

The **Standard**

2024 Edition

COLLABORATION IN MOTION



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UMD Students Learn 'How to Fly' with Motion Capture





IMOGEN MOORHOUSE
VICON AND OXFORD METRICS CEO

Welcome to the 2024 edition of The Standard. This is an important year for Vicon, and I'm thrilled to be sharing it with you, our community.

On a personal note, it's been a privilege to add the CEO role of Vicon's parent company, Oxford Metrics plc, to my duties here at Vicon. As a group, we've recorded record revenue (up 53.5 percent year-on-year) driven largely by the continued excellence of Vicon, and made a major step into the world of industrial smart sensing with the acquisition of Industrial Vision Systems.

2024 also brings Vicon to its 40th birthday. Most technology companies don't like to talk about their age, but we're not most technology companies. We've spent 40 years leading the field of motion capture, and we're incredibly proud of that heritage. It's the institutional expertise gained over those four decades that makes us the innovative organization that we are today, and it's that pedigree that gives our users trust in Vicon solutions. Being pioneering is in our DNA. It has been for four decades.

But while a strong, dynamic Vicon is good for our community, the most important business at hand is the work we're doing to expand the possibilities of motion capture.

We're certainly in a pivotal moment on that front.

We've been investing heavily in markerless tracking so that, when it becomes an integral part of our motion capture ecosystem, Vicon users will have a solution they know they can trust. We offered a first glimpse of that technology at SIGGRAPH and it couldn't

have resonated more powerfully with the delegates there.

At this point in our markerless development cycle, we're extremely focused on accessibility and reliability. That's why we took the opportunity presented by our SIGGRAPH showcase to launch the Pioneer Program; that's why we've partnered with key clients such as Industrial Light & Magic and Dreamscape as Cornerstone Customers; and that's why we will soon be launching our markerless beta program.

Markerless has an important place in the multi-modal future of motion capture, and we intend to set the standard—just as we do in optical. But we understand that strong products come from understanding the wants and needs of our community, which is why it's so important to us to include you in the development of this innovative new technology.

Beyond markerless, the launches of Nexus 2.15, Shōgun 1.11, Tracker 4.0 and Evoke 1.6 mean our flagship Valkyrie camera range is now integrated into the pipelines of every industry that we serve. Other features, such as Shōgun 1.11's introduction of graphs and calibration scaling and Tracker 4.0's System Health Reports and System Healing functionality, serve to diversify the way users can access their data and streamline their workflows.

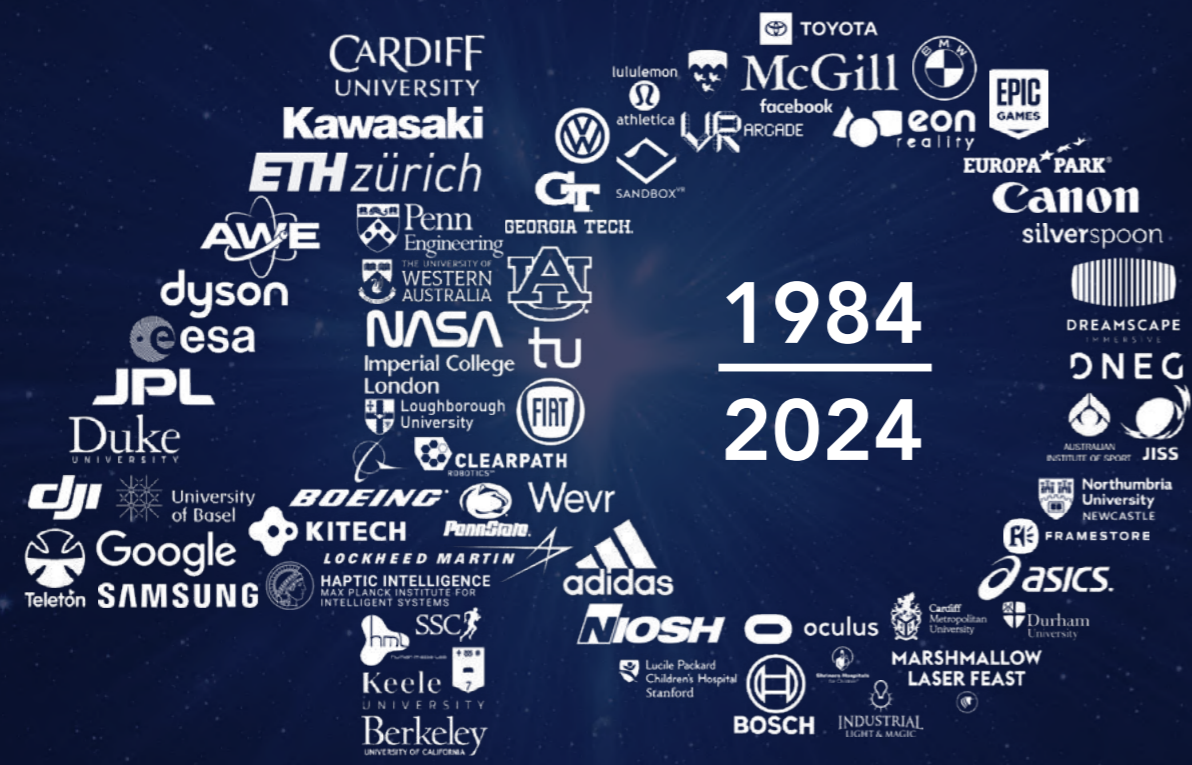
Our headline when it comes to how our customers access their data, though, is the launch of Nexus Insight. It will

eventually replace Polygon as our main reporting tool for the life sciences with clean, modern presentation and an intuitive user interface. We believe it will not only offer users a powerful new tool for the interpretation of their data, but also open up new opportunities for involving patients and other subjects in their analysis.

None of the above means much without our customers taking our technology and using it to deliver great work. This issue of The Standard is once again packed with the real-world application of Vicon technology across the life sciences, entertainment and engineering. We have stories of our technology empowering Native creators in Canada, helping with the design of insect-sized nano-drones, enabling an innovative crossover between biomechanics and game design and much, much more.

One of the most inspiring aspects of my role is seeing our customers pick up our technology and run, dance, fly, or capture some other movement we couldn't possibly have imagined with it. So, thank you to you, our customers, partners, distributors and everyone else who makes the work we do meaningful. And thank you, of course, to the staff who make Vicon such an exceptional organization.

Our company is 40 this year. I look forward to the future of Vicon with excitement and optimism. I'm grateful to you for being part of that story.



40 YEARS OF COLLABORATION



HIGH-SPEED FINGER TRACKING OFFERS NEW INSIGHTS INTO JAPANESE BASEBALL

Next Base, a Japanese sports research lab and data analytics company, is using its Vicon system to deliver laser-focused insights into the biomechanics of baseball.



Mr. Shinichi Nakao, CEO at Next Base

Established in 2014, Next Base uses cutting-edge technology to push performance to new heights. The company is led by Mr. Shinichi Nakao, CEO. "Our aim is to empower athletes to maximize their performance, using efficient and effective training methodology with biomechanics research to back it up," says Mr. Nakao.



Dr. Tsutomu Jinji, Executive Fellow and Principal Researcher at Next Base

Dr. Tsutomu Jinji, Executive Fellow and Principal Researcher for the company, obtained his doctorate by conducting research into the biomechanics of baseball pitching, with a particular emphasis on the mechanism that creates spin on the ball. This granular approach forms part of Next Base's current program. "We provide a pitching biomechanics service, including finger movement on the ball, by capturing and analyzing full body motion," explains Dr. Jinji.



“Our Vicon technology is a vital part of our lab, not only for motion capture but also for visualizing our data in a way that our athletes can understand - Dr. Jinji.”

As well as being similarly well-versed in the biomechanics of pitching and hitting, many of Next Base’s staff have played baseball at a competitive level. This hands-on experience of the sport gives them an advantage in explaining the scientific data in practical terms to the players they work with.

Next Base caters for athletes from the Nippon Professional Baseball leagues (NPB) right down to school-age players. Many of the players they assess are pitchers, but the number of hitters coming through is increasing, bringing more variety to the company’s practice. “Training requirements vary from player to player,” says Dr. Jinji. “Our goal is to provide safe and effective training

protocols tailored to each athlete’s personal technique and needs.”

THE NEXT BIG SWING

In 2022, a surge in demand for Next Base’s services prompted the company to take the next step and build Next Base Athletes Lab. “Prior to opening our lab in August last year, we rented facilities to work with our athletes. With the increase in the number of players we were seeing, we invested on our own to establish a dedicated motion analysis lab, located 30 minutes away from Tokyo Station. The lab is equipped with 14 Vicon Vantage cameras, three force plates integrated through Vicon Nexus, four RAPSODO

baseball tracking units, and an InBody body composition analyzer,” says Dr. Jinji.

“The recent advancements in sports technology have been immense,” he explains. “Our Vicon technology is a vital part of our lab, not only for motion capture but also for visualizing our data in a way that our athletes can understand. Alongside conventional strength-training methods, we have introduced velocity-based training tools to enable athletes to continuously measure their improvements. On top of this, to enhance hitters’ cognitive abilities, we have developed our own virtual reality system.”

Next Base uses a custom full-body marker set consisting of 46 markers. “It’s a rigid link model with 18 segments from the feet to fingers on the ball. Our calculations are not restricted to kinematics, but extend to kinetics and energetics. With the inclusion of force plate data, we calculate segmental and joint kinetics written in a custom MATLAB script,” explains Dr. Jinji.

“We rely on our Vicon system to comprehensively evaluate individual movements,” Dr. Jinji continues. “In the context of pitching, we have developed a logic tree diagram with seven key elements based on the principles of energy flow. This helps us to understand which movements affect the ball’s overall speed, rotation, and distance. We can then provide personalized training recommendations on how to transfer greater energy to the ball by enhancing the skill, strength, and conditioning of the athlete.”

For the speed and accuracy Next Base requires, a state-of-the-art motion capture system was the only option. “Our marker model consists of small markers attached to the fingers and the ball,” Dr. Jinji says. “We measure at a high rate in order to comprehensively capture the fine points of the movement. To fulfill this requirement, we needed a high-resolution and high-speed motion capture system.”



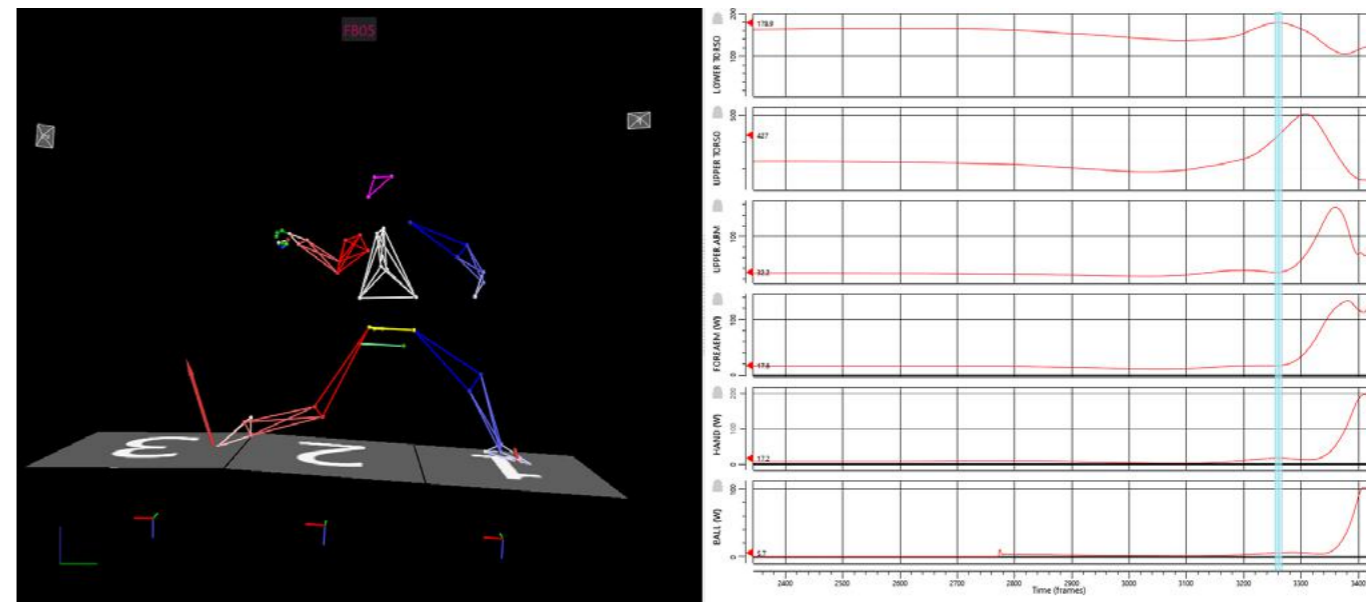
Dr. Jinji says that his Vicon system’s acute accuracy is one of the key advantages it offers for their research and is why it was the best system for their lab. “Movement signals are very sensitive in each player. We capture all the tiny details without them being removed, adding custom filters to help sort through the data.”

In addition to helping players improve performance, Next Base also aids in making adjustments to their technique to avoid injury. Dr. Jinji gives the example of a visitor who was experiencing discomfort in his shoulder. Next Base’s tests revealed excessive muscle contraction in the adduction of the shoulder joint. Dr. Jinji explains how this change in the player’s normal shoulder motion was resulting in an increased energy loss through

his pitching. “Our performance and conditioning coaches prescribed a training program to counteract the extra muscle load going through the shoulder, helping him return to his usual performance immediately.”

In the future, Next Base hopes to expand in a couple of different directions. “We plan to start online services for those who are unable to visit our labs frequently. We are also expecting to expand our lab network across Japan and overseas. Furthermore, we hope to scale up our Vicon system to use VR for improving hitting performance,” says Dr. Jinji.

For more information on Next Base, visit: www.nextbase.co.jp/en





SWINGING FOR THE INTEGRATED NETS

THE VALKYRIE-POWERED LAB THAT'S BLURRING THE BOUNDARY BETWEEN SPORTS SCIENCE AND CLINICAL BIOMECHANICS



Blesson Varghese, B.V.Crafted Photography LLC

In late 2023, Houston Methodist Hospital and Rice University launched a unique new venture—the Center for Human Performance, a space for the study and advancement of exercise physiology, injury prevention and rehabilitation of both student athletes and general population subjects.



Jordan Ankersen
Clinical Research Engineer at Houston Methodist

The 6000-square-foot facility combines a state-of-the-art system of Vicon's Valkyrie cameras with force-plate measurement, region-by-region quantification of bone density, metabolic analysis, cardiovascular screening and aerobic performance testing.

"For a hospital research department, we are very fortunate not only to have the system that we have, but also the space," says Jordan Ankersen, a clinical research engineer and recent PhD graduate in Biomedical Engineering. "Not only do we have motion capture and its affiliated technology, we've got a Biodex, we've got metabolic carts with treadmills and bicycles, we've got a DEXA scanner that we can use to assess body composition, and we have a wet lab space, giving us blood and tissue sampling capabilities."

SWINGING FOR THE NETS

A key focus for the Center so far has been baseball. "I could probably count on one hand the number of groups who have done marker-based hitting motion capture, because it's so difficult," says Ankersen.



Blesson Varghese, B.V.Crafted Photography LLC

“*I could probably count on one hand the number of groups who have done marker-based hitting motion capture, because it’s so difficult.*”

As she puts it: “If a baseball can go in a given direction, it’s going to. If it can’t, it’s still going to.” But because the Center’s designers knew it would be capturing baseball from the start, they were able to accommodate the sport.

“We have integrated nets installed in the lab,” says Ankersen. “That’s something that’s really unique. We went ahead and extended our raised flooring for the force platforms down the full-length pitching lane. So, not only do we have a full-length pitching or hitting lane, but we can also have somebody run or jump, and we could use it when working with ballet dancers.”

The work they’ve done has paid off. “The data set that we’ve collected is, as far as I know, one of the biggest in the field,” says Ankersen.

CROSSING FIELDS

Unusually, the Center’s remit is a roughly even split between sports and clinical work. “On the surface, what we’re doing with baseball and with our total knee and total hip replacement patients does seem really different,” says Ankersen.

But as far as she’s concerned, that crossover is one of the Center’s strengths. “It’s honestly rooted in a lot of the same questions and the same goals. Firstly, what is the immediate clinical application for this?”

“But the other thing that we really are passionate about and that I’m really trying to push forward, is that our

doctors want the same information as we’re generating for our athletes. They would cry tears of joy if they could send every patient they have to me and I could give them an immediate report with that depth of data.

All Vicon customers have access to support engineers who offer tools and advice to all of our customers, so they can easily customize the technology to their needs.

“The more code I write, the more we automate things, the better I get at it. And the more we share knowledge and automate our system, the better we’re going to get at providing that extra level of data to clinicians.”

BETTER REPORTING, BETTER OUTCOMES

Something that will help across both populations is Nexus Insight, Vicon’s new life sciences reporting tool, which the Center plans to adopt.

“Reporting that’s user-friendly to non-biomechanists is great, because that’s one of the things that we really would like to be able to do, whether it’s for a physician, a patient, or an athlete and their trainer.”

She gives the example of the baseball players she works with. “My baseball players don’t give a hoot that they had 45° of external rotation, but the other player had 39°. What they need to know is they’re getting lazy on their arm-cocking phase, so they need to put more power in that way, or whatever it may be.

SHARING PRACTICAL KNOWLEDGE

Ankersen is passionate about the knowledge-sharing piece, too. She turns back to her work with baseball players as an example. “We’re going to have to adapt or write new code for the baseball player who has a crazy arm when he’s winding up to throw his baseball. I can’t use an algorithm for that, I’m going to have to write custom code.

“But if somebody has written custom code for something else and gotten me 95% of the way there, fantastic.

“Or there’s going to be that one kid that markers don’t stick to. And it took me three years before I found the stickies and the skin tack and then figured out how to incorporate a fan in there to speed up the process.”

That’s the sort of information that’s unlikely to find its way into papers, but that Ankersen hopes to see shared more widely in the future.

DIVERSE VOICES

Another thing that Ankersen believes could add value to the world of motion capture is a greater diversity of users. “I’m in a wheelchair,” she explains. When she started out in the world of motion capture, though, she still had use of both her legs. “It would be so hard to break into the field in my current physical condition,” she says.



And yet, she argues, her physical condition offers clear advantages to her work. “One of the unique opportunities that I have is to be involved in healthcare as a researcher. I get to see it from the patient’s perspective and the researcher’s perspective, and consider how I want this data to be used to make a surgical decision in my case, or in the cases of my friends who have similar experiences to me. And so I think that keeping the users of the technology in mind, keeping in mind the people who aren’t yet users but would be really good users of motion capture, is really important.

“Keeping patients or athletes or whoever it is in mind, keeping that macro perspective about who we can really impact and what voices are important to hear, is essential.”

WILL THE FUTURE BE MARKERLESS?

Vicon is currently working on a markerless tracking technology that will prioritize real-time integration.

Ankersen sees potential for markerless tracking in the Center’s future.

“I think it’s important to have an open mind about these things and to acknowledge that markerless may be a part of our future. But even if markerless technology is awesome, I don’t think we’ll ever not need these optical, marker-based systems in the life sciences world,” she says.

It could be that markerless falls into the bracket of technologies that the Center for Human Performance uses its Vicon system to validate.

“We have a pretty large system, especially from a life sciences perspective. We’re trying to take advantage of that, using motion capture capabilities in conjunction with other technologies so that we can validate them for these and other applications.”

For more on the work of Jordan Ankersen see our feature on her [Lessons from studying sheep in the Texas summer](#) on P66.

For more on the Center for Human Performance, visit: www.chp.rice.edu



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GAME DESIGN MEETS BIOMECHANICS FOR A REHAB JOURNEY IN THE EXERCUBE



The ZHAW Zurich University of Applied Sciences, the Zurich University of the Arts (ZHdK) and Swiss startup Sphery have taken the gamification of fitness to the next level with an immersive rehabilitation program for athletes with ACL injuries.



Eveline Graf,
Professor of
Physiotherapy
at ZHAW Zurich
University of
Applied Sciences.

"This project came about through discussions we had with Sphery, the company who developed the ExerCube. We saw the potential for exergames to fill a gap in rehabilitation, something that the physiotherapist cannot offer by themselves," says Eveline Graf, Professor of Physiotherapy at ZHAW Zurich University of Applied Sciences.

The idea was to go beyond the generic fitness offering that was pioneered on game consoles and advanced by the ZHdK spin-off Sphery. The developers planned to offer an extremely focused program drawing on the expertise of biomechanists, PTs and games designers. "We know that there's a lot of untapped potential in this field of interdisciplinary R&D when it comes to exergames," says Anna Lisa Martin-Niedecken, founder and CEO of Sphery, as well as head of the Institute for Design Research at Zurich University of the Arts.

Sphery describes the ExerCube as an 'immersive fitness game setting'. It consists of three walls, which serve as projection screens for 3D game environments and provide haptic feedback when players make contact with them. There are currently ExerCubes at around 50 different fitness and rehabilitation centers globally.

"In our project we specialized in ACL injuries," says Graf. "The ACL is one of the most commonly torn ligaments in sports, and it leads to a long rehabilitation process."

The earlier crop of 'exergames' for the ExerCube provide users with a workout by having them jump virtual obstacles, reach for different objects, and respond to a host of other virtual inputs. To provide effective rehabilitation, however, the developers needed deeper insights into how participants were responding to different elements of the games.

ESTABLISHING GROUND TRUTH

“The first step is that we need to know in more detail how people actually move during an exergame, and how they do it while playing it over 25 minutes—maybe they get fatigued, and there are different levels of physical and also cognitive challenge” says Graf.

“That hadn’t been done at the level of kinematics of the joints,” she explains. “So the first step was to use an existing ExerCube game and record movement data of people playing the game. We looked at athletes, and then also athletes after an ACL injury, to see what kind of movement patterns they are producing. We needed to determine which movements are safe and which ones are a little more risky and might need to be left out. The Vicon system, for us, was the key to get that information that we needed—the detailed three dimensional kinematics of the lower extremities.”

“The data we gained from the biomechanical analysis really topped expectations, because we were able to very accurately see exactly which movements are better or worse for inclusion in the training concepts we’ve developed,” says Martin-

Niedecken. “It was really vital to have this Vicon system at the very beginning of the project to allow us to include the right movements for the training concept we were developing for the new exergame concept.”

The system that the interdisciplinary R&D-team used consisted of mixed Vantage cameras, Vero cameras and video reference cameras. “It was a real advantage to be able to combine all those different products and make one system,” says Graf.

CROSSING DISCIPLINES

Sphery’s use of Vicon motion capture goes back to the design of the first ExerCube games. “We used Vicon to be able to track all the movements of a real personal trainer to transfer to our core range of games. So for designing new games it offers a lot of benefits, because it’s really accurate,” says Martin-Niedecken. The development of the partnership with ZHAW, however, was the first time they had taken an interdisciplinary approach that paired motion capture for game design with biomechanics.

“One of the factors that I think made our project so successful is that we had experts from their respective fields come together and figure it

out together,” says Graf. “I know marker-based motion capture, while Anna and her team come from a game design and game research background. It’s too much for one person to know it all, but then to take that interdisciplinary approach, to stand in the lab together and figure things out, that was really crucial.”

The exergame would not have been possible without a versatile motion capture solution. “The Vicon tracking system allows a lot of freedom to do things differently,” says Graf. “We really had to think a lot about how we were going to capture and analyze the data we needed, because usually when you do an analysis of gait or running, there are standard protocols. Here, the subjects did 25 minutes of exergaming and there was a lot of variation in the movements.”

One challenge was the setup of the ExerCube itself. “We have those three walls,” says Graf. “You’re really enclosed and we use a marker-based system. So the question was, how are we going to do the analysis under those constraints? We worked closely with Prophysic, our distributor, and figured out how we could capture this broad range of motion in our enclosed space by removing parts of



the walls of the cube and then placing cameras in strategic positions where we could actually capture the volume.

“Having a Vicon system that is so modular meant we could add new cameras and customize our setup. We had the freedom to place cameras where we wanted—from down low, looking up; and then other cameras looking from the top of the space, downwards. We really needed a system that was flexible enough to adapt to our needs.”

“Because the participants played for 25 minutes, they sweated a lot,” says Graf. “We had to figure out how to make those markers stick. So for this project, we started using a cluster marker set—rigid bases with markers screwed on top. Having the freedom to use different marker sets was crucial in being able to capture this data.”

The current version of the newly developed game, which has already

been rolled out to various ExerCube locations, lasts 25 minutes and has two phases. “One is mainly focusing on strength training for stability, and there’s an element of cognitive performance but it’s rather controlled. Whereas the other section is more focused on representing the chaos and high cognitive load that comes when you’re getting back to your actual sports field,” explains Martin-Niedecken.

Graf and Martin-Niedecken have ideas for future projects for the ExerCube. One natural extension of their work would be to develop exergames for different types of injury, such as issues with the foot or shoulder.

Graf is also interested in creating assessment protocols for physiotherapy. “One idea is going in the direction of implementing clinical assessments. It’s very important that there are objective

assessments to decide, for example, if an athlete can do more complex exercises during rehabilitation, and implementing them in the cube would be very interesting,” she says.

Martin-Niedecken, meanwhile, is interested in further refining the experiential side of exergaming. “I want to find the sweet spot of immersion, because that was one of the starting points for this project. You will be able to perform more or less accurately depending on the grade of immersion, and then it’s very important that you are still in a safe, controlled environment while having the benefits of being immersed.”

To see The ExerCube in action, see our video case study: <https://youtu.be/Xy0eTFtXxGU>



FIT FOR PURPOSE

BOA IS USING ITS VICON SYSTEM TO CREATE NEXT-GENERATION FOOTWEAR



Sports technology brand BOA's Performance Fit Lab has two key challenges to contend with: the diverse range of sporting disciplines it analyzes and the high volume of tests that it performs. Thanks to a combination of BOA's Vicon system and an integration with The MotionMonitor that ties it to other performance analysis tools, the company's biomechanists are managing their high output levels and delivering performance insights for a variety of athletes.



*Kate Harrison, Ph.D.
Manager of
Biomechanics
Research at BOA*



*Eric Honert,
Senior Manager
at BOA*

BOA was founded in 2001 by snowboarder Gary Hammerslag. His goal was to apply the engineering expertise he had acquired while designing medical solutions to elevating the performance of snowboard boots. The result was a 'Fit System' that improves the way footwear conforms to the foot using a dial and metal wiring to replace conventional lacing. In the two decades that have followed, BOA has partnered with brands designing footwear across fields ranging from trail running to golf to medical bracing.

While the technology was born of Hammerslag's intuition, the BOA Fit System is now informed by the work done in the company's Performance Fit Lab at its headquarters in Denver, Colorado, USA. The 200 Sq.ft space knits together a Vicon motion capture system, Vicon Blue Trident inertial measurement units (IMUs), force plates, force insoles and a dual radar system with integration of The MotionMonitor, which delivers data in real-time.

A critical part of the lab's design is its adaptability. It includes an instrumented treadmill, a ski treadmill

and a golf bay. "It really has the flexibility to be doing tests across multiple segments in a given week, because we don't have to reconfigure everything," explains Kate Harrison, Ph.D. manager at the lab.

That adaptable setup enables the lab to study disciplines including running, agility movements, workwear, hiking, golf, cycling, skiing and snowboarding, basketball, badminton and tennis. Eric Honert, a senior manager at the lab, was excited by how fast this data could be integrated with their system. "I was awestruck," he says.

A TIGHTLY INTEGRATED WORKFLOW

BOA conducts over 400 hours of elite athlete performance testing each year. It typically turns around a 10 person study in three weeks, and it will have two or three studies running in parallel, meaning the lab has to perform upwards of 850 tests per year.

Having BOA's Vicon system integrated with its other technologies is an important factor in hitting those demanding targets. "That integrated partnership means that everything is



“The level of support that BOA has received from Vicon has also been important in maintaining the lab’s high level of throughput.”

just so seamless and efficient,” says Harrison. “It’s great being able to use Vicon through The MotionMonitor and integrate with our other equipment, and the post-processing is so smooth. The live data visualizations make it easy to make sure the data quality is great as you’re collecting it. Compared to other experiences I’ve had with motion capture it’s just so much more streamlined and efficient, which has been awesome. That’s been really critical for us.”

The MotionMonitor is a 3D motion analysis platform that collects real-time data from multiple types of movement measurement hardware. Innovative Sport Training, the maker of The MotionMonitor, has been partnered with Vicon since 2008 and provided BOA’s movement analysis hardware and software in a turnkey system. BOA’s Vicon data streams into The MotionMonitor live, and the biomechanical models are built from there. In many cases this avoids the need for multiple templates and enables a subject to be set up in two to five minutes, helping to streamline BOA’s high-volume workflow.

“We’ll place clusters of markers on individual segments and then digitize the joint centers,” explains Honert. “It helps in terms of post processing—you don’t have to do some sort of calibration afterwards to get those joint centers.”

“I would associate a process this streamlined with a clinical setting, where you’re doing one thing really fast, but where you can’t change your model to ask a different question and the system is more plug and play,” says Harrison. “The combination of the streamlined and efficient nature of our setup with the ability to do all the different types of testing we do here is pretty incredible.”

The level of support that BOA has received from both Vicon and The MotionMonitor has also been important in maintaining the lab’s high level of throughput. “The support has been awesome,” says Harrison. “Having a company like Vicon that you can get on the phone the same day as you have a problem to troubleshoot is great. With the number of tests that we’re doing we just can’t afford to be down for a week, so being able to get immediate hardware support has been critical.”



MEANINGFUL RESULTS

“The first study we did in the lab was into agility and speed, studying court athletes from basketball, tennis, badminton etc, and looking at how effectively they could change direction and how fast they were in various types of footwear,” says Harrison. “We found that by improving the fit of a shoe we could, for example, change how efficiently they changed direction by up to nine percent. We saw some really meaningful improvements in those agility sports, and that was a really nice foundation to build from.”

Other headline improvements the team have found in athletes wearing BOA-enhanced footwear include 1.5 percent improvements in speed with the same exertion; seven percent reduced ankle rotation velocity and increased stability; and three percent improved connection to the midsole and heel hold.

“1.5 percent doesn’t sound like that much,” says Honert. “But for these high-performance athletes, that could be the difference between making the podium and not making the podium.”

While the size and flexibility of BOA’s lab offers the team a wide range of options for the diverse set of movements they capture, they have begun to take their tests further afield. “We’ve started extending our testing beyond the lab,” says Honert. “We recently went out to a local trail here and we had athletes run a one mile loop in different shoes and monitored them with Vicon’s Blue Trident IMUs. We’ll also do snow testing, looking at different ski and snowboard boots.”

GETTING PRACTICAL

The team at BOA has been able to publish results in areas of sporting performance that have barely been touched by serious motion analysis. “There’s so little research and testing on sports like snowboarding, because it’s so difficult to do,” says Harrison. “We’re getting to share so much with the scientific community on things that haven’t really been explored before, like ‘how do you even biomechanically define performance in snowboarding?’ Being able to help progress those fields has definitely been a cool aspect of what we’re doing.”

All of that knowledge is being acquired with practical applications in mind. The work Harrison, Honert and their colleagues are doing in the BOA Performance Fit Lab is about improving the products BOA is creating. “We’re really integrated with the rest of the company,” says Honert. “Our work informs BOA’s design and development to create solutions that change how footwear fits for the athlete, really enabling superior performance.”

In the future, BOA hopes to extend the work it’s doing out in the field. “When we bring people into the lab we get a really great snapshot of how they’re performing over 30 seconds, for example,” says Harrison. “But so much of performance is determined over the longer term—how people are performing at the end of a marathon, for example. Hopefully these tools will allow us to capture a much greater volume of an athlete’s movements over the course of a day or a week. That will open up more avenues for research.”

“As the technology becomes more accessible, that will allow people to go outdoors into these ecologically valid scenarios to really test how footwear works in realistic settings,” Honert adds. “That’s what we’re really trying to do—create these realistic tests to see how our footwear performs in those real-world scenarios.”



For more on the innovative work being done by BOA, visit: www.boafit.com

To learn more about The MotionMonitor visit: www.innsport.com

PUSHING CLIMBING TO NEW HEIGHTS WITH MOVEMENT ANALYSIS

MOTION CAPTURE REMOVES THE GUESSWORK FROM COACHING IN THE HIGH-STAKES SPORT OF CLIMBING

“At the University of Derby we’re all about applied research,” explains James Mitchell, Program Leader for BSc Performance Analysis and Coaching Science at the university. “The beauty of Vicon is the ability to translate research into practice. It’s an amazing tool to help us really understand climbing movement from a scientific point of view, and then actually translate that understanding into practice.”



James Mitchell, Program Leader BSc Performance Analysis and Coaching Science, Derby University



Simon Briley, Lecturer in Sport & Exercise Science, Derby University

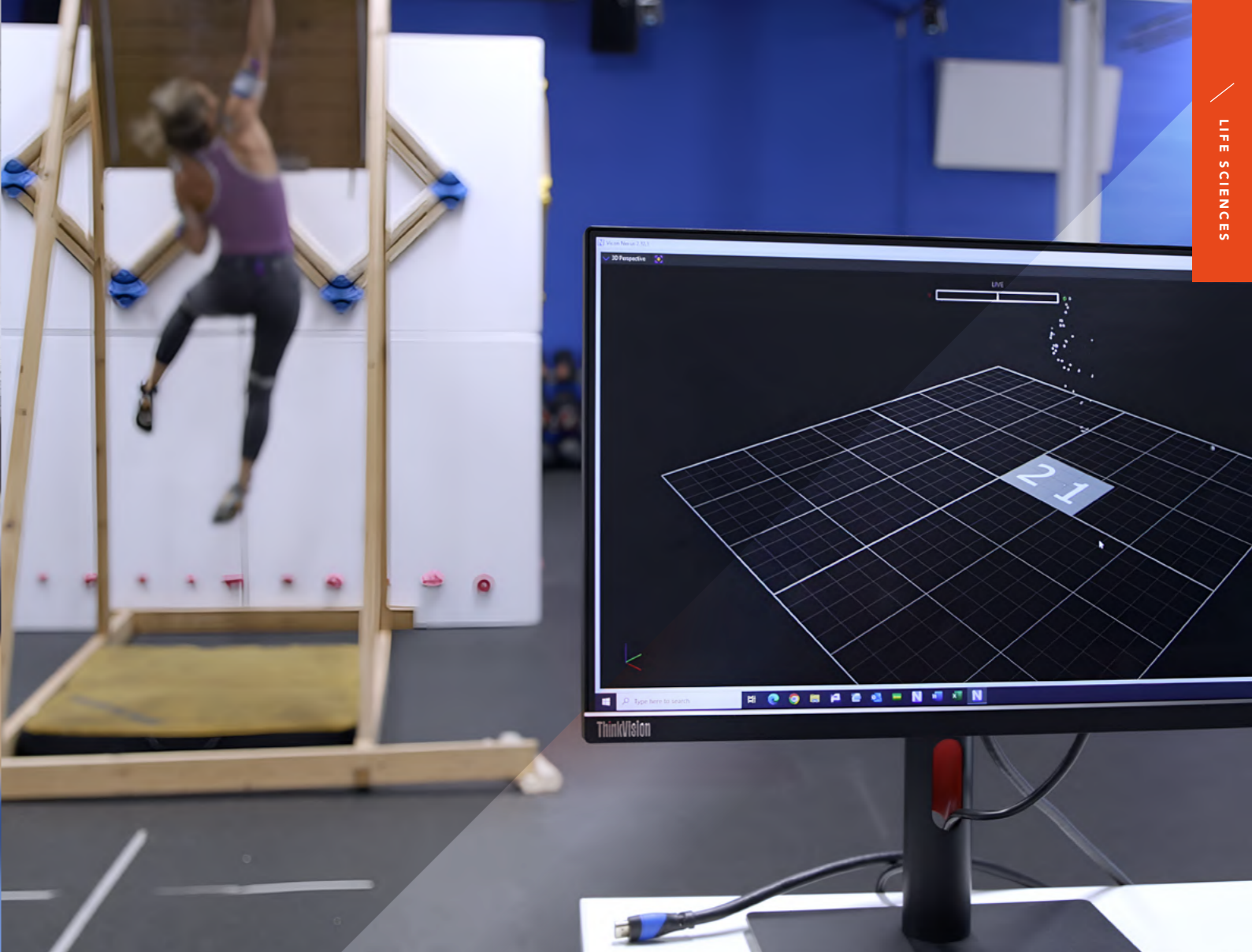
To help bridge the gap between research and practical application, the university has partnered with Lattice Training, an organization that provides assessment, coaching and training plans for climbers. Lattice, which has worked with elite climbers such as Alex Honnold, Emily Harrington and Tommy Caldwell, helped put together the university’s climbing systems and equipment.

“Traditionally, climbing has been analyzed using just a video camera or purely through the subjective experience of coaches,” expands Simon Briley, Lecturer in Sport & Exercise Science. “What we’re trying to do is take that guesswork out and provide really detailed, objective data for coaches and athletes.”

The result is a volume equipped with a climbing wall, 12 Vantage cameras and a number of Blue Trident IMUs, all running alongside Nexus in the Vicon life sciences ecosystem.

“Vicon offers amazing tools to really develop our understanding of climbing performance, of how to improve it, and how to reduce injury. What’s been amazing throughout this research is the connectivity between the Vicon cameras, the IMUs, and Nexus. It’s just really seamlessly integrated, which means I can pass on all that data straight to coaches and athletes,” says Mitchell. Combining the optical motion capture and the IMU data has been really valuable to better understand these techniques.





“Vicon offers amazing tools to really develop our understanding of climbing performance, of how to improve it, and how to reduce injury. What’s been amazing throughout this research is the connectivity between the Vicon cameras, the IMUs, and Nexus. It’s just really seamlessly integrated, which means I can pass on all that data straight to coaches and athletes.” - James Mitchell, Senior Lecturer in Sport Outdoor and Exercise Science at the University of Derby



Ian Cooper, Climbing Coach and Trainer, Lattice Climbing

“From a coaching point of view, you can look at what an athlete is doing in comparison to stronger climbers, or to climbers who can do things that they can’t do,” says Ian Cooper, a Climbing Coach and Trainer with Lattice Climbing. “And from a research point of view, you can look at performance trends in the differences between very good climbers and less proficient climbers.”

Movement analysis is providing the university and Lattice with unprecedented new insights into climbing performance.

“Motion capture potentially answers a lot of questions that we’ve not been able to answer using previous techniques,” says Mitchell. “It provides a new level of detail to help improve climbing movements. Vicon is constantly coming up with new and better ways to help us measure and improve performance.”

And it’s really exciting that we’re now able to take these technologies into real-world environments. We’ve got less constraints, and it makes the information a lot easier to translate to coaches and athletes.”

“The endpoint in terms of data capture and performance is giving coaches a set of tools based on all our detailed kinematics and all the data that we collect with the Vicon system,” says Briley. “We can say that if we want this athlete to be at the top level in the next few years, this is exactly what they need to work on.”

For more information on the University of Derby visit: www.derby.ac.uk

For more information on Lattice Training visit: www.latticeclimbing.com

COMMUNITY IS THE VOICE FOR VICON LIFE SCIENCES

Community is at the heart of every innovation that Vicon delivers to the life sciences. The insights generated by our users are the driving force behind our development process. One strong message has prevailed: innovators want tools that streamline their processes, and they want them to be vetted by the research community. We're working hard to deliver on that, and to continue expanding the possibilities motion analysis brings to the life sciences.



Dr. Kim Duffy, Senior Product Manager
- Life Sciences

UNVEILING VICON'S LATEST LIFE SCIENCES ADVANCEMENTS

REVOLUTIONIZING IMU JOINT CALCULATION

Responding to the call for simplicity in IMU-based joint angle calculations, Vicon collaborated with Exponent to seamlessly integrate OpenSense into Nexus and Capture.U. This eliminates the need for users to generate Python code to make joint calculations, allowing researchers to focus on efficiently capturing data in the field.

INNOVATIVE UPPER LIMB BIOMECHANICAL MODEL

Addressing the under-utilization of motion capture for upper limb assessment, our collaboration with Dr. Martin Warner and the University of Southampton resulted in a new ProCalc solution that's available with the Nexus license. This model enhances upper limb research across various applications, providing new avenues for exploration.

PRECISION IN MOTION - IDENTIFYING SQUAT EVENTS IN NEXUS

In partnership with Scottish Rite for Children, Vicon introduced an algorithm for accurately identifying squat events within the Nexus platform. This collaboration enhances the precision of data analysis and interpretation, aligning with our commitment to community-driven advancements.

NEXUS INSIGHT - A MODERN REPORTING REVOLUTION

The biggest development in Vicon Life Sciences has been the release of Nexus Insight, our latest reporting tool tailored to the evolving needs of the life sciences community. Responding to user feedback, we've crafted a modern, intuitive, and flexible reporting platform. Whether you're an experienced biomechanist or a student, Nexus Insight's out-of-the-box reporting meets the demands of clinical practice, providing digestible information.

COMMUNITY-POWERED DEVELOPMENT - NEXUS INSIGHT UNVEILED

Embracing community feedback, the Nexus Insight development journey was informed by our expansive Early Adopter Program (EAP). Engaging with over 40 organizations from across the world, this comprehensive program validated Nexus Insight and provided invaluable insights into its diverse applications across research, clinical practice, and academia.

BEYOND EXPECTATIONS - DISCOVERING UNFORESEEN USES

The EAP not only validated Nexus Insight but uncovered unexpected use cases, particularly in education. The Split View layout allows users to understand the immediate correlation between visual outputs and data. Nexus Insight has proven to be a powerful tool for educators, enhancing biomechanics learning through immediate visualization.

LOOKING AHEAD - A FUTURE SHAPED BY COMMUNITY FEEDBACK

As we stride into the future, Vicon remains dedicated to incorporating user feedback into Nexus Insight's ongoing development. Expect enhanced flexibility, note-taking features, and seamless collaboration on reports. We anticipate these updates will entice even our dedicated Polygon users to transition to Nexus Insight, and we're excited about the community members ready to make the switch.

YOUR JOURNEY WITH VICON

We're grateful for the positive response to our community-driven approach. Stay tuned for upcoming Early Adopter Programs in the next year as we continue bringing you further into our development process. Explore the possibilities of Nexus Insight and join us on this exciting biomechanics journey on our [Vicon Nexus Insight page](#).



CUSTOMER SPOTLIGHT: LUX MACHINA

CONSULTING ON BARBIE AND
HOUSE OF THE DRAGON

There are very few tentpole cinema releases or effects-based, premium TV shows that haven't been touched by Vicon technology at some point in their production cycle. Vicon counts the best effects houses in the entertainment world among its users. Even within such a high-performing group, Lux Machina Consulting stands out, thanks to its work pioneering virtual production in an LED volume on *The Mandalorian*, and more recent high-profile projects including *House of the Dragon*, *Barbie* and *Masters of the Air*.



Wyatt Bartel,
Vice President
of Production,
Lux Machina



Jephtha Valcich,
Camera Tracking
Specialist,
Lux Machina

We put some questions to Lux Machina's Poom Wattanapan, production specialist; Wyatt Bartel, vice president of production; India Vadher-Lowe, lead motion capture specialist; and Jephtha Valcich, camera tracking specialist, about the studio, their work, their experiences with Vicon and the future of motion capture in VFX and virtual production.



India Vadher-Lowe,
Lead Motion
Capture Specialist,
Lux Machina

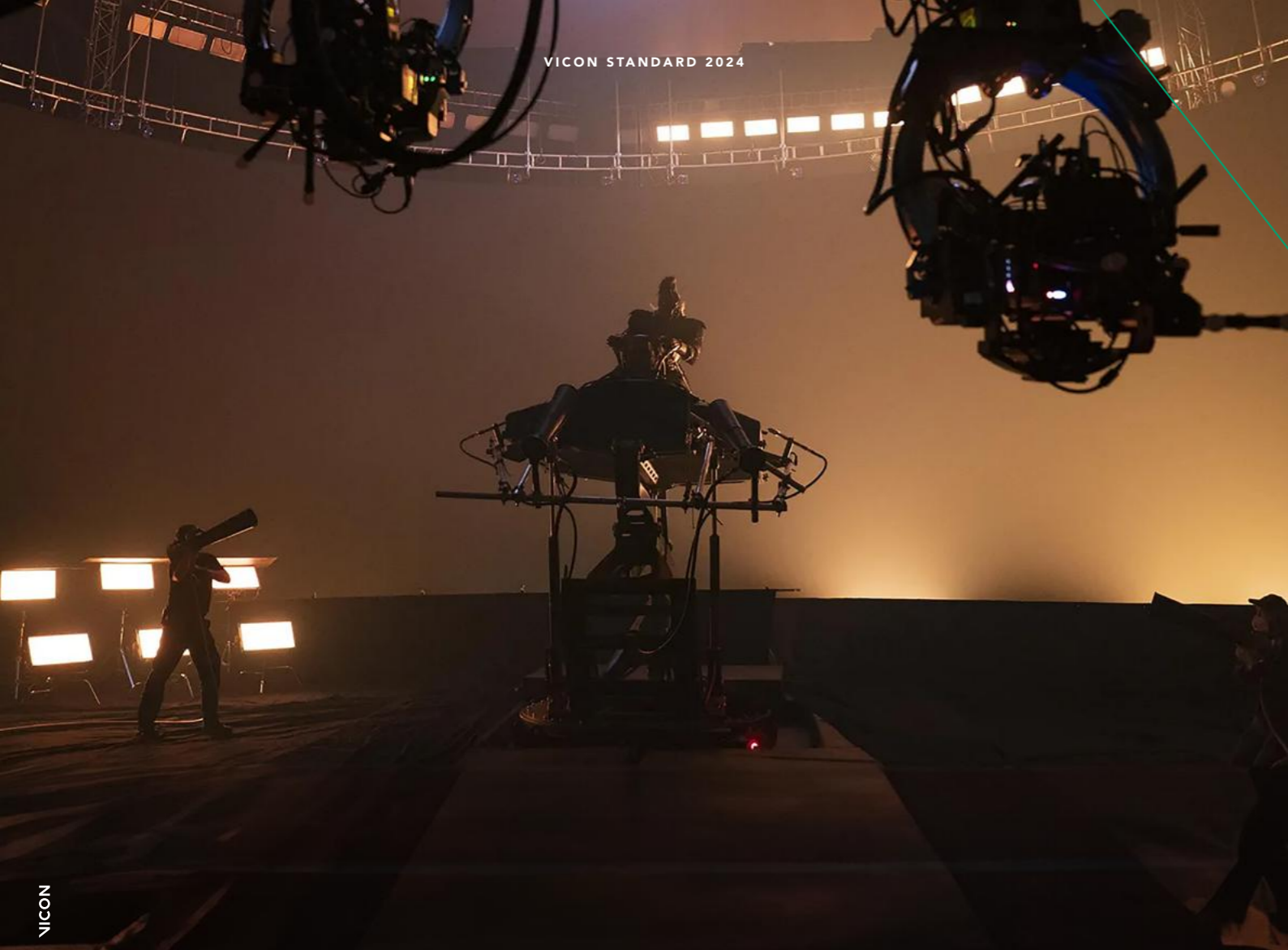


Poom Wattanapan,
Production Specialist,
Lux Machina

FIRST, CAN YOU TELL US A BIT ABOUT LUX MACHINA?

Wyatt Bartel: Lux Machina Consulting is a design, management and technical consulting firm, specializing in virtual production, in-camera visual effects, display technologies and creative screens control for large scale productions and installations.

Since its early involvement in high-profile projects like *Oblivion*, *The Mandalorian* and *Masters of the Air*, Lux Machina has consistently led the field in integrating cutting-edge technology with creative vision. What truly sets Lux Machina apart is our commitment to in-house design and implementation of service solutions.



This approach allows us to harness the extensive, specialized expertise of our team, ensuring that each project benefits from tailored, state-of-the-art solutions.

Our ability to adapt and evolve with the industry's demands, combined with a team deeply versed in both the technical and creative aspects of virtual production, positions us uniquely among our peers. This blend of pioneering spirit, technical excellence and bespoke service offerings not only drives the industry forward but also delivers unparalleled value to our clients.

HOW HAS LUX MACHINA'S VICON SYSTEM ENHANCED YOUR WORK?

Poom Wattanapan: Throughout the course of House of the Dragon, Vicon proved to be essential in the production environment. The quality of tracking data and the reliability of the system allowed us to feel confident walking into each production day.

Over the course of my time in virtual production I have had the opportunity to work with a large variety of tracking systems. I strongly believe in using the right tool for each job. We turn to Vicon when we need a system that offers maximum flexibility. On House of the Dragon, cameras would often shift from a technocrane to a dolly then back within a single shoot day. Using a reliable, outside-in tracking system was key in providing freedom for directors and DP to shoot scenes the way they wanted to.

India Vadher-Lowe: I have been very lucky to have spent most of my career working with Vicon systems. This is so important when consulting on projects, as I need to be able to advise on the right solution for the job, and not every solution will be capable. Vicon offers incredible precision and versatility on productions that require a lot of flexibility and change. Some productions require complex set builds, technically difficult shots and multiple camera rigs, so I rely on Vicon's quick lens calibrations and ease of system adaptation to minimize time taken away from the production.

TELL US ABOUT THE V STAGE AT WARNER BROS. STUDIOS LEAVESDEN.

Wyatt Bartel: Warner Bros. tasked Lux Machina with building a world class virtual production volume at Warner Bros. Studios, Leavesden, and to fulfill our camera-tracking and object-tracking needs, we chose Vicon.

Our goal was simple: deploy a production-ready, rigid-body tracker that could track multiple cameras within an LED volume with a minimum of impact to the DP and production workflows. It had to be low-noise, low-jitter and flexible to adapt to the multiple productions that it serviced. Our goal is always to enable workflows that extend the opportunities for filmmakers rather than confining them to innovative yet rigid pipelines. Vicon allows us to move at a pace and make choices on the fly with camera rigs; Veros getting set up quickly to help extend volumes; lens profiles and quick software to keep us on pace for meeting the needs of the shoot every day.

AND YOU RECENTLY LAUNCHED THE LUX STAGE AT TRILITH STUDIOS. WHAT CAN YOU TELL US ABOUT YOUR EXPERIENCE WORKING AT THE NEW FACILITY?

Jeptha Valcich: Francis Ford Coppola's Megalopolis was the first project to shoot on our VP stage at Trilith Studios. My goals were to do whatever I could to make Mr. Coppola enjoy his first experience on an LED volume. Vicon's optical tracking was critical in getting this project done. The tools at our disposal allowed us to move quickly and efficiently, matching the production's pace. The camera tracking remained stable even in the tightest of spaces when most of our Vantage cameras were occluded. We have a custom-built wand designed to speed up the calibration of larger spaces. It can calibrate our 91-camera system in around five minutes.

IS THERE ANYTHING YOU CAN SHARE ABOUT HOW YOU CUSTOMIZE YOUR WORKFLOW TO FIT WITH LUX MACHINA'S NEEDS?



India Vadher-Lowe: Shōgun is a great piece of software. It's easy to learn and enables you to use multiple tools to get you out of a tricky situation. Traditional film and lighting techniques aren't always best suited for an optical system as they can cause noise and occlusion. Being able to create custom filters and modify live data processing thresholds allows us to counteract any negative effects that the temporary occlusion might cause, without having to stop to change the camera positioning.

HOW DO YOU ANTICIPATE YOUR USE OF MOTION CAPTURE EVOLVING?

Poom Wattanapan: In the future I suspect we would like to track more real-world objects as we look at how virtual production could be more efficient or interactive.

Wyatt Bartel: I see Lux Machina's adoption of the forthcoming Vicon markerless solution as a wonderful addition to help augment our existing pipelines and rental stock. The ability to mix and match workflows will help us enable experiences for our customers that were previously locked to the motion capture studio but will now be able to be experienced out in the wild in temporary locations.

Jeptha Valcich: I think the race right now for motion capture is towards markerless tracking. Once you have a system that permits actors to work free of a suit and headgear, it will be a huge game changer. I expect that as the technology becomes easier to use, it will appear more frequently during the production process. My hope is that more actors get to see themselves as the virtual characters that they become because I think it's fun for everybody.



For more on Lux Machina visit: www.luxmc.com

BRINGING VIRTUAL HUMANS TO LIFE

For Dr. Zerrin Yumak, a computer scientist specializing in socially interactive virtual humans at Utrecht University, there's a missing piece in today's crop of digital humans. "I think the most urgent question right now is how we can generate animations for non-verbal communication including with the face and body, but also holistically," she says. "Multimodal generation of social animations is still missing and it's a challenge that we need to address."



Dr. Zerrin Yumak, Assistant Professor, of the Information and Computing Sciences Department, Utrecht University and Director of the Motion Capture and Virtual Reality Lab

Dr. Yumak is an assistant professor in the Information and Computing Sciences Department at Utrecht University and director of the Motion Capture and Virtual Reality Lab. A member of the Human Centered Computing group, she's been working in the field of 3D digital humans for the last 15 years.

The field covers avatars for humans in virtual spaces, but also digital characters that could be used in video games or to embody chatbots or dialogue systems such as ChatGPT or IBM Watson.

"I'm working on how to make these characters interact naturally with us using natural ways of communication such as facial expressions, gestures and gaze behavior," Dr. Yumak explains. "Lately, I've mostly been working on speech- and music-driven animation. Given speech or music as input, we are automatically generating motion. We are aiming for natural and controllable motion synthesis and to automate these processes for faster and less costly pipelines."

"Our recent work on FaceXHubert and FaceDiffuser aims for generating

facial motion using advanced deep learning algorithms both for 3D vertex-based and rigged characters. We have worked on a project in collaboration with Guerilla Games to generate gaze motion and our results show the advantage of a data-driven approach with respect to a procedural gaze model."

These behaviors, whether applied to human avatars, non-player characters in video games or a digital character acting as an interface with a chatbot, are informed by motion capture data.

MAKING DIGITAL HUMANS WELL BEHAVED

Dr. Yumak says that believable, natural animation is an important next step in virtual character development. "We are in a situation where we have a lot of developments in the fields of computer vision/graphics, AI and natural language processing, and VR/AR technologies," she says.

"All of these technologies are now merging, which really lets us develop very realistic virtual characters, virtual environments and dialogue capabilities, but there is more work to be done to generate social behaviors that are correct and convincing. That is a very complex and interdisciplinary research field." She organized the MASSXR (Multi-modal Affective and Social Behavior Analysis and Synthesis

in Extended Reality) Workshop at the IEEE VR 2023 conference to bring together researchers and practitioners in this field.

Perhaps the most obvious application for Dr. Yumak's work is in the gaming and immersive tech industry, but there are also opportunities in other fields. "For example, the use of digital humans to deliver training in communication skills, or for business and marketing. For instance, you can have virtual characters as chatbots to advise people on things like mortgages. And there are use cases in telecommunications using Social XR, enabling remote people to interact and work together. Virtual human animations play a crucial role in creating a sense of presence and trust in these applications."

"In health and education, we can have virtual characters or companions that can help children to learn or interact with elderly people. I have worked, for example, on a project where we were developing companions that can play instruments like piano for children with motor disabilities, or a robotic tutor enabled with memory and the appearance of emotions."

Dr. Yumak has been working with Vicon systems dating back to Blade, the precursor to Vicon's Shōgun software platform for digital creators.

The lab at Utrecht University consists of 14 Vantage cameras, now running alongside Shōgun. The software, in particular, has done a lot to streamline her work. "Everything is just great out of the box, and the solving and everything works nicely, especially finger-tracking, also tracking multiple people all at the same time. The nice thing is you can have a solver that combines body solving and finger solving together," she says.

"These elements are very important for our research because we're collecting data in the lab and then using this data to train our deep learning models to generate the movement of the virtual characters, and also to conduct perceptual user experiments. Being able to do that fast is very useful for us."

"I want to capture these small group conversations in great detail, at micro-gesture levels. Tracking is important for us to capture all the nuances in the face, the finger movements and the body movements. We have collected a new dataset called Utrecht University Dyadic Multimodal Motion Capture Dataset-10 hours of natural conversations between two actors, including detailed body movements, facial animation and finger movements. That is a crucial step for us towards multi-modal motion synthesis in small group-interactions."



A FRESH APPROACH TO AI AND XR

Dr. Yumak is in the process of putting together a group that will tie some of the disparate strands of the AI and extended reality (XR) fields together. "Currently, we're setting up a new lab bringing together experts and researchers but also public and private partners, and this is called the Embodied AI Lab for Social Good. We want to bring AI and immersive technologies together, and the concept is about embodiment and artificial intelligence. We want to collaborate with technology companies that develop animations, but also with educational or health organizations that use these virtual characters to improve human/machine communication."

The new lab has its sights set on a number of challenges. "One of the things that we're working on is speech-driven gesture motion synthesis. At the moment this is mostly done

using datasets and algorithms that do not include semantic aspects of gestures. In other words, the motions look natural at first glance, but their semantic grounding with respect to accompanying text is lacking. In collaboration with colleagues from Max Planck Institute for Psycholinguistics, we are addressing this challenge"

Audio-driven and text-driven gesture generation at the micro level remains a priority, but applying those behaviors to group interaction between characters is increasingly a focus. "At the moment, the current techniques are really directed at monologues," says Dr. Yumak. "You deliver the audio and then you get a character that's talking by itself. But what happens if we are having a two or three-party conversation? Who looks at who, who takes the speaking turn? How do you manage this dynamic?"

"Can we automate this process? The listening behavior, talking

behavior, but also the style control: Can we create a character that is automatically moving given a certain emotional or personality style?"

Yet another challenge is bringing these behaviors to multi-party interactions between humans and virtual characters. "Can we feed these (facial and body language) signals from the real users to the behavior of the virtual characters? Because everyone is focusing on the language or vision half of the pipeline. The other half, the physical and embodiment, is not really well-studied yet," says Dr. Yumak.

There are applications for the lab's work beyond the digital sphere, too. "The techniques that are relevant for socially interactive digital humans can also be applied to robotic characters. They include very similar pipelines, they use similar algorithms and datasets, but the medium, the embodiment, is different," says Dr. Yumak.



THE CORONAVIRUS EFFECT

Covid did a lot to accelerate Dr. Yumak's work. "I think after the pandemic, we really started to talk about new ways of communication using 3D tools—immersive spaces, virtual reality, augmented reality and spatial computing. That has definitely had a very big impact on my research too," she says.

Dr. Yumak notes that studies have shown 2D video conferencing can

create fatigue due to issues like failure of eye contact and a lack of appropriate non-verbal communication, and also notes the environmental impact of reducing travel for meetings.

Thanks to this confluence of technological and social factors, research into immersive telepresence is growing. "We are coming together with a consortium of people to work on the topic of social XR, working on how realistic virtual humans can be used for next generation

telecommunication where we can represent ourselves with avatars. It can be really useful, instead of having these 2D screens, to be able to meet in virtual spaces and then interact in a more natural way," Dr. Yumak says.

She's sensitive to the fact that this isn't only a question for engineers and designers. "This is not only about the technology development but how people are perceiving this, whether we can include different perspectives in this kind of discussion when we are developing intelligent behavior in immersive environments.

"So, do we really want to create life-like digital characters or even replicas? To what extent can we ensure privacy and security? We often try to engage in these conversations with people from different perspectives, with backgrounds in humanities and social sciences, and even from philosophy and law. At the end of the day, we should see these technologies as tools to enhance people's quality of life, and not as a replacement for real human communication, and we need to clearly communicate the advantages and potential risks."

For more information on Utrecht University's Motion Capture and Virtual Reality Lab, visit: www.uu.nl/en/research/motion-capture-and-virtual-reality-lab



ZEROSPACE USES ITS VICON SYSTEM TO POWER THE NEXT GENERATION

CONCERTS, DOCUMENTARIES AND REAL-TIME INFLUENCER LIVE STREAMS

“Vicon really offers the best quality motion capture data that you can get. And it’s just so powerful to have talent in the space, and to be able to have them see their character and adapt and modify their performance based on what they’re seeing, all in real time.”

- **Elena Piech, Real-Time Producer, ZeroSpace.**



Juan Carlos Leon, Character Technical Director, ZeroSpace



Elena Piech, Real-Time Producer for ZeroSpace

“Every single time we’re on the stage, we get a chance to do some very unique R&D testing that you rarely see other studios do,” says Juan Carlos Leon, Character Technical Director for ZeroSpace. “We definitely love innovating in this space.”

ZeroSpace is a 50,000 sq ft next-gen production and creative studio that specializes in blending the real with the unreal. The Brooklyn-based company has both a Vicon-powered motion capture stage and a virtual production stage, and has worked with partners including Reeses, Paramount, Nike, Fortnite, Disney and Justin Bieber.

Not too long ago, however, the space served a different purpose entirely. “Essentially, before the pandemic, ZeroSpace was a ticketed immersive art experience in Manhattan, located

right next to Madison Square Garden,” explains Elena Piech, Real-Time Producer for ZeroSpace. “They were doing super well and they had a team of about 100 people. They were getting ready to open their second location in California and then March of 2020 happened. ZeroSpace went from a team of 100 people to just our CEO, Jon Kreutzer.

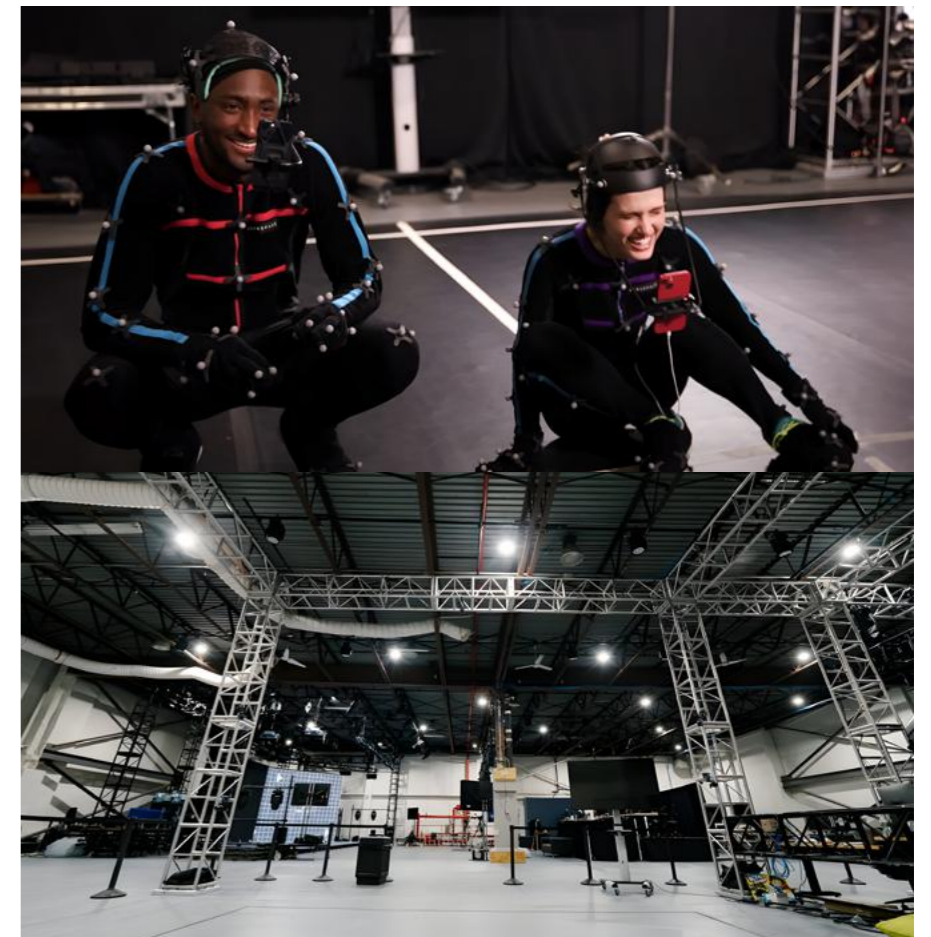
“The Mandalorian had just come out, and Jon realized that virtual production was about to explode. At the same time, there were these LED tile manufacturers that didn’t really have much business because concerts and events weren’t happening. So he partnered with another company to build what was one of the largest virtual production stages in New York City.

“And we’ve since grown and now have a larger stage. And we pivoted from this immersive art experience into being a 3D content creation studio.”

While ZeroSpace’s focus has shifted, its DNA remains relatively unchanged. “Really, the experiential art is at the very core of our identity,” says Piech. “We try to always take on projects where we can think about really great ways to interact with audiences and find cutting-edge ways to do it. When we have downtime, we’re focused on R&D and thinking about things from a live performance standpoint.”

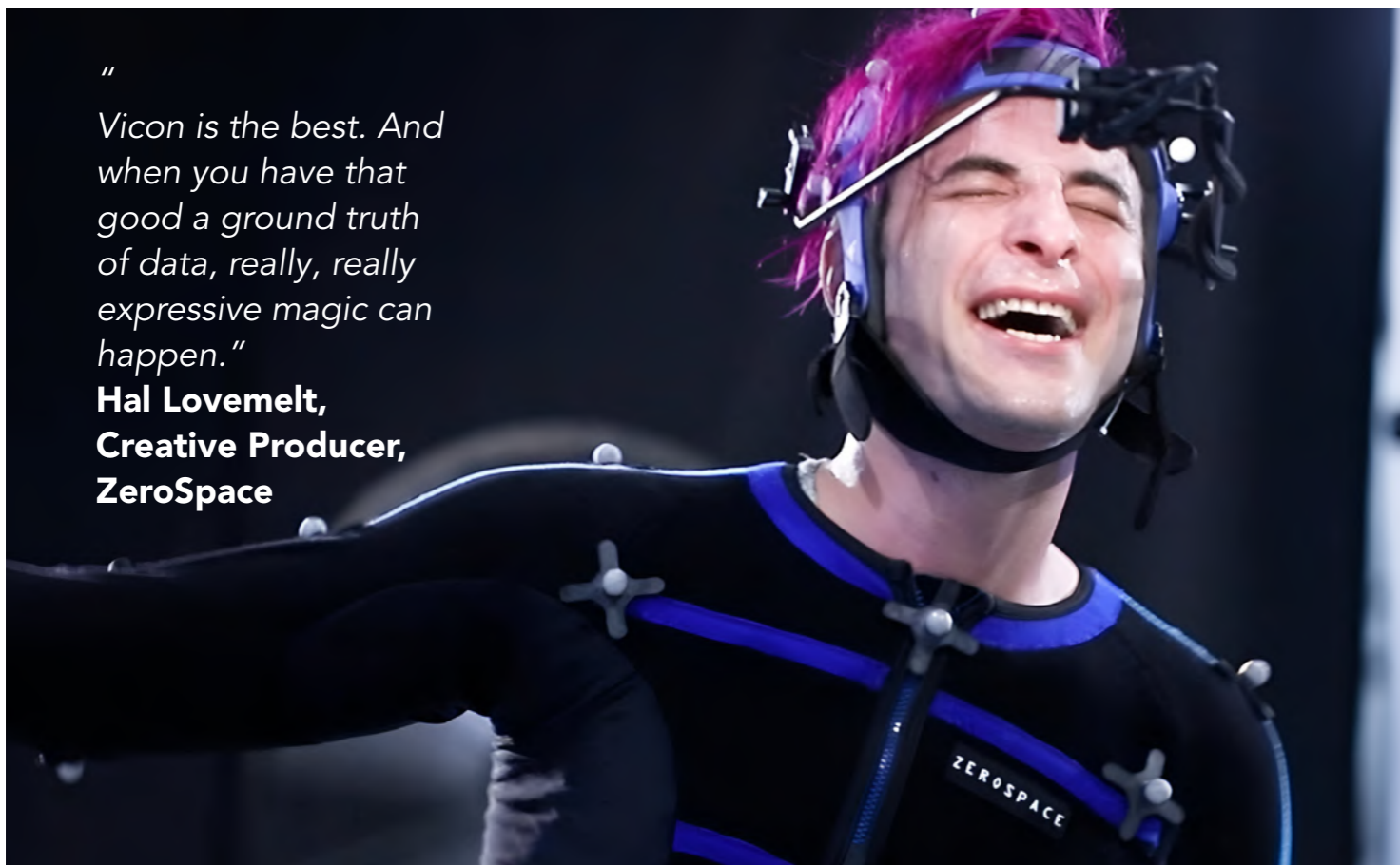
A STRONG FOUNDATION

ZeroSpace’s innovative creative work depends on the power of the technology it uses, says Creative Producer Hal Lovemelt. “Vicon is the best. And when you have that good a ground truth of data, really, really expressive magic can happen,” he says. “We have a lot of fun with our R&D initiatives on top of our client work to help drive the next generation of performative and expressive motion capture tooling.”



“
Vicon is the best. And when you have that good a ground truth of data, really, really expressive magic can happen.”

Hal Lovemelt,
Creative Producer,
ZeroSpace



Hal Lovemelt,
Creative Producer,
ZeroSpace



Samuel Sords,
Motion Capture
Operator, ZeroSpace

Motion Capture Operator, Samuel Sords gives an example: “Since we have the virtual production stage, we can put somebody in a Vicon suit, stream them to the virtual production stage and have a real human and avatar interaction all in real time. We were one of the first studios to master how to use that, how to have really low latency, how to have great eye lines.”

ZeroSpace sees Vicon’s markerless technology as a powerful new tool that could create novel possibilities, especially as demand for motion capture beyond the confines of their studio continues to grow.

The company has already experimented with mixing markerless and optical capture for Jack Daniels, creating a virtual concert experience that works in conjunction with technology from XR firm Spatial. “We used Vicon to track the props, getting the cymbal movement from the drumming, for example, but using markerless for the performers so we could get five people all in one day.”

Lovemelt highlights work ZeroSpace is doing that could be transformative in the world of dance. “Right now, we’re building a system that we’re calling the Augmenter,” he says.

“Using Unreal Engine and remote virtual cameras, starting with Vicon as the ground truth, we’re able to build systems that can visualize where the camera is using glasses, and also use controllers as a performer to manipulate how the body moves.

“For example, one of Vicon’s classic images is the Planet of the Apes system, with Andy Serkis and the other actors in their arm extensions. We’re trying to build a proof-of-concept where there’s a lot more pre-viz to that whole process, where you can really see and feel and notice the way the fingers are working or the way your arms are working



in an augmented fashion. You can actually see and feel how the body is manipulated in different ways.

“And that’s something that will change the dance community a lot in the coming years – especially as motion capture gets democratized. There aren’t a lot of dance companies with a Vicon volume, so it’s always a collaboration, but imagine a dance company that’s strictly focused on Vicon performance. There’s a whole world of potentiality there.”

‘THE NEW ERA OF MOTION CAPTURE’

For Leon, this gets to the heart of what ZeroSpace wants to achieve. “Experimentation is what’s going to lead us into the new era of motion capture,” he says. “For the past five years, every single celebrity who’s done motion capture has wanted an avatar based on their likeness, but no-one is ever saying ‘I want to be a dragon’. You have to ask yourself, well, how am I going to puppet a dragon using a mocap system?”

“You have to find ways to experiment, and what we’re getting into right now is an era of experimentation. With motion capture, you have all this data and the best thing about it is that you can take that data and pump it into other things.”

Ultimately, however, it all comes back to how the tools can empower performers. “Vicon really offers the best quality motion capture data that you can get,” says Piech. “And it’s just so powerful to have talent in the space, and to be able to have them see their character and adapt and modify their performance based on what they’re seeing, all in real time.”

ZEROSPACE



JUSTIN BIEBER

In 2022, Justin Bieber performed a virtual concert in the battle royale game Free Fire, and also used his digital double to create the video for the song Beautiful Love. ZeroSpace was behind the transformation of Bieber’s likeness into a metaverse-ready asset.

“Bieber came by the studio and we scanned him with our photogrammetry rig,” explains Piech. “We built an avatar using the data, and had him come into the space to dance. We took that data and combined it with his photogrammetry scan.”

The resulting content attracted over 100 million views.

For more information on ZeroSpace, visit: www.zerospace.co

ANOTHER BODY

Another Body is an award-winning documentary that follows a student’s search for justice after her likeness was used by an ex-boyfriend to create deep fake illicit content.

ZeroSpace used its photogrammetry rig to create metahumans based on the two main characters of the film, then used its Vicon motion capture stage to animate the metahumans for the documentary’s flashback scenes.

The film has garnered coverage and accolades from publications including The New York Times and Rolling Stone.



VIRTUAL INFLUENCER LIVE-STREAMING

“We are working with a skincare brand on launching a virtual influencer that will go live next year,” says Piech.

“We’re recording all the data here in our space and we’ll make original content for TikTok, and we’ll even do live streams. It’s great for us that the Vicon data is so good that we can trust it enough to do live streams.”

PUBG STUDIOS IS GETTING INCREDIBLE RESULTS WITH THE USA'S FIRST VALKYRIE SYSTEM

"The biggest thing that sticks out to me is the speed at which we can shoot. The system's always on, never down, there's no time wasted. It's very different from previous systems that we've worked on."

- **Caleb Zart, Animation Director at PUBG STUDIOS**



Caleb Zart,
Animation Director,
PUBG STUDIOS



Caitlin Fifield,
Stage Manager for
PUBG STUDIOS

KRAFTON's PUBG STUDIOS is used to being an early adopter. The team was at the forefront of the wildly popular battle royale video game genre when they launched PUBG: BATTLEGROUNDS in 2017. Its innovative game design has resulted in one of the best-selling video games of all time. Now, the developer is at the leading edge of digital production with one of the most powerful motion capture systems in the world, having recently partnered with Vicon to install the first US-based Valkyrie-powered motion capture stage in its Madison, Wisconsin studio.

PUBG Madison was in talks to buy a Vicon system while Valkyrie was approaching launch, even though at the time very little had been said about the camera publicly. There was a question around whether to purchase

a Vantage system or be among the first customers to get the then-unknown Valkyrie cameras. "Ultimately," says Caleb Zart, Animation Director at PUBG Madison, "making it withstand the test of time and be the greatest system it could be—that was an easy decision for us to make."

The company bought 26 VK26 cameras, the first Vicon product to push 26 megapixels, establishing the first Valkyrie installation in the US in a purpose-built new studio in Madison, Wisconsin.

One benefit of choosing Valkyrie was apparent before a single camera had been set up. "One of the really nice things about the Valkyrie transition is we were able to get a lot of coverage with fewer cameras," says Zart. "With the previous generation we were slated for 36 or 40 units.

The prospect of going through and focusing all those cameras is obviously significantly more labor-intensive than focusing a simple 26. It's just less to worry about. Especially with our studio having high ceilings—it means less time up ladders."

Caitlyn Fifield, Stage Manager for PUBG Madison's motion capture studio, has found establishing both the setup and her workflow to be a smooth process. "Getting the pipeline set up has been a fun and collaborative process. I worked closely with the tech support who helped with the install, and who also fielded my questions after, to adapt things to our needs even more with each shoot," she says.

"It was a great experience getting things rolling and starting new pipelines, without old habits that we were happy to get rid of. There's also much more documentation than I'm used to with other mocap systems, which let me hit the ground running before we even received the cameras. And the first few captures went smoothly. It was really exciting doing those first couple of shoots."



“Ultimately, [buying a setup that will] withstand the test of time and be the greatest system it could be—that was an easy decision for us to make.”

**Caleb Zart,
Animation Director,
PUBG STUDIOS**



Zart says that the new setup immediately began sparking creativity in the studio. “We’ve just started playing around, throwing new assets into the shoots,” he says. “During one session we were building campfires live while the actor was improvising, miming warming himself in front of the fire. We didn’t plan to do that. That flexibility and review quality is something that Caitlyn and I aren’t used to.”

While the setup is still new, it has already been used for a number of projects, including the animation of new zombies for PUBG: BATTLEGROUNDS’ zombie mode. The data was captured in the Madison studio then shared with the team in Seoul for cleanup and animation.

“We have been doing a fair amount of the retargeting directly inside Shōgun,” explains Fifield, discussing the new pipeline. “We’ll live-retarget the actor solve that Shōgun comes up with to the PUBG skeleton or the Unreal Engine mannequin, and that gets us most of the way there for any of the more standard content that we’re shooting. We can run that fbx

export through our Maya tools to put the data on our animation rigs. And when I do need to feed the data into other software, it’s easy to get what I need out of Shōgun.”

SUCCEED FAST

“The biggest thing that sticks out to me is the speed at which we can shoot,” says Zart. “The system’s always on, never down, there’s no time wasted. It’s very different from previous systems that we’ve worked on.”

“Getting everything rolling during the shoot day, calibration, getting the actor set up, it’s all faster,” adds Fifield. “The real-time being so solid is incredibly cool, too, and the playback switching is really fast and smooth if we need to compare takes.”

“It’s so solid,” says Zart. “We shoot movements where the person falls on the ground and their entire chest or back suite of markers is totally obscured, but the system doesn’t blink. We don’t have to stop the shoot to fix things and re-identify lots of markers in order to review it in real time. We just keep going.”

The speed at which PUBG Madison can operate its Valkyrie system has a tangible impact on the studio’s work. Zart gives an example: “We have arm extensions for creatures that don’t have humanoid proportions. We captured some data with them, and were able to adapt to that in real time without sending everyone away for 20 minutes while we adjusted everything.”

The utility of Valkyrie for virtual production has been an asset, too. “Our leadership group was appropriately impressed by being able to have content up and running live in Unreal. Being able to see a live action non-human creature that we had been working on inside the level that we were developing is really useful.”

The uptick in speed stretches beyond sessions in the studio. “The data processing has been really fast, and we’re getting the quality we need out of it. Shoot sessions that I’m used to potentially taking a significant amount of time, I have delivered in less because of the robust post processing.” Fifield says.

It has all added up to boost PUBG Madison’s creative output.

“We’ve been doing a lot of internal prototyping on some unannounced things,” says Zart. “That speed, where we can just churn through material really quickly, is incredibly valuable in that arena.”

The coverage Valkyrie offers is making performance capture shoots easier on a technical level, and it is also enabling PUBG Madison to create content it wouldn’t have been able to produce before. “One of the things that we’re most excited about is the amount of distance we can cover,” says Zart. “Because of the Valkyries, in tandem with the size of the space, we have a lot of options. We can do bigger shoots where you might have multiple people traversing a bigger area without having to stop, reset, and move all of our set pieces and start again, and then stitch that all together on the back end.

“That gives us more flexibility to experiment and lets us keep the flow of a scene moving without having these hitches. It helps with the work downstream, but it also helps the actor on stage stay in character and not have to think so much about the technical facets of motion capture. It allows them to focus on the most important aspect of the shoot—their character and their performance.”

To learn more about
PUBG: BATTLEGROUNDS,
visit: www.pubg.com



TECNOLÓGICO DE MONTERREY AND VICON ARE CHANGING THE MOTION CAPTURE LANDSCAPE OF LATIN AMERICA

VICON

In the last six years, the relationship between Tecnológico de Monterrey and Vicon has deepened even further, with entertainment applications (and virtual production in particular) becoming a driving force in the relationship.

A FLEXIBLE APPROACH

One strength of the university's VFX program is its flexibility, which allows it to adapt to the rapidly changing needs of the industry. "Part of that comes from the new model that we have. It's called 'Tec21' and it's a model that's focused on competencies rather than content," says Glenn Sidney Miller Montoya, regional director of the digital arts department.

"A lot of people are getting into digital arts through self-education," says Miller. "We needed to give something to our students that would make them better equipped for the field than going down the self-education route.

"So we focus on competencies and not content. Because when it's about content, you become outdated extremely fast, especially in technology. Learn the process. Learn the players. Learn the industry. We teach an attitude and a way of working. I think that's one of our core strengths. It's going to be the commitment of this university for the next 10 years at least.

"What's important is that the students learn to create a narrative, and learn to integrate leading-edge technology into that. We don't dictate what technology. That's up to the professor and the department to define, and it's partially determined by the interests of the students. We are able to define projects so that they match what's going out in the industry. I think it's very rare for an academic or institutional educational institution to work so closely with industry."

The fit between Tecnológico de Monterrey's VFX program and the needs of industry was borne out when it became the first academic partner for Epic Games in Mexico and Central America three years ago. "It's helped us to develop a specific diploma for adults," says Vilchis.

"We are covering how to use Vicon for motion capture to produce animation for use in Unreal Engine. This was an important part of ensuring our training offers a complete package. And we'll offer a virtual production diploma at some point, too," says Vilchis.

Miller commends the university's leadership for committing to its motion capture offer. "Ramiro Estrada, our regional dean of the Architecture, Art and Design School is a visionary



Carlos Vilchis, Virtual Production Educator & Consultant



Glenn Sidney Miller Montoya, Regional Director of the Digital Arts Department.

"Tecnológico de Monterrey was the first school in Mexico, maybe in all of Latin America, to offer a digital arts program BA," says Carlos Vilchis, a virtual production educator and consultant who helped the university establish its pioneering motion capture labs.

Tecnológico de Monterrey is a privately owned university based in Mexico. It has 26 campuses in 33 cities across the country, and is widely considered one of the top universities in Latin America. Its first motion capture lab, equipped with Vicon T40s, was established in 2009 for use by the digital arts program.

"The digital arts program became very popular, and as people from the university's life sciences and engineering departments became aware that Tecnológico had these laboratories, they started to ask how they could use it," says Vilchis.

Other departments began to acquire the software licenses they needed to use the system, and additional labs followed. As of 2024, the university has 10 motion capture labs spread across multiple departments and campuses, all operating Vicon systems and covering animation, VFX and virtual production; life sciences and engineering.

Vilchis, who has worked for companies including Industrial Light & Magic, was brought in as a professor and consultant on the development of Tecnológico de Monterrey's motion capture labs and the VFX teaching programs associated with them.





Tec de Monterrey was the first organization to install a Valkyrie system in Latin America and has made significant contributions to sustainable technologies and infrastructure

and he trusts his team. He's always asking me, 'Glenn, what do we need to do? Whatever you need, we're going to make it happen.' New proposals need that kind of leadership—someone who is ready to bet on new models, new technologies, to have an open mind. It's rare to have that kind of leadership."

LEADING THE FIELD

That bet has paid off. A decade and a half after Tecnológico de Monterrey installed its first Vicon system, the university has a laundry list of achievements and successes.

In the VFX world, the university has its Epic partnership and can also boast the first dedicated virtual production stage in Latin America, ownership of Mexico's first Vicon Cara facial capture system and a host of academic contributions to the world of animation.

In the life sciences, the university built Mexico's first biomechanics motion capture lab in Guadalajara, performed the first motion analysis

of a quadruped in Latin America and has made numerous other contributions to the healthcare sector in Mexico.

And, in the engineering world, Tecnológico de Monterrey was the first organization to install a Valkyrie system in Latin America and has made significant contributions to sustainable technologies and infrastructure.

Tecnológico de Monterrey's contributions to motion capture in Latin America have earned it a leadership role in the field. Vilchis refers to it as the flagship Latin American university in the technology space, and says that other institutions are following its lead and adding Vicon systems to their facilities.

In October 2023, the university took this role a step further when it hosted its first virtual production summit. "We had almost fifty of the most important companies who work in virtual production in all of Latin America," says Vilchis.

Crucially, Tecnológico de Monterrey's flexible, forward-facing approach to motion capture is paying dividends for the university's students. "We're already seeing the results," says Miller. "A lot of our students, particularly in the VFX industry, are finding very, very good positions out there."

"The students get employability, and not just in Mexico," says Vilchis. "I'm living in Vancouver now, and every time I meet people working in studios like ILM, Moving Picture Company, etc, I will say almost half of the Mexican people working on VFX/animation in Canada are our students because they speak English fluently and they have a different mindset to other graduates in the field. They are placing students in North America thanks to the collaboration with Vicon in teaching these technologies, and improving their opportunities in the field thanks to their experience in mocap."

A WINNING BET

If one thing has secured the future of motion capture at Tecnológico de Monterrey more than any other, it's the boom in virtual production.

While Tecnológico de Monterrey's motion capture offer has become a resounding success, that success wasn't inevitable. "It was a challenge 10 years ago, because obviously we made a big bet on this technology, but it wasn't clear whether the students would use it because the industry in Mexico was so small at that specific moment," says Vilchis.

"Before, we had these mocap capabilities and it was cool, but as soon as this craziness of virtual production, real-time technologies and digital humans became so popular, everything went to another level. We had all that technology there waiting for this amazing peak in the industry that has changed

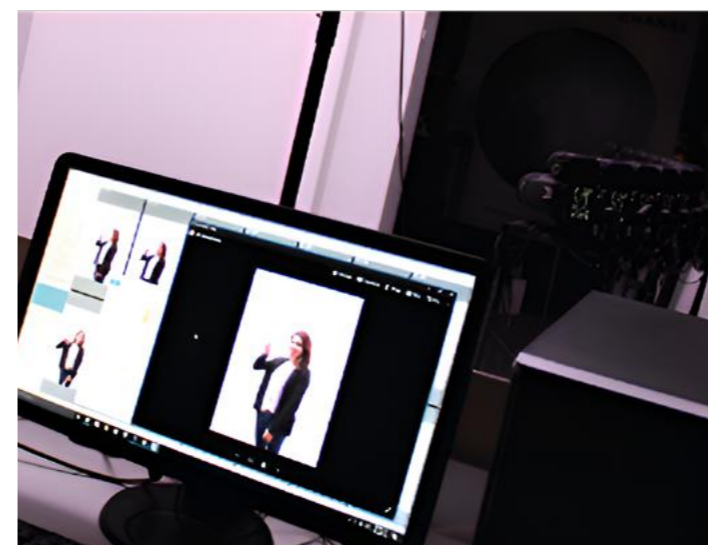
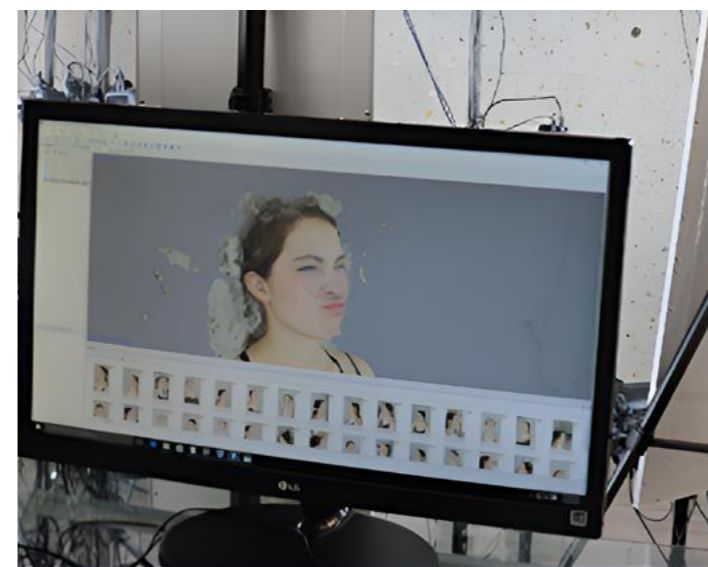
everything. So right now I will say that Tecnológico de Monterrey is prepared for the next five or seven years without any problem," says Vilchis.

Those next five or seven years promise further expansion. "What's amazing is the fact that we are growing steadily," says Miller.

And that growth offers yet more opportunities for future-facing bets on motion capture technology. "Yesterday, we were talking about building the first LED volume stage in all of Latin America in Tec de Monterrey," says Vilchis, "because it's the only place where something like that will be possible."

For more on Tecnológico de Monterrey, visit: www.tec.mx/en

For more on the university's virtual production summit, visit: www.virtualproduction.es/summit



VIRTUAL PRODUCTION AND AI ARE ONLY AS INSPIRING AS THE HUMANS CREATING WITH THEM

Even by the standards of a rapidly-evolving industry like VFX, where technological innovation scales as quickly as consumer demand, the last few years have been fast-paced.



David 'Ed' Edwards,
VFX Product Manager
at Vicon

Two developments have dominated the conversation—virtual production and artificial intelligence. To a casual observer, they have little in common. For the people working in VFX however, both are disruptive forces that pose challenging questions about how they can be deployed; the risk they pose to existing human operators; and the future of motion capture in VFX.

Virtual Production has been around as long as VFX companies have been tracking people and cameras alike. In-camera VFX (ICVFX), however, was in its nascent years when adoption scaled intensely in response to the global pandemic. As we enter 2024, ICVFX is beginning to mature and find its place in the production pipelines of the entertainment world. When enjoying any of the incredible spectacles captured in movies or TV shows that were only made possible by ICVFX, it's easy to forget that just a few years ago it was still a disparate set of disciplines being cobbled together on the fly in a complex, global tapestry of users and experiments.

Normal questions (What does it cost? How does it work? Will it scale?) were, for a time, subsumed by the drive to deliver, deliver, deliver in the face of the streaming platforms' ever-growing appetite for content. This, alongside the obstructions presented by the pandemic lockdowns, led to the rapid bootstrapping of new technologies and methods in the service of getting the job done. Technical and situational knowledge were acquired on the fly until a body of expertise and best practices emerged and began to settle.

The maturation of ICVFX (and virtual production more broadly) was, of course, to be expected. What could not have been anticipated was Covid accelerating deployment to the point that it's still finding its place in production pipelines even as the technology reaches mass adoption.

While virtual production, and all its associated technologies and workflows, will continue to evolve, it's already clear that 'traditional' methods of motion capture and digital creation still have an important place in our industry.

THE EVEN-NEWER KID ON THE BLOCK

If virtual production is maturing and going through a stage of adolescence, AI is in its infancy by comparison—though the scale and speed of its growth may dwarf everything else we've seen to date. It's clear that it will impact every part of the information economy and, further down the line, markets that are more reliant on physical processes, too.

We're seeing it in music production, report generation, statistical analysis and a whole host of other sectors. And Hollywood is already in the throes of debating just how AI will be deployed in the world of movies and TV. Many think the conversation shouldn't get that far until we've determined if AI even should be used, with applications in storyboarding, scriptwriting, concept art and environmental art all on the table.

These are all professions dominated by talented, competent individuals with centuries of experience between them, all with livelihoods to consider. To say the topic represents an existential challenge, alongside an ethical and technical one, is no exaggeration.

At a more granular level we're beginning to see how artificial intelligence might impact animation, with AI animation-generation and AI motion capture both showing early promise. There's plenty of exploration and experimentation underway, the excitement about which is accelerated by an ever-growing thirst for user-friendly, entry-level solutions for content generation. Much of this process is also about identifying and addressing concrete use cases, since the value proposition (and thus, adoption rate) of any technology ultimately comes down to making users' lives easier. It's very early days, so it's to be expected that we're yet to see many concrete examples actually make it to our screens.

We're still in the looking glass stage of predicting exactly where the use of AI is heading in our industry. There's lots of speculation, but we're still very much in an exploratory phase and making concrete predictions is therefore very difficult. . . Projects are being completed, but there's yet to be a single example that has put the role of AI in our ecosystem into proper context. Tempting as it might be to state with absolute confidence that 'AI will change the world in these ways', humans are predictably unpredictable, and we will always surprise each other with our approaches to new challenges.

Nevertheless, it is inevitable that AI will have a significant role in VFX. Its potential, and the current climate for content creation, are just too ripe for it to be left on the shelf. Irrespective of the ongoing ethical questions—which I think will mature and lead to conclusions far more slowly than the actual adoption of the technology, which raises numerous questions itself—it represents an opportunity for reduced costs. It 'democratizes' certain parts of the business, and as the demand for production just keeps on increasing, it's difficult to argue against maximizing the benefits it provides .

The inevitability of AI in VFX is driven largely by the absence of comparable solutions to this increasing disconnect between the scales of supply and demand. Creators are fighting to keep pace with audience expectations in terms of quality, scale and spectacle. They will ultimately defer to whichever technology facilitates this.

So, an obvious question—what connects virtual production and AI?

FORCES OF DISRUPTION

It's an oversimplification to think of either of these things purely as solutions, technologies, or groups thereof. They are forces and, as such, they represent significant change for the VFX industry, despite being at very different stages of gestation. ICVFX is settling into its role within production pipelines and broadening the adoption of Virtual Production as a result, while AI is further back along the curve and yet to find its place in our world.

Nevertheless, both are the way that content gets made.

Initially, ICVFX presented an incredibly compelling solution to just 'getting things done' at a time when options were limited. We have been out of that environment for a while, so it's gradually finding a longer-term place in content creation where it can offer the most value.

One of the most exciting elements of the increased adoption of ICVFX is how it has encouraged (and indeed, necessitated) creative collaboration between technical specialists. It's unlikely that this will stop being the case. We can always expect ICVFX stages to be places of experimentation and innovation with a view to 'getting the job done'—regardless of where it finally settles in production pipelines.

As far as 'getting things done' is concerned, AI appears poised to

significantly increase the industry's options, but the question of where it can actually offer the most value still looms large. Likewise, AI is faced with a myriad of ethical questions, such as ownership and the legalities surrounding data scraped from the web which was never formally intended for such use. It would be naive to think that legislation will not have to evolve alongside the use of AI itself, which makes predicting where it eventually 'settles' a far more complicated prospect.

So, we have this interesting tapestry where both are at different stages of their adoption and are faced with distinctly different challenges, while presenting similar promises to their respective userbases; flexibility, control, scope. All the while, the explosion in streaming is creating more and more demand for content. Even while that business model itself is facing challenges of its own, that demand and level of customer expectation is not going away. And audiences expect quality and spectacle in their games and VFX shows which was previously only available in summer blockbuster event movies, resulting in spiraling production costs.

One knock-on effect of this boom in demand is the extreme pressure being put on creators. More than anything, they need flexibility. ICVFX was a real-time example of how technology can bring that to the VFX world, building on several years of development and innovation within the broader virtual production space. It also offers a recent example of how quickly a new technology can 'settle' once it becomes better understood. It has become one more tool in the creator's tool kit, offering increased flexibility in what can often be an inflexible business.

For all the uncertainty that a new technology such as AI can bring, I hope that we as an industry can reflect on what we've learned from the boom in virtual production. The true impact of these solutions comes from the way in which they're deployed by their users. As exciting and promising as the technology is, at the core of its output are groups of people with diverse skillsets pursuing unified goals. As is the case with virtual production, AI will only be truly transformational if it is put to work by creators with the vision to see new possibilities and new ways of working. It's this human response that will be truly inspiring.



SMALLER, SMARTER, FASTER

BLINK AND YOU'LL MISS THE
FUTURE OF AUTONOMOUS
ROBOTS



Nitin Sanket, assistant professor at Worcester Polytechnic Institute's Robotics Engineering Department, hopes that one day you'll barely notice a drone flitting by.



*Nitin Sanket,
Assistant Professor
at Worcester
Polytechnic
Institute's Robotics
Engineering
Department*

Sanket and his team are advancing the creation of small, autonomous robots. He envisions a future in which we're surrounded by miniature drones performing tasks including pollination, searching for survivors in disaster zones, providing entertainment, delivering payloads and even serving as pets.

Taking his cues from creatures such as insects and hummingbirds, Sanket hopes to program drones that can navigate cluttered environments, dynamically evade moving obstacles and safely navigate through small gaps. To keep the robots secure and able to operate in environments where control loops might be difficult, all of the above needs to be achieved using only onboard perception and computing. That means no assistance from GPS, cloud-based computation or, eventually, motion capture.

"At some point, we want to be able to do search and rescue in the wild, flying fast enough through a forest fire to save somebody, or perhaps to look for poachers, and every second matters in these scenarios. That's one of the major reasons why we are pushing the boundary of speed, and we want these robots to be small enough that it's safe for them to move that fast. You have narrow spaces in a forest, and one option is to make your perception better, make your controls better. But the bigger the robot, the higher the probability of it running into something. So we're asking, can we make the robot small, as well as making it smarter?"

To get to a point where his robots won't need a system such as motion capture to navigate, Sanket first needs to use motion capture as his source of ground truth.



"We want to eventually fly at 30 or 40 meters per second," he explains. "Similar work is being done in drone racing, but we want to do it in a completely unstructured environment. Our focus is on the vision side—how do you actually process the data that fast?"

"So how can we test that? You can't take it into a forest and actually fly at freeway speeds. You'd immediately run into a tree. So we want to do it virtually first. So, you have an empty space where all the trees are computer-generated and you have a perfect state estimator, which is motion capture. We want to start the journey there and that's how our lab got set up."

The lab in question is 36 ft long, 15 ft wide and about 12.5 ft high, and is equipped with 14 Vicon Vero cameras running on Tracker 4. "We were the first people in the country to get trained on Tracker 4," says Sanket. "It's awesome. Such an improvement."

THE FIRST STEP IS MOTION CAPTURE

"The first step towards working on onboard computing and testing for autonomous drones is testing it in the motion capture space," says Sanket. "You want to prototype something quickly, and you can inject any amount of noise into it and see how it behaves without actually subjecting the real robot to those conditions and potentially crashing a half-million-dollar drone."

"I call the process 'sim-to-real-to-sim', because you go from sim to real, then you see what issues crop up and you go back to sim and you fix your simulation model. You do this loop a couple of times and you get a very good model at the end."

Sanket and his team began by simply flying their drone as fast as they could using manual controls, and Tracker's turnkey offering worked perfectly.

The next step required a deeper exploration of the software. "Then we said, let's see if we can do this autonomously," he explains. "And that's where we started moving more towards things like the ROS API."

Sanket also emphasizes the importance of the control stack. "The other side of the story is also true," he says. "If you actually want to fly that fast, you have to do the controls. You cannot cheat. You have to do whatever nonlinear work you need to do. And for that you need a motion capture system right at the start of your project."

Sanket says that his Vicon system offers another benefit, too. "The other thing which is beautiful is it gives us free data that you need if you want to do vision work. This gives us real IMU data and real noise performance data that you cannot get otherwise. That's what makes our life a lot easier to actually do the simulation-to-real transfer."

Having used motion capture systems from multiple providers, Sanket says he insists on working with Vicon technology because "it's just easy. It works every single time. It removes painful procedures that you don't want to think about because you're focusing on the research. You don't care how the motion capture technology works—you just want to get the data you need."

"Vicon just gives you that peace of mind which you want as a researcher so that you don't have to worry about the nitty gritty details. You focus on your research and a Vicon setup just enables you to do that. And I think that's the hallmark of a good product."



He also praises Vicon's support offering throughout the procurement process. Sanket's long-term professional relationship with his Vicon rep meant that his work and needs were quickly understood, making the process extremely straightforward. "I probably interacted with the company over four emails that took me 10 minutes to write. That's it. I appreciate that a lot because when you're dealing with 300 different things, anything that makes life simple is a bonus. I value that relationship a lot," he says.

GETTING FASTER

The research that Sanket and his team are doing has already yielded dramatic results. "When we started out, we could process our motion estimation at about 30 Hertz, which was state-of-the-art at that time," he says. "Now we can do that at 100 Hertz. We have improved it by 3.3 times in the last year."

"The goal would be to push that boundary even further. Right now our perception stack is there, but our control stack is nowhere close."

Sanket has big plans to meet those goals with an improved motion capture volume. "I eventually want to expand the space," he says. "Right now we can hit about 11 or 12 meters per second, which is already very, very, fast. It's probably state-of-the-art at this stage, but it's just not fast enough for us. We want to hit 30 or 35 meters per second. Eventually, we are planning to rent out an aircraft hangar and buy another set of Vicon cameras to put there so that we can actually fly at those speeds."

For more on the work of Nitin Sanket's and his team, visit: www.wpi.edu/academics/departments/robotics-engineering



BRIDGING BIOMEDICAL RESEARCH WITH AEROSPACE ENGINEERING IN THE LAB OF TOMORROW



“My goal with this lab is to take biomedical research and tie it into a school that is grounded in aerospace and aeronautical engineering,” says Assistant Professor of Mechanical Engineering at Embry-Riddle Aeronautical University’s Daytona Beach Campus, Christine Walck. “How do I make that connection? That’s the question I’ve been working on for the past couple of years with Vicon.”



Christine Walck,
Assistant Professor
of Mechanical
Engineering at
Embry-Riddle
Aeronautical
University's Daytona
Beach Campus

Walck has been at Embry-Riddle for four years, following eight years working as a mechanical engineer at the Tactical Electronic Warfare Division - Vehicle Research Section of the U.S. Naval Research Laboratory. Her work at Embry-Riddle covers biomechanics, computer science, imaging, and neuroscience to study muscle function, analyze human movement, improve rehabilitation protocols, and optimize human performance.

For Walck, that list of specializations sits under a larger goal: “My aim is to make sure that we can take biomedical work into the space and aeronautics world. We are really integrating biomedical with aerospace, showing

that there is a fit. Vicon is a tool that we can use to further that goal.”

A number of the projects being worked on in Walck’s lab span both worlds, while some lean in one direction or the other.

To facilitate the dual purposes of the lab, Walck has two Vicon systems running in parallel within the same space. “We have two separate lock boxes, so they’re two separate systems, but they can act as one,” explains Walck. “There are 12 Vantage cameras all along the perimeter of the ceiling which we use for flight testing and robotics. There are eight Veros on the tripods for human clinical trials and small robotics. We have two

video recorders and then we have the AMTI force plates and Delsys EMG system. Our back bay door opens up all the way, so you could study sports movements like pitching.”

The Vantage system runs on Tracker, while the Veros work with Nexus, with post-processing software using OpenSim 4.0 (musculoskeletal modeling) and EMGworks software rounding out the workflow.

One of the things that made this hybrid lab possible was the versatility of its Vicon cameras. “Vicon is not limited to your lab. You can go outside with these cameras, which is incredible because Embry-Riddle grew really fast. We have so much going on that we’re always looking for a new space. When you can work outside, and when you can have flight and biomechanics in one lab, that’s a huge asset. It’s affordable, allowing research to never be limited. Vicon allows our researchers to not have to sacrifice anything in their work.” says Walck.

Another key element of the lab’s success is the support Walck receives

from Vicon. “University professors tend not to learn hardware or software. Their students do,” says Walck.

“But then the students graduate, and if the student doesn’t teach the next group, the technology sits there and collects dust. But then when I’m on my next project, I’m left wondering ‘What was that pipeline again?’ So I will call our rep and say ‘I need some help!’ And he will walk me through everything. This man is why we are able to grow so much. He’s incredible. Our sales manager is also super helpful.”

THE PROJECTS

PHYSIOLOGICAL RESPONSES TO MICROGRAVITY

“One project that we’re working on involves how the body responds in microgravity. To simulate this type of environment, we use a head-down tilt bed. The one we have also has a lower-body negative pressure box which encloses the patient’s lower half,” says Walck.



It's a machine thought to counteract some of the adaptations astronauts' bodies make to microgravity, such as poor cardiovascular responses.

"A negative pressure box basically acts as artificial gravity," Walck explains. "It's a gigantic vacuum that sucks on your lower half to redistribute fluids that have been displaced by microgravity."

Walck is working on redefining space fitness by researching different exercise devices that can operate within the box, to counteract more adaptations like muscle atrophy and bone loss. Here is where Vicon comes in.

"We can adjust the cameras to pick up markers inside the box. So, when the subject is exercising, we can track the angular position of their joints and then run an inverse dynamics workflow to find muscle force output. We can run this with and without the negative pressure and then optimize both systems. Without Vicon it would be difficult to optimize the systems."

ASSISTIVE KAYAKING DEVICE

"We also have our smart assistive devices, which I call adaptive devices. Currently, we are focusing on an adaptive device for kayaking as our case study," says Walck. "We work with Oceans of Hope Foundation, a nonprofit which organizes watersports for people with disabilities. A lot of their members are either spinal cord injury survivors or stroke victims who are paralyzed from the waist down, resulting in sub-optimal performance."

A rudimentary assistive device already exists, but it only allows users to do what Walck describes as "a teeter-totter motion" that doesn't really reflect how kayakers paddle.

Embry-Riddle's senior design students decided that they could improve on the device mechanically and add an AI component. The thinking was to make the device capable of adjusting to imperfect inputs and still fulfill its intended

function successfully. Dr. Walck is also investigating how this device affects the cognitive responses, if at all.

"The research is investigating the questions I hope I never have to answer: 'what would you do if you had to continuously adapt to the world around you?'" says Dr. Walck. "Using kayaking as a case study, we aim to develop a workflow that allows engineering to develop adaptable devices versus assistive devices."

"When I say adaptable, I mean devices that are designed with flexibility and versatility in mind, allowing them to adjust their functionality based on different inputs or situations. You want something that says, 'Oh, today you need me to help you complete 1/3 of the rotation, but tomorrow you might only need 1/4'. So it's a smart device that's able to sense and learn your motion and then complete what you can't do. This is very different from the standard assistive device people are currently stuck with. An assistive device



is something like a wheelchair. I have to push the wheels the same each time, even if one day my right arm hurts."

EXOSKELETONS

"We also research braces for hip dysplasia," says Walck. "Using OpenSim, we're trying to develop an infant model using an adult musculoskeletal model as the foundation. One might think that you can just scale it down, but that's not the case. Everything is different. However, the first step is just getting the motion right. So we put little markers on a tiny baby and put the baby on a force plate. And we use that model for the infant's motion profile. This allows us to model the movement profile that the hip dysplasia is causing."

QUADCOPTERS

One of the more conventionally aeronautical applications that the Embry-Riddle lab is used for is drones. "We're investigating the performance of multiple off-the-shelf quadrotors to see if we can build one that surpasses them," says Walck. "So we got the main ones

and are looking at the data for each. Then ranking a few parameters we will see if ours can beat them."

"I remember one year, for a competition, a quadrotor had to fly into a building through a small window and locate a thumb drive on a table. In order to get the flight parameters correct so it didn't hit the window we used Vicon. It ended up having to fly in sideways. It was real James Bond-type stuff."

EQUINE THERAPY

"Another thing you can do with Vicon, that I'm just getting into, is investigating equine therapy for people with disabilities," says Walck. "I rode when I was younger and worked with Horses for Handicapped and we had participants with a range of disabilities come in and they would just light up. Their whole attitude would change. And then when they got off the horse, they felt better—much more relaxed."

"So I want a way to quantify what the muscles are doing and how it is having a therapeutic effect. And, then,

find a way to create an adaptable saddle that can help with balance, but that will gradually lower the level of assistance as the rider progresses."

"To do that, you need the motion patterns of the person to calculate the internal forces. The calculation is made easy with Vicon and OpenSim. We start by measuring the positions of markers that are placed on the participant using Vicon. Then Nexus gives us the data for each joint angle. The software does the hard work. Then I take this joint angle data and use it as input data to OpenSim. I have OpenSim run a few workflows to give me the internal parameters I need such as muscle activation, joint compression forces and so on."

"And a great thing about the Vicon system is that it accepts the EMG sensor data, which enables us to do optimize the OpenSim results."

For more on the motion analysis lab at Embry-Riddle, visit: www.ernal.mystrikingly.com/

INDUSTRY 4.0 IS ABOUT TO EXPLODE, AND VICON IS READY

FELIX TSUI, PRODUCT MANAGER FOR ENGINEERING AT VICON, EXPLAINS HOW VICON AND TRACKER 4 ARE ENABLING THE FOURTH INDUSTRIAL REVOLUTION



Dr. Felix Tsui,
Product Manager for
Engineering at Vicon

As Vicon turns 40, it is humbling to reflect on the innovation and impact our company has delivered since we helped transform the world of clinical gait analysis. In the engineering world we now see Tracker, an engineering tool originally built to help facilitate training in virtual reality caves, being used in drone light shows or for developing robots for space exploration. It has absolutely become an essential part of the innovator's toolkit and I am incredibly proud to be a part of that legacy. Tracker continues to innovate alongside the users it serves, helping to build the technologies and infrastructure of tomorrow.

Industry 4.0 is undeniably the next frontier—a revolution that will integrate intelligent digital technologies into manufacturing and industrial processes. This concept has been circulating for over a decade now, but the past few years have really accelerated its timeline.

The pandemic forced certain organizations to rely on automation to backfill their workforces where in-person work has not been possible. Meanwhile, AI and machine learning have benefitted from exponential growth in computing power over the same period. Even automation itself is better understood and has reached a level of maturity that means it can be trusted at a much larger scale.

Vicon has been facilitating smart sensing since it first introduced its Tracker software almost 15 years ago. This includes creating solutions that were not only suitable for research, but also those that could be used in situ on the factory floor. As the Product Manager for Tracker, it's an exciting time to realize the future we've envisioned for this product for quite some time.

HISTORY OF FACILITATING AUTOMATION

Our technology has been helping engineers to automate their robotics for years now. That much certainly isn't new. Tracker systems are used by many of the world's leading technology companies to develop early control algorithms or to provide ground truth in the development of other movement-based sensors.

Bell is a great example of this. The aerospace company is developing a mobility-as-a-service offering that will deploy networks of autonomous drones to move both cargo and people around cities. It flies smaller drones in a warehouse-sized space to model this service, and uses its Vicon system to track and monitor the network.

In earlier phases of automation, motion capture was used to facilitate very simple operations, such as static obstacle avoidance. Now, however, we're seeing glimpses of more advanced automated robots such as self-driving cars or Boston Dynamics' famous robot dog, even if they still remain on the cusp of being operated in public settings.

VICON IN INDUSTRY 4.0

The real differentiator between Industry 4.0 and previous waves of automation, however, is the recent advances made in AI and machine learning. Technologies such as neural networks are enabling software to make more non-trivial decisions in situations beyond highly-controlled environments. For these algorithms to make decisions, they need 'smarter' sensors working in real-time and with lower latency. Crucially, they need incredible accuracy, especially in manufacturing, where every last millimeter counts.

Driven by these advances, Industry 4.0 is impacting the world at multiple levels.

A powerful example of this is Northrop Grumman, which has used its Vicon system for digital transformation, testing maintenance procedures on digital models of aircraft that have been simulated down to the last component. Northrop Grumman conservatively estimates that this process saves it around four million dollars per 30

assessments. In the real world, catching a problem at this stage can mean the difference between a relatively easy design fix and a product recall on aircraft that may be located in remote locations across the world.

Another great example is the work Nitin Sanket is doing at Worcester Polytechnic Institute's Robotics Engineering Department with miniature drones ([see page 50](#)). He and his team are building small autonomous robots that they hope to design down to the size of insects. For these tiny drones to reach speeds of 30-40 meters per second, Sanket needs to improve their perception so that they can navigate cluttered, dynamic environments using only onboard computing, and his Vicon system is enabling him to do it.

TRACKER 4

Tracker 4 was our banner release in 2023. It brings our flagship Valkyrie camera, which features the highest resolution on the market, into the engineering world. Leveraging advancements in computational power, Tracker strives to 'leave no pixel behind'. That means simultaneously providing its users with the lowest latency and highest data fidelity in terms of tracking and accuracy. One such example is Tracker's long-standing ability to uniquely identify merged markers in real-time—functionality that is unparalleled.

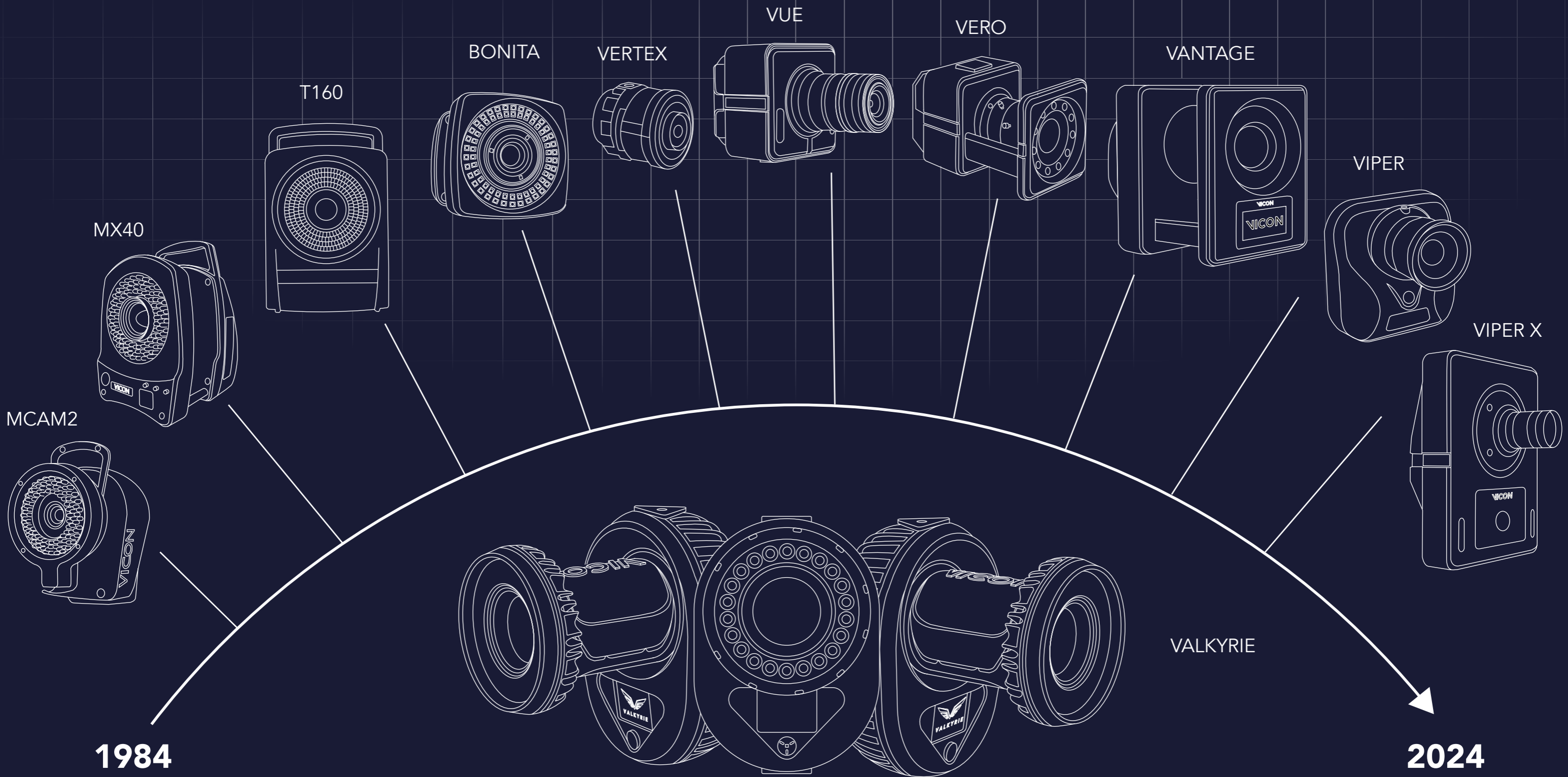
In the spirit of Industry 4.0, Tracker 4 also combines with Valkyrie to enable users to 'set and forget' their system. Features such as automated system healing allow users to operate their setup with minimal input—crucial for applications in challenging outdoor environments or huge volumes, and for projects with highly complex automated robotics.

It's a privilege to be part of this new wave of technologies reshaping our physical infrastructure, but we know we've earned it by delivering decades of excellence. I look forward to seeing what you do with our technology over the next 40 years.

For more on Tracker 4,
[download the brochure.](#)

HARDWARE HISTORY

For 40 years Vicon has been designing and building the best motion capture solutions in the world, and the focal point of every system is one of our leading-edge cameras. When it comes to hardware we don't iterate, we innovate. Every one of our cameras has offered a leap forward in the state of the art for motion sensing, expanding the possibilities of movement analysis for our users. Every one of them has opened up new territory for exploration in the world of motion. We're as proud of the engineering behind the systems we offered in 1984 as we are of the Valkyries our customers are using in 2024.





OUR SIGGRAPH MARKERLESS SHOWCASE DEMONSTRATED THAT THIS TECHNOLOGY IS FINALLY READY FOR THE MAINSTREAM

VICON'S CHIEF TECHNOLOGY OFFICER, MARK FINCH, DISCUSSES OUR VISION FOR MARKERLESS MOTION CAPTURE

In the world of technology, most of the time you can be first or you can be best.

Markerless motion capture has been around in one form or another since the 1990s. Occasionally someone has produced a version of it that has been technically impressive. But technically impressive is not the same as fit-for-purpose.

Five years ago I met with our CEO, Imogen Moorhouse, to survey the state of the art. We concluded that the technologies underpinning markerless had matured sufficiently for Vicon to build a truly robust, powerful, markerless motion capture solution.

Half a decade later at SIGGRAPH 2023, our markerless showcase, developed in partnership with Dreamscape and Artanim, proved that we were right.

It took a lot of work to get there, though. Before we even started, we needed certain extrinsic factors to come together. Without the development of machine learning and AI that's taken place in the autonomous vehicle field, or the raw computing power that has become available thanks to advances in GPUs, markerless would still be in the dark ages.

Then we needed to build a team. When I started as CTO at Vicon, there was no such thing as the markerless technology team—so we built one from scratch. We needed specialists with skill sets that didn't exist a decade ago, such as machine-learning scientists, AI data analysts and ML ops personnel, not to mention all the infrastructure that comes with doubling your team.

And then there was the invaluable input of the Vicon community. We established the Pioneer Program to invite our customers to help shape the future of this important technology. The responses were astounding.

There are now over 200 organizations signed up from across the breadth of our customer base. We have everyone from location-based VR companies, such as Dreamscape, to AAA VFX studios, to indie games developers. We're thrilled, in particular, by the interest from our life sciences community—researchers

from hospitals, universities and sports organizations have signed up to investigate our markerless solution and its potential applications.

You've shown us exactly what we wanted—a host of fascinating use cases, many of which we never would have considered if we were working in a silo.

VFX users, for example, are keen to slot markerless into their pipelines early. While the mocap stages for blockbuster films will always require the extreme precision of marked optical tracking, our VFX users have shown us that they can reimagine their shoots by including markerless in their pipelines, either by integrating it with optical or in the form of markerless pre-visualization.

Dreamscape and Artanim, of course, have demonstrated how freeing VR users from the need for markers can give them an incredible, immersive experience. (For more on the resounding success of our SIGGRAPH showcase, see our accompanying article.)

The life sciences community has told us that without the need for marker placement, they'll be able to capture the movement of patients for whom it wouldn't be possible otherwise, such as children or the elderly. Similarly,

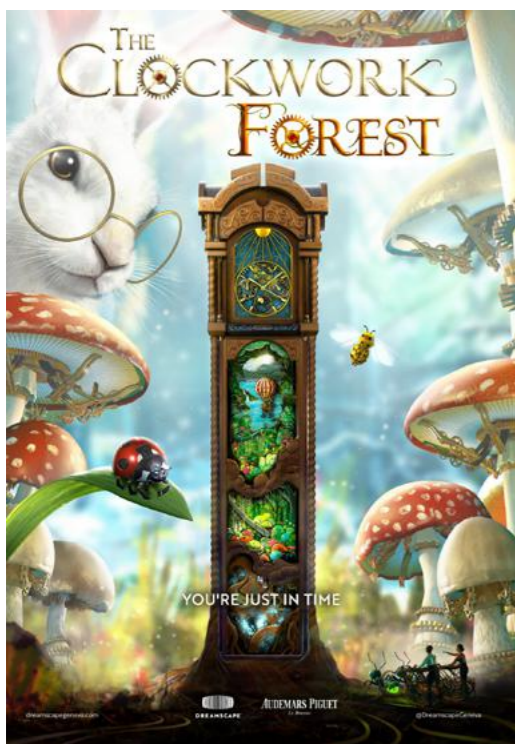
using markerless makes capturing children and people with mobility difficulties smoother and faster, enabling clinicians to see more patients in a compressed period of time.

The strategy that underpins all of these use cases comes back to accessibility every time. Being able to walk into a volume with a minimal array of cameras and just start shooting creates a huge range of options. Users without extensive backgrounds in motion analysis can tap into the tools with much greater ease. Suddenly, motion capture becomes accessible in circumstances where previously it wouldn't have been.

Importantly, though, the Vicon markerless solution is backed by our deep expertise in motion capture. It's an end-to-end markerless solution that fits within your existing pipelines—we're not asking you to learn a new tool and process. And because this will be a Vicon solution running on Vicon hardware and integrating with Vicon software, the end result is a fully integrated solution backed by Vicon Support from start to finish.

Furthermore, our solution doesn't put you in an either/or situation where you have to choose one mode of motion capture over another. You can mix and match tools, even within the same system, to get the results you need.





Dreamscape's Clockwork Forest adventure at SIGGRAPH was a perfect example of a multi-modal solution—users' bodies were tracked using markerless to create a sense of immersion and streamline the experience, while the VR helmets and props were tracked using active markers.

We know that we're only scratching the surface here. One of the most exciting aspects of working at Vicon is seeing our customers come up with uses for our technology we never dreamed of. Ten years ago, no one thought that Vicon solutions would be used to manage automated drone cities, for DIY real-time content creation, or for performing virtual maintenance on aircraft. We're excited to see where our customers take our markerless technology once we release it to the world.

I've been Vicon's CTO for five years now. Every one of those years has felt like another leap forward for my team and for this company. A huge part of the work, for me, has been developing our markerless solution and the infrastructure we need to deliver it. And we're ready. My sixth year as CTO will not only be about the regular cadence of releases for our existing solutions—it will also be about executing on all the preparation and building we've been doing in the markerless space.

When we release our markerless motion capture solution to the wider Vicon community I'm excited to see the amazing things you'll do with it.



MARKERLESS MOTION CAPTURE SETS USERS FREE TO ROAM DREAMSCAPE'S CLOCKWORK FOREST

The debut of Vicon's markerless motion capture solution at SIGGRAPH 2023 brought to life an impressive, immersive experience that dazzled attendees. The showcase featured Clockwork Forest, a new virtual reality adventure built by Dreamscape that shrinks participants down to the size of an ant to explore a magical, super-sized world.

"I've been coming to SIGGRAPH since 1996 and this is the best thing I've ever seen here, hands down," said one delegate. "I think this technology is going to revolutionize a lot of theme park experiences, and I'd love to see what it could do for education and museums where you could experience being part of historical events. I think it has a lot of applications in training, too. It was just breathtaking."

As well as winning plaudits from delegates, Vicon's markerless solution was recognized by CGW (Computer Graphics World) with the Silver Edge award as one of 'the most innovative and impressive technologies' at SIGGRAPH.

Six users at a time were able to explore the Clockwork Forest's rich, interactive environment wearing only a VR headset, thanks to the multi-modal, real-time solving of Vicon's markerless technology.

Dreamscape, driven by its research arm, Artanim, develops immersive VR storytelling experiences for entertainment, training and education. The capabilities it demonstrated at SIGGRAPH mark a leap forward in location-based VR, reducing friction for users and increasing their sense of immersion in the virtual environment.

"What we showcased is the ultimate evolution of our virtual reality solution," said Sylvain Chagué, Founder and Chief Technology Officer for Artanim and Dreamscape. "Thanks to the markerless tracking solution and the cloud streaming of VR experiences, we're able to reduce the equipment to just a head-mounted display and offer the same quality of immersive experience as we used to with a fully marked, optical tracking system, so this is incredibly exciting."

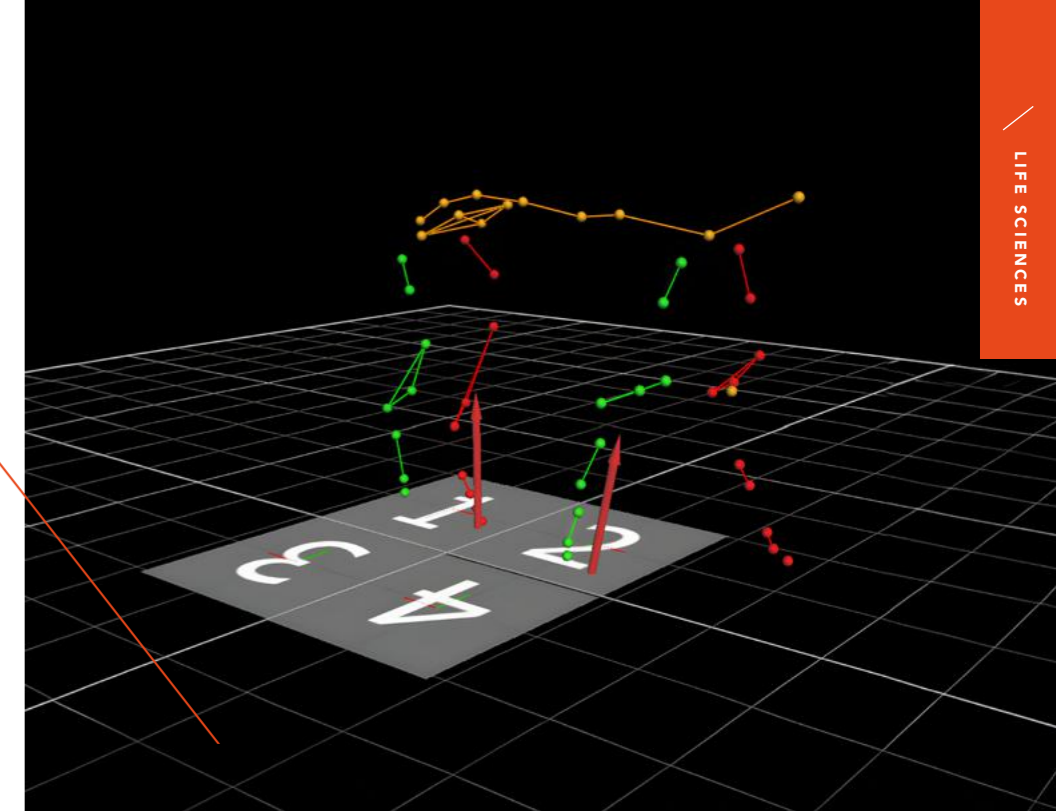
President and COO of Dreamscape, Aaron Grosky, added, "We have been anxiously awaiting the time when markerless could break from concept and into product, where the technology could support the precision required to realize its amazing potential.

"Vicon's reputation for delivering the highest standards of motion capture technology for 40 years and Dreamscape's persistent quest to bring the audience into the experience with full agency and no friction meant that working together on this was a no-brainer," Grosky expanded. "We're thrilled with the result. The implications for both quality of experience and ease of operations across all our efforts, from location-based entertainment to transforming the educational journey with Dreamscape Learn, is just game-changing."

For more on Artanim and Dreamscape, visit www.artanim.ch and www.dreamscapelearn.com

3 AM STARTS, UNCOOPERATIVE QUADRUPEDS AND A 100°F BARN

LESSONS FROM ANALYZING
SHEEP GAIT IN THE
TEXAN SUMMER



Aaron Henry,
PhD researcher
at Texas A&M
University's
Department of
Multidisciplinary
Engineering

“One thing that we’ve learned but never actually implemented is to not do it in the middle of summer in Texas,” jokes Aaron Henry, a PhD researcher at Texas A&M University’s Department of Multidisciplinary Engineering. He’s describing a 2021 motion capture project he co-led, under the supervision of Dr. Andrew Robbins and Dr. Michael Moreno, that saw a team of researchers and veterinarians analyze the gait of 20 often uncooperative sheep in a barn in 100-degree Texas heat.

While the project will sound like a worst-case scenario for many movement analysis practitioners, the research team hopes that it will advance the study of hypophosphatasia (HPP), an extremely rare metabolic bone disease that causes abnormal development of the skeleton and teeth. They also hope to develop a model similar to Plug-in Gait, which can be used for future quadruped studies.

“Dr. Gaddy and Dr. Suva, who are the principal investigators studying HPP, have a granddaughter who has hypophosphatasia, so they’re invested in this project from a personal standpoint,” explains Henry. “The disease is super rare and presents itself with extreme variability, so it’s difficult to study or even to put

a cohort together. Even when you do have a cohort, the subjects have varying presentations of the disease.”

“In people with the same gene mutation, the symptoms can range from females who will lose their teeth post-menopause to, if you have the most severe form of it, something incredibly tragic like kids who can’t breathe without a respirator and can barely walk,” explains Jordan Ankersen, a Clinical Research Engineer and recent PhD graduate in Biomedical Engineering at Texas A&M, who co-led the project with Henry.

While the rarity and variability of hypophosphatasia make studying it in humans difficult, the condition can also be modeled in animals, offering alternative research routes.



VICON



Jordan Ankersen, Clinical Research Engineer and recent PhD graduate in Biomedical Engineering at Texas A&M

Dr. Gaddy and Dr. Suva previously looked into using small animals to study the disease but found that they didn't offer sufficient variety in the condition's presentation. Mice don't lose baby teeth, their bones form and remodel differently from humans and the mouse models did not show the altered gait of humans with HPP. As a result, large animal models, in particular sheep, who do have two sets of teeth, were the next step.

Despite the fact they're quadrupeds, sheep have musculoskeletal similarities to humans that make them ideal candidates for investigating gait biomechanics. "They allow you to do much more gross locomotion biomechanics, which is particularly helpful for a disease that affects the musculoskeletal system and impacts gait," says Henry.

Sheep with hypophosphatasia move, for example, "like Victoria's Secret models, they cross their legs when they walk," says Ankersen — something

that corresponds with some of Dr. Gaddy and Dr. Suva's observations of human subjects with the condition.

"Another thing was that they wiggle like snakes when they walk — the bottoms of the sheep with the mutations sway back and forth," expands Ankersen.

A CHALLENGING ENVIRONMENT

In 2019, the research team did a pilot study that proved foundational to its efforts in 2021, leading them to a setup of 12 Vantage cameras, two Bonita video cameras, and one Vue camera, complemented by four force platforms. While the tools were high-tech, the setting was not.

"We learned a lot," says Ankersen. "We already knew we were going to 3D-print marker bases so that we could glue them to the sheep, because you don't have a great chance of sticking markers to them otherwise. And I had the idea to color-code the markers

so we could help the veterinarians put them on, and we printed out sheets that matched the colors so they would be easier to count.

"We knew what cameras we needed and how we were going to place them. However, we were not prepared for the true magnitude of how much you have to change the capture environment.

"We didn't realize how much of a challenge the lighting was going to be because we were in an open-sided barn. It wasn't like we were in full sunlight, which would have meant we could set the cameras accordingly," Ankersen says. Instead, full sun would come into the barn at certain times of day, but there would be none at others.

"If you set the cameras one way in the morning, you'd have to recalibrate every 30 minutes, so we ended up having to put tarps up," Ankersen says. "But when you tarp the barn in, you essentially cut off the airflow and then you have 12 cameras, all of your switches and your computers running in this tarped-off barn in 100-degree weather, so keeping the cameras cool becomes a really non-trivial challenge! We ended up knowing that we had to get there at 3am, set everything up and start going at 5am so that we could finish by 11am."

Another problem came from moving the animals around in the tight space. "We knew that we had to have room for them to turn around. We thought



LIFE SCIENCES

we had accounted for the side that the handler was going to walk on by putting a few extra cameras over there. But we learned we really had to have them switch sides because you still don't get great coverage when there's a handler walking. Especially because you can't predict which sheep are going to be lovely and which will be uncooperative."

As well as modifying their motion capture setup, the team learned tricks to change the sheep's behavior. "We learned to have a student sit under one of the tripods with a bag of food so that the sheep would walk to him," says Ankersen. "And we learned that since sheep are herd animals, they get a lot of comfort from companionship. So, we had to have another sheep in the capture area that we positioned too close to one of the cameras for my comfort."

KEEPING YOUR CAMERAS STABLE

Working on a large project with so many moving parts made user-friendliness a top priority for the team.

"Being able to monitor the camera temperature was super useful with heat being such an important factor," says Henry. "Then also, just general quality of life things, like being able to quickly reconstruct and make sure that we have all of our markers on a sheep is invaluable. When you've got over 50 markers on a sheep it's easy to miss one and not

realize it, so being able to do a quick calibration and spot that he's missing one on his spine is really useful."

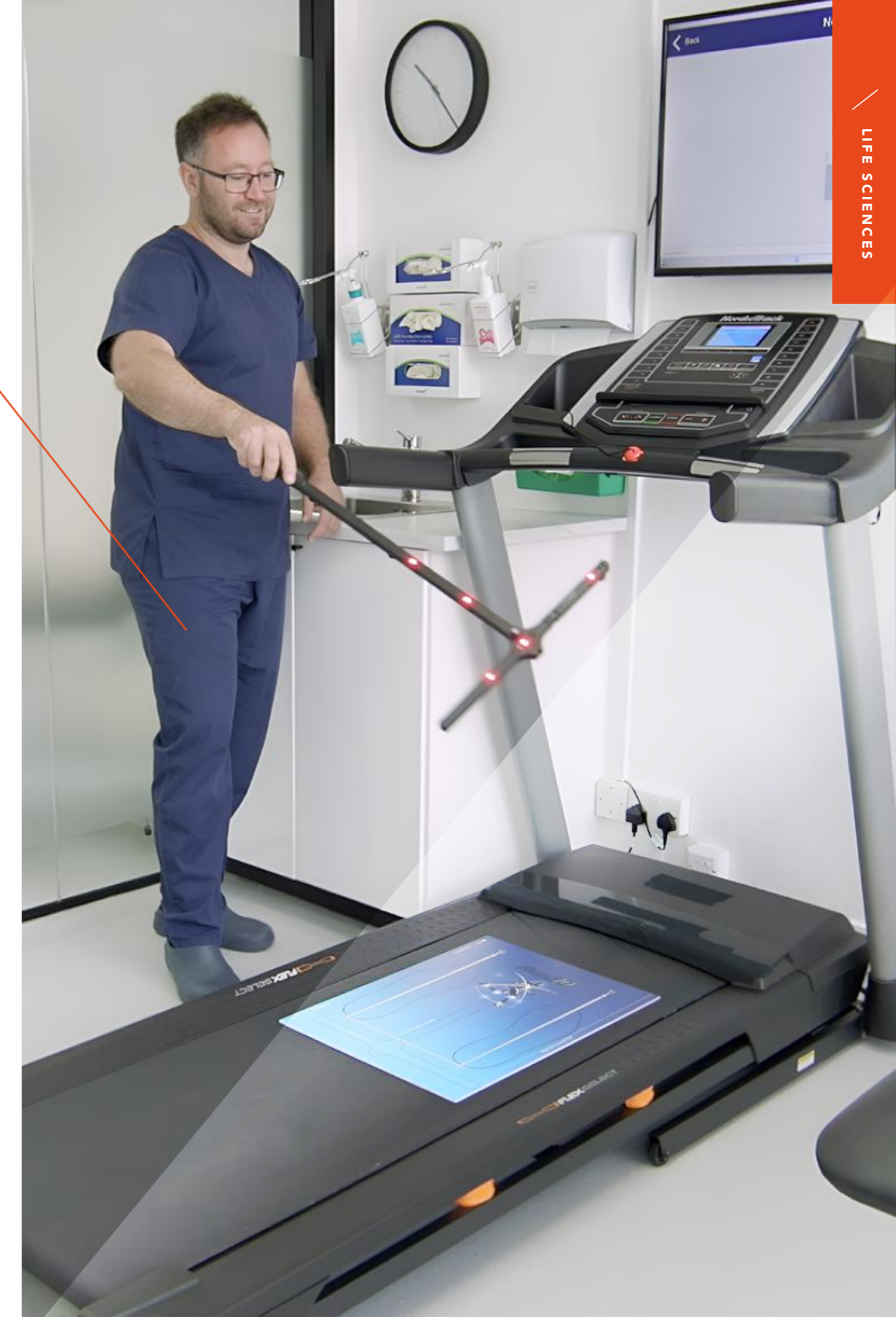
Ankersen concurs. "There would be times where a handler who's never worked with motion capture before would look at the screen and say, 'Oh, a dot moved on the screen, he lost a marker!'" she says.

Ankersen hopes that their work will prove useful beyond the sheep study, too. "We're trying to publish some more methods-based learning," she says, "because the data collection that we did in October 2021 was by no means perfect, but it went exponentially better than the collection we did in 2019 because we learned so much. We hope to give other researchers that same head start."

One of the outcomes of the project that could prove most important is the custom model Henry developed in collaboration with the veterinarians they had on site.

"Being able to apply it to other quadrupeds is the end goal, and really what would be ideal is having a Plug-in Gait quadruped model. You need to be careful with that because of the different morphologies that you would see in different quadrupeds, but a baseline that you could build off would be super helpful. I think it would help a lot of people that don't 'speak in squiggles', as it were, to get started in more animal studies, and do so correctly."

VICON AND RUN3D BRING MOTION CAPTURE TO HIGH STREET PHYSIOTHERAPISTS



Thanks to the partnership between Vicon and third-party gait analysis platform Run3D, grassroots physiotherapists are using optical motion capture to help patients out in the community.

South West Podiatry, which runs clinics in and around London, is one of the practices using Run3D software and Vicon cameras to take biomechanic analysis beyond the confines of university labs and elite sporting organizations.

Developed by Oxford University biomechanists, Run3D is a software platform that uses Vicon cameras to analyze walking and running, enabling podiatrists, physiotherapists or clinicians to prevent and treat gait-related injuries.



"There's a huge amount of data which is captured in the assessment," Kay says. "The role of the clinician is really to strip it down and highlight to the patient which bits are important, and then target how they can rehab and improve that patient's pain."

The Run3D and Vicon solution also helps South West Podiatry to remove guesswork and variability from its practice. "This technology really does standardize our procedures and processes. It's invaluable for our patients," says McManus.

"The feedback that I've had for the patients is about the thoroughness of the process. Once they leave they're saying 'Wow, you really check everything,'" Kay says.

George Simmonds-Gooding, a patient who has been through the treatment process, is certainly happy with the results that South West Podiatry and Run3D have delivered using their Vicon cameras. "My main hope was just to walk with a more normal gait. This process has literally put a spring back in my step - I can walk more normally again," he says.

For more information on the Run3D is doing using Vicon technology, visit: www.run3d.co.uk

For more information on South West Podiatry in London, visit www.swpodiatry.co.uk

VICON



Liam McManus, Clinical Director at South West Podiatry

"South West Podiatry predominantly specializes in musculoskeletal pediatric medicine," explains Liam McManus, Clinical Director at South West Podiatry. "We've invested in Run3D software, and as part of Run3D we have these three cameras that come from Vicon. That partnership with Run3D and Vicon gives South West Podiatry the opportunity to offer state-of-the-art 3D data analysis based on 3D motion sensor technology to our clients."



Penny Kay, Podiatrist at South West Podiatry

"What working with Vicon gives us is greater depth to how we can look at the foot, the ankle, the knee, the hips and the pelvis, and how they're moving in relationship with each other," says Penny Kay, a podiatrist working at the practice.

The setup is simple and manageable for a common clinical practice - three Vero cameras, a treadmill and a monitor. With this, patients can see their 3D skeleton moving in real-time, receiving feedback on their movement or condition.

"What working with Vicon gives us is greater depth to how we can look at the foot, the ankle, the knee, the hips and the pelvis, and how they're moving in relationship with each other."



PUTTING A NEW SPIN ON THE STUDY OF CRICKETING BIOMECHANICS



Historically, much of the motion analysis done on cricketing performance has focused on male players, but researchers at Loughborough University are broadening the field of study.



Dr. Stuart McErlain-Naylor, Sport & Exercise Biomechanics Lecturer, Loughborough University

Loughborough University's School of Sport, Exercise and Health Sciences has been using motion capture to study sporting performance since the 1990s. In 2016, it opened the National Centre for Sport and Exercise Medicine, complete with three Vicon-equipped motion analysis labs and an array of other cutting-edge technology, to deliver education, research and clinical services in sports.

In collaboration with the England and Wales Cricket Board (ECB), Professor Mark King has put over a decade and a half of research into the biomechanics of cricket to enhance performance and reduce injuries in players. Previously being focused on male batters, the batting-specific work with ECB recently shifted to studying female players, with the England women under 19 cricket squad, ahead of their 2023 World Cup.

"Over the last five years or so, we've done a series of studies on power hitting and batting," says Dr. Stuart McErlain-Naylor, Sport & Exercise Biomechanics Lecturer, Loughborough University.



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“We’re looking at batters facing both fast bowling and spin bowling and how the techniques may differ between the two modes, but we’re also looking at the technical characteristics that are associated with the carry distance.”

To get the necessary data, the team is using a relatively large setup. “We’re using 17 Vicon cameras in conjunction with Nexus, and that allows us excellent precision with understanding joint angles and just how the players move in relation to their performance,” says Dr. Alway.

Researching the under 19 age group is part of a wider push to cover the broadest range of female cricketers as possible.

“We’re assessing their power hitting technique so that we can provide feedback to them. We can compare it to data from the senior women’s squad, who we tested previously. It can also feed into our ongoing research program, identifying factors that are associated with success in power hitting within cricket,” says Dr. McErlain-Naylor.

“It’s really important that we specifically research female participants ranging from junior all the way up to the elite senior players in order to provide

tailored recommendations,” he goes on. “The ideal outcome from this research in the short term is to help them to assess their power hitting technique and provide some feedback, as well as any recommendations around how they differ to the elite senior squad, who we tested previously.

“In the medium to long term, the results will hopefully also feed into our research so that we can provide recommendations around the associations between technique factors and bat speed, ball speed, and carry distance. Those relationships ultimately determine success within a power hitting task across different ability levels and different age groups within women’s cricket.”

For more on the work Loughborough University and the ECB are doing with women’s cricketers, see our video case study. <https://youtu.be/hVRFUqQM9Es>



Dr. Peter Alway, Research & Operations Manager, England and Wales Cricket Board (ECB)

“However, all of that research was specifically on male batters. It will be really useful for us to know whether that research applies equally to the female squads, or whether we need to be coaching women differently to the recommendations that we’ve developed for male participants.”

SAME SPORT, DIFFERENT GAME

“Some of the challenges women face are quite different to the men, which is why it’s important to collect this research on the female participants,” says Dr. Peter Alway, Research and Operations Manager, ECB. “They have a different physiological makeup to the men, such as their anthropometrics being smaller. Typically, they have different strength profiles to the men, and they also face a much greater proportion of spin bowling compared to the men’s game, so it’s important that we understand how they bat against this mode of bowling.”

“We’re using 17 Vicon cameras in conjunction with Nexus, and that allows us excellent precision for understanding joint angles and just how the players move in relation to their performance.”

Dr. Peter Alway, Research & Operations Manager, ECB



CGM2 IS GAINING GROUND WITH AUSTRALIA'S BIOMECHANICS COMMUNITY

Monash Health Kingston Centre in Australia has one of Australia's longest-standing gait labs, specializing in adults with neurological conditions including stroke, MS, and cerebral palsy. Corey Joseph, one of the leading biomechanists at the laboratory, is part of a community of researchers working to validate the Conventional Gait Model 2 (CGM2) with the hope of introducing it into clinical settings in the near future.



*Dr. Corey Joseph,
Biomechanist and
Researcher,
Clinical Gait
Analysis Service,
Monash Health
Kingston Centre*

"Curiosity is really what got me wanting to experiment with CGM2," says Joseph. He was very familiar with Plug-in Gait but, as he puts it, "You can't look in to see how things are done in Plug-in Gait. It's a black box, and there are very well-known limitations to it."

When he learned about the work being done by Dr. Fabien Leboeuf on CGM2, he was intrigued. "I was interested in it being open access," he says. "You could download the kit and work with it yourself. I wanted to experiment with it for a few reasons. One was because I was interested to see the improvements that had been made from Plug-in Gait. And, in particular, things like removing Knee Alignment Devices (KAD), so you can just use two medial and lateral markers in the knee like you do on the ankle. And some additional things that you could do with a foot—just really simplifying it into two structures instead of one.

"The other thing that interested me was the ability to use clusters, rather than using tibia and thigh markers—that's really problematic because patients knock them a lot and then we have to spend time fixing that."

NATIONAL INTEREST

CGM2 is attracting a lot of attention in the Australian biomechanics community. “The momentum behind it is picking up,” Joseph says. “There’s now a national group in Australia that’s talking about using it as their primary model, but nobody’s transferred over to it yet because we just don’t know enough about it.”

Joseph is excited by the number of researchers experimenting with the model, and the potential that its incorporation into Nexus offers. “I commend Vicon for incorporating it into the software platform because I think that’s an opportunity for everybody to use it and experiment with it,” he says. “Everybody has barriers in their technical capacity, and including it in Nexus takes away that huge hurdle of having to know how to download something from GitHub, work with Python and then just knowing how to use it.”

Joseph and his colleagues at The Kingston Centre are interested in seeing how CGM2 performs with both clinical and general populations. Their data was captured with a legacy Vicon system which, despite

its age, Joseph describes as “the gold standard of motion capture”.

“The main project we’re working on is testing CGM2 on our entire normative data set,” says Joseph. “Essentially what we want to do is look at each iteration of the model, either relative to itself or with respect to Plug-in Gait. So, for example, looking at Plug-in Gait versus CGM2 1.0, then looking at the improvement with 1.1, then the change in the hip joint center for 2.1. They’re the ones we can retrospectively use with our data set.”

The project got off to a challenging start. Over the course of 2020, Joseph ran each version of the model, from 1.0 through to 2.1, on their data, but felt he needed more information on the development of the model. He and his team put the project on hold.

“It wasn’t until recently, when we started working with it more and communicating with Dr. Leboeuf that we came back to the project,” says Joseph. He and his team integrated the most recent CGM2 updates into their pipeline and began working closely with Dr. Leboeuf, feeding back on the model as they were testing it.

“**We’re sitting on 20 years of clinical data for 10 plus neurological conditions. I can see anything we publish in those spaces being outputs from CGM2.**”

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FROM RESEARCH TO PRACTICAL APPLICATION

Four years on, Joseph is keen to begin using CGM2 in clinical settings. “We want to start implementing it in the clinical world, because we see its advantages,” he says. “We love Plug-in Gait. We know what it gives us, its pros and cons, and we’ll work with it. But there are lots of advantages to CGM2 and I want to cross over to using it in our clinical practice.

“We have a working group that consists of all the clinical biomechanics labs in Australia. We’re all committed to experimenting with it, with the view to move straight over to using it when it’s proven to be ready. In the medium term everybody will adopt it, but it’s not quite there yet.”

Joseph applauds Dr. Leboeuf’s approach to working with researchers seeking to validate CGM2. “Dr. Leboeuf has been really forthcoming and willing to help out with the work that we’re doing. We’re collaborating with him on it, and when we publish our findings he will be a co-author. It’s been a really positive relationship,” he says.

He hopes that other members of the biomechanical community will pick up the baton, too. “I would encourage people to experiment and help progress the model,” he says.

For Joseph, at least, CGM2 is the future. “We’re sitting on 20 years of clinical data for 10 plus neurological conditions. I can see anything we publish in those spaces being outputs from CGM2,” he says.

“The concept of having an open access model that you can use outside Nexus didn’t exist until CGM2, and I think it is awesome that we have it now. Having a model that goes across software platforms is really useful. It’s really positive science.”

For more information on using CGM2 within the Vicon ecosystem, see our Nexus online help pages, <https://docs.vicon.com/display/Nexus216/Modeling+with+CGM2>

For more information on Dr. Fabien Leboeuf’s work, see <https://pycgm2.netlify.app/>



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NFL HOPEFULS' MOVEMENT ANALYSIS DATA OFFERS 'A BLUEPRINT FOR MOTION'



Data has transformed the personnel side of coaching in football, with GPS tracking and machine learning being used to anticipate player success from college through to the NFL, but there are still significant gains left to be had. Elite coach Pete Bommarito and sports scientist Dr. Monique Mokha are taking football analytics to a new level using motion capture.



Pete Bommarito, Elite Coach

"The game today isn't just 'I'm injured, I had surgery, I go to physical therapy, now I'm returning to train and I'm returning to play'," explains Pete Bommarito. "No, sports itself is stress, and quantifying the magnitude of what sports does to the body helps the overall game."



Dr. Monique Mokha, Professor of Health and Human Performance at Nova Southeastern University, Florida

Bommarito has a background in sports and clinical biomechanics, but has built his career as a practitioner offering elite-level coaching to athletes through his company, Bommarito Performance Systems. He's discussing a study of would-be NFL players that he and Dr. Mokha, a Professor of Health and Human Performance at Nova Southeastern University in Florida, USA, are undertaking.

The pair met at a conference in 2017 and got talking. "We were just sketching ideas, like two battery sparks popping back and forth. And then as our lab at Nova started developing, we started asking, 'What's possible?'" says Dr. Mokha.

Bommarito and Dr. Mokha have established an annual project that uses motion capture and other technologies to quantify the performance of NFL hopefuls ahead of the Scouting Combine and Pro Day, which gives talent assessors an opportunity to see players undergo a battery of physical and mental tests.

They worked out a system that involves Bommarito's athletes being tested in Dr. Mokha's lab ahead of his pre-Combine training camp, with data on each player being fed to Bommarito before training starts. Following the six to eight week camp, players return to the lab, which has 10 Vicon T-Series cameras and a Bertec treadmill, to be tested again so that the research team can analyze changes in the athletes' performance.

QUANTIFYING ACCELERATION

"It's not just draft prep and having people run fast," explains Bommarito. "It's a blueprint for motion, period. Anytime you're moving in sport, you are accelerating. People talk about multidirectional sports, and how you've got to be able to change direction. Well, that's great, but the challenge of changing direction is accelerating out of the change of direction. That is a stride that needs to be quantified."

Bommarito says that the study is proving his theory that speed and injury prevention are related. "If you're striving towards symmetry, you will not only be more efficient in terms of your speed, you're going to be more efficient in terms of injury prevention," he says.

"That's a theory I've had for years, but we've had to look at symmetry using



capture integrated with our Bertec force treadmill. We are looking at contact time, average peak forces and we're looking at symmetry. In terms of kinematics, we have the 3D hip, knee and ankle motion, and because we know the role of hip internal rotation, we also look at transverse plane hip motion."

Dr. Mokha has a history of using Vicon technology dating back to the late 90s, having initially worked with Peak Performance Technologies, which was bought by Vicon in 2005. It wasn't familiarity that kept her working with Vicon solutions, however. "It's because of their superior cameras," she says. "And the tech support people are outstanding."

Taking deep dives into motion analysis and force plate data enables researchers to pick up issues that are visible when an athlete is sprinting but might be hidden from a therapist working with a stationary patient.

"This is where the industry is going," says Bommarito. "We're so good at neuromuscular therapy, but it's guesswork. We look at an asymmetry, we treat it, we look at the splits, we look at the motion, it gets better. It's great, but it's still guesswork."



all the medical disciplines: look at that holy grail of maximizing the splits, maximizing your time, and finding that when the medical team says we're symmetrical, and we're running better. But it's got to be quantified. And now we're actually proving my theory to be accurate, that symmetry equals not only injury prevention, but performance."

Because the study is focused on training for the speed- and strength-focused Combine and Pro Days, rather than football-specific skills, its applications aren't limited to football. "We're able to document the movement strategies that change when you're trying to get someone faster," says Dr. Mokha.

REMOVING GUESSWORK WITH OBJECTIVE DATA

The NFL hopefuls offer a perfect subject group for this type of work. "This is going beyond the NFL draft," says Bommarito. "The reason why we

like to study these individuals is that you're eliminating the independent variables that plague research studies. These players are with me 8-10 hours a day. We control every single thing that they do from the moment they wake up until the moment they go home for dinner. We're controlling everything: recovery, regeneration, all their training, all their nutrition, all their supplementation.

"We're not just trying to prove how NFL players get faster in the 40-yard dash. We are proving the ultimate question of how do you maximize acceleration related to any sport motion? And how are you limiting injuries? We're solving that question, and we're taking this baseline data and redirecting it back into the research community to go into a million different directions.

Digging into the specifics of the data her team is capturing, Dr. Mokha says that they are gathering "motion



"This 3D motion analysis, that's not guesswork. Now we're actually giving more data to the therapist to treat things that they might not see because they can't evaluate hip internalization at 20 miles an hour. It can only be evaluated through devices like this. That is where this industry needs to go. And we're the first people to actually produce research detailing this type of data."

The data are already changing the way Dr. Mokha looks at different types of athletes. "The magnitude of how much better the biomechanical metrics get in the heavy players, like your offensive and defensive linemen, is huge," she says. "It makes sense from a practical standpoint but that's data that has surprised me: how much better they can get at applying the force to accelerate, and accelerating the thighs at just the right time. They're over 300 pounds!"

She hopes to further deepen her dataset by using Blue Trident IMUs

out on the field at some point in the future. "It is kind of that never-ending question of how close can you get. It's definitely the way things are headed, absolutely. I have already envisioned a huge use for this when Pete's doing his battery of testing at his facility. He doesn't have optical capture out there, but let's put the IMUs on them."

Bommarito hopes to further integrate data capture into his work, but also to improve turnaround times. "It all comes back to how efficiently this 3D motion analysis can be done and how fast the data can come back," he says. "To a performance coach like me, when I get those reports they're like gold, and the medical team and I spent a lot of time on this and I truly do believe that's why we get the results we get."

"This is the way the industry is going and we scientists have to get it in the practitioners' hands as quickly as possible," Dr. Mokha agrees.



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IM4 LAB IS OPENING DOORS IN VIRTUAL PRODUCTION

FOR THE INDIGENOUS FILMMAKING COMMUNITY



“You can go anywhere with your imagination when you’re working in motion capture, working with Vicon, working with LED screens. That’s what’s really exciting,” says Loretta Sarah Todd, Creative Director at IM4 Lab.



Loretta Sarah Todd, Creative Director at IM4 Lab.



Carlos Vilchis, Virtual Production Educator & Consultant / Unreal Authorized Instructor

Indigenous Matriarchs 4 (IM4) Lab is dedicated to helping Canada’s Indigenous community tell stories using leading-edge tools and techniques. The organization offers training in immersive media production, offering Native artists the tools they need to deliver innovative storytelling through an Indigenous lens.

“We’ve been having these discussions about indigenizing technology for a long time. It goes way back to when I started making films,” says Todd. “There was always this sense that storytelling is really important and these are new tools that we can use and we can indigenize. We were talking about virtual reality, back in the day.

“Fast forward, and when Canada was celebrating its 150th birthday, virtual reality projects from different Indigenous storytellers and filmmakers were being commissioned. They were all really good and they were all significant. But I was thinking, OK, here we go again. We’re going to have technology that’s going to be out there in the world, but we as Indigenous people won’t have ready access to it, unless we’re commissioned or unless somehow there’s something to initiate this.



“What was really important for me was to be out there at the beginning with VR and AR, but also real-time virtual production because that was just starting to come in. The more of us who have these skills, the more we show ourselves as equal in those spaces and, in fact, maybe we have something special to bring.”

BUILDING CAPACITY

IM4 Lab was established in 2019 to make access to these skills free and inclusive to the Indigenous community. The organization has a governance structure that is made up of matriarchs: “The idea was that I didn’t want to just replicate the way the industry works.

I wanted to model a more Indigenous way of how we go about doing our business,” says Todd.

The structure of the grant that IM4 Lab needed to fund its virtual production project made it necessary to partner with Emily Carr University of Art & Design (ECUAD) in Vancouver and the University of Victoria, which were able to support IM4 Lab with the resources and facilities the project needed.

The cohort included 24 creators from a variety of professional and creative backgrounds. It lasted 12 weeks, blending online and in-person

learning as attendees worked to create a short film.

Motion capture was a key part of the project, with the creators using a legacy Vicon system for performance capture and camera tracking, adopting the same workflow as studios such as ILM and Pixomondo.

The technical lead was Carlos Vilchis, a virtual production educator and consultant and Unreal-authorized instructor who has worked at AAA studios, including ILM. “The course leaders were completely agnostic about which motion capture technology to use, but I decided to introduce them to Vicon. I thought that if this is the specific technology we use at ILM for virtual production, why not use the same one?” says Vilchis.

“It was really important to make it as professional as we could within the budget we had, so that the cohort can take that knowledge and experience of a professional environment with them when they’re looking for work or making their own films,” says Todd. As well as the equipment and Vilchis, they brought in an experienced director of photography and veteran actors to help create the final shorts.

LEGACY SYSTEM, CUTTING-EDGE TECHNIQUES

The system that the creators used consisted of 24 Vicon T160 cameras, coupled with Shōgun 1.8 and paired with a hired LED screen. Not only was it an older motion capture system—it had also sat dormant for several years. That didn’t turn out to be a problem.

“One of the advantages of Vicon technology is that we just needed to turn on the system, check that the license was working and that it was able to stream into the virtual production workstations, and it was ready,” says Vilchis. “Despite being 15 years old, it was working perfectly with the latest version of Unreal Engine. We didn’t need to change anything related to the motion capture system. The setup was perfect for doing the tracking in real time without any major changes to the stage.

“These were filmmakers with no previous experience of rigging, no previous experience of doing animation in Maya or anything like that. They just got started, and I was surprised how easy it was for them to do the calibration and put on their suits. They started streaming into

Unreal Engine in just 30 minutes, and then the integration with the virtual production context and the real-time camera work was really smooth.”

Vilchis says that if they had tried to use an alternative tracking solution, they would have run into difficulties mixing the different technologies into the same workflow. “In this case, I love the way that it was just a single software platform. Shōgun will get everything into Unreal Engine without any major problems. Just track the camera, track the actors and then you are doing everything in a single solution in a few clicks. That was super-useful for me, as I was trying to train people without previous CG experience.”

Vilchis notes that while in an ideal motion capture environment there would be no occlusion, in professional settings such as ILM, it’s extremely common for markers to become blocked from the cameras’ view as props and people move about the stage. “But the tracking was solid, it was perfect for the camera, for the objects,” he says.

“I like the fact that this university invested in a professional-level program for beginners in the field. It’s uncommon,” Vilchis says.



‘PEOPLE JUST SAW THE POSSIBILITIES’

Vilchis and his colleagues spent five days working with the filmmakers and three actors to produce the shorts, which were shown at an event in August 2023.

“I think the people just saw the possibilities,” says Todd. “Within a few classes they were building worlds and creating characters and telling stories and they were just so excited. And then when they got into the studio,

they were so excited to see that ‘Oh, I can actually make a film!’

“People saw that possibility and they’re really motivated. I really want to be able to keep that momentum going and provide them with more opportunities.”

For some of the attendees, the project has already opened doors. “One of the virtual production houses here in Vancouver reached out to us—they want to interview our graduates for eventual hiring. We also have another VFX company that’s very interested in talking with our graduates to see if they could come in as paid interns,” says Todd.

More broadly, she hopes that participants will take what they’ve learned back to their respective communities and share their skills.

Looking ahead, Todd has plans for IM4 Lab to do further AR and VR workshops, but she also wants to continue supporting the virtual production cohort with further learning and one-to-one mentoring. She also hopes to branch out and offer training in animation and the use of Unreal Engine to the Indigenous community.

“I really do think there’s huge excitement around virtual production in the native community,” says Todd. “We feel like we’re starting to build this community, and I think what’s great is there are other great labs out there supporting artists, too.”

For more on IM4 Lab, visit:
www.im4lab.com/im4



'CAPTURING THE ESSENCE OF A SOUL'

EDUCATING THE NEW GENERATION OF PERFORMANCE CAPTURE ARTISTS



"At the beginning I was saying, 'I don't know what this is, I don't know what it entails'," says actress and entrepreneur Victoria Atkin, discussing her first performance capture job. "I'd come off Hollyoaks, a big soap opera in England, and I was over in America and I had a goal to be the next action heroine. My manager at the time pitched this performance capture video game job that was all secretive. They said, 'come on, let's just try and do it'."



Victoria Atkin, Actress and Entrepreneur

The role turned out to be Evie Frye for Ubisoft's 2015 blockbuster, Assassin's Creed: Syndicate. It changed the course of Atkin's career, and soon she would be able to add 'performance capture educator' to her list of roles.

In the decade since that first motion capture job, Atkin has acted for AAA games including Call of Duty titles, Ghost of Tsushima and Horizon: Forbidden West. Spinning out of that work, she launched the Vicon-sponsored Performance Capture Podcast, now in its sixth season, and a series of online courses designed to prepare professional actors for motion capture roles.

"It's so fun, you can play as if you were still a kid. And that's what most of us get into acting for," Atkin says. "It's capturing the essence of a soul."

"I realized, and I'm still realizing, that there's a huge gap in knowledge education around motion capture for actors," Atkin explains. "There's a lot of education about the production side of it, but not really from the perspective of being in the volume and acting."

Although Atkin says that, fundamentally, acting for performance capture draws on the same skill sets as other forms of the discipline, she has seen some of the challenges that newcomers can face. "I know some fantastic theater actors that come onto the mocap stage and they struggle because they're used to props and costumes and sets. It's the same with voice actors—they're just used to using their voice. Now, suddenly, they have to use their whole body."



BRIDGING THE KNOWLEDGE GAP FOR ACTORS

It's this knowledge gap that led Atkin to her current path as an educator. "I don't even know what came first, the podcast or my classes, but I just got on this train of wanting to educate people," she says. "I want this work to be recognised. I want the people that are in this work to be recognised. There's no category for it in the Academy Awards—there are no categories for it, really, in any sort of awards. And there are so many people who are working so hard and doing such fantastic work that I want to celebrate that. I want to create an archive of the people in this industry so that when we're not here, people understand that this was where it started and this is how it grew."

It was Covid that ultimately prompted Atkin to start her coaching, courses and podcast. "During the pandemic a lot of people reached out to me while TV and film were all completely shut down," she says. "A lot of us who had already established ourselves in

voiceover were working non-stop. Anyone who had a home studio and a lot of credits had people coming to them to keep projects going. And other people who had not done this before were going, OK, this is an opportunity to make money."

An actor approached Atkin for a coaching session, but she quickly realized that she could achieve much more with a regular class. She started her 'Weekly Workouts' course, which brought together groups of students for online classes over the course of four sessions per week.

As lockdown restrictions eased Atkin shifted focus. Now, her teaching is available as an E-course called 'Video Games With the Pros', put together in collaboration with fellow performance capture specialist Michael Antonakos, who has starred in games including Assassin's Creed Odyssey and Gotham Knights.

The podcast was started as another way to showcase the possibilities of motion capture for actors. Vicon was an early sponsor. "We had a meeting

in LA about how this could benefit everybody, how Vicon would be able to give back and celebrate the work, and how it was able to support new people in the industry and share information with people who are already in the field. Because a lot of us kind of stumble into this work—it's still an emerging field and the technology is growing and improving all the time."

Atkin also hoped that the podcast would help her to expand her knowledge and improve her performances on the capture stage.

"I have this dialogue with actors who know me in this field, but I don't really understand the tech. And my question was, 'do I need to understand the tech as an actor to make my work better in this field?'" Atkin says. "It was almost an experiment—let's listen to directors, producers, and other people who are working in the field. And 100% it has helped my work. Even if I don't have the full technological understanding, I have compassion and I have an understanding of people's jobs and responsibilities.

"I think it's helped me as an actor and as a coach to share that information, so that everybody's coming at it as a team. It's such a collaborative effort that there's no room for ego."

'IT'S ADVANCING EVERY DAY'

In the course of the last decade Atkin has seen dramatic changes in performance capture. "It's so different," she says. "I mean, doing Forspoken with Square Enix recently, there were so many more facial markers than there would have been a few years ago. It took a lot longer to put those on and get going.

"I've even noticed that the directing styles are changing to adapt to the medium too. The acting shouldn't really change—everything that we're doing should be based in truth and bringing the character to life. But it certainly is heading, in my opinion, towards more filmic performances in many ways because of the close-up. Becoming so close and so detailed, the hybrid between theater in the round and a film close-up is becoming even more heightened. It's knowing that you're taking up space like you do in the theater, but your performances don't need to be that big because there's a camera closer than it will ever be in film on your headcam."

Atkin believes that the advances in both process and technology are yielding powerful results. "The final product now is just incredible with these systems," she says. "It's just

getting better and better. Vicon is on the leading edge of this. I'm so grateful to be working at a level where I have the privilege of being captured by these types of systems. Not all of the games that are being produced have their motion capture done with Vicon systems, so I've been extremely fortunate to be working on these AAA titles."

Atkin believes the advances will continue. "This is not going away," she says. "This will probably become the leading way that actors are used in the future."

Victoria's next course PCAP WITH THE PROS which she conducts in May and November each year is now sold out for participants but she encourages anyone who works with actors in the volume to audit the six week course with her to understand the actors process in this arena.

Visit www.bookvopcap.com to find out more.

www.victoriaatkin.com/#pcap

For further exploration of performance capture in the entertainment world, listen to *The Performance Capture Podcast*, sponsored by Vicon.



UNIVERSITY OF MINNESOTA DULUTH STUDENTS LEARN 'HOW TO FLY' WITH MOTION CAPTURE

Above: Jake Lieder & Thressa Schultz

When the Upper Midwest Film Office approached Lisa Fitzpatrick about providing motion capture for a project that the organization was consulting on, it highlighted a problem. The Viz & MMAD (Motion + Media Across Disciplines) Lab that she runs for the University of Minnesota Duluth has a motion capture setup comprising 12 Vicon cameras and licenses for multiple Vicon software tools. Professors at the MMAD Lab had until then mostly used its Vicon system for biomechanics projects with Nexus. However, the MMAD Lab had barely explored the animation side of the system using Blade.



Lisa Fitzpatrick,
Director, Viz Lab &
MMAD Lab, University
of Minnesota Duluth



Dan Fitzpatrick,
MMAD Lab video
producer, University of
Minnesota Duluth

Hundreds of working-hours later, Lisa Fitzpatrick, a team of undergraduate students and MMAD Lab video producer, Dan Fitzpatrick (no relation), had produced a whimsical, partially-improvised short film about two characters playfully soaring through the air. Accompanying it was the true focus of the project, a behind-the-scenes video displaying the process of making the film and the skills that the team had developed in the process.

It was a lengthy journey, however, during which the team had to reacquire lost institutional knowledge of how to operate the university's Vicon system.

"When COVID happened, things really closed down," explains Lisa Fitzpatrick. "As we were coming back, I got this request from the Upper Midwest Film Office here in Minnesota and they asked if we could do animation and motion capture."

There was no current professor who specifically worked with the Vicon system and, over the course of the pandemic, any students who knew how to operate it had left the university and professors with biomechanics expertise had retired. Successive lockdowns meant that nobody had been able to come into the lab to learn from



Above: Jake Lieder & Thressa Schultz

information that was readily available to be able to optimize our space where we can still do everything we need," he says.

Rood highlights an interaction he had with Vicon Customer Support while he was trying to integrate third-party force plates with the lab's motion capture system. "They were able to dig up a random file that isn't even on the website. It's ancient at this point, but that's what was needed for our particular setup and it just works. That was impressive," he says.

HOW TO FLY

The demo that Rood, Schurman, Haeun Lee, Lisa Fitzpatrick and Dan Fitzpatrick ultimately put together to showcase the system was an animated short called How to Fly and the accompanying behind-the-scenes video, filmed and produced by Dan Fitzpatrick.

"We wanted to make the primary product be the behind-the-scenes video, and have the animated content be the secondary product," says Rood. "We specifically wanted to show the process rather than just the final product."

The video was carefully calibrated to make use of the Lab's capabilities while working around gaps in their knowledge or resources. Actors Thressa Schultz and Jake Lieder were brought in from the university's Theatre program to improvise an offbeat scene built around flight, with motion capture, green screen and conventional footage all shot in the same space in a three-hour shoot on February 28th, 2023.

"None of us had experience with this," says Schurman. "It was this moment of rapid creativity, doing the best we could in the moment, and it was fun! The production day went really well."

Dan Fitzpatrick agrees, "It was energizing! For years I've wanted to produce a video combining video and motion capture. I documented the process by shooting with three video cameras, then I synced the edited clips up with the animation and Blade files to create a split screen video."

The data was processed using Blade to animate characters from Adobe Mixamo in Blender for the final videos. Lee, a digital arts major, applied motion capture movements to characters.

The team spent over 470 hours prepping, rendering, animating, editing and syncing the files to produce the video, though Rood says that he believes they could do it in around half the time now that they have established a workflow.

"My biggest priority in this Lab has always been establishing standard protocols and infrastructure that will allow people to use this space ad infinitum," says Rood.

The knowledge base the team established can now be used and grown by the MMAD Lab's loose-knit group of users. "I call it the collective brain, because both of the labs I run

are like play spaces and they're very interdisciplinary, with people from art, biology, theater, computer science, communications and engineering all working together," says Lisa Fitzpatrick.

Rood speaks highly of his time working in the Lab. "Being able to go from the very theory-based stuff we learn in classrooms to a practical application while still in university has been just absolutely invaluable.

"There have been several times where in my studies in computer science I've been like, okay, I know how to use this tool. What do I use it for? So being able to identify good use cases and practical applications has been a very important skill that I've gained from this space and my interactions here," he says.

There are several potential projects in the works for the MMAD Lab. The university has plans that could see the lab used to tell stories about climate change, and it also plans to experiment with teaching applications for virtual reality to test the concept's viability.

View *How to Fly* and the MMAD Lab's accompanying behind-the-scenes videos: <https://www.youtube.com/watch?v=1EpYLeSiSZA> and https://www.youtube.com/watch?v=-twmxZT_uPY

outgoing students, leaving no-one with a working knowledge of motion capture.

"I didn't want to say, 'Oh no, we can't do that,' because I wanted to see if it was still possible, despite the loss of institutional knowledge," says Fitzpatrick. "That's where Ethan (Schurman), Brendan (Rood), Haeun (Lee) and Dan (Fitzpatrick) came in. I said, 'Let's relearn how to use this. Let's do a fun project so that we can all learn.'"

A STEEP LEARNING CURVE

Rood, who was an undergraduate studying computer science at the time, took it upon himself to learn from scratch how to run a motion capture project. "I came in knowing pretty much nothing, and had to document our entire system in enough detail that hopefully, when I'm gone, someone else can still do what they need to do in the space," he says.

The documentation and learning resources provided by Vicon proved crucial. "I found the tutorial playlist on the Vicon YouTube channel extremely useful," says Rood. "That was the main resource I used to learn the process. Also, the computer that had the system installed on it did have some old files that I was able to explore and reverse-engineer to see how they did it."

Fitzpatrick, meanwhile, cites the importance of Vicon Support in getting the lab's system up and running. "I've been blown away by how helpful the tech support staff is," she says. "Anytime we've called, they know exactly how to help us. We're very happy to work with them. There is not another company I would say this about!"

Schurman, a digital art major, who directed, animated and rigged the project, seconds Fitzpatrick's sentiment: "There was help and there was guidance and there was



Brendan Rood, Student, MMAD Lab, University of Minnesota Duluth



Ethan Schurman, Student, MMAD Lab, University of Minnesota Duluth



VICON

CAPTURING ONE OF THE FALL OF USHER'S DARKEST MOMENTS

The Murders in the Rue Morgue by Edgar Allen Poe is widely considered to be the first modern detective story, but it has a climax that stretches credulity for modern audiences: the killer turns out to be an orangutan. It was a version of this ending that Beyond Capture and legendary creature actor Terry Notary had to bring to life for Netflix's The Fall of the House of Usher – something that, despite some technical challenges, they achieved to chilling effect.



Graham Qually, Owner/President of Beyond Capture

Beyond Capture is no stranger to horror-themed content, with credits across TV and video games including Netflix's The Order, The Walking Dead: Saints & Sinners, Back4Blood and Resident Evil 4.

The studio was founded by Graham Qually in 2017, building on experience he'd gained over the course of 16 years in the visual effects industry.

"I started in mocap back in 2006, at a company called Rainmaker Entertainment in Vancouver," he says. "They had a Vicon motion capture stage with 16 of the MX40 cameras. From there, I went off and helped build the Ubisoft Toronto stage where we had 80 of the T160s. So, of course, when I started Beyond, there was no choice other than Vicon."

Beyond Capture already operates two large motion capture volumes (its Montreal location boasts one of the biggest volumes in the industry) and has plans to build out additional stages with Vicon cameras.

The capture session for The Fall of the House of Usher took place on the company's Vancouver stage. The volume there is fitted out with 100 Vicon Vantage cameras and Shōgun, with additional processing done by custom tools that plug into the studio's Vicon pipeline. "We have a lot of proprietary tools. We have four full-time programmers on our team that are building proprietary capture, solving, tracking and administration tools like file movement," says Qually.

Netflix's The Fall of the House of Usher draws on a number of stories by Edgar Allen Poe to weave together a multi-generational horror epic about the wealthy, corrupt Usher family. The scene that Beyond Capture worked on is the climax of the series' third episode, 'Murder in the Rue Morgue', in which a chimpanzee rather than an orangutan attacks and kills a character.

Terry Notary, who has done performance capture for films including Avatar, The Adventures of Tintin, The Hobbit trilogy, Kong: Skull Island, and, most relevantly, the rebooted Planet of the Apes trilogy, was joined by stunt actor Devyn Dalton for the session.

"Terry's a household name, especially when it comes to motion capture," says Qually. "It was just so awesome to have the guy on our stage and to watch him transform on a snap of a finger from a human to a monkey. You know, the way he would roll around and run on his hands with these extensions on them was mind blowing."



The studio originally requested on-set motion capture, rather than running the shoot on Beyond Capture's Vancouver stage. "They were looking to either use an inertial suit or to bring us onto the set to do optical capture," says Qually. "They needed to capture a monkey attacking a character, but since the monkey is significantly smaller than the actor, we knew the best method to capture high quality, realistic data was to shoot at Beyond and re-scale the proportions to set.

We took Terry Notary's size and the dimensions of the monkey, and then we built a cage in our space that fit that ratio. We shot all his monkey data inside that super-sized cage, and then we had the data scaled to match the proportions on the set," Qually explains.

USING VIRTUAL PRODUCTION TO BRING IN REMOTE PRODUCERS

Virtual production was a key component of the shoot. "We were working on it both remotely and in-house," explains Qually. "We had directors at the stage and we were also streaming it over Zoom to different producers. We had already built the cage weeks earlier and built it as a

digital asset for use in real-time, as well. As we had both the cage and the monkey in real-time we were able to visualize everything as we did the capture.

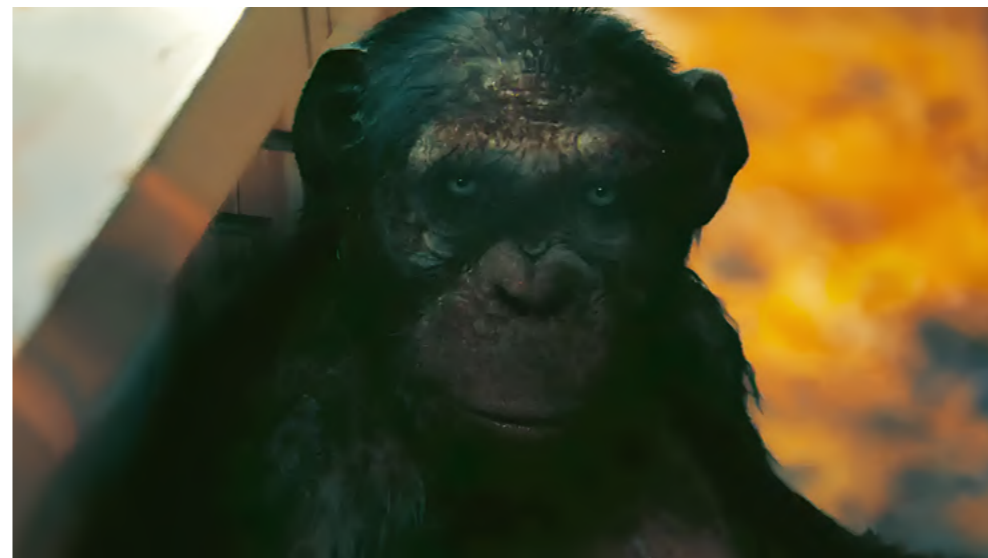
"The system held up perfectly and we were able to have nice, smooth real-time visualization for the people on set and the ones watching remotely."

"We integrated StretchSense gloves with the Vicon system, and got really good finger data when he was grabbing the bars and shaking them," adds Michelle Wiens, Facility Manager at Beyond Capture Studios.

"They said that because they wanted to shoot the monkey removing the woman's scalp, they needed really articulate finger capture to get the fine detail. I remarked that this is why I do what I do. It's these kinds of phone calls where people say things like 'we need monkey scalping fingers!'" Qually jokes.

"One of the biggest helps was being able to do real-time visualization without having to worry about occlusion, because we had all the parts of the cage we built blocking various markers," says Qually.

"Even though our actors were inside an actual cage, with arm extensions on and the finger capture we were doing, we were still able to achieve really high fidelity real-time visualization. The directors were very particular about the way the chimp moved, and they were able to see this because of our Vicon technology. That was a huge advantage for us."



To find out more about Beyond Capture visit: www.beyond-capture.com

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