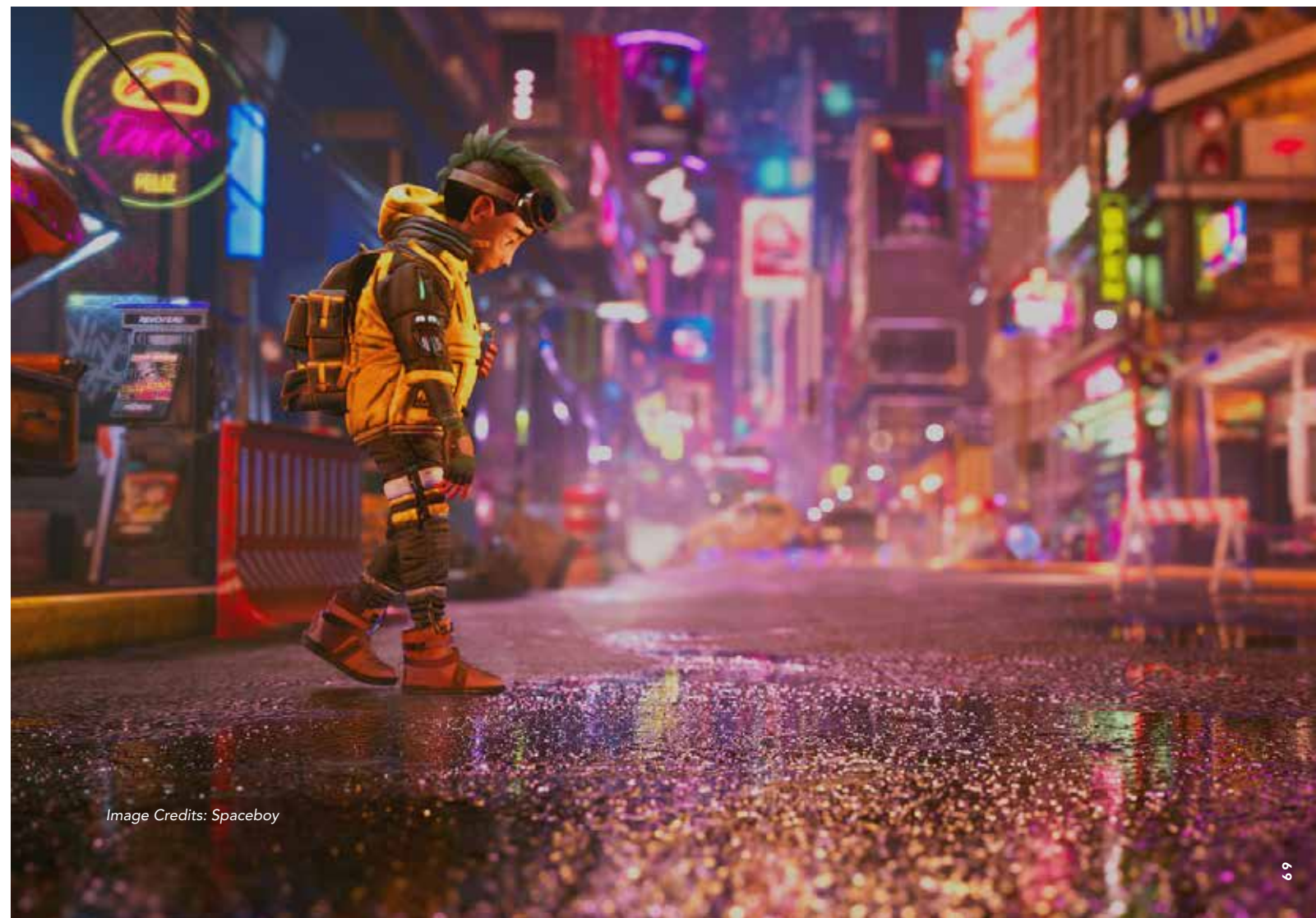


Image Credits: Spaceboy





VICON STANDARD 2022

VICON

# LOWER LIMB MONITORING AND ACL BEST PRACTICES

IMEASUREU REVISITS SOME OF OUR  
RECENT CASE STUDIES PUBLISHED  
WITH WORLD-CLASS PRACTITIONERS

Anterior cruciate ligament (ACL) injuries are some of the most feared injuries from players and clinicians. Time loss, rehabilitation challenges, and the risk of re-injury make it an injury to avoid at all costs.

We only have to look at the literature to see the devastation that an ACL injury can have on an athlete's career. Ardern et al. (2014) in their systematic review and meta-analysis highlighted that on average, one in three patients did not return to their pre-injury function, and only 55% returned to competitive sport.

The incidence of female ACL injuries is 3.5 times greater than males in basketball and 2.8 times greater in soccer. These worrying statistics do not go unnoticed in college athletics. But despite lots of work going into preventing these injuries, they do still occur. Research from Markus Waldén et al and colleagues in 2016 found that the ACL injury rate in male professional football players did not decline during the 2000s after a 15-year prospective study.

In this article we are going to revisit some of the case studies we have published with world-class practitioners over the last two years, examining the key themes and best practices for ACL rehab and prevention.

## BENCHMARKING BEFORE INJURY

In mid-October 2020, a member of the Virginia Tech Hokies women's soccer team sustained an ACL

injury. Fortunately for her, Professor Jay Williams, Athletic Trainer Emily Whitaker, and Associate Director of Strength and Conditioning Brandon Dillard recognized the importance of benchmarking and had healthy data they could reference throughout her rehabilitation. Benchmarking is the process of collecting data on a healthy subject that can be referenced should they get injured. When speaking to clinicians who have guided ACL rehabilitation, this crucial work done in the months and weeks before an injury even occurs is what makes the process easier.

Standardized tests are needed to collect benchmark data. In individual sports, there is often more freedom and fewer logistical issues with conducting benchmarking. However, in team sports, the type of tests used and the time taken to navigate a full squad through those tests is something that requires a lot of thought and planning.

In team sports, the warm-up is often the most standardized part of the program. It's often similar in length, has a largely similar goal each day with some additional elements which prepare the athletes specifically for the type of training to come. This means that the warm-up is often the ideal place to collect benchmark data.

"The incidence of female ACL injuries is 3.5 times greater than males in basketball and 2.8 times greater in soccer"





## STANDARDIZED TESTING OPTIONS

In March, we spoke to Professor Jay Williams at Virginia Tech who has introduced a standardized run at the start of each day as part of the players' warm-up. This standardized run with the IMU Step sensors has enabled the team to ask better questions. Their process includes –

- A general warm up
- Elements of a sport-specific warm up
- A 200m jog at a self-selected pace up and down the field

"Collecting the preliminary data is to have an idea what a player's 'normal' is," Jay explained. "Following injury these data can then be used in the return to play process. For example, we had a player a few years ago who had a natural asymmetry of about 5%. She injured her ankle so was naturally limited with the activity she was able to do. However, when she was able to run, we saw that the asymmetry had reduced to almost symmetrical. We knew then that there was a negative change. Had we not had the preliminary data we would have looked post-injury and thought her gait was symmetrical and would have been pretty pleased. As we progressed through the rehab knowing that changes had occurred, that natural asymmetry re-emerged."

Professor Jay and the team at Virginia Tech dove into their standardized

run protocol. However, there are alternative outlooks when it comes to benchmarking. Practitioners may opt for more controlled tests that focus on specific physical qualities. These may also be linked to outcome measures during the return to play process developed in conjunction with a medical department.

## TESTING IN A TEAM SPORT ENVIRONMENT

Choosing this produces more granular data, though it can lead to increased logistical issues, especially in a team sport environment. Despite that, Dr. John Harry and Graduate Assistant, Jacob Hurwitz at Texas Tech have developed a battery of tests that takes 30-40 minutes to get through with a squad. For their men's basketball team, they have included a mixture of both unilateral and bilateral movements to allow deeper analysis into asymmetries. They chose 6 tests focusing on jumping, landing, and running which included –

- **Leap matrix** – a unilateral jump test
- **5-10-5** – a change of direction test
- **Three hurdle hop** – a bilateral jump test
- **Run-step-run-step-shuffle** – a lateral shuffle to sprint test
- **Light reactive test** – reactive agility test
- **Curved running** – curved running test to identify right left deficits

"

A good ACL rehab program, carried out by a good coach, I believe means that asymmetries are going to reduce over time, especially if the training load remains relatively controlled"

– Andrew Gray

## MONITORING ASYMMETRIES

As we fast forward to the return to play process, asymmetries become a key marker of progression. A common practice among elite clinicians is the use of a Biodex machine. The Biodex measures muscle strength by applying constant resistance against muscles in repetitive motions. The importance of this part of the process was highlighted when we spoke to Connor Norman at the University of Georgia. Connor had an athlete that had recently sustained an ACL injury.

More functional tests are introduced to monitor asymmetries and track progress as rehabilitation progresses. The healthy limb is often used as a comparator in these functional tests, though ACL injury has been shown to affect strength in the non-injured leg as well. It's important to keep this in mind as we benchmark progress.

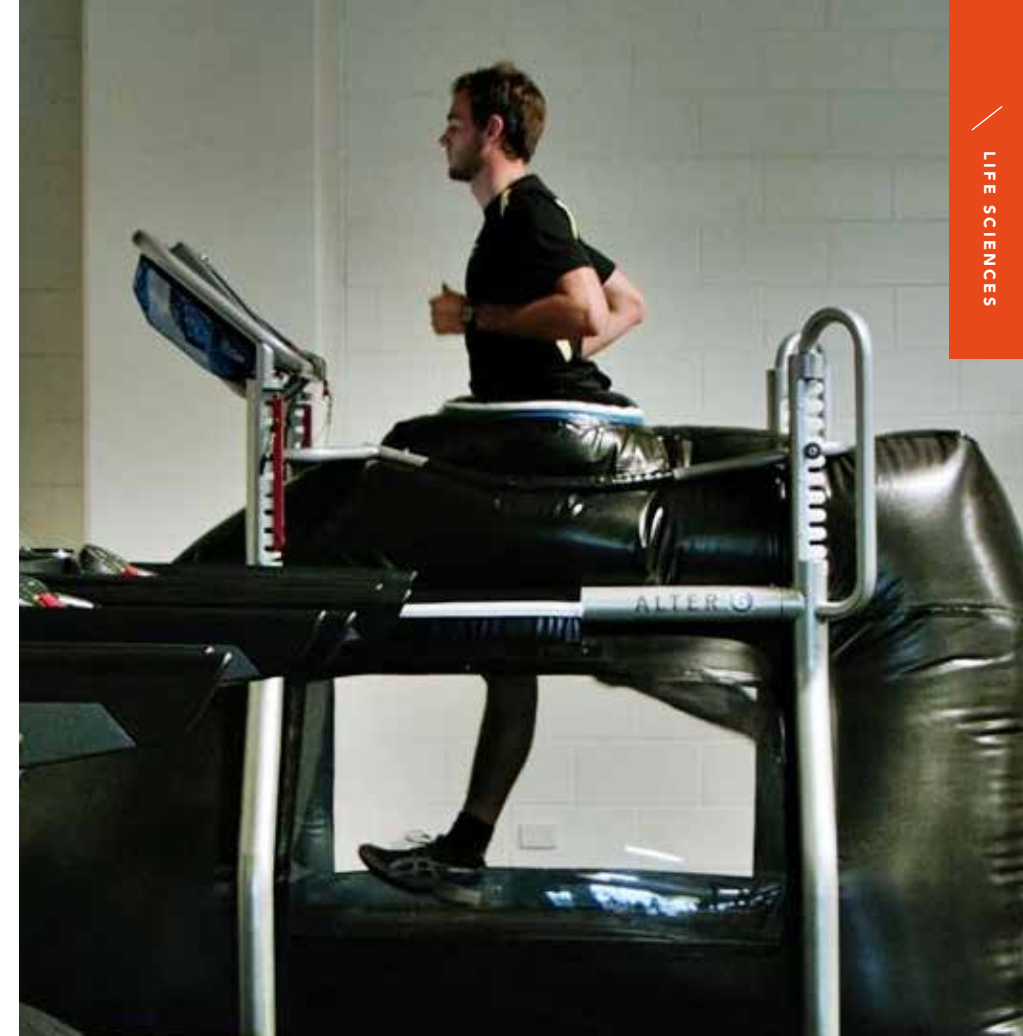
"As we progress through the rehab," Connor said. "We go into more functional tests which include jump testing. Within that, we test a single leg hop and a triple hop for distance. These give us a marker of limb symmetry in the athletic training room. But in football, or any other sport, we need to be looking at activities and movements they are actually going to perform on the field and then look at the symmetry."

As Connor mentioned, as we move through the rehabilitation process, we need to be measuring activities that the patient will be expected to perform; steadily moving away from controlled environments and towards those which are more game-like. To collect vital asymmetry data in the field, wearable technology should be used.

## MANAGING REHABILITATION INTENSITY

In May 2019 we spoke to Andrew Gray as he managed a high-profile ACL rehabilitation. Andrew wanted to monitor and manage rehab intensity with Cronulla Sharks captain, Wade Graham.

"A good ACL rehab program, carried out by a good coach, I believe means that asymmetries are going to reduce over time, especially if the training load remains relatively controlled", said Andrew. "You may see asymmetry reduced but as you continue to add



complexity and fatigue to sessions and drills, increase the running speeds or changes of direction for example, that asymmetry typically returns. This is something we have been aware of for some time but IMU Step has allowed us to track the extent of those fluctuations so we can progress our drills at the right rate. We were able to communicate this asymmetry improvement with Wade which gave him reassurance that we were making progress."

In the first 2 years after ACL reconstruction, 30% of people who returned to level I sports sustained a reinjury. Compared with 8% of those who participated in lower level sports. While we may not ever be able to predict and prevent initial ACL injuries, reinjury is an area that we have much more control over. We believe that with proper management and tracking, the ACL reinjury rate should be close to zero.

We will continue to learn from world-class practitioners as we try to understand and refine the rehabilitation program more and more. Be sure to sign up for our newsletter for all of the latest developments.

"

When I test somebody in the athletic training room when returning to play from an ACL injury, we first get them on the Biodex to investigate the hamstring to quadricep strength ratio and we compare left to right."





# THE ROLE OF MOTION CAPTURE IN EDUCATION IS CHANGING FAST

HOW UNIVERSITIES ARE EVOLVING THEIR MOTION CAPTURE OFFERS TO KEEP PACE WITH THE TECHNOLOGY



Nick Juschyshyn,  
Program Director  
of VR & Immersive  
Media, Drexel  
University, USA



Alex Counsell, Faculty  
Technical Adviser  
for the School of  
Creative Technologies  
University of  
Portsmouth, UK



Carlos Vilchis, Lecturer  
of Animation & PhD  
Student, Tecnológico  
de Monterrey, Mexico

As cost and technical barriers of entry to the world of motion capture come down, universities are adapting fast to keep up with both the proliferation and diversification of commercial motion capture applications. Vicon gathered together a panel of leading motion capture educators to discuss how the field is changing and where it might be heading.

"There's a democratization going on with the technologies," says Nick Juschyshyn, Program Director of VR & Immersive Media, Drexel University, USA, summing up the overall arc of commercial motion capture as it relates to education.

"Today, there are tools that will just use a single video camera to shoot a video and a machine learning system processes it and produces a moving joint system. It's not as accurate as a full-blown, studio-grade optical system, but you've got an FBX file that you can start animating with. Then, all of a sudden that leap to a full-blown optical system isn't that big of a step," says Juschyshyn.

"It's a great thing, because it just widens the scope of what we can do with motion capture in education," adds Alex Counsell, Faculty Technical Adviser for the School of Creative Technologies at the University of Portsmouth in the UK.

"We talk about democratization because it's so much easier now to get amazing results instantly," he goes on. "Our

volume has become a much more collaborative space through the years. There are more and more people coming in and more and more people trying new things. People are attracted towards it rather than scared of it because it's not so deeply technical anymore."

That growing interest is being reflected at an institutional level, according to Carlos Vilchis, Lecturer of Animation & PhD Student at Tecnológico de Monterrey, Mexico. "Universities have started to see that motion capture is more than just making small characters move. It's amazing the interest we're seeing now that programs like media want it for virtual production or for digital humans."

Vilchis, Counsell and Juschyshyn note that within their universities motion capture is being used in fields ranging from fashion to aerospace to architecture, and the jobs available after graduation are in sectors that are just as diverse.



VR & Immersive Media,  
Drexel University, USA



School of Creative Technologies University of Portsmouth, UK



Jesse Woodward,  
Lecturer of Animation  
for the Design  
Department,  
University of  
Wisconsin-Stout, USA

## CHANGING COURSES

To cater to these new fields, universities are increasingly offering courses that break out of the VFX and videogame design silos.

"Where Drexel traditionally had a game design program and we've had an animation program or visual effects program, we saw an opportunity to create a new offer," Juschyshyn says. "VR and Immersive Media pulls in components of all of those disciplines and brings them together. It's virtual production, motion capture, virtual reality, augmented reality, full dome projection and projection walls, all of that working together."

Counsell says that in the UK, where getting a course accredited can be a long process, having degrees that feature a variety of different digital production techniques is useful. "It allows us to be reactive and agile within the course, rather than having to establish a new program and get it accredited," he says.

"That's one thing we've definitely been doing over the last few years - these open-ended modules and programs that allow experimentation. They allow the music students to talk with the students doing mocap, for example, and this collaborative work becomes easier and builds skillsets."

"I'm struggling to try to keep up with the amount of demand that there is for these kinds of skills, this real mix and match of all these skills that bring different elements together," Counsell adds.

## BEYOND THE TECHNICAL

The increasing accessibility of motion capture hasn't only changed the applications teachers are covering. It has also changed the skills they are teaching. As the tools have become simpler to use, educators are able to shift focus beyond the more technical aspects of tracking.

Juschyshyn agrees. "There are always problems to be solved, even though

the front-end user interface has been optimized and it's easier to get through a calibration process. Well, that gives you more time for motion capture, and it gives you more time for creativity and experimentation. When that experiment didn't turn out the way you thought it would, you wonder why. You dig in under the hood - what's the calculation going on there? Is there a way that we could make a Python script to automate something and make this a little bit more efficient, more repeatable, etc.? So there's always more to be done."

Jesse Woodward, Lecturer of Animation for the Design Department at the University of Wisconsin-Stout, USA, gives an example. "A couple of weeks ago we did a motion capture shoot for our animation production class. In one of their shots, the main character is walking on a tightrope. And I said, if you try to do standard walking, foot after foot on a flat surface, it's not going to look the same. So we decided to get a

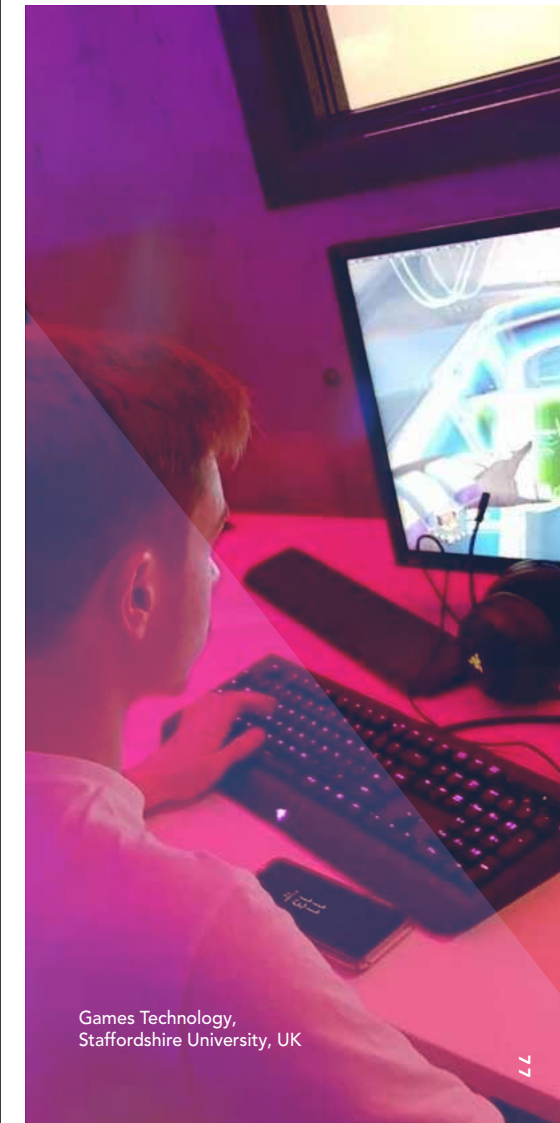
standard two by four, put it on the ground and have them stand on it, because that's a much better feeling. It looked a lot more genuine. Creative problem solving can be something as simple as just putting a board down for a prop."

## SOFT SKILLS

One element of motion capture work that's getting more teaching time now is soft skills. Part of that, Woodward adds, is teamwork. "Whoever is going to be in the suit, whoever's working with props and whatnot, the first and most important thing is to make sure that they feel comfortable in what they're doing, and feel comfortable in the suit, and making sure that it's a good experience for them."

*For more insights into the present and future of motion capture in education, see the full panel discussion on Vicon's YouTube channel.*

"Teaching is creativity and problem-solving rather than showing students really mundane, repetitive processes that will drive them mad."



Games Technology,  
Staffordshire University, UK



# EVOKING A CHANGE IN REHABILITATION

THE UNIVERSITY OF STRATHCLYDE  
WANTS TO DEMOCRATIZE THE PROCESS  
OF PHYSICAL REHABILITATION



While motion capture has proven itself to be an invaluable technology in rehabilitating subjects with impaired movement, the funds and technical expertise required remain prohibitive. For the biomechanics department at the University of Strathclyde, however, the tools for overcoming those barriers already exist elsewhere in the world of motion capture.



*Philip Rowe,  
Professor of  
Rehabilitation  
Science, Biomedical  
Engineering  
department,  
University of  
Strathclyde*

The university recently opened the Sir Jules Thorn Centre for Co-Creation of Rehabilitation Technology, funded in part by a £449,000 grant from the Sir Jules Thorn Charitable Trust. In it, the university is pioneering applications that will use Vicon technology to make motion-capture-powered rehab methods accessible at scale.

The use case for motion tracking in improving movement is clear — visual and haptic feedback are both extremely effective in helping subjects form new neural pathways to improve physical movement. Philip Rowe, Professor Of Rehabilitation Science for the university's Biomedical Engineering department, points to the massive improvement in Team GB's performance between the Atlanta and Beijing Olympics, attributing much of that success to improvements in the biomechanics technology the athletes were training with.

"The trouble for us is that they have huge resources that we don't have for clinical rehabilitation. We're trying to get that kind of performance enhancement at scale for patients, using the same type of technology," says Rowe.

## IF IT'S NOT USER-FRIENDLY, IT DOESN'T GET USED

Even where the budget and technology exist, says Dr Andrew Kerr, Senior Lecturer in Biomedical Engineering, the time and expertise required to operate such systems offers another hurdle.

"A good example is the Lokomat, which is a walking exercise that was designed a few decades ago for spinal cord injury patients," says Kerr. "It's a treadmill and exoskeleton that helps them relearn their ability to walk."





Dr Andrew Kerr,  
Senior Lecturer  
in Biomedical  
Engineering,  
University of  
Strathclyde

"I have come across places where it is not used anymore. It literally has a thick layer of dust on it. When you speak to the physiotherapists they say, well, it takes 20 minutes to get it all set up and we just don't have the time to do that. And of course, the less people use it, the less people remember how to use it. It's a brilliant piece of technology, but it's not helping anyone because it's not user-friendly."

It's not a case of needing to invent brand new methods and technology, then. Rather, Rowe and Kerr's team is finding ways to make existing processes more affordable and more accessible.

The Strathclyde team isn't working with the suite of Vicon tools typically used by biomechanists. Rather than using Nexus, they're using Evoke, the Vicon software designed for location-based VR (LBVR) applications.

### CROSSOVER TECHNOLOGY

Rowe says that while motion capture began as a tool used in the world of biomechanics, advances made in the VFX and videogames industries have eclipsed those in the medical sector.

"We're trying to use the efficiency gains that those two sectors have brought about, and use them in rehabilitation," says Rowe. "We're building a rehabilitation gym, using Vicon technology to provide feedback and gamification and exercise to our clients."

"The question we're asking in our center is, can we make our entire lab spaces motion capture volumes, utilizing Evoke and marker clusters? And can we have multiple users in our gym spaces, using different pieces of equipment and getting visual feedback from the system in real time?"

Evoke, which is designed to be run by operators with minimal technical expertise at costs that make it viable for use on the high street, is a strong fit for patients' needs.

"We know that there are four main pillars associated with a more successful rehabilitation process," says Kerr. "The first one is the intensity of the movements. The NICE guidelines recommend 45 minutes a day after a stroke. I'm using stroke as an example of rehabilitation, because it's probably the biggest challenge in the UK."

"The second pillar is cognitive engagement with the task. So, the idea that randomizing some of the tasks through gamification or introducing more complexity, in order that the users are focused on the task, helps relearning. The third is feedback so they can correct errors, and also that helps to motivate them. Finally there's an aerobic component, which helps because it stimulates blood flow through your brain."

A system based on Evoke ticks all those boxes. "Patients can come in, they're in control, they can do the practice themselves, they'll get feedback, monitoring, progression and cognitive engagement from the technology," says Rowe.

### PUTTING RECOVERY BACK IN THE PATIENT'S HANDS

"We use the term democratic rehabilitation," says Kerr, "because in the past, it's always been, here's a therapist, you have to come in and work with them. But it's your rehabilitation, your body, your life, and to give people the tools for them to recover their movement and to manage their own rehabilitation can be incredibly effective."

"We also talk about liberating rehabilitation," says Rowe. "At the moment it's constrained to a service delivery model that we think is failing. Physiotherapy professionals need to support people undertaking their own process of rehabilitation, rather than providing it. We call this supported self-management. Our dream is that we will produce technology that can then be put into community spaces where people can access it alongside professional advice."

"We're in talks about using leisure and community centers, and about suitable technology for people's homes. The process is simple enough for that. If it's on the high street as LBVR, people will think well, we could use that too. When LBVR gaming centers become common, I think people will just accept that the technology is also available in the gym."

It wasn't just the fact that Evoke fits the department's goals that made Vicon the right supplier, "I think we share the same vision," says Rowe. "Vicon has always supported the rehabilitation and clinical biomechanics community, even if it's not the most profitable market. Vicon understands the social value of motion capture for clinical populations."

"In terms of companies, I think it's by far the market leader in motion capture. And then we get to the LBVR technology. What we're trying to do in real time, with multiple marker analysis of multiple subjects, simply and inexpensively; that requires high quality data and reliable technology. I can trust the Evoke software and its cluster tracking algorithms, I think the Origin hardware is stable."

"I don't think I would have attempted what we're trying to attempt with any other mocap company."

For all Rowe's faith in the technology he's using, an exciting question mark still hangs over the work his department is doing.

"It's an ambitious experiment to see if motion capture can be used to routinely support rehabilitation," he says. "I don't think we know yet. We have a vision of what we'd like to achieve, but whether we can achieve it, whether patients will think it's usable and beneficial, that's our big experiment. Without Origin and Evoke we would not be able to try it."

"I don't think I would have attempted what we're trying to attempt with any other mocap company."






 VIRTUAL  
PRODUCTION

# BREAKING NEW GROUND

IN A GALAXY  
FAR, FAR AWAY

VICON.COM/VPROD

## TURNING VISION INTO REALITY THROUGH TECHNOLOGY

At the heart of every project that ILM has utilized performance capture for over the last 25+ years lies a core technology that helps push the boundaries of visual effects: Vicon motion capture systems.

It is no exaggeration to say that the collaboration between ILM and Vicon has helped redefine the extent of our imagination.

The latest example of this work is one of ILM's most challenging and ambitious projects ever –

### The Mandalorian.

Following the Emmy Award-winning season one, the latest season of The Mandalorian pushes the thrilling ride for fans to new heights — all thanks to ILM's ground-breaking StageCraft technology that achieves a giant leap forward in filming techniques.

Working with Vicon, ILM has evolved well beyond traditional VFX motion capture to become a world leader in virtual production.

With The Mandalorian, filmmakers Jon Favreau and Dave Filoni have been explicit in their desire to “bring Star Wars to the screen in a new way.”

With the scope and ambition of the series only increasing on the second season it was crucial that the actors and viewers not only experience a huge range of new worlds — but truly believe in the reality of the worlds being created and are able to build emotional connections with the characters.

This ambition has required new filming techniques to be rapidly developed and deployed — chief among them virtual production techniques including camera tracking for in-camera VFX (ICVFX).

Virtual production in its simplest form is the merger of physical and digital worlds. Through a combination of immersive technologies like virtual reality (VR) and augmented reality (AR), as well as ILM StageCraft and real-time render engines, virtual production allows filmmakers to view their projects live on set to quickly react and make changes as needed, rather than having to wait until post-production.

Virtual production also offers several logistical benefits as it allows for more iterations of scenes or shots to be created with fewer personnel in a shorter space of time, therefore significantly reducing production costs.

Allowing the creative team and the actors themselves to better visualize the environments on shoot day is paramount. Production teams previously had to imagine the final scene while using green screens to shoot, with visuals applied in post-production after the fact.

ILM has invested heavily in leading the way with these techniques – and projects such as The Mandalorian and George Clooney's feature, The Midnight Sky has been a tour de force of just what is possible with virtual production.

Motion capture technology in a virtual production pipeline is a crucial component in making these endeavors a reality. Vicon's technology has allowed ILM to recreate the universe of Star Wars in compressed time with 60 different live environments, which they can use over and over again.

## SETS EXTENDING OUT OF THE CAPTURE VOLUME

Additional Camera tracking towers outside the Volume

Back of the LED Panels

Normal LED Volume

Audio

Camera on a crane arm

Focus Puller

Video Village

Active set outside the normal Volume

Stage rise for the crew



## MAKING THE IMPOSSIBLE, POSSIBLE FOR 25 YEARS

“  
ILM always looks to collaborate with those who are making best-in-class software/hardware solutions for problems we’re solving.”

For Rachel Rose, ILM R&D Supervisor who oversees the studio’s developments for virtual production, the success of *The Mandalorian* and all ILM projects requiring motion capture owes much to the collaboration:

“Since day one Vicon has enabled us to do things that were never possible before — and that’s as true today as it was in the 90s. Vicon’s technology and hardware have constantly advanced throughout our relationship, and the processing power available to us with their technology is like no other. We can deploy and always count on Vicon’s tech as it’s such reliable, robust hardware requiring only a quick calibration.”

If a solution doesn’t exist, we’ll solve it on our own, but we’re not looking to reinvent a solution that’s already there.

We are incredibly lucky that we have a long-standing relationship with such an innovative company like Vicon. The absolute best thing I can say is that with Vicon I have a powerful performance capture system that just works.”



## UNLEASHING A NEW WAVE OF CREATIVITY

With ILM’s StageCraft virtual production technology, ILM and Vicon have realized many filmmakers’ vision for creating fully digital worlds that are as close to reality as possible.

The *Mandalorian* is just the start of a new wave of creativity that will be unleashed as film directors explore new ways to take advantage of the virtual production techniques pioneered by ILM and Vicon.

As we have seen in recent projects, the possibilities within highly accurate virtual production pipelines are endless. Rose concludes,

“As excited as I am about what’s been accomplished by our StageCraft team and the visionary filmmakers we have been fortunate to collaborate with, we’ve only just scratched the surface of what we believe the system is capable of. What’s really exciting is where filmmakers will lead us next.”

While the landscape of film and TV is constantly evolving, it is certain that whatever happens next, motion capture and virtual production will play a key role in innovation. High-quality tracking technology, offering ultimate precision, is central to enabling the advances that will allow creatives to make leaps and bounds forward and to continue to revolutionize the entertainment industry.





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*Support is a crucial part of the Vicon offering  
and we're very proud of it.*



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