

TheStandard

2020 Edition

A large, circular, metallic industrial component, possibly a camera lens or a sensor array, dominates the center of the page. It features a ring of numerous small, glowing yellow lights around its perimeter. In the center of the component is a larger, circular lens or sensor that is emitting a bright blue light, creating a horizontal lens flare effect across the image. The text 'POWER UNLEASHED' is superimposed over this central blue light.

POWER  
UNLEASHED

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VANTAGE  
A NEW  
POINT





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Beyond optical measurement



# STRONGER TOGETHER



## STRONGER TOGETHER

IMOGEN MOORHOUSE  
VICON CEO

Welcome to our 2020 edition of The Standard which has been written and edited during the most challenging of global events.

I would like to take the opportunity to thank the Vicon team for the way they have all risen to the challenge of altered working practices whilst continuing to develop & manufacture our products and support our customers.

And thank you to our customers who have contributed their stories showcasing the continuing growth in the novel and inventive uses of motion capture.

It is this increasing breadth of use which drives our development pipelines and we have been excited in 2020 by the uptake of Blue Trident IMUs alongside our optical motion capture and, moving forward,

what our customers will be able to achieve with the launch of the free Vantage + high speed option within our Vantage platform.

During recent times we have seen growth in several emerging markets.

In remote monitoring and healthcare with the drive to improve global general health levels, in virtual production the demand for content is driving rapid expansion of this technique globally and in Location Based Entertainment a desire to develop techniques in Education to assist with online teaching and learning.

It seems likely that we will all need to function in shifting operational and market conditions for an undefined period, nevertheless I would like to close by assuring you that everyone at Vicon is there to support you in continuing to educate, to research and to create in these challenging times. We are stronger together.



# LEAPS & BOUNDS

*Capturing the elite athletes  
of the NBA for 2K*



Pixelgun Studio has flourished in an unusual niche - it specializes in photogrammetry, vocal recording and motion capture of elite athletes and high profile actors in highly compressed timeframes.

Working for the likes of the NBA 2K and WWE 2K video game series, Epic Games, Telltale Games and Facebook, the studio has fine-tuned the process of capturing the movements of time-starved athletes.

The studio was formed eight years ago when 2K was looking for a company that could capture extremely high-fidelity 3D

imagery of basketball players, to improve the graphics in its NBA 2K series. "Before, they'd been basically modeling and texturing by hand, as other video games do," says Bill Gale, Supervising Producer for Pixelgun. Now, they were looking for the next step towards realism.

2K deals with elite athletes on very demanding schedules, and therefore needed a team that could do the specialized work very quickly. Pixelgun's solution for photogrammetry and audio, developed over a number of years, is a mobile studio ("People compare it to what Darth Vader lives in," jokes Bill) that tours the United States and can have athletes in and out in seven minutes.

MAYBE A PLAYER COMES IN SPORTS GOGGLES, AND WE'VE GOT TO DEAL WITH HOW THE INFRARED IS GONNA REFLECT OFF OF THOSE. THERE'S ALWAYS SOMETHING."



**BRIAN COPENHAGEN**  
Mocap Lead  
Pixelgun

## MORE MOVING PARTS

Over the years, 2K has evolved its games to include sophisticated story modes with extended cutscenes. Photogrammetry and audio are no longer enough, and Pixelgun has expanded its offering to include motion capture. Mocap is, by its nature, a lengthier process than photogrammetry, but Pixelgun still has to work in very tight capture sessions.

Brian Copenhagen, Mocap Lead for Pixelgun, says that a shoot would normally involve a four-day round trip by air, including time to get their bearings, set up, pack away and get home. In the middle of that is just a single two- to three-hour session to capture everything they need from a player, and it happens very much on the player's terms.

"The timing is really set by them," says Brian. They might show up with just a manager, or they might have a whole entourage in tow. They might be excited about being shot for a videogame they've been playing for years or they might be unnerved by being fitted into the capture suit and having markers placed all over their body.

"You better have your act together," says Brian, because shoots are unpredictable. "Maybe a player comes in sports goggles, and we've got to deal with how the infrared is gonna reflect off of those. There's always something."



//

WE'RE JUST TRYING TO BREAK DOWN THAT BARRIER AND GET THE FANS CLOSER TO THE GAME THAN THEY COULD ANY OTHER WAY."



**BILL GALE**  
Supervising Producer  
Pixelgun

## MOVE FAST, DON'T BREAK THINGS

Speed is an important factor both before and during a session, too. "One of the things about the Veros which made the difference is being able to do the quick setup," says Brian. "We put it up on stands, and because they have the motion-sensing capability to tell us when they've been bumped, that gave us the opportunity to have the mobile stage

"It's going to happen because we've got a bunch of stands in a not-very-large volume and somebody is going to kick a stand at some point. But an individual camera could say, 'I got bumped' and in about two minutes we are able to recover that camera and carry on."

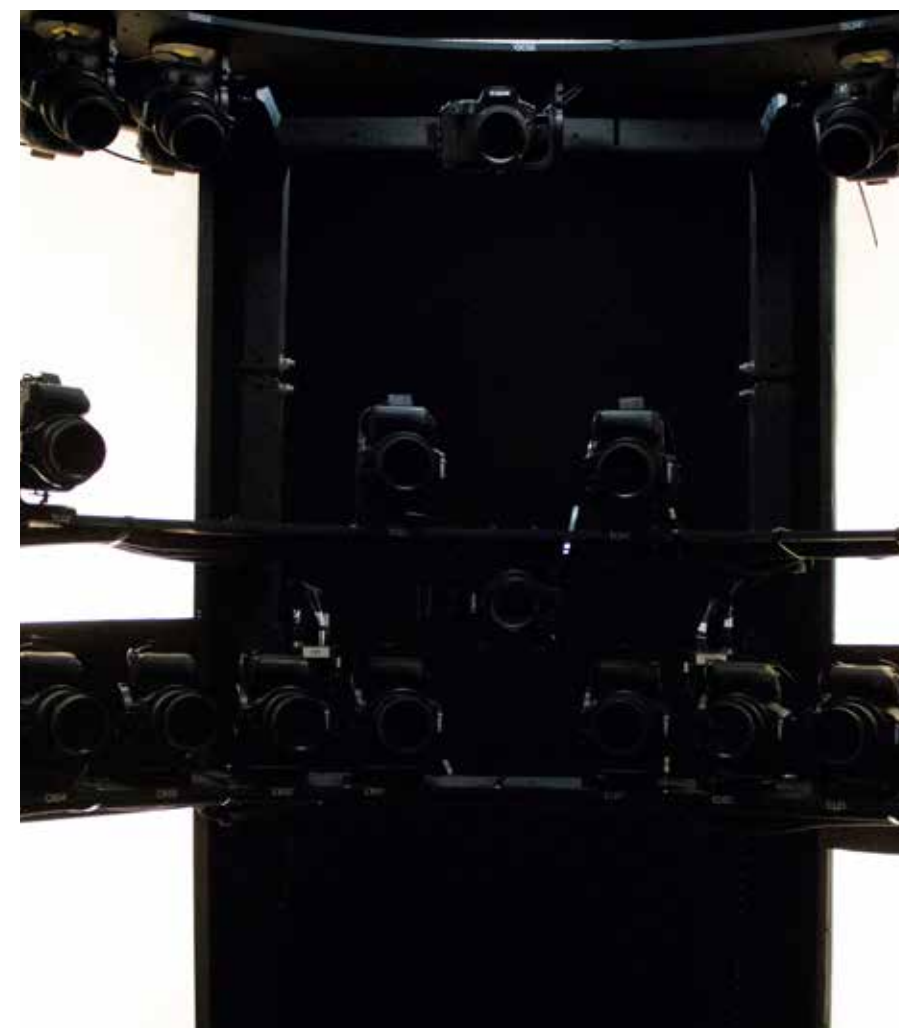
Shōgun is also an important tool. On a technical level, it reduces Pixelgun's workload. The sync tool is useful for marrying audio and mocap data gathered in different sessions, while the software's processing power keeps the amount of resolving that the team needs to do to a minimum.

Mauricio Baiocchi, Pixelgun's 'head guru' who worked in animation for years, has said he can barely tell whether data has been post-processed. "I think that speaks to the power of Shōgun in its resolving capabilities."

A recent update that enables calibration within a defined volume without having to send people out of the room has also been a big help.

Meanwhile, being able to do visualization on set helps Pixelgun engage nervous athletes. "We'll put a Vicon skin on them and let them see what they're doing," says Bill. "That usually breaks the ice pretty quick, because you see a player out there moving and grooving and he's like, 'That's me!' That's a never-fail instant connection."

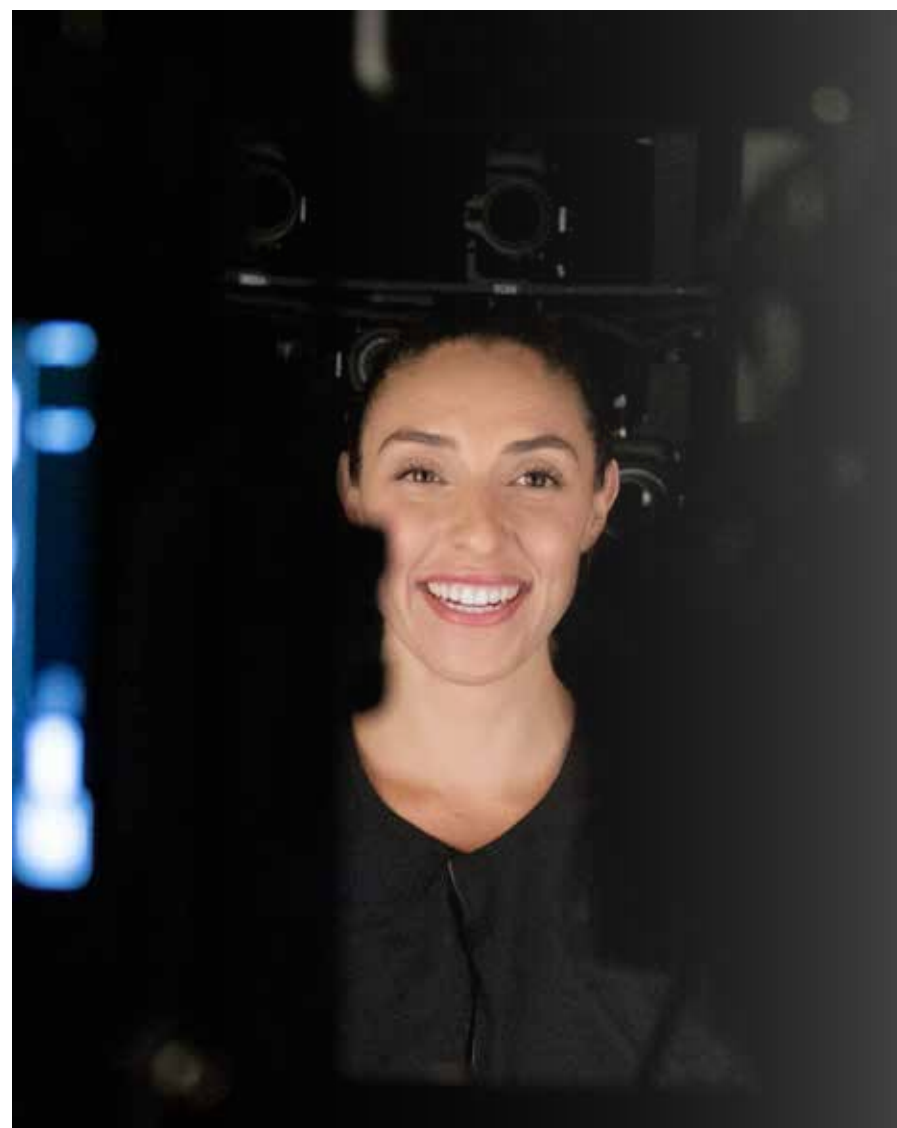
The end result of all these different factors is something Pixelgun is very proud of - data that is indistinguishable from that captured by 2K's in-house, bespoke studio, despite having been gathered in a mobile studio under challenging conditions.



## THE END GOAL

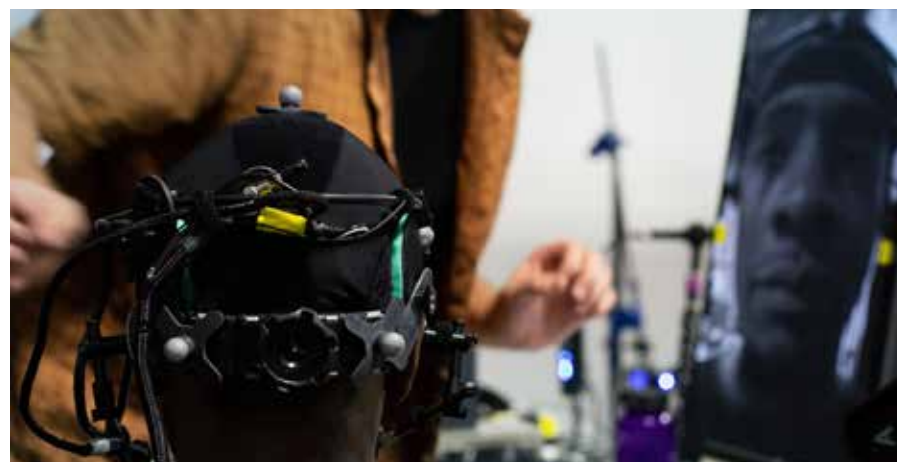
Both the consumer applications and the professional functions of the technology boil down to one thing for Bill: immersion. As motion capture evolves, he hopes that more affordable versions of the technology will find their way into homes to draw players deeper into 2K's games. On the production side of the equation, he envisions one day adding outdoor markerless tracking to Pixelgun's mobile studio so that he can quickly capture more data on the road, enabling games developers to create greater volumes of realistic content.

The end goal, however, is the same: "We're just trying to break down that barrier and get the fans closer to the game than they could any other way."



That means there are two main criteria Vicon's motion capture technology has to meet: it needs to be portable and extremely reliable so that the team can remain laser-focused on getting the data they need.

"Veros came out and we knew that that would probably be a good option for us because they're so compact. Many of the other cameras that are built into stages are twice the size, easily, and you can't call it a mobile rig if you're going to haul 20 cases of gear around," says Brian.





## MOTION CAPTURE HAS BECOME A SIXTH SENSE FOR AUTONOMOUS DRONE FLYING

Bell Innovation is using mocap to model flight  
in the smart cities of the future

Bell has an 85-year legacy in the aerospace industry. Despite a rich history as one of the leaders in the field, however, the company is not content to trade on its impressive record.

In 2018, Bell preempted the technology-based disruption that has shaken so many other industries by moving into the tech sector itself, positioning an innovative, mobility-as-a-service business model at the heart of its offering.

The Bell Innovation arm is now, as Technical Lead for its Intelligent Systems team, Grant Bristow, puts it, “targeting autonomous mobility – moving people, packages and data.”

The centerpieces of this new strategy are the Bell APT delivery drone and the Bell Nexus 4EX, an air taxi that flies using four tilting ducted fans powered by a hybrid-electric or all-electric engine. The point of mobility-as-a-service, however, is not simply to sell individual vehicles, but to deploy fleets offering seamless city-wide coverage.

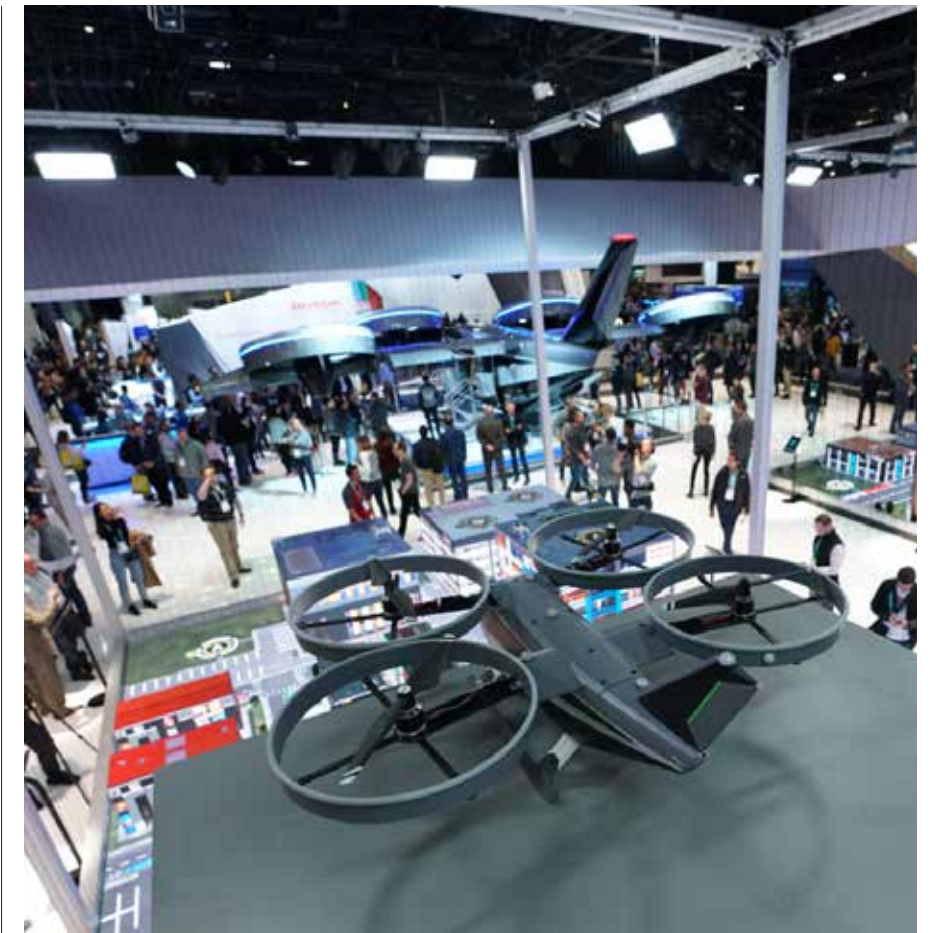
“Within Intelligent Systems, we’re looking beyond the independent vehicle,” says Grant. “How do we connect all these vehicles? How do we develop the digital backbone? How do we operate it as an ecosystem of vehicles, not just independent vehicles? We’re developing a fleet scheduler suite of services that would help manage and connect all these vehicles.

“For us to rapidly develop in the space, we wanted a fleet of vehicles that we could fly indoors as proxies for APT or Nexus, so we could develop in parallel and converge by the time Nexus was flight-worthy.”

WITHIN  
INTELLIGENT  
SYSTEMS, WE’RE  
LOOKING BEYOND THE  
INDEPENDENT VEHICLE”



**GRANT BRISTOW**  
Technical Lead  
Intelligent Systems  
Team Bell



### FLYING BLIND

The problem was that, out in the wild, the vehicles can use GPS data to complement other sensory inputs, but inside it doesn’t work. That’s where Bell’s Vicon system comes in.

“We use the Vicon system to basically emulate GPS indoors,” says Casey Hanner, a hardware and software innovation engineer at Bell. “We set the system up, we calibrate it, and then set an origin. Then we would tie the origin that we set in Vicon to an actual latitude and longitude point on Earth, so our vehicles actually don’t know the difference between GPS and Vicon [data].”

In the lab, Intelligent Systems achieved this with 16 Vantage V5 cameras positioned around an indoor volume. Using the Vicon system to capture the positions of numerous drones in real time, Bell effectively simulates a network of Nexus and APT vehicles that it can use as a proxy for a real fleet while it develops AerOS, the software that will control the network.

### CITIES OF THE FUTURE

As part of Bell’s strategy to position itself in the tech sector, the team was presented with an even bigger challenge – to replicate the setup with a ‘Nexus City’ at CES.

“We wanted to show the world what a future city would look like with the Nexus 4EX deployed in it,” says Grant. This scaled-down smart city was to be the centerpiece of Bell’s presence at the largest technology show in the world, complete with a fleet Nexus 4EXs flying autonomously, nonstop, all day long, around a volume filled with replica buildings.



"This was not a demonstration just to be pretty – this was a demonstration of technical capability," says Grant.

"We needed redundancy on top of redundancy. We needed more cameras and drones and it needed to be bigger," says Patrick Smith, Innovation Engineer for Intelligent Systems. They now needed to fly 12 drones across two different model cities, so they enlisted the help of George Miller from Vicon Sales and John Porter and Felix Tsui from Support for additional help.

"We gave them drawings of the space and the obstacles and what we wanted to do. They were very helpful in curating some of the cameras that we already had and then lending us some cameras that Vicon had in storage. We ended up having two distinct setups of 16 cameras each," says Patrick.

Having two networks for two distinct cities led the Intelligent Systems team to take a novel approach in networking them – funneling the data from two networks through one switch. "All of that camera data, all that traffic, which started in two separate cities, it's sort of smashed together



through one physical network connection, using virtual networks," says Patrick. It was a solution that was new to John Porter, a longtime Vicon engineer, but it proved effective, with the network remaining consistent, despite high volumes of camera data traffic alongside a dozen tablets and all the more general network demands of running the Bell booth.

The real test, however, was in whether the Vicon setup would enable the team to keep the drones in the air. "Our operating area was so small, 20 feet by 30 feet or so. To be able to fly multiple air vehicles in that same proximity, without crashing into each other, the precision was not only a luxury, it was a necessity. We needed to leverage that precision, because if we had just been limited to the precision of normal GPS to try to operate multiple vehicles in that small space, it wouldn't work," Patrick says.

"It was very successful," Grant says.

"We had basically no issues with the camera system at CES," Patrick expands.

"John's expertise in setting up the specific orientation and configuration of all the cameras and the calibration on site was hugely important to us and a huge factor in our success.

WE USE THE VICON SYSTEM TO BASICALLY EMULATE GPS INDOORS... WE SET THE SYSTEM UP, WE CALIBRATE IT, AND THEN SET AN ORIGIN."



**CASEY HANNER**  
Hardware & Software  
Innovation Engineer  
Bell

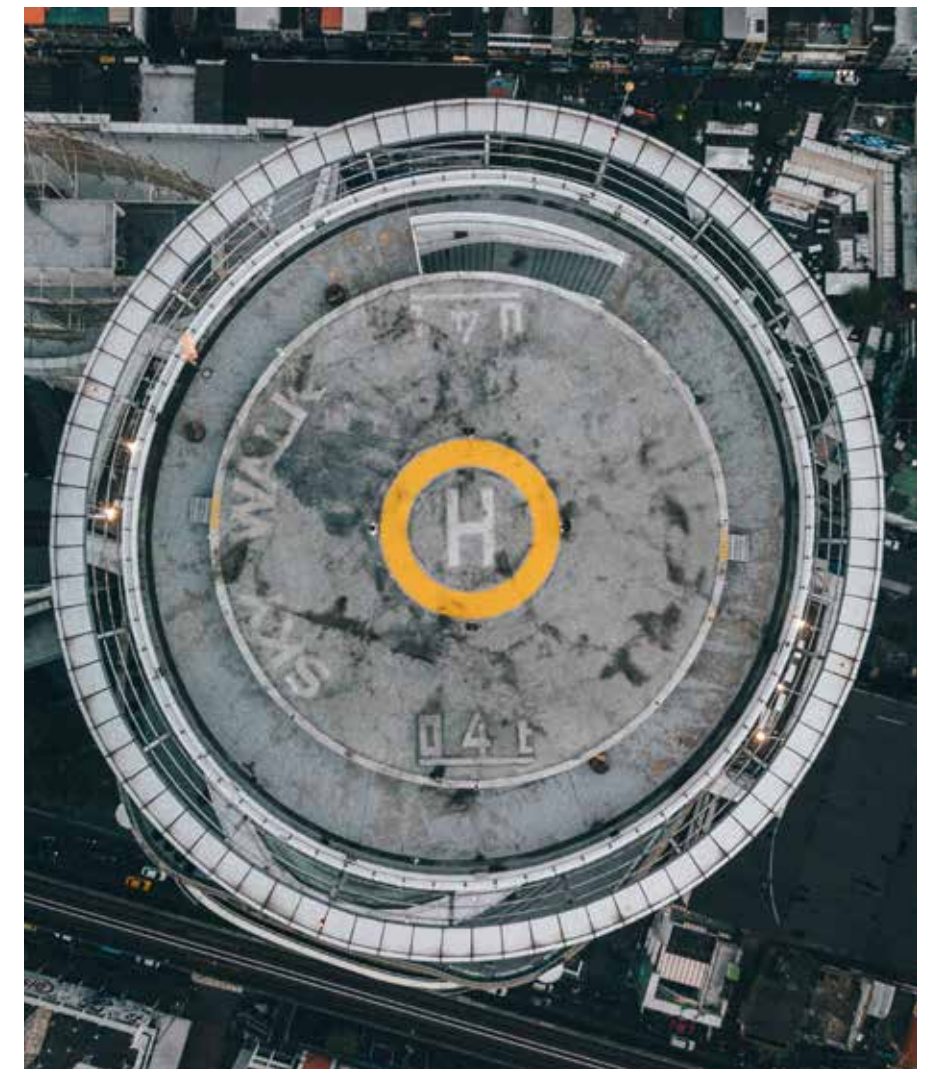


"I think one of the biggest benefits that Vicon presented to us was confidence. We had confidence that the feedback the vehicles were getting was accurate and precise."

With the success of the CES show behind them, the Intelligent Systems team is back at the lab refining AerOS, and its drone/mocap operation has followed the arc of all novel technologies. "After you fly six drones for 33 consecutive hours over 4000 flights and 400 battery changes, flying a drone indoors is now second nature," says Grant.

"So we're continuing to improve and invest in this lab. Now it's become the status quo. Flying the drone is not the cool thing. But it allows us to test and improve AerOS and go from idea to deployment and testing very quickly."

Vicon motion capture has, in other words, become for Bell the tried-and-tested tool that it is in other engineering fields, in VFX, in LBVR and in life sciences.



Photography courtesy of: Bell



# MOTION CAPTURE'S NEWEST FRONTIER

*Flinders University is using its capture stage to help TV and games makers adapt to the pandemic*



In early 2020 Flinders University finished installing a brand-new entertainment-focused motion capture stage. The university was ready to begin teaching with the stage, but when coronavirus stopped campus-based learning dead in its tracks it pivoted, showing local studios that there's more to virtual production than elaborate VFX.

Dan Thorsland, Business Development Manager for Flinders' College of Humanities, Arts and Social Sciences, was already familiar with using cutting-edge technology to tell stories when he joined the school. After a decade editing comics in the USA he moved to Australia to make videogames, working with brands including Disney, Lucasfilm and LEGO.

Professor Vanessa Lemm, Dean of the college, approached Thorsland after hearing him talk about the technologies students need to master if they want to become digital storytellers. He joined the department in 2019 to better orient the course towards industry, bringing together the drama and screen schools and focusing, in particular, on the department's motion capture volume.

Occupying a space that was originally set up to mimic a TV studio, the volume is named 'the VOID' ('Virtual and Optical Image Dimensions') and has 20 Vantage cameras running on Shogun.

Vicon was an obvious choice for the department. Thorsland was already familiar with the company's systems from his time in industry, while the university already had cameras in use to study biomechanics. "We knew it was an artist-friendly, content-friendly, content-enabling product for capturing great clean performances," says Thorsland.

## ADAPTING TO THE PANDEMIC

"It's meant to be a place where local screen practitioners as well as students can come in and do research and development experiments with state-of-the-art hardware," Thorsland says.

The plan was to have students working in the VOID by April, but Covid-19 struck.

Unwilling to let the pandemic entirely derail his plans, Thorsland began making calls. "People started getting over the shell shock of the pandemic," he says. They were seeking to "find ways of doing virtual production and ways of putting actors on location when you can't drive them anywhere."

These studios didn't necessarily need to produce fantastical VFX - they just needed an alternative to a busy set, where coronavirus might easily be spread.

PEOPLE STARTED GETTING OVER THE SHELL SHOCK OF THE PANDEMIC," THEY WERE SEEKING TO "FIND WAYS OF DOING VIRTUAL PRODUCTION AND WAYS OF PUTTING ACTORS ON LOCATION WHEN YOU CAN'T DRIVE THEM ANYWHERE."



**DAN THORSLAND**  
Business Development Manager  
Flinders' College of Humanities,  
Arts and Social Sciences

The help of a local events company helped Flinders round out its offering. "We're very lucky that we got together with a company called Novatech, which had 3.9 pitch LED walls, two big ones," says Thorsland. The two organizations came up with a plan to sync these large LED walls with the Flinders Vicon system and, with the help of Unreal Engine developer Epic, run it all through the engine.

"So fast-forward into August and we have an operating virtual production stage that integrates some real LED walls and the Vicon camera system," Thorsland says. "And, I have to say the Vicon system has been such a pleasure to work with. We had our first non-digital client come in who was shooting a television show. They had never worked with motion capture, never worked with virtual production. We planned on a two-day shoot and they knocked it all over in a day."

The stage has been used in a variety of ways. "I've had a local producer who has relatively modest budget projects in the two to five million dollar US range," Thorsland says. "We're booking in for weeks at a time. They're doing simple things like day for night shoots, so they don't have to drive out to location and worry about getting stuck there with a sick person, all the way up to very complex video game pieces with four actors at a time on the stage doing running and sword fighting."

"I've had about 10 people from industry through the doors now. All the way from very small scale production people who do web series, up to high-end visual effects houses like Mr. X."

## THE FINAL FRONTIER

Even for professional production teams, however, Thorsland sees an educational aspect to what Flinders offers with its stage.

"So what we're trying to do with our virtual production stage is get directors to feel very comfortable coming in and setting up a lighting environment that really surrounds the actors, even if they are in a motion capture suit, so that they're in that environment, and they're not acting to cardboard sticks in green screen," he says. "They can really be immersed in the experience of what they're doing and experiment with their performances and become very comfortable with it."

"I refer to motion capture as the last frontier of disassembling and reassembling the screen experience. We've chopped up sound, we've chopped up sequence, we've learned how to work in visual effects environments. But actually capturing human performance, breaking it down into a set of digitally transportable pieces, that's still a relatively new art, especially for directors and students."

While the coronavirus might be sharpening the learning curve, however, Flinders is showing that virtual production has a big future beyond the prescribed realms of videogames and blockbuster filmmaking.



Photography courtesy of: Flinders University





## FROM EXTREME TO MAINSTREAM

*The wide variety of elite athletes in Red Bull's stable presents a unique set of motion capture challenges*

“THERE'S A HUGE VARIETY OF DIFFERENT MOVEMENTS. THE CHALLENGE IS TO FIND OPTIMAL MOVEMENT PATTERNS FOR A SPECIFIC PERSON”



**CHRISTIAN MAURER-GRUBINGER**  
Athlete Performance Centre  
network's headquarters  
Austria

The term 'Red Bull athlete' used to conjure images of daredevils throwing themselves out of planes or down mountains, but over the years Red Bull has evolved into a mainstream sporting dynasty. Its broad church of sponsored teams and athletes ranges from soccer to ultra running to kayaking to F1 to cliff diving. One thing unites them: they're performing at an elite level. That demands an elite level of care.

Red Bull's Athlete Performance Centres, located around the world, rehabilitate and train the company's world-class athletes, helping them improve performance and return from injury. A key element of that project is gathering and utilising extremely precise kinematic data, something made possible by the centre's Vicon technology.

The challenge isn't only working in the broad range of disciplines covered by Red Bull, it's also working with athletes who have finely-tuned, highly singular biomechanical profiles.

“The movements are very individual - there's not a normal running pattern, a normal walking pattern, a normal jumping pattern,” says Christian Maurer-Grubinger, PhD, from the Athlete Performance Centre network's headquarters in Austria. “There's a huge variety of different movements. The challenge is to find the optimal movement patterns for a specific person.”

Red Bull's aim, then, is to take highly-focused insights into the minutiae of an athlete's movement and turn that into a highly-tailored programme that's specific to each individual.

When you're looking at that level of fine grain detail your data has to be bulletproof. There's already a certain amount of volatility in how people repeat movements, so it's crucial to have very low volatility in tracking so that Red Bull's biomechanists can be confident the data is accurate. To get that data, they use 12 Bonita 10 cameras and two Bonita 720c cameras in a setup that's combined with force plates and EMG instrumentation.

### CALL OF THE WILD

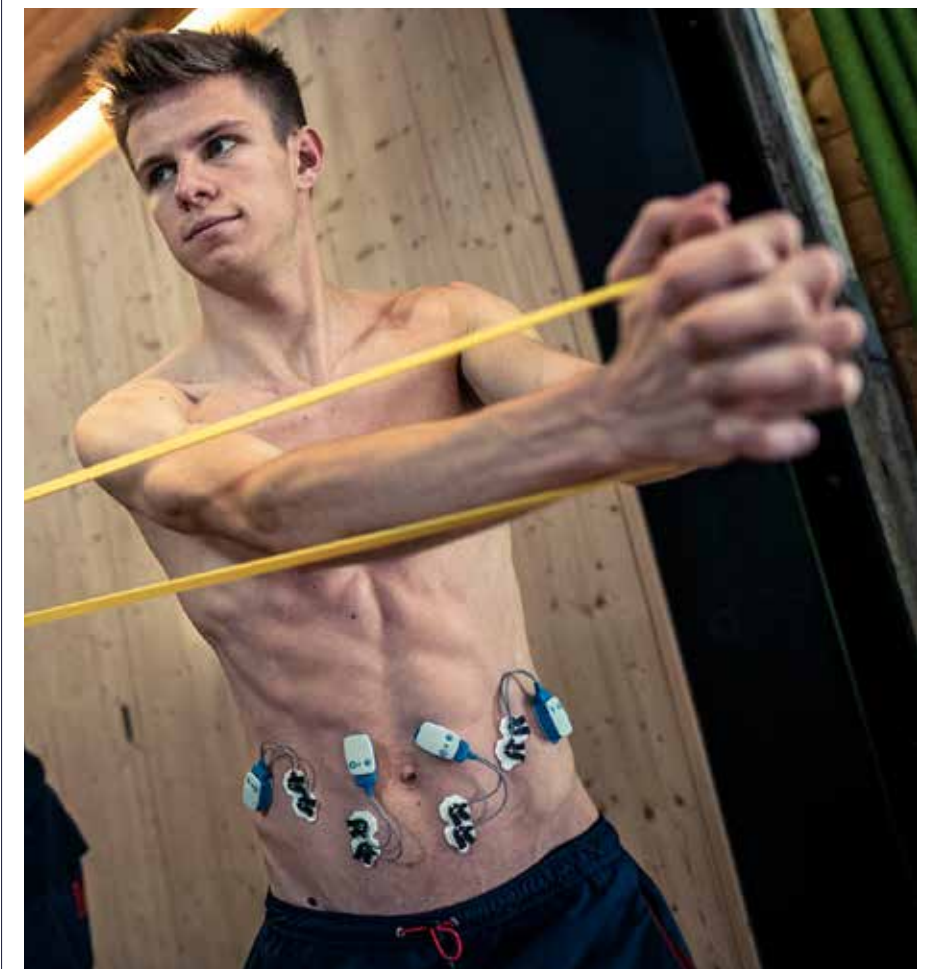
There's a further challenge, however. The team is working with athletes whose movements can't necessarily be captured in the lab. Christian gives the example of a snowboarder performing a jump in a halfpipe: it's not just about forces - it's about timing, momentum and

psychological components. “The limit is not how high they can jump in the lab setting,” he says. “There's a huge drive to go outside, into the field. But it always has to be with high quality data.”

Recently, therefore, Red Bull has invested in an IMU inertial system using Vicon's Blue Trident sensors so that Christian and his colleagues can gather insights from out in the field.

By doing both optical and inertial capture through the Vicon ecosystem, says Christian, “we can combine two technologies.”

He gives the example of Red Bull's runners. “We have the high precision of the running analysis on the treadmill with the markers, where based on the forces we measure we can calculate back to the joint movements etc.





But with IMU we can then better transfer the results from the more detailed lab capture sessions to the field."

Furthermore, with the forthcoming addition of IMU to their setup, Christian and his team can work more collaboratively with other Red Bull personnel. "We can train the coaches to understand the data they record and immediately give feedback to the athletes," he says.

The input of athletes and their coaches is critical, as they understand their performance with a depth that can only come from long periods in the field. "I can show them the technology, show what we usually do," says Christian. "But in the communication with the athletes and coaches we establish whether that's a fit or whether we need something different. For instance, for snowboarders we look a lot at rotation and how that works in comparison with rotating the pelvis and leaving the ground. It's fascinating - in every discussion with a coach or athlete we learn so much."

WE CAN TRAIN THE COACHES TO UNDERSTAND THE DATA THEY RECORD AND IMMEDIATELY GIVE FEEDBACK TO THE ATHLETES."



**CHRISTIAN MAURER-GRUBINGER**  
Athlete Performance Centre  
network's headquarters  
Austria

## GETTING SPECIFIC

It comes back to providing highly tailored solutions, Christian says. "In sports science there are all these principles about what you should do to, for example, become a good sprinter. But we've been measuring five different sprinters and they all have completely different movement patterns.

"So every athlete gets his or her unique suggestions and ideas. That's the fun part, but also the challenging part, combining that with known values. We calculate the mean angle for, for example, the knee [across all athletes performing a given movement]. That's important, because we know where the athlete is in terms of this norm." But, Christian goes on, that doesn't mean that an athlete outside that average is doing something wrong - the mean just provides a reference point from which to interpret the data.

Christian can give example after example of athletes his team has helped in this way.

One is a soccer player who had issues with knee stability. Christian's team was able to determine that the player had an imbalance between the muscle chains across his hip in the front and back. This created a large angular momentum causing the thigh to move forward and introduce the instability to the knee.



Photography courtesy of: Red Bull Diagnostics and Training Centre



Another example is a distance runner who had an achilles problem - she had too much rotational momentum which she ended up compensating for with her achilles, though it could just as easily have been her knee.

In both cases the team was able to link the symptoms in one part of the body to a problem in another - insights that wouldn't have been possible without reliable, high fidelity data.

Building on that foundation, Christian is excited about where Red Bull can take these tools and insights in the future. He talks about the possibilities of full 3D modelling out in the wild, and of using inertial sensors to capture the movement of athletes half the world away.

Not satisfied with conquering the breadth of sporting achievement, Red Bull is intent on delving into the depths of human performance.





# FINDING THE + IN VANTAGE

*Vicon CTO Mark Finch on the spirit of innovation  
that has taken Vantage to the next level*

//  
I CAN'T WAIT  
TO SEE WHAT YOU  
DO WITH THE NEW  
POSSIBILITIES OFFERED  
BY VANTAGE+."

Vantage has been the standard bearer for motion capture cameras for five years now. Half a decade. That's a lifetime in the technology world. In an industry in which everyone is relentlessly striving to find the next edge in performance, Vicon launched something in 2015 that was so powerful it's still at the forefront of motion capture hardware in 2020.

A team that delivered a camera that future-proof might be forgiven for patting itself on the back for a job well done and moving on to the next project. But that's not how we work at Vicon.

## RELENTLESS FORWARD PROGRESS

In the five years since we launched Vantage the world has changed, and the needs of our users have changed with it. Drones have moved from a field of

investigation for futurists and the military into the mainstream. Robotics has advanced dramatically. Biomechanists are probing deeper and deeper into natural movement (and finding new applications for the aforementioned advances in robotics). Virtual reality, which has been '10 years from taking off' for decades, is finally reaching a mass audience, thanks in part to tracking-based LBVR.

You don't have to look further than the pages of this very magazine to see some of the incredible work being done using motion capture. From wearable robots at Epic Lab to simulated cities at Bell Innovation, to chasing down the white whale of finger capture with Framestore, the work our partners do is, frankly, inspiring.

So it's up to Vicon to stay a couple of steps in front, pushing the frontiers of motion capture ahead of them so that our technology can enable our customers to keep doing their best work.

It's that spirit of innovation that drives every advancement of our technology, including Vantage+.

## MAKING THE BEST BETTER

In a nutshell, Vantage+ is a free update to every single Vantage camera that digs into the hardware's untapped potential to broaden your options for capturing at high speeds.

Our existing windowing mode enables users to capture fast-moving subjects such as drones or athletes by reducing the camera's field of view to focus its resources on capture speed.

If, however, you need to cover a large volume such as a warehouse or section of athletics track, you might want to prioritise maintaining your field of view.

With the new High Speed Mode offered by Vantage+ you can do that, boosting speeds while maintaining field of view by selectively reducing pixel count.

It's up to you. We know that our customers are going to find applications for motion capture we haven't even thought of yet, so there's no point in us deciding what's best

for them. The best thing we can do is make the tools we build as flexible as possible and then help our users put it to work in a way that works for them.

## MINING OUR HARDWARE'S CAPABILITIES

I'm incredibly proud that, five years after Vantage launched, we're still finding untapped potential in its hardware. Our engineers have done amazing work - both in building a camera that powerful in the first place, and in continuing to find new ways to utilize that power.

On a personal level, it's thrilling to be working with engineers who have the kind of drive, work ethic and curiosity that it takes to deliver these kinds of advancements.

As CTO of Vicon it's also great to be able to provide this level of ongoing support to our partners for free. We've never been the sort of company that considers our job done when we ship. We know that we can help our customers do better work by listening to them, learning from them and improving

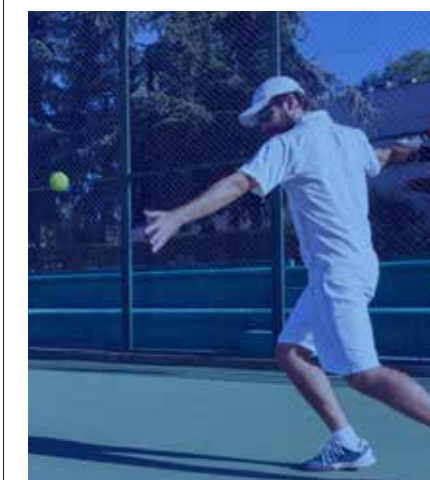
our technology so that it can enable them to move forward. Development doesn't stop when we ship, it's an ongoing process.

That means, of course, that there are more exciting developments in the pipeline. There are always more exciting developments in the pipeline. But I'll bite my lip and save those for another day.

In the meantime, I can't wait to see what you do with the new possibilities offered by Vantage+.



**MARK FINCH**  
CTO Vicon





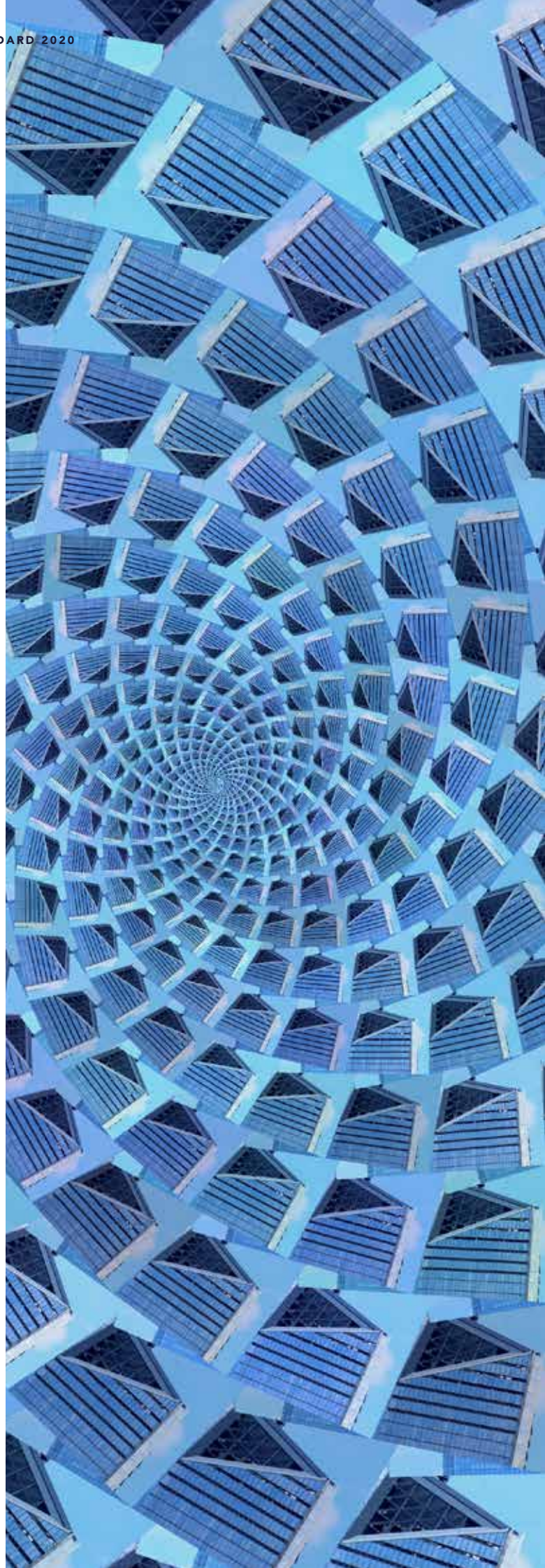
# CROSSING THE UNCANNY VALLEY

*Neoscape is discovering new horizons through motion capture storytelling*

“We’re about telling stories regardless of the medium that we use, whether it’s a still image or a film or an app or a brochure,” says Carlos Cristerna, RadLab Director for Neoscape. While motion capture has been a powerful storytelling tool for years, Neoscape is pioneering its use in new sectors.

Neoscape is a full-service marketing agency founded as an architectural visualization firm. The studio was created in 1995 and in the years since, has worked internationally with some of the biggest architects and real estate firms in the world. More recently, the business has also made a shift into visualizing more traditionally unusual projects.

Whether they are static 2D images or animations, the visualizations that Neoscape creates serve an important purpose – to bring scenes to life for communities and other stakeholders in development projects.



**CARLOS CRISTERNA**  
Principal and RadLab Director  
Neoscape

“MY HOPE IS THAT IT BECOMES SO EASY AND SO INGRAINED IN OUR PROCESS, THAT IT’S JUST A MATTER OF FACT THAT WE’RE GOING TO BE PUTTING CUSTOM ANIMATED CHARACTERS IN EVERY SINGLE PIECE”

## TAKING A CUE FROM THE ENTERTAINMENT WORLD

In more recent years, Neoscape has begun looking to Hollywood for techniques and tools that can elevate its craft to the next level, allowing it to incorporate layers of storytelling that help clients bring their projects to life.

“The architectural visualization and entertainment industry are kind of apart, even though it’s the same skill set and the same tools,” Carlos says. But across that divide Carlos saw a solution to a recurring problem for his sector: the use of human characters.

“People in architectural visualization films, they’re always in the wrong place, doing the wrong thing, and they’re the wrong people. There’s a guy talking on a cell phone, and then there’s no cell phone,” says Carlos. “They walk like they broke their legs. It’s horrible.”

Green screen is one solution, but it comes with its own set of issues. “It has its place for different foreground elements, or if we have a main character that needs to fit a certain ethnicity or a specific look and feel. [But] that can be expensive and time consuming.”

Carlos and his colleagues had been considering a motion capture system as a way to redress some of these problems for a while, but the cost was a problem. While Neoscape is one of the largest studios in the architectural visualization field, it doesn’t have the budget that VFX houses in the entertainment industries do.

When Carlos and his team got the opportunity to do a day-long shoot on a Vicon stage in Mexico, however, they were sold. The price-performance ratio of the Vero, with its ability to perform in their compact Boston studio, convinced the studio to take the leap.

It’s paying off. “We’re trying to find the right balance of storytelling and just bring the quality of the work we do up a notch,” says Carlos. “It’s partly about narrowing the uncanny valley, so you send these subconscious messages to people that this is a real place.”





“Motion capture,” Carlos says, “allowed us to tell a much more complex story in a much less didactic way, in a more engaging way. There’s nuance to the movement of the people, and I can actually direct them. It allows you to have another layer of storytelling.”

Neoscape’s Vicon stage is now being used in over a dozen projects and Carlos hopes to expand that. “My hope is that it becomes so easy and so ingrained in our process, that it’s just a matter of fact that we’re going to be putting custom animated characters in every single piece,” he says.

Beyond differentiating Neoscape by avoiding off-the-shelf animations, Carlos hopes to get more creative in his use of the system. He wants, he says excitedly, “to start doing things like they’re doing in using the motion capture system to track the camera and do some live green screening, maybe use it with Unreal Engine and just use it in many other creative ways. Not just tracking humans but tracking objects moving and using them in different ways.”

In other words, if Carlos has his way then VFX practices in the entertainment and architectural spheres will be indistinguishable in the very near future.

*All images courtesy of Neoscape, Inc*



## PRACTICAL APPLICATIONS

Neoscape recently put its Vicon setup to work on one of the largest mixed use developments on the Manhattan river side of NYC. The studio was hired to tell the story behind some of the project’s designs, including the creation of media to be projected inside the elevators that take users to its observation deck, the highest in the western hemisphere.

One of the telling details that Neoscape was able to include is an animation of the observation deck’s glass floor. “You have a shot of the family taking a selfie on the glass floor, and then you cut to the underside of the observation deck,” says Carlos.

In the past, he says, the people would have disappeared during the cut. “So there’s no continuity, right?” says Carlos. “It’s little breaks in continuity like this which will break a viewer’s suspension of disbelief.” Using the capture stage, however, his team were able to use tracking data to create animations of the family from multiple angles without having to start from scratch each time.

Another more unusual project is the animation that Neoscape created of an ongoing space mission for Draper Laboratories. The company is behind the navigation systems on a mission to extract material from an asteroid, and wanted a visualization of the project. To humanize the story, Carlos wanted to include a fully populated mission control back on Earth.

# THE BEST JUST GOT BETTER

THE ORIGINAL INDUSTRY LEADING MOTION CAPTURE CAMERA



VICON VANTAGE+



# SCIENCE FICTION TO SCIENCE FACT

## EPIC LAB IS CREATING THE FUTURE OF WEARABLE ROBOTS

Robotic limbs and exoskeletons are  
enhancing mobility options

Photography: Courtesy of Georgia Tech



I think that a lot of the students are initially inspired by some of the comics like Iron Man,” says Aaron Young, PhD, Assistant Professor at Georgia Tech’s School of Mechanical Engineering.

While science fiction may be one of the gateways into robotic research, Dr Young’s work with the EPIC Lab is very much in the realm of science fact.

EPIC (‘Exoskeleton and Prosthetic Intelligent Controls’) Lab was established three and a half years ago to perform bleeding-edge movement analysis for prosthetics and wearable robots. The application for the research is, as Dr Young, puts it, “wearable robotic devices for enhancing human mobility.”

“It’s looking at how robots can help people move out into the community,” he says. “We focus a lot on community ambulation and helping people to be able to do daily tasks.”

That means primarily (though not exclusively) working with subjects who have mobility issues. “Researchers using the lab want to know how humans can control these wearable devices so

that they can enable better mobility outcomes as measured through biomechanics and other clinical measures of human mobility,” says Dr Young.

To enable that, Georgia Tech built one of the most adaptable and versatile motion capture labs in the world.

### A WORLD-CLASS LABORATORY

The EPIC Lab facility boasts two full Vicon systems, a host of force plates and an array of equipment that can be configured in highly innovative ways to simulate real-world conditions.

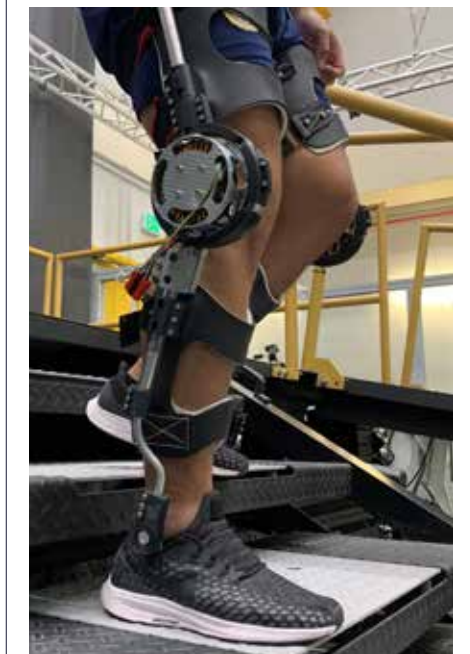
The first Vicon setup is a 36-camera mix of short- and long-range devices in EPIC Lab’s overground gait facility. It’s a large capture volume made up of four primary walking zones equipped with force plates to complement the Vicon system, and a large overhead harness track. Alongside areas for capturing straight walking and turning, the volume includes a terrain park made up of adjustable stairs and ramps, with the Vicon cameras set up to capture movement across a range of different configurations.

The overground capture area is complemented by the Motek Computer-Aided Rehabilitation Environment (CAREN) system and its 10-camera Vicon setup. This volume is used to analyze subjects in a

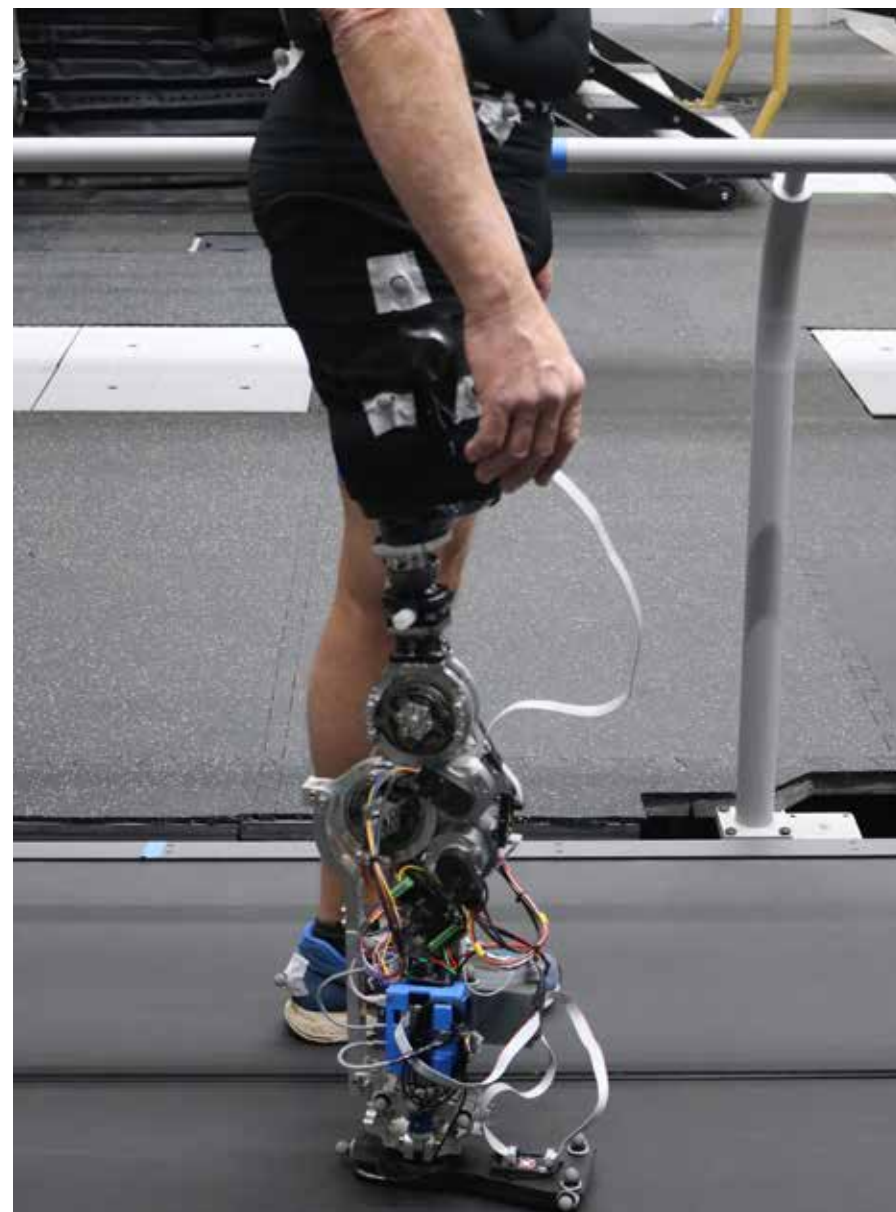
virtual reality environment, and alongside a large projection screen, it includes an omni-directional treadmill that can be used to test the stability of users and to analyze how they respond to changes underfoot.

“We’ll perturb someone using this treadmill and then look at how they recover, and what kind of strategy they use. Whether it was, for example, a stepping strategy versus just using their joint torques to counter the perturbation” says Dr Young.

This data can then inform the programming of stability measures for wearables and prosthetics: a crucial factor for their usability beyond the confines of the lab.







## A PREMIUM MOTION CAPTURE SOLUTION

When it was time to equip the lab for optical motion capture, Vicon was a natural choice. Dr Young says that Vicon is seen as “one of the premium motion capture companies and very reliable and accurate for doing this kind of work.” As such, many researchers and students have already logged a lot of hours on Vicon systems before they even step into the lab.

Another factor is cross-platform functionality. Vicon data can be easily integrated with Bertec, which is used with a lot of force plates, and the lab’s Delsys electromyography (EMG) system.

Finally, Vicon’s user-friendly software enables researchers to work quickly. Dr Young points, in particular, to the Nexus Plug-in Gait model which allows researchers to make fast progress during the early stages of projects before they move on to building models of their own.

## ENHANCING MOVEMENT AMONG THE DISABLED AND ABLE-BODIED ALIKE

The research at EPIC Lab will help a range of subjects both in groups with mobility issues and among the able-bodied.

One of the larger patient populations that the lab works with is amputees.

Dr Young says amputees tend to favor their healthy side. “This leads to long-term degradation in their joints... and these passive prostheses that are mostly the standard are great for level walking but are not very helpful for most other tasks.”

Researchers hope that with the data they capture it will be possible to build smart robotic devices that interpret the user’s intent and move in a way that naturally assists them, relieving biological joints of added strain and enabling more natural movement.

The lab also works extensively on exoskeletons or ‘wearable robots’. One subject group is children with cerebral palsy, who tend to walk with a crouch-like gait. Rather than correct that gait with ongoing use of a wearable robot that is used by the likes of stroke subjects, the aim of the exoskeleton would be to rehabilitate the child’s movement.

Children have enough neuroplasticity that the hope is with the right corrective training, they might relearn to walk with a more normal gait. In this context the exoskeleton becomes a tool for physical therapy rather than a mobility device intended for prolonged use.

There are also potential applications for the technology for able-bodied users. “Companies are interested,” Dr Young says, “in using exoskeleton-type technology, or powered exosuits, to enable people who have extremely physically demanding jobs who have high risk of injury, high rates of fatigue, to be able to improve their efficiency and safety in the workplace.”



IT’S LOOKING AT HOW ROBOTS CAN HELP PEOPLE MOVE OUT INTO THE COMMUNITY,” HE SAYS. “WE FOCUS A LOT ON COMMUNITY AMBULATION AND HELPING PEOPLE TO BE ABLE TO DO DAILY TASKS.”



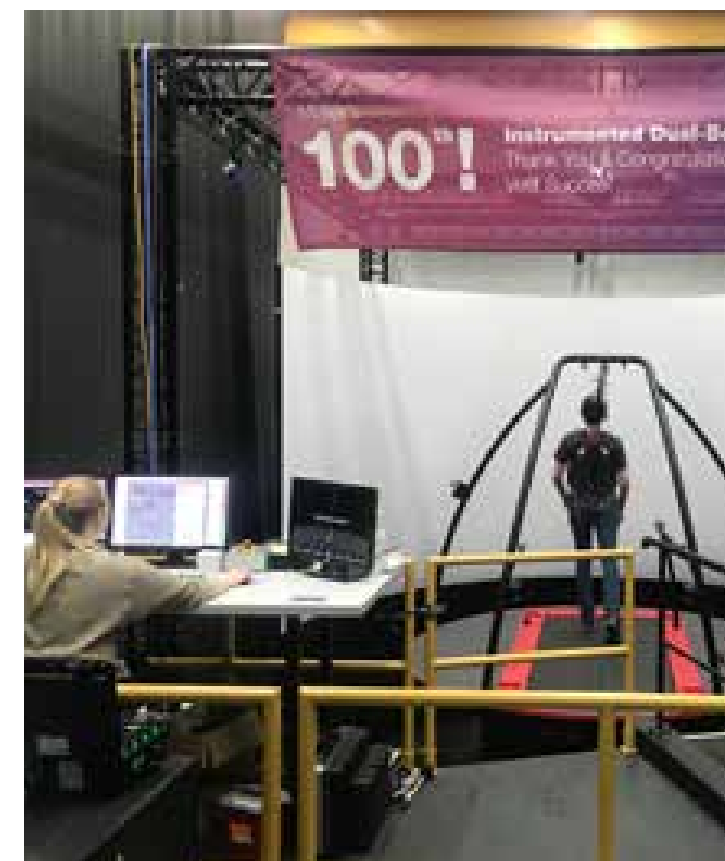
**AARON YOUNG PHD,**  
Assistant Professor  
Georgia Tech

## GOING MAINSTREAM

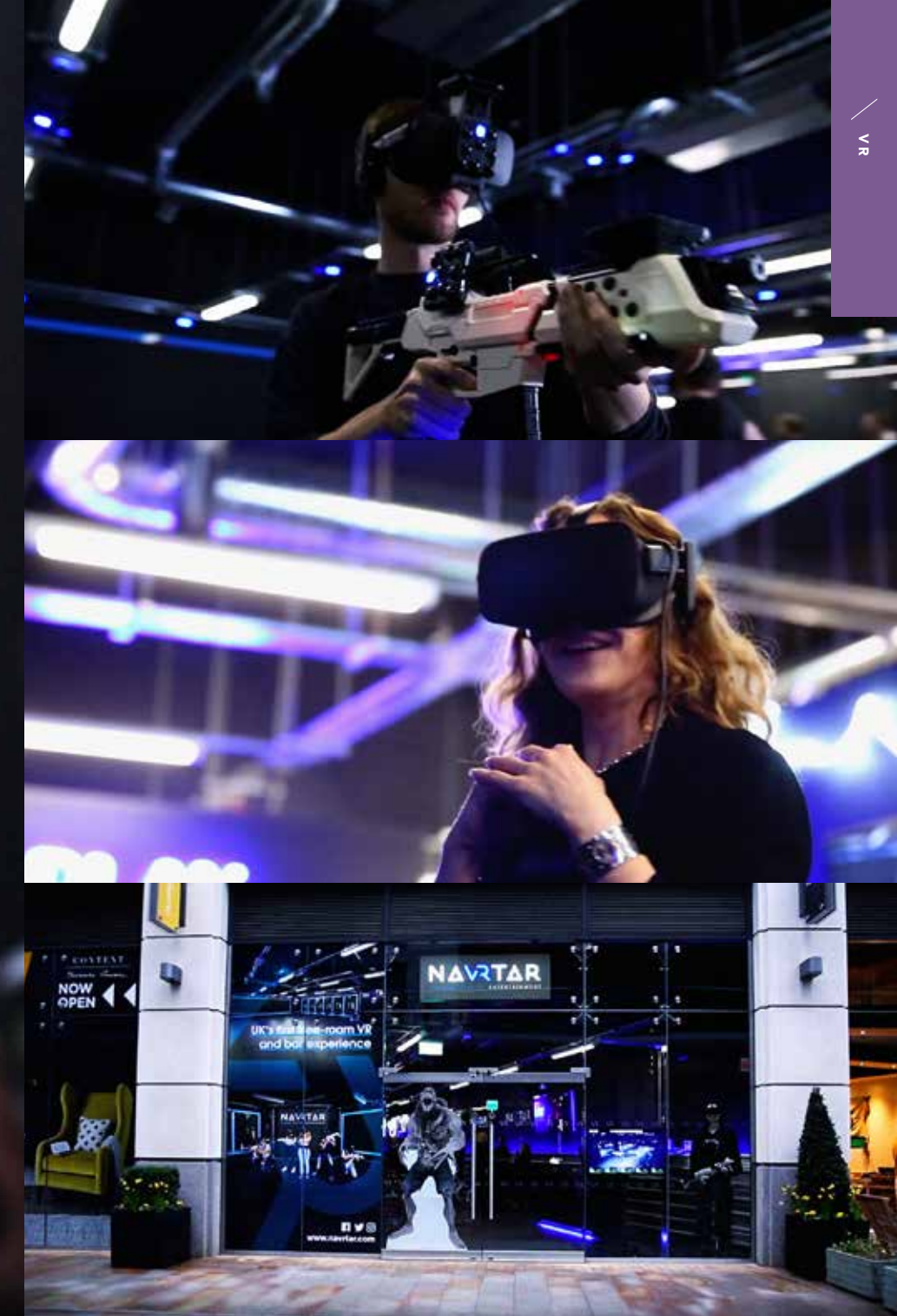
At this point, wearable robots and powered prosthetics are still very much a nascent field. “The technology is a long way from being ubiquitous,” says Dr Young, but it’s definitely on an upward curve. “We do see a lot of start-up companies and excitement,” he says. “In the last few years there have been three FDA-approved exoskeletons.”

As more and more companies have moved into the space, looking for practical applications for the technology that EPIC Lab is working on, wearable robots are moving out of academia and into the wider world.

Or, as Dr Young puts it, “They’re starting to become reality.”







# FIGHTING FOR THE FUTURE

*How Vicon technology helps teams save the world in Navrtar & VR Arcade's free-roaming virtual reality experiences.*

Origin by Vicon powers Navrtar and VR Arcade as they create the future of location-based entertainment in the virtual reality industry.

For decades virtual reality has been promising users full immersion in digital worlds, but it's only now – thanks in no small part to the advancement of motion-tracking technology such as Origin by Vicon – that the potential is being realized.

Navrtar is the UK's first free-roaming virtual reality and bar, designed to offer users a social, location-based experience that plunges them into new worlds rife with zombies, aliens and criminals. Worlds that users are able to explore and interact with freely thanks to Origin by Vicon.

Co-founders Nik Parmar and Saaj Kanani saw the potential for VR to finally go mainstream when affordable hardware such as PlayStation VR, Oculus Rift and HTC Vive began to hit the market, but those headsets were all initially limited to the confines of

the users' homes. They explored London to find an operator offering a deeper VR experience but found the capital lacking. In the UK VR was still, says Saaj, a technology "which had incredible amounts of potential, but with limitations of space, wires and the inability to interact with other players."

"Really the aspect of it is we wanted the social experience. We find that people will want to do stuff together," says Nik.



A lot of 'social' virtual reality experiences, Nik notes, involve people being together in a virtual space but being separate in physical space. Furthermore, movement is limited and defined by controller accessories, with little range for bodily motion.

Nik and Saaj cast a wider net, exploring Europe and Asia to find the offering they were looking for until they found VR Arcade, with motion-tracking powered by Vicon's Origin system, in the Netherlands.

VR Arcade, founded just a couple of years earlier, had found that between the arrival of affordable VR headsets, powerful content creation tools such as the Unity game engine and adaptable motion capture technology, it had become viable to quickly establish itself as a leader in the space. With three locations, VR Arcade already knew how to set up a virtual reality experience in a pre-existing space with a minimum of fuss.

Nik and Saaj quickly decided that they would partner with VR Arcade to establish a franchise and bring the experience to London. Navrtar was born.

Inside one of VR Arcade's spaces a VR headset, with a dedicated wearable PC to run it, waits for each user, leaving them unencumbered by trailing wires. But it's Vicon's Origin motion tracking technology that allows the user to move, and for that movement to be reflected in the game. In the first version of VR Arcade the company used a competitor's motion tracking set-up, but they were finding its maintenance, operation and upkeep unwieldy. It wasn't something they wanted to replicate as their operations evolved.

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VICON BASICALLY PITCHED TO US A SYSTEM THAT WILL WORK WHEREVER, WHENEVER, AND WE NOW HAVE FIVE SYSTEMS UP AND RUNNING."



**WILCO VOS**  
CTO  
VR Arcade



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REALLY THE ASPECT OF IT IS WE WANTED THE SOCIAL EXPERIENCE. WE FIND THAT PEOPLE WILL WANT TO DO STUFF TOGETHER,"



**NIK PARMAR**  
Founder  
Navrtar

"At that point we wanted something that was stable, reliable, and which worked without a technician on sites," says VR Arcade CTO, Wilco Vos. "Vicon basically pitched to us a system that will work wherever, whenever, and we now have five systems up and running."

Origin consists of Viper, a self-healing tracking camera; Pulsar, wearable tracking clusters that emit unique, active infrared LED patterns for Viper to track; Beacon, which creates a seamless wireless network that ties together Vicon devices and Evoke, a highly-automated software platform that integrates with the Unity and Unreal games engines, provides unbreakable tracking and, crucially, auto heals cameras that may have been knocked during a session

"It's night and day compared to what we are used to," says Vos. "And the auto healing is very important in that the system will get bumps, it will get interference, but it will recover itself. There are no doubts. We just know it'll do what it's supposed to do."



Furthermore, the whole system can be operated via Evoke which, with its fullyfeatured API, enabled VR Arcade to build an intuitive app that allows invisible in-game trouble-shooting and speedy maintenance.

Between Origin's self-healing capabilities and user-friendly operation the system

allows a key requirement for VR operators to be met - high throughput. Since they don't need to spend time rectifying camera issues or recalibrating Evoke, Navrtar and VR Arcade are able to get users into a new session in under a minute without the need for highly trained technicians.



# USING MOTION CAPTURE TO CREATE PERFECT COMMUNICATION

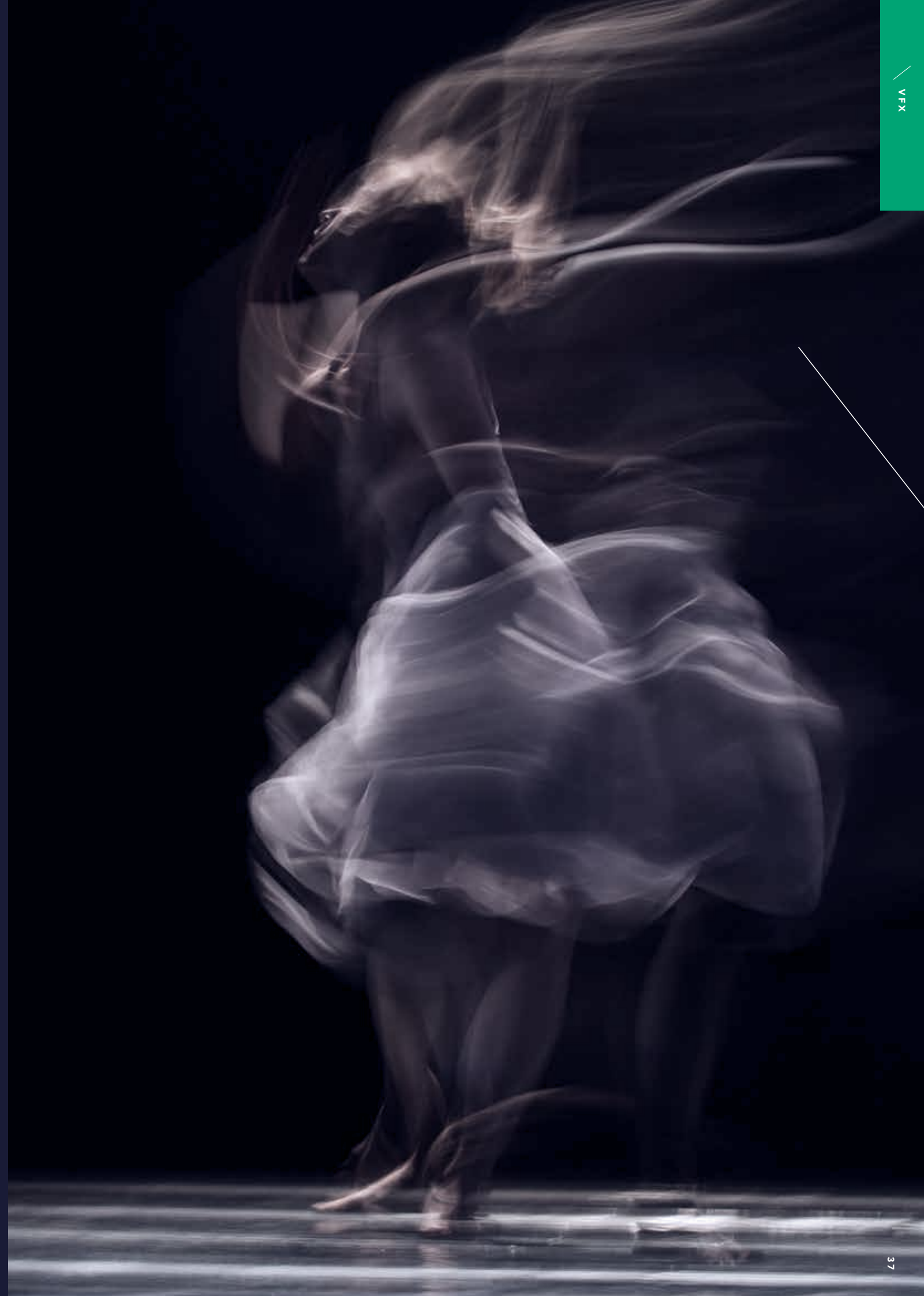
*Drexel University is preparing students  
for the VFX applications of the future*

The Animation Capture & Effects Lab (ACE-Lab) at Drexel University's Westphal College of Media Arts & Design looks, on the surface, like a training program for VFX-led entertainment industries.

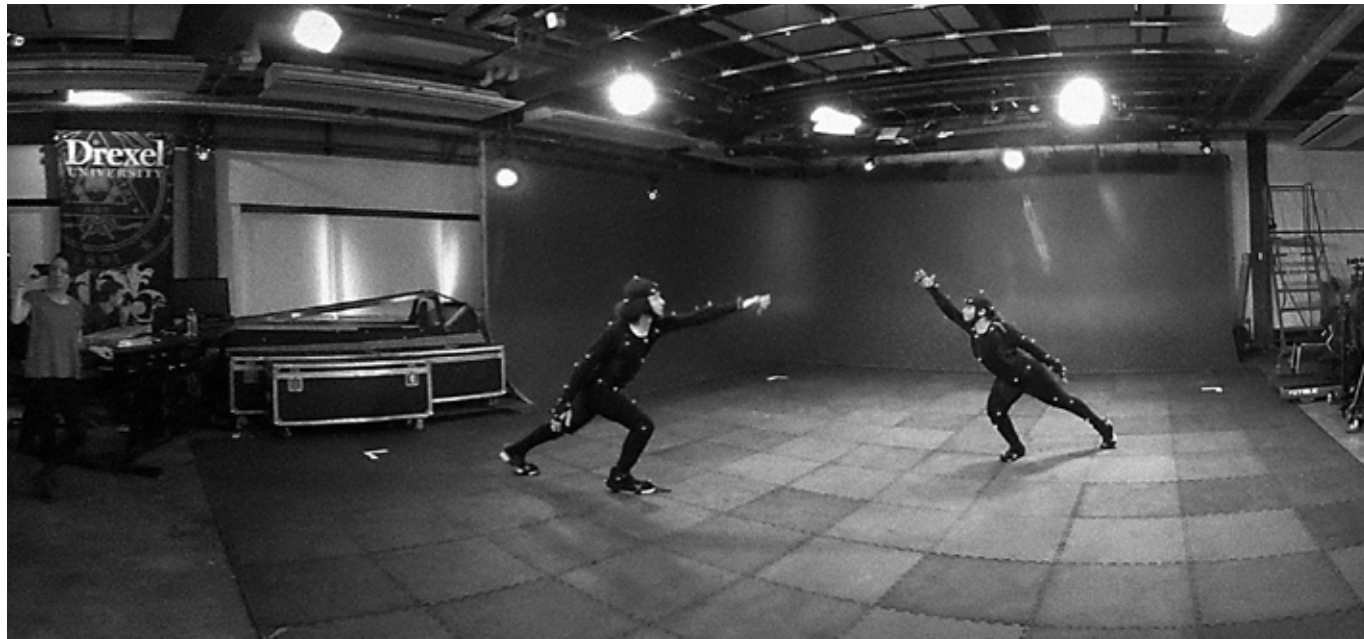
Drexel, however, prepares students, not only for visual effects applications that exist right now, but also those that are coming up five or even 10 years down the line.

The department's news page is full of headlines about alumni working on high-profile projects such as Star Wars and Frozen II, but the ACE-Lab takes its students down less well-trodden paths too. In fact, it's had a wide-ranging mission from the outset.

ACE-Lab resides in Drexel's Digital Media Department, founded by Dr. Glenn Muschio, a doctor of anthropology. That anthropological influence is part of the lab's DNA. "From the very beginning, it was all about communication," says Nick Jushchyshyn, Program Director for VR & Immersive Media. "It just happens to be that entertainment is a really fun form of communication. But leveraging these technologies in teaching venues, in training and other experiences, has always been an integral component to our programs."







## EARLY ADOPTERS

Motion capture is a core part of the department's offering. ACE-Lab was an early adopter of Vicon's Vantage cameras, proud that its entertainment setup was one of the first Vantage installations in the US. The lab upgraded their T-Series system when the department moved to a larger 40 ft x 40 ft stage, complete with a huge green-screen cyclorama. "The big deal for us was covering our larger volume, higher frame rates, higher accuracy," says Nick.

The fact that expanding the setup is relatively straightforward helped the decision to upgrade with Vicon. So did the presence of Vicon systems on many production stages, ensuring students are able to enter the workplace already fluent in the use of an industry-leading tool.

Nick also points to the value that the system offers. "Price-to-performance was hands-down the best for what we needed. There was nothing at that price point that would deliver that type of performance - five megapixel cameras, and several hundreds of frames per second. That was a whole new order of accuracy for us."

Nick notes that while a typical studio or lab might need only a handful of software licenses, his courses sometimes have as many as 60 or more students using the system and software. At that level, Vicon offers a market-leading price point.

## A VERSATILE APPROACH

ACE-Lab uses the system in extremely varied ways. The department has brought in subjects ranging from martial artists to dancers to a troupe of performers in the mold of Cirque du Soleil for capture sessions.

The stage has been used for more esoteric projects, too. "We've had a grad student work with literally deconstructing motion capture. There was this piece where the performer was dancing in the volume with markers scattered all over the floor. Sometimes she would roll on the floor and extra markers would be picked up, and then she'd take off markers. Literally that data would get worse and worse and body parts would start falling off. That was surprising to me, after dedicating a career to striving for this photorealism and accuracy in motion capture, for her to completely subvert that was shocking to me - I loved it for that reason."

Other collaborations have brought in the engineering college, the education college, the law school and nursing and medical students.



**NICK JUSHCHYSHYN**  
Program Director for VR & Immersive Media  
Drexel University

THE TRAJECTORY IS THEN TRANSFERRING THESE TECHNOLOGIES THAT ARE BEING DRIVEN BY ENTERTAINMENT PRODUCTION INTO NON-ENTERTAINMENT FIELDS"



Engineering students studying robotics have used the stage to track a robot navigating the space with acoustic sensors. One computer sciences student utilized the system as part of a project to use AI machine learning to teach square dancing.

Virtual production is an increasingly crucial component of ACE-Lab's programs, both for entertainment and for other sectors. "Right now we're investigating and deploying virtual production technologies towards remote teaching and learning scenarios, incorporating motion capture into virtual production and to leveraging that for teaching," Nick says.

"We're looking at ways of creating virtual learning experiences that are better than in-person. What can we do in these spaces that isn't even possible when you're here in person?"

So while ACE-Lab alumni end up at games developers and big-name animation studios, such as Pixar and Dreamworks, just as many are hired in non-entertainment sectors. They might, for example, be recruited by an architect, where they could be the first person in the company with an understanding of tools like Unreal Engine and be tasked with starting a VR visualization program.

"We have some employers that are focusing on the use of digital media in museum spaces and public spaces," Nick goes on. "So there are service providers where they'll do 3D scanning, for example, of a tall ship and create animated experiences around that for the museum that ship is docked next to."

"We've had law firms hire our students to do forensic reconstruction of accidents sites and crimescenes. These technologies are an incredibly effective means of communication. And so anywhere there's communication, you'll find that some of our students have been hired into those industries to create that perfect communication."

The diversity of industries that the program feeds into means that Nick and his colleagues are constantly looking to the future. "The trajectory is then transferring these technologies that are being driven by entertainment production into non-entertainment fields," he says.

"How would you use virtual production in aerospace design, automotive design? How do you use that in training law enforcement? How can you build up awareness and train people without putting them at risk? How can you create simulations that are genuinely visceral, that feel completely real, but they're completely safe and allow people to experience all sides of a scenario?"



"These technologies enable that. Because we can, with a motion capture system, have performers recreate genuine circumstances. We do that in the entertainment industry all the time. But that could be leveraged for social issues, it could be used for educational issues. It could be used to transform public spaces."

"Those are the directions that I see our practitioners moving towards in the years ahead."

Photography courtesy of:  
Drexel University



# VICON STUDY OF DYNAMIC OBJECT TRACKING ACCURACY

*At Vicon we understand that we produce a system where our real-time data is relied upon. It's natural for either our existing users or potential new customers to want to understand what the quality of that data is.*



Example Test Object as described in ASTM E3064

There is already a wide body of work in which assessments of various motion capture systems, Vicon included, have produced a wide range of different results.

These studies produce useful and relevant results for specific use cases, but they frequently measure different things and the methods, or even the terminology that is used, vary significantly in several important ways.

The nature of optical motion capture systems means that there is a large range of variables, making answering questions about accuracy complicated, and some of the most important factors in system performance are also unintuitive.

Conditions affecting data quality can include: the size of the space, the geometry and speed of the object, the nature of the movement, and changes in ambient conditions – as well as the characteristics of the system itself – such as the number, resolution and quality of cameras; the quality and size of markers used; the camera calibration process; and the algorithms used to compute the rigid object pose from the camera data.

Even with a completely controlled environment, the motion of objects can affect the measurements. For example, we can continuously observe the length of a test object. It's possible to observe a highly significant difference, depending on whether the object is at rest or in motion. This shows how crucial consistency and control of the variables are before comparisons can be made.

Terminology can often mean different things in different contexts, with terms such as 'accuracy' and 'precision' taking on very different meanings. In addition to this, they are often case-specific: for example the meaning of the term 'accuracy' may be understood differently in the study of biomechanics to robotics to visual effects.

As part of this work, we really wanted to provide information that would be informative and help customers to understand what level of performance they could expect. This demanded a method that was appropriate to the audience that most frequently asked about this topic, was easily explainable, and produced sensible results across a range of different uses.

We also wanted to start a conversation – internally during development, as well as externally – with a method that was understood, so that future developments and improvements could be communicated in that context.

As a company, we felt it was important to use an externally-published method, to be fully transparent about that method and therefore about what results are achieved.

Vicon pulled together a group with a wide array of experience in the details of how motion capture worked: in practice – not just in theory – after installations with customers. They were a group who knew how we could help make sense of this problem in a way that would be useful and informative for our customers.

Over a period of months we reviewed a range of external methods, trying some of the most promising, to assess their effectiveness and relevance to how the systems were being used.

AS A COMPANY, WE FELT IT WAS IMPORTANT TO USE AN EXTERNALLY-PUBLISHED METHOD"



**TIM MASSEY**  
Engineering and VR  
Product Manager  
Vicon





We decided that a method developed and assessed by the subcommittee for 3D measurement systems at the American Society of Tests and Measures (ASTM E57) was most appropriate. The method E3064 ("Standard Test Method for Evaluating the Performance of Optical Tracking Systems that Measure Six Degrees of Freedom (6DOF) Pose") is a simple one that allows a uniform measurement between two rigid objects while moving in a controlled way in an optical motion capture volume.



It's important, though, to mention that there is no 'correct' method and many different alternatives, and each method has different merits. However, we felt this was an informative method to help explain to customers the type of performance they may be able to expect with an assessment that was relevant to how Vicon systems are used by our engineering customers.

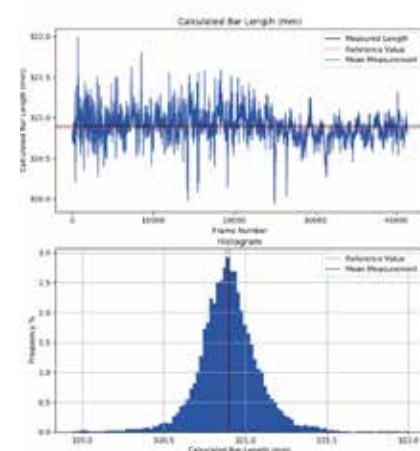
We tested two separate but similar setups, made up of Vantage 5 MP or 16 MP cameras, and measured the distance between the two rigid objects. This was a known fixed distance that was constructed of thermally-neutral plastic to eliminate, as much as possible, physical differences that might arise from movement or temperature changes.

This enabled the measurement accuracy to be measured consistently against this known fixed reference as it moved around the volume, and the measurements to be assessed. Observation was consistent even though the object was moved across the capture volume and in continuous motion.

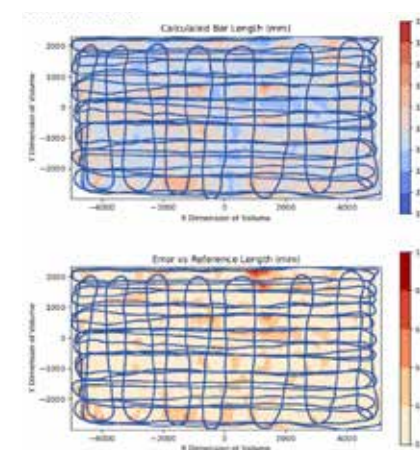
This work now enables us to better communicate how new developments improve the quality that Vicon provides.

A great example of this is the recent release of Vantage+ where we're now able to clearly explain the huge benefits that the increased frame rate can deliver, but also the inherent trade-offs that exist within the technology.

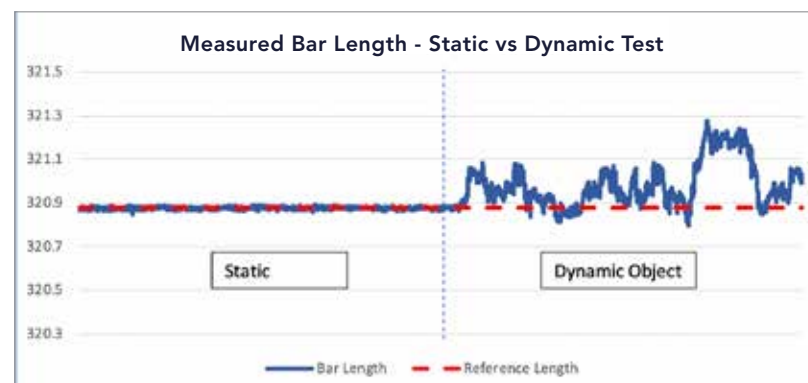
We're excited to be able to move forward and better help our customers to understand better how to get the best possible results for their own amazing projects.



This method had the advantage of being simple to understand and explain. But it also had the benefit of assessing a continuously moving object (a critical component of a motion capture system, and a variable that can make a significant difference!) and assessing errors quickly in many locations within the capture volume.



Representative – Single Trial Results for a representative high-end volume



Single capture showing difference between measurement of a static and dynamic object

	Mean (mm)	Max Error (mm)	RMSE (mm)	Std Dev (mm)
Static Object	320.875	0.035	0.007	0.005
Dynamic Object	320.979	0.397	0.142	0.102



# ADD POWER ADD INTELLIGENCE ADD VANTAGE



## FREE YOURSELF FROM THE CAPTURE PC.

Vicon's Control app saves you time during the camera setup and enables you to capture with its simple, intuitive interface. Change camera settings, calibrate the system and start or stop capture all from the palm of your hand.

## THE POWER TO CAPTURE IS IN YOUR HANDS.

Onboard sensors, LEDs and a digital display are intelligently combined to provide you with up-to-the-minute system status and feedback on the fly, so you can capture your data with the peace of mind that everything is as it should be.

## YOU CAN DO MORE WITH VANTAGE.

The most powerful processing algorithms and electronics, combined with industry-leading tracking and data fidelity, mean Vantage provides market-leading motion capture solutions. Advances in Vicon's technology IP allow Vantage to hit resolution and speed sweet spots that make it truly unique.

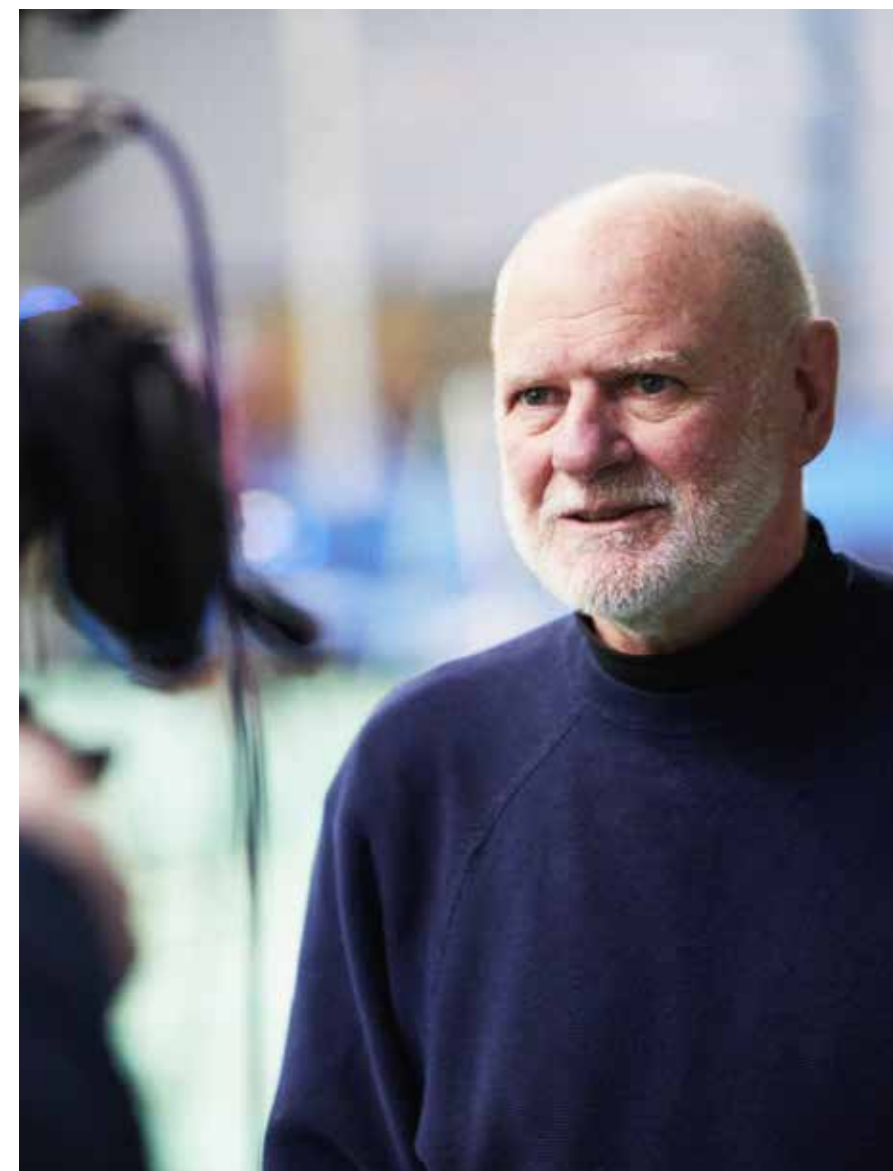
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# BRINGING NEW MOTION CAPTURE TECHNOLOGY TO OLD BIOMECHANICAL PROBLEMS

*A collaborative approach to gait analysis is shedding new light on how athletes' joints work when they run through a bend*



THE VICON SYSTEM ALLOWS US TO CAPTURE THREE DIMENSIONAL DATA, THREE PLANES OF MOTION OF EACH OF THE JOINTS"



**DR GILLIAN WEIR**  
Biomechanics Researcher  
University of Massachusetts

## MORE MOVING PARTS

Using both optical and inertial capture methods enabled the team to build two complementary data sets. "So we're going to have our Vicon motion capture system," said Irwin, "we're going to be looking at all the kinematics, the motions of the joints and the segments as they're running around the bend [and] running in the straight.

"And we're going to have the IMU information from the inertial measurement units - they're going to measure the acceleration characteristics of those segments. So we're going to be able to look, potentially, at the loading of those."

Being able to capture the athletes' full range of motion was crucial. "The Vicon system allows us to Capture three dimensional data, three planes of motion of each of the joints," said Dr Gillian Weir, a biomechanics researcher from the University of Massachusetts. "So we can look at the hip, knee and ankle and it allows us to collect really high fidelity data and use that information to make certain comparisons with a really accurate set of equipment."

In the 1980s, when the field of biomechanics was first getting to grips with the potential offered by motion capture, Professor Joe Hamill investigated the mechanics of running through a bend. 30 years on, he has been able to glean new insights on the matter thanks to Vicon's most recent strides in tracking technology.

"I did a paper in 1988 running on a curve, but it was a flat curve," says Hamill, Professor of Kinesiology at the University of Massachusetts. "And our results showed that the legs do two different things in the bend. So I wanted to know - is that true on the curve? So 30 years later, Gareth and I decided to do this particular study."

To build on Hamill's earlier work he, Professor Gareth Irwin, Head of Sports Biomechanics at Cardiff Metropolitan University, and a team of researchers set up a study at the National Indoor Athletics Centre (NIAC) in Cardiff. The centre features a curved but also banked running track, in contrast with the flat track used in 1988. The team set up an array of Vicon cameras around the track as well as fitting their athletes with Vicon's IMU inertial sensors.

"That allows us to infer lots of other things," said Irwin at the NIAC.

"It develops on quite complex motor control theories, like dynamical systems, and some nonlinear dynamic approaches to understanding human movement."



OUR RESULTS SHOWED THAT THE LEGS DO TWO DIFFERENT THINGS IN THE BEND. SO I WANTED TO KNOW - IS THAT TRUE ON THE CURVE? SO 30 YEARS LATER, GARETH AND I DECIDED TO DO THIS PARTICULAR STUDY."



**PROFESSOR JOE HAMILL**  
Professor of Kinesiology  
University of Massachusetts

that it's so mobile that we're able to take it outdoors," says Rachel. "We can use their IMU sensors and the Blue Tridents to capture data outside, away from a computer, which is fantastic."

The end result of all this work will be to improve the health and performance of athletes. "Having this type of fine-grain research allows us to make objective decisions about health and wellbeing of athletes, about whether there are things we can change within sports to make it safer, healthier, and also at the elite end optimize performance," said Irwin.

"That information can then drive the more recreational athletes and the wider population to get involved in sport and also improve their health and well being as well."

Professor Irwin also praises the collaborative approach he has found working with Vicon. "An industrial partner like Vicon, being able to provide those essential methodologies to allow us to collect data, it's fundamental," he said.

"I think one of the advantages of working with a company like Vicon is that they're big enough to respond to your needs.

"Certainly within sport it's really important that you have a company that can identify the needs of the user and the need for not just applied research, but to be able to do that from a fundamental basic research level as well. I think that's where Vicon kind of gives you the whole package."

years, has said he can barely tell whether data has been post-processed. "I think that speaks to the power of Shogun in its resolving capabilities."

A recent update that enables calibration within a defined volume without having to send people out of the room has also been a big help.



Hamill said that to capture data this complex you simply have to use a high-power system. "Vicon, actually, has become the world standard, because it's a 3D system," he said. "Your joints are not two simple hinge joints, they rotate. You've got flexion, extension, and you've got internal varus and valgus angulation. And you can't get that unless you have a system like this."

The flexibility of being able to incorporate inertial data into the modeling from within the same ecosystem was an important factor, too. "The great thing about the Vicon system is







VICON

# BRINGING VFX TO LIFE IN THE PHYSICAL WORLD WITH VIRTUAL PRODUCTION

*DNEG uses pixel-perfect motion tracking of its cameras to support filmmakers' creativity*



Photography courtesy of: DNEG © 2017 Warner Bros. Entertainment inc. All rights reserved.

ENTERTAINMENT

Headquartered in London and with studios across the globe, DNEG is one of the world's leading visual effects and animation companies, boasting credits including Avengers: Endgame, Westworld and Tenet, along with five Academy Awards. While its services are wide-ranging, its Vicon motion tracking system has one very specific function - to help filmmakers to develop their vision using virtual production techniques.

Virtual production effectively enables directors to visualise their VFX in real-time rather than having to wait for sequences to be developed and rendered. Some form of tracking technology is attached to a 'virtual camera' which the user can then move around a physical set, merging physical actors or objects with digital effects on a screen. The technique enables directors and cinematographers to get a sense of what their finished effects will look like or to compose shots.

Isaac Partouche, DNEG's Head of Virtual Production, saw the value of those techniques early.

Prior to his work at DNEG, Isaac established his own VFX company in 2007, SolidAnim, and (among other things) developed with his R&D team a piece of software called SolidTrack, based on SLAM algorithms. The tool enabled directors to visualise an animation in three-dimensional space.

"SolidTrack was a mixed-reality tool created to replace, in real-time, blue or green screens on-set. It would detect features, corners, edges, etc... and replace the screens with on-set previs" says Isaac. "We provided filmmakers with a representation of what the final image was going to be. However, at the time, the 'footage' seen through the virtual camera didn't match the quality of the final visual effects."

Isaac wanted greater control of the workflow and the ability to transition from rough virtual camera pre-vis to the final effects more seamlessly. To do that, he needed incredibly precise motion tracking of on-set cameras.







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DNEG'S APPROACH IS TO UTILISE CUTTING-EDGE TECHNOLOGY IN PURSUIT OF OUR CLIENTS"



**ISAAC PARTOUCHE**  
DNEG's Head of Virtual Production



Photography courtesy of: DNEG © 2019 MARVEL

Fast forward to 2020 and Isaac, now working for DNEG, has closed the gap with pixel-perfect positioning of cameras that enables him and his colleagues to seamlessly merge footage with motion capture and other VFX data.

Adopting the right tracking technology was crucial. He could have opted for markerless optical tracking or mechanical encoders which attach to cameras, cranes and dollies. The former, however, lacked the accuracy and framerate he needed while the latter is too expensive and time consuming to set up.

DNEG's in-house virtual production lab in London uses a Vicon setup of 24 cameras coupled with Tracker and Shogun software, giving the team the accuracy that it needs, along with the flexibility to expand or reduce the setup as needed.

"It makes sense to have the same form of tracking for both the actors and the camera; it is easier to combine the data", says Isaac. "We need to synchronize everything: the camera speed, the motion capture, the LED panels, etc... Everything on set has to be on the same frame rate. Everything has to line up, down to the level of a pixel or, in some cases, even smaller."

Isaac also praises Vicon's Tracker software, noting that its anti-jitter features mean that even on a busy set where markers might get jostled or occluded, the data remains consistent.

## THE GROWTH OF VIRTUAL PRODUCTION

Virtual production has exploded in importance in recent years, with more and more VFX studios making use of the technique.



More than just a way of speeding up production, it has become an important tool that boosts filmmakers' creativity. "DNEG's approach is to utilise cutting-edge technology in pursuit of our clients' storytelling goals," says Isaac. "The director, the director of photography and the crew can visualize the work in real-time in order to explore their vision further."

DNEG's Virtual Production crew has delivered services for productions such as Denis Villeneuve's 'Dune' and Kenneth Branagh's 'Death on the Nile'. It is currently in high demand to help content creators for both film and episodic projects overcome the impact of the COVID-19 pandemic on production. By leveraging advances in computing power, DNEG's VFX expertise and game-engine technology, DNEG Virtual Production offers filmmakers a range of solutions to keep the production going while respecting social distancing and other safety measures in place to protect the cast and crew.

"Virtual Production is also a useful tool for engaging directors who previously might have eschewed visual effects because they felt disconnected from them," adds Isaac. "All our tools at DNEG are designed to fit within our clients' workflows and processes. We want to make things as simple as possible for the filmmakers and provide a creative setting that will support their storytelling."

With more powerful virtual production tools, DNEG is able to support the creativity of filmmakers at every level, from directors of multi-billion dollar blockbusters to auteurs creating most intimate character films.



## CROSSING THE DIVIDE BETWEEN VFX AND LIFE SCIENCES

*Cross-pollinating the two major fields of  
motion capture at the Western Australian  
Academy of Performing Arts*

VICON

Formulating a name for Luke Hopper's role at the Western Australian Academy of Performing Arts' motion capture stage is difficult. "I haven't thought of a catchy title for myself yet," he jokes. His role has become increasingly awkward to pin down because the work he does now often traverses motion capture disciplines and their different languages.

"It's been interesting, crossing between the languages that the entertainment guys and the life sciences guys use," he says. "It's the same dots and the same cameras, but you

have to switch your brain into life sciences or entertainment. It's this funny sort of competitive collegiality."

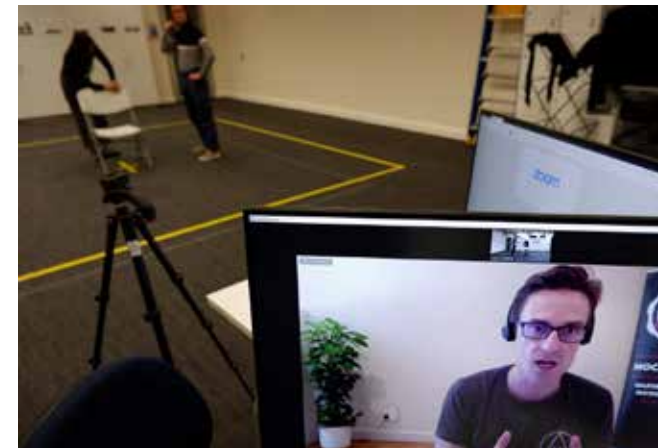
Luke's letterhead avoids putting him into either camp, giving him the vague title of 'Vice Chancellor's Research Fellow' at Edith Cowan University. A biomechanist with extensive experience in ballet by training, Luke now works with the university's motion capture lab on both entertainment and life sciences projects, increasingly bringing the two together.

### A MOCAP MELTING POT

That crossover isn't an accident - it's part of the lab's DNA. "We thought it would be an interesting experiment to see what would happen if we brought scientists into the Arts Academy," Luke says.

The experiment resulted in a capture volume equipped with 12 Vicon T40 cameras and, following a research trip by Luke to the UK, six Vicon Vantage 8 cameras along with Nexus, Blade and Shogun software.

That research trip, funded by a Churchill Fellowship, proved particularly instructive for the capture studio's current direction. Luke toured major dance and performing arts research centres as well as visiting leading companies in the motion capture field including the likes of Audio Motion and Vicon. "It made me realize you can do really excellent, world-class work with just a handful of people. You just have to contextualize it within the scope of the way the studio was going to operate," Luke says.



"In Australia, we've got a lot of opportunity in that we're a Performing Arts Academy, we've got animation and game design, film and TV all on campus with the Motion Capture Studio. So there's some great potential for that interaction and collaboration happening there."

Despite Luke's background in biomechanics, he's been surprised by how entertainment applications have come to the fore. "We've found some good collaborations with the health school and within the arts and humanities school and in game design," he says. "So I'm increasingly working in the visualization space and using the motion capture for production of aesthetic outputs. We've still a couple of biomechanical projects on the go, but I really feel like the direction is changing a lot."

### LIFE-SAVING APPLICATIONS

One particular project that encapsulates the cross-discipline approach of the lab is a training simulation for paramedics. "It's for them to practice triage of multiple casualties and prioritization of casualties in a mass trauma situation," Luke says.

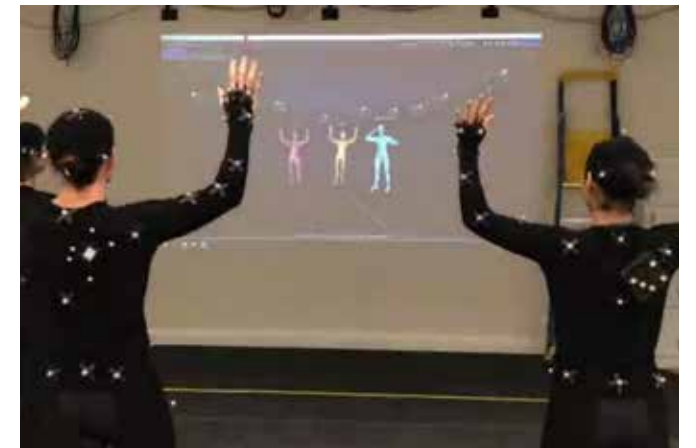
"Normally it's really expensive to run. Typically you'll have to employ 10 to 20 actors, you have to give them the brief, you have to have a big scenario set up and then you get maybe two paramedics through an hour." With the virtual version based on mocapped actors, Luke says, it's possible to get many more trainees through a simulation - something they might not otherwise have done before graduating.

"It's been a really great experience because no one person within the project could have done it by themselves," says Luke.

"Knowledge of the health sector was just invaluable in providing that rigorous information so that we're producing something that's relevant and that the paramedics aren't going to look at and go, 'well that's not right'. But they've got very little experience in game design and all the mechanics and the programming that you need to work that knowledge into the application.

"Nor did the game design guys have a good handle on animation and motion capture. So it was really quite fortunate that we got people that could all speak to each other and work together in that space. It's been fun in that way, we're continually trying to translate one another's intentions into our own disciplines."

Another project has directly brought life sciences data processing techniques into the field of animation. "Working with a Japanese colleague we've published a paper that basically uses biomechanical methods and marker placement and algorithms in the Blade animation software, so that you're producing a scaled avatar that matches the body proportions of the actor, so We've been using that in dance because it's a sort of a first step in bypassing a lot of the assumptions that are made in the animation models for the fast production," says Luke.



"One of the software developers in Oxford said to me it's probably a good way to go in that the labeling and the processing in the animation software is actually more powerful because of the developments that have happened in that space. So when we're doing a biomechanical application we're sort of crossing over and in between the two," he adds.

Luke stresses the fact that there's still a lot of work to do when it comes to bringing his lab's practices in VFX and life sciences together. "But we're really hoping that we'll start to get some projects off the ground that start to push the two together," he says. "Let's see where it can go from there."



Photography courtesy of:  
Western Australian Academy of Performing Arts



# A SIMPLE MOTION CAPTURE SYSTEM DELIVERING POWERFUL RESULTS

*UW-Stout is proving that it doesn't need an elaborate system to capture the imaginations of students*



**DAVE BECK**  
Director, School of Art &  
Design and Associate Dean  
of Humanities College  
University of Wisconsin-Stout

Several years ago the University of Wisconsin-Stout was ready to upgrade its design offering with a motion capture studio, but as a public institution it had to walk a thin line between providing students with an industry-ready, premium technology and managing a tight budget. Vicon had the flexibility to offer that balance.



"We're the largest art and design program in the upper Midwest," says Dave Beck, director for the award-winning School of Art and Design and an associate dean at UW-Stout. "We're just over 1,000 students in art and design. Two of the largest and fastest-growing programs are game design and animation, and our game design program is nationally ranked by the Princeton Review."

Destinations for alumni include Dreamworks; Last of Us games developer, Naughty Dog; and the studio behind the more recent Halo games, 343 Industries. Sectors such as construction and architectural visualization are increasingly taking an interest in the programs' graduates, too.

It's not just big players on the national stage who are drawing on UW-Stout's graduate pool, either. Staff are seeing growing opportunities to work with, and provide a talent pipeline for, local companies interested in the possibilities of animation and gaming. To keep pace, it was important to provide students with experience in using the latest production technologies.

"A polytechnic university is all about preparing students for careers through applied, hands-on learning. Everything they're doing is not just doing it from afar, it's actually getting your hands dirty and creating it," says Beck.

With all of that in mind, establishing a motion capture offering was increasingly becoming a priority.

"We felt that it was important to provide the students with an additional set of tools, an additional set of knowledge and competencies," expands Andrew Williams, program director for game design and development. "When we look at the game and animation areas, especially in the larger, upper echelons of the industry, specialization is absolutely key to any viable path. We felt that this is another area where our students could specialize so that they could even better position themselves for some of those opportunities in the future."





## A RESOURCE-BASED PROBLEM

When the chance to carve out a motion capture space emerged, the School of Art and Design leapt at it.

"We were renovating and there looked to be a perfect opportunity to essentially create a cube that would work as a small mocap setup," says Beck.

There was a catch, however. "We were looking at two or three different mocap options ... to be perfectly honest, we are a state institution with little to no resources for additional equipment that would take us to that next level."

While some of those options might have cost less, at least initially, Beck pushed for a Vicon system.

"It was a higher quality product and is used much more often in the industry," he says. "And I wanted to make sure that we were preparing our students to work with the highest quality equipment and, historically, technology that has a lot of legitimacy in the industry. But then, finally, also [a product] that branches beyond just entertainment if and when we would want to take it in that direction with other partners on campus.

"It was honestly one of those rare situations where I said, I know it's going to cost more money to do this, but I really believe strongly that we need to get this product specifically," says Beck. Getting training and support with installation was a big factor, too. "We knew we needed to have that from the ground up for our staff and our faculty and our students as well."

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THE GROUPS ACTUALLY TORE OUT THEIR ANIMATIONS AND THEN REDID THEM ALL IN MOCAP,"

## A SIMPLE SOLUTION

Despite being, at first glance, a more expensive motion capture option, Vicon offered a solution that met both UW-Stout's need for quality and its budget. The combination of the Vero camera and Vicon's Shogun software allowed the department to start with just eight cameras, while retaining the flexibility to add cameras.

Furthermore, the department could bring in additional Vicon software solutions if the university wanted to expand the setup's use into fields such as biomechanics or engineering.

The system has only been in place for a year and a half, but even before it was formally incorporated into the animation and games design programs students were rushing to use it.

"When the system became available while one of our cohorts was finishing its projects, [some of] the groups actually tore out their animations and then redid them all

in mocap, because they want to have that experience in their project," says Williams.

Jesse Woodward, a lecturer of animation at UW-Stout, adds that using the system to output animation through a game engine in real time excited the students, prompting some informative ad-hoc experimentation in VR.

Between the animation and game design programs, some 250 students already have access to the system, and there are more plans on the horizon. Looking ahead, Williams anticipates potential applications in telepresence, while design classes are already showing an interest in using the setup to study ergonomics. Sports science projects and partnerships with industry may follow.

What has started as a simple, compact system is already delivering big results and promises to open up even more doors for students in the future.



Photography courtesy of: University of Wisconsin-Stout



# BEYOND OPTICAL MEASUREMENT

*How new tracking technologies will benefit life sciences*

Over the past 35 years the use of motion capture has expanded from lower limb analysis to encompass full body analysis and broader biomechanical research. This work covers a huge range of conditions and applications – from working with amputees to cerebral palsy, motor control, neuroscience, and in sport science. This work is fundamentally driving a better understanding of human motion.

For much of the last 35 years motion tracking has relied on optical systems. However, while those systems remain the gold standard

in both clinical and sport science settings, we are seeing new devices, such as highly advanced inertial capture sensors coming to market that are changing what is possible when it comes to biomechanical data capture.

At the same time, increased automation of the data processing pipeline – from labelling, to event detection, biomechanical modelling, data export, and post-capture analysis – is helping more research to be conducted more efficiently, benefiting researchers, patients and athletes alike.

There is still so much more value that motion capture can bring to the life sciences though. The question is – what are the key developments we are likely to see in the next few years?

## BALANCING THE TRADE-OFF BETWEEN ACCURACY AND ACCESSIBILITY IN LIFE SCIENCES

What distinguishes the life science sector in its use of motion capture is its demand for accuracy. Where the technology is used to inform surgical decisions or to support injury prevention strategies accuracy is clearly non-negotiable.

While this has obviously been necessary, there is still huge potential in making the data collection system simple enough that anyone can 'self-administer' a motion sensor. Making the technology easier to use in this way opens up a range of new use cases.

The most obvious example is enabling more continual observations of patients, therefore making it easier to track conditions like Parkinson's over time. On the sport side, if an athlete can set a sensor up themselves then you open the door to 'in the moment' biomechanical feedback, something that has huge potential in injury prevention and performance evaluation.

Ultimately, the easier it is to use the technology, the more monitoring and evaluation you can do – which can only be a good thing. Making the technology more accessible, without compromising on accuracy, is inherently beneficial for patients and athletes.

But what does 'more accessible' motion capture really look like?

## REALIZING THE POWER OF INERTIAL SENSORS

When it comes to unlocking these new use cases one of the key points to understand is that there are a huge raft of conditions or situations where the full level of accuracy enabled by optical systems is not strictly required. Instead, huge numbers of assessments could be done using wearable inertial sensors.

Body-worn inertial sensors are inherently easier to use – you simply strap it on and it works. This simple fact is a huge tipping point for motion tracking technology.

It means that wearable sensors can be used to support real-time assessments outside of the lab. This is particularly important when

it comes to something like injury prevention in sport – no athlete wants to wait weeks to see results when they might be risking injury right now.

Wearables also give us the potential to access more 'contextual' data. While lab-based systems still provide the gold standard in precision, capturing motion data in the lab remains inherently 'unnatural'. As a controlled environment, it is impossible for lab-based motion capture to factor in the more chaotic nature of movements in the real world, which limits the sorts of analysis you can do. The use of wearable inertial tracking promises to fill in those gaps.

The other advantage of inertial sensors is that they be used more broadly because they are cheaper than optical systems. This opens up some interesting possibilities. For example, inertial sensors could be prescribed to patients to capture motion data over an extended period prior to a lab-based consultation, giving clinicians far more real-world motion data to compare with lab assessments and aid the decision-making process.

## LOOKING TO THE FUTURE

Alongside wearables, the other key development will be the deployment of artificial intelligence and machine learning (AI/ML) techniques to support the development of markerless tracking systems.

AI and ML will support an even bigger step forward in the accessibility of motion capture – completely removing the need for markers



**KIM DUFFY PHD**  
Life Sciences Product Manager  
Vicon

or set up. It offers us the potential to capture detailed motion data direct on a smartphone and instantly analysed in the moment. Clearly this will significantly accelerate workflows and pipelines.

While in 2020 we are still dipping our toe into the potential for more varied tracking technology to support life and sport science research, over the next few years clinicians and researchers will have a much bigger toolbox to choose from.

Vicon is at the forefront of driving these developments. We are constantly expanding our ecosystem and striving to make our market leading systems even better. Our goal is simply to deliver the highest quality motion capture data, no matter the method.

With the continuing development of the technology and closer collaboration with researchers and coaches, we will continue to extend our understanding of human movement – improving athlete's and patients' lives physically, mentally and emotionally.





# CRACKING KNUCKLES, METACARPALS AND PHALANGES

*How Framestore and Vicon finally  
solved hand capture*

Most people talk with their hands a lot," says Richard Graham, Capture Supervisor for VFX house Framestore. "There's so much information we give to each other when we speak through hand gestures."

Despite the importance of hands in communication, however, finger tracking has long been a white whale in motion capture - one of the barriers stopping VFX artists from crossing the uncanny valley to create a complete 'digital human'.

"Framestore is very much an animation-led studio, and one of our fortes is character work. We hold ourselves to a really high standard of performance and

a large part of the work we do isn't just action, which you can do very well in mocap. It's characters talking and emoting and gesticulating," says Richard.

For Framestore, accurate hand capture is a significant step towards greater emotional authenticity in its characters, but until a recent project completed with Vicon it simply wasn't viable, with animators having to pick up the slack manually.

## TECHNICAL BARRIERS

"With a hand there's just so much occlusion going on at any pose," says Tim Doubleday, Entertainment Product Manager for Vicon. Markers disappear from the view of cameras, getting tangled up in processing, and the sheer complexity of hands aggravates the problems further.

"The number of degrees of freedom that your hands have compared to, say, your spine creates a problem that's an order of magnitude bigger," says Richard. "So to capture a full human hand accurately requires a lot of small markers. This in turn means you need lots of cameras and you start to hit resolution issues if the cameras are too far away."

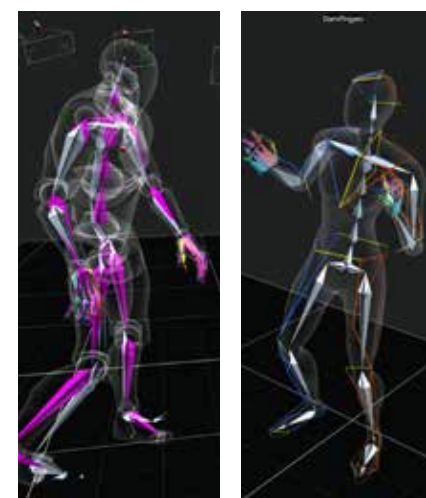
The result would be messy data, with models often resembling pretzels more closely than they did hands.

There were existing solutions. Using optical capture, studios would sometimes track three digits and extrapolate their positions out to animate five, but it required such a tremendous amount of cleanup and post-production solving that it wasn't really useful.



There are also data gloves, but they're expensive, easily damaged, often unreliable and require the integration of a further set of data into the animation process.

Framestore wanted a process that would fit seamlessly into their workflow to produce accurate models without sucking up valuable time and resources. To finally address it, the studio collaborated with Vicon on a 2017 Innovate UK funded project called ProDip to come up with a working solution over an 18 month period.



## TRAINING SHOGUN

Vicon's approach was to build a virtual model of a hand skeleton that Tim's team, led by Lead Developer Jean-Charles Bricola, trained to understand what a 'real' pose looked like. To do this, they had a number of different subjects of various hand sizes be captured. Each subject placed 58 markers on a single hand. They then performed a range of key actions, meticulously tracking them as they went along.

"You basically use that as training data to constrain the hand model. For each subject that came in, we knew where the joints should be placed and then also how their hand deformed during the range of motion," says Tim.

The model produced by the team then became a reference point that Shogun can use to interpret a hand movement tracked by a dramatically reduced number of markers.

"Vicon offers markersets supporting ten, five, or three markers on each hand. The hand model then looks at the marker cloud and based on the training data knows which marker is which and how the hand skeleton fits within the markers," says Richard. "So therefore it can't ever do something that the human hand can't do."



## PUTTING THE SOLUTION TO THE TEST

Framestore has wasted no time in putting the new process into action. The system has been used for everything from characters in blockbuster movies (including Captain Marvel, Aeronauts, and Spider-Man: Far From Home) to producing reference material in real-time, directly out of Shogun, for animators doing character-work to use. Basically, it has been put to the test in every Framestore mocap project over the last two years.

Internally, Framestore has been testing the sensitivity of the process. "We've used it in the last year on capturing animation studies of small, very subtle moves, quite subtle bits of performance," says Richard.

It's been a hit with clients, too. "The takeaway for us is that when we offer fingers to our clients they always say yes, and now it's much less of a headache. It's been a great advantage for the last two years that we've been using it."

Richard expects to be able to make much more use of hand capture in the future, while Tim envisions using the same techniques to build better models of other parts of the body. "We have plans to kind of use the same approach, using dense data to train a model for working out spine articulation," he says.

Tim isn't done with hands yet, however. He has a very specific milestone he hopes to hit. "So the challenge for us is sign language, and being able to deliver a performance from the hands that somebody who is deaf can read and understand exactly what the characters say. You can imagine a videogame where one of the characters actually sign in the performance. And that's never been done before, but hopefully using the system that would be achievable."



# DEMOCRATIZING MOTION CAPTURE IN PHYSIOTHERAPY WITH IMU

*SquareOne is pioneering the use of inertial capture  
in private physiotherapy practice*



**CAMPBELL HANSON**  
APA Musculoskeletal  
physiotherapist and Clinical  
Director, Square One

WHAT WE SEE,  
IS INFINITE VALUE  
IN THE PRODUCT"

Among professional sports teams and biomechanics researchers, IMeasureU's IMU Step software and Vicon's Blue Trident inertial sensor are becoming established tools for understanding, improving and rehabilitating athlete performance.

At the level of private physiotherapy, however, SquareOne is breaking new ground in making inertial motion capture accessible to semi-professional and amateur athletes.

SquareOne's first patient for its foray into inertial tracking was Rebecca, a semi-professional marathon runner who came for treatment following a right femoral stress fracture, the third she'd had on that limb over a period of four years. With Blue Trident and the IMU Step software the team at SquareOne wanted to add further biomechanical insights to their clinical decision-making around stress fracture rehabilitation.

## OBJECTIVE MEASURES

"You usually program your rehab for endurance runners with volume, speed and time on their feet," says Campbell Hanson, an APA Musculoskeletal Physiotherapist and Clinical Director at SquareOne. "But you don't really know what the bone-load or the impact is."

Typically, physiotherapists rely on a mixture of experience, research and the acute-to-chronic training ratio to guide their rehab programs. SquareOne, however, was looking to incorporate more objective data into its process.

"Firstly, we wanted to start getting our heads around how we load the bone to get an optimal healing response with what we know about bone cell turnover," says Campbell. "Secondly, how do we load to get response but also have some idea of what the overall bone-load is, so that we don't push them too far?"

Campbell and SquareOne physiotherapist Chris Beckmans also wanted to look for asymmetry in Rebecca's movement, with an eye to reducing it by improving form.



The Blue Trident sensor with IMU Step was a perfect fit. The solution was in line with SquareOne's budget and, more importantly, allowed Campbell and Chris to track Rebecca's movements out on longer runs, where she would perform most naturally rather than being limited to a treadmill.

From the Blue Trident sensors attached to each of Rebecca's legs SquareOne was able to assess bone loading - an estimate of the mechanical stimulus that would cause the bone to respond and remodel, which is based on the number of steps Rebecca was taking alongside the impact of each step.

"We were figuring out the best way to use that in our planning," says Chris. "Due to the osteogenic effect of mechanical stimulus on bone cells you're going to get a larger effect very early on in the bone-loading, then the curve starts to flatten somewhat. So we were seeing how to most effectively load for optimal bone cell response through her running or by applying a jumping load in the gym."

Meanwhile, they were using IMU-Step's asymmetry metrics to spot any asymmetries in Rebecca's movement. "The loading in the injured limb was significantly less in comparison to the uninjured limb, so we were looking at the G-forces being placed through the right side in comparison to the left and trying to improve that," says Chris.

As the symmetry of Rebecca's movement improved, training could increase in intensity and volume, looking for what Chris calls the "sweet spot" for a getting positive osteogenic response that doesn't risk overloading the athlete.

## CHANGING PRACTICES

The data has given SquareOne insights into bone stimulus through different exercises and how they might substitute, for example, three sets of 40 pogo jumps for an entire hour of easy running. "You can get the same response for a lot less effort

and a lot more recovery time from a bone stimulus point of view," says Campbell. "So it's opened up our minds to looking at how we structure running rehab."

One thing that's been relatively straightforward with Rebecca and subsequent users has been athlete buy-in, despite the fact semi-professionals don't have as much time to dedicate to the process as their professional counterparts.

"They love all that data," says Campbell. "A lot of it correlates to what they are feeling, validating their experience with some objective measures."

## THE BIGGER PICTURE

Looking to the future, Campbell hopes to embed inertial capture into SquareOne's process, backing up the programs it creates with objective data. In particular, Campbell and Chris are interested in establishing additional baseline data and extending the use of live data through Vicon's Capture.U app - which allows for real-time capture and assessment of movement data and the overlaying of that data video - both for injured and non-injured clients.

"When athletes are undergoing rehab for ACL or bone stress injury, we'll use it to help prescribe planning and rehab, as well as use Capture.U to look at asymmetries and then direct them to see if we can make meaningful changes within the session," says Chris. SquareOne has since had successes with athletes who came to them for treatment following Rebecca by making changes in the field based on real-time data they've captured through the app.

While SquareOne is still a pioneer of the use of Blue Trident and IMU Step in private physiotherapy, for Campbell it presents huge possibilities in the field. "What we see is infinite value in the product. We just need time to continue to test it and apply it."



# HOW RESEARCH HELPS ANIMATORS CREATE MORE REALISTIC CHARACTERS

TOM SHANNON PHD,  
FOUNDER

Perception by humans can best be described as organizing, identifying and interpreting chemical and physical nervous stimuli from the senses to understand their environment that is also shaped by a recipient's expectations, cognition, and attention to translate the information into high level cerebral functions such as recognition and situational awareness.

Researchers drawing on archaeological findings during the course of the Pleistocene age have started investigating social evolution and the perception of familiarity, similarity and attraction among groups. Could this work help to explain a phenomenon first reported in the 1970's by Masahiro Mori of the Tokyo Institute of Technology when he proposed the concept of the 'uncanny valley' to describe his observation that as robots appear more and more human, they become more appealing until a person's affinity or positive emotional responses are countered by stronger feelings of unease as they descend into his valley?

The concept has been found to be equally valid when applied to the creation of characters or avatars in the film, games and virtual reality market sectors.





Photography courtesy of: Digital Domain and Disney

VICON

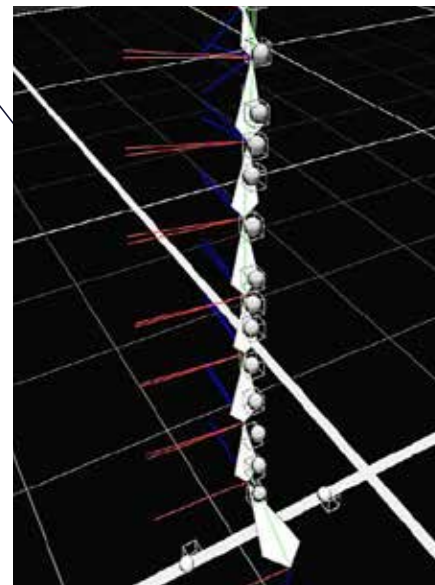


## THE SCIENCE OF EXPECTATION

Contemporary neuro-imaging studies are now employing naturalistic sources such as film, avatars and androids to provide stimuli to accelerate research into a better understanding of how the brain processes complex situations and perception whilst maintaining experimental control. An exaggerated caricature can be accepted as familiar if the viewer expects it to be less human-like but still retaining recognizable characteristics. An example is the high-quality characterizations achieved in the two Disney® Maleficent films, made even more complex by requiring a seamless transition between conventional performances by well-known actors and their anthropometrically different fairy avatars. Similarly, Rémi Brun has employed his extensive special effects and motion capture experience to create amazing and seminal light sculptures, using small numbers of

carefully placed and synchronized lights, to create compelling illusions of the motion of bipeds and quadrupeds in a viewer's imagination.

The goal of every animator remains to elicit a desired emotional response from audiences to keep them engaged with their story. Technologies now exist to create realistic human-like characters to a degree where the subtlety of gait, body language, and expressions of emotion can be perceived by most current observers to be aligned to that presented by physical actors, with similar behavioral, physiological and neuronal stimulations, in particular empathy. We have all identified weaknesses in the anatomical realization of humanoid characters that even recently would have been considered innovative and ground-breaking. Producers, creators and manufacturers can continue to expect ever increasing demands for greater reality within imagery from their viewing public in the years to come.



## CROSSING DISCIPLINES

A recent example of the application of basic clinical research outcomes to directly benefit animators was the work undertaken by Vicon's Dr Jean-Charles Bricola on modeling the human spine to further improve motion capture body tracking and solving. He chose to describe the spine as seven hardy-spicer joints from the vertebra prominens to an estimation of the location of the sacrum between the two palpable posterior superior iliac spines. He added slider joints between each bone to account for the actions of the spinal muscles, in particular the erector spinae, upon the vertebral column. Jean-Charles faced the challenges to correlate the poses of the underlying vertebral bodies to track spinal motions using a sparse set of surface markers and to then verify that his model responded as expected.

The solutions came from research into quantifying changes in back surface shape among patients diagnosed with Adolescent Idiopathic Scoliosis, a nasty disease where a spinal deformity can progress over time

JUST ONE EXAMPLE OF HOW MULTI-FACETED AND LATERAL REVIEWS OF FUNDAMENTAL RESEARCH CAN HAVE A POSITIVE IMPACT ON THE DEVELOPMENT OF COMPUTER-GENERATED IMAGERY AS IT CONTINUES TO EVOLVE."

by simultaneously curving towards the arms and rotating. In some cases, it can force the ribs outwards causing a characteristic hump. The recent discovery of the skeleton of Richard III confirmed he had suffered from scoliosis, described unkindly by William Shakespeare that he was "rudely stamp'd", "deformed, unfinish'd". Suspicion continues to linger widely that the playwright, with a mastery of perception, intentionally depicted the last Plantagenet king as a "hunchbacked spider" to curry favour with his Tudor masters and audiences.

Jean-Charles first challenge was addressed by drawing on published research undertaken by Dr Alan Turner-Smith of the Oxford Orthopaedic Engineering Centre in 1988 where he measured a selection of cadaver spines to create a mathematical relationship to calculate the offset in the Sagittal plane between each spinous process and locus of the vertebral body acquired from typically developed subjects and later patients.

A small number of scoliosis patients require surgery to stabilize the progression of the disease with a growing emphasis within the clinical community to include an assessment of an individual's quality of life, interests and personal goals when planning a treatment. The intervention can introduce some physical impairment as the procedures rigidly fix vertebral bodies that are normally capable of inter segmental motion and affecting spinal global ranges of motion. A number of researcher centers have presented papers where they compared pre and post-operative forward and lateral trunk

flexion and transverse rotation, concluding that post-operative range of motion was reduced in both fused and unfused regions above and below the surgery when compared against that acquired from un-affected subjects. Jean-Charles was given access to anonymized motion capture trials acquired from thirty typically developed adults. All subjects followed a common exercise protocol which he was able to use to successfully compare and to verify the performance of his model against the published normative clinical results.

## LATERAL INFLUENCE

The experience gained through this and other studies towards improved body tracking and solving is now incorporated into the latest versions of the Shōgun software. This is just one example of how multi-faceted and lateral reviews of fundamental research can have a positive impact on the development of computer-generated imagery as it continues to evolve.



# FLUENT IN THE MANY LANGUAGES OF MOTION CAPTURE

*Texas A&M's Starlab has a truly cross-discipline mocap volume*

The presence of a motion capture lab on a university campus isn't unusual, but the scale and scope of the work Starlab does is. Where most university mocap volumes focus on one particular field, Starlab has projects ranging across arts and visualization, aerospace, mechanical and electrical engineering, kinesiology, agriculture, robotics and autonomous vehicles.



**MICHAEL WALSH**  
Professor, Texas A&M  
University Rellis Starlab

MY GOAL IS TO BUILD A COLLABORATIVE SPACE WHERE CROSS-POLLINATION ACROSS DISCIPLINES CAN HAPPEN TO PUSH THE BOUNDARIES OF TECHNOLOGY AND CREATIVITY."

Texas A&M University's RELLIS Starlab Facility exists to support and enable students, faculty and external partners in learning and researching motion capture and augmented reality technologies. "My goal is to build a collaborative space where cross-pollination across disciplines can happen to push the boundaries of technology and creativity," says Professor and Starlab Director Michael Walsh, a veteran of the VFX industry.

To facilitate that goal, Starlab has a cutting-edge, 2,000-sq-ft capture volume equipped with 44 Vantage V5 cameras and additional custom-built 5MP, 350 FPS Vantage cameras, as well as an array of other sensors including LIDAR and RADAR. Crucially, for the variety of disciplines across which lab users work, the space is equipped with three of Vicon's four processing platforms – Shogun, Tracker and Nexus.

Simply having the equipment for cross-disciplinary motion capture is not enough, however. "I think there can be a language issue," says Walsh. "With users coming from so many academic disciplines and industries, we're speaking different languages, using different terminology, and that can hamper the cross-pollination and collaboration."



ALL THE COMPUTING IS DONE ONBOARD THE CAMERA"





Photography courtesy of: Starlab

WE'VE BEEN HAVING A LOT OF DISCUSSIONS WITH EMERGENCY SERVICES TO HELP THEM WITH THEIR TRAINING"



## A QUESTION OF CULTURE

Those language problems have not stopped a diverse range of projects from being realized at Starlab. Beyond the leading-edge technology that the lab boasts, the key to this diversity is in its culture, according to Dr. Zohaib Hasnain, assistant professor and collaborator at Starlab. "We got to this point, more than anything else, by keeping an open mind," he says.

"A lot of these labs in academic settings are highly focused in nature. You go to them, and they'll perhaps entertain you if you're doing something exactly along the lines of what they're doing, or something that doesn't require too much modification. One of the things that we pride ourselves on, though, is that our setup is meant to be fluid.

"It's meant to be, 'okay, you tell us what you're doing, and we will tell you how we can make it better.' And that's what's propagated through the campus community. That's what's brought a lot of people here."

The team around Starlab is equipped with such a broad range of finely-honed expertise that, regardless of discipline, they're able to make a project work. As Walsh puts it, "It's not just the stage, it's the team. You get the whole package."

This approach has led to a wide-ranging slate of projects using the lab, covering everything from emergency services training to robot development for the agricultural sector.

## DESIGNING FOR THE FUTURE

Dr. Hasnain notes that the team was tapped by a large architectural firm involved in city planning on projects that won't be completed for 20, 40 or even 50 years. "So one of the things that they came to us for was one of those hospitals that's going to see a traffic of about 100,000 to 500,000 people a day," he says.

The particular problem they needed to solve was accounting for changes in transport. "The consideration is that five or 10 years from now, autonomous vehicles will be commonplace. And they'll have this huge volume of people

that are coming in and out, and how should they design their parking garage to accommodate the fact that vehicles would be able to drive themselves, and perhaps allow for more efficient ingress and egress and alleviate traffic stress?"

The solution, executed at Starlab, was to create a miniature parking garage in the space and model autonomous vehicle traffic flow with remote-controlled vehicles, using motion capture in place of GPS.

Dr. Hasnain also mentions a new project that is focused on the agricultural sector. Starlab is working with a professor interested in solving a unique problem: in order to test grain, farmers have to lower themselves into huge grain silos, but because there's no stable footing, it's not uncommon for people to fall in and to effectively drown. To address the problem, the professor and Starlab are using the Vicon system to investigate what sort of robot might work in such an environment.

Yet another problem that researchers are working on at Starlab is the biomechanical challenge presented by Parkinson's, while a further group has used the lab to develop an early-stage powered-limb prototype for above-the-knee amputees, which was built for just \$500.

The list of discipline-spanning projects goes on, and Starlab shows no sign of stopping its pioneering work. One avenue that Walsh is interested in pursuing is location-based VR for training. "We've been having a lot of discussions with emergency services to help them with their training," he says.

"Both military and police personnel are accustomed to handling weapons, and it is essential that any VR simulation be realistic. The weight and feel of the weapon and the real-time response by the user must match to ensure that those guys will be willing to accept it in the simulation. That's the kind of thing that you get with the Vicon system, with the latest cameras, because all the computing is done onboard the camera, so it's all super-fast, the latency is very low. And that's all-important for training."

The team is unlikely to stop there, however. "It's just tip-of-the-iceberg stuff. It could be so much more in-depth than that," says Walsh. The main stumbling block in the application of LBVR to training is usually, he says, "a lack of understanding of what could be possible by those not accustomed to the capabilities of the technology."

That's not a problem you'll encounter at Starlab. As the wide-ranging use of the facility in other fields shows, Starlab's bread and butter is using cross-discipline thinking to push the applications of motion capture technology in unexpected directions. Imaginative, open-minded thinking is at the heart of what Starlab does.







# BRINGING MR PEANUT

## (BACK) TO LIFE

*How Silver Spoon entertained millions with  
real-time animation during the Super Bowl.*



Photography: Courtesy of Silver Spoon





Just one week before the 2020 Super Bowl, Mr. Peanut sacrificed himself to save his friends.

Left without its 104 year old mascot, snack food brand Planters needed to do something big to make a marketing splash on the day of the game. Creative use of motion capture and real-time animation technology proved to be the well-received solution.

Mr Peanut sacrificed himself in an explosive commercial but, in a move worthy of Game of Thrones, he was brought back to life as Baby Nut. Planters, VaynerMedia and Silver Spoon teamed up to introduce Baby Nut to the world during a 4.5-hour animated livestream running on Twitter during and after the 2020 Super Bowl. It was something that hadn't been seen at that scale before – an animated character responding live, in real-time, to a worldwide audience following along through Twitter.

Game actress Erica Citrin, with direction from director Marcus Perry, took on the role of Baby Nut for the duration of the livestream Silver Spoon's Vicon motion capture set-up allowed Baby Nut to play, dance and delight viewers throughout the entire performance.

The stunt was a hit, with 1.9 million people viewing the livestream, 20.9k likes, 5.8k comments and 4.6k retweets. It was mentioned in a host of publications, including Vanity Fair, BuzzFeed, Vox, The Daily Mail, Mashable and Business Insider. The campaign wasn't just a success for Planters, it was also a big step into an exciting new frontier for Silver Spoon.

## THE ROAD TO REAL-TIME

Silver Spoon was originally conceived by founder Dan Pack as a one-stop shop for visual effects support to other businesses working in the field. Motion capture was initially a small part of the equation, but it became apparent that there was a gap in the market and mocap grew as part of Silver Spoon's business.

Over time- that motion capture offering has evolved further into real-time animation. "We're being much more involved in the creative end, too, and taking our technology and years of experience working in this format, and applying that to these new types of opportunities and new types of engagements with viewers," says Pack.

Silver Spoon's Vicon setup, which can capture 12 or more people at once with its 48 Vantage cameras and Shogun software, is a crucial element of the equation. "For production, we still consider it the gold standard," says Pack. "It's just unbelievably powerful."

He points to developments in fingertracking as especially important to Silver Spoon's work. "Finger tracking has always been a complex issue. They are small, they cover each other, they are complicated! Vicon has always been leading the pack in pushing mocap development and they were the first to really nail down proper finger tracking."

"So now, we're capturing unbelievable finger movement, which is such a big deal, especially when you're doing any type of real-time engagement with a client. It adds a depth and realism to characters that body language and facial expression alone can't offer", says Pack. Then Shogun, plugged into Unreal Engine, enables the turnaround speed that Silver Spoon needs to generate animation in real time.



FINGER TRACKING HAS ALWAYS BEEN A COMPLEX ISSUE. THEY ARE SMALL, THEY COVER EACH OTHER, THEY ARE COMPLICATED! VICON HAS ALWAYS BEEN LEADING THE PACK IN PUSHING MOCAP DEVELOPMENT AND THEY WERE THE FIRST TO REALLY NAIL DOWN PROPER FINGER TRACKING."



**DAN PACK**  
Founder  
Silver Spoon

WITH TECHNOLOGIES LIKE VICON AND UNREAL ENGINE, SILVER SPOON CAN TURN AROUND LARGE VOLUMES OF CONTENT QUICKLY WHILE STILL RETAINING A VERY HIGH LEVEL OF QUALITY."



**LAURA HERZING**  
Executive Producer  
Silver Spoon



## LOOKING FORWARD

Silver Spoon has big plans for the future. One avenue the studio plans to explore alongside the character work is real-time photorealistic shoots done in-engine, enabling actors to be filmed live 'on location' anywhere in the world without having to leave the studio.

"We can utilize this technology to tell engaging stories and to create rich interaction between viewers or consumers," says Pack. "And if we can do it in a way, like with any good VFX,

## REAL-TIME ANIMATION ON A NATIONAL STAGE

The Planters campaign was a bold move, using Silver Spoon's real-time approach in front of an audience of millions. The team built a virtual, interactive bedroom for Baby Peanut ahead of time, and then created physical props in the studio that were twice their normal size to reflect the fact that Baby Peanut is only half the size of the actress. Vicon's ability to track multiple props made the integration between the two seamless.

When the big game rolled around, Silver Spoon was ready. "The technical aspect of it wasn't really different from what we've done

in the past," says Laura Herzing, Executive Producer at Silver Spoon. "The difference was that we distributed it via a live stream. So, we had a truly interactive back and forth with the Twitter community, which was something that we hadn't done before, that the brand hadn't done before."

"I think it was, from our perspective, technically a great success," she adds. "And I think from the brand's perspective, we achieved what they were going for. They got a lot of eyeballs, they got a lot of attention. They were able to really roll out this character in a groundbreaking new format."

that makes less of a spectacle of the technology and allows people to interact with characters in a way that's more seamless, that's what we're all about.

"With technologies like Vicon and Unreal Engine, Silver Spoon can turn around large volumes of content quickly while still retaining a very high level of quality."

"We're poised, I think, to do a lot more of it," adds Herzing. "Because what brand doesn't want their character to be able to really interact live with people? That's the next level."





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