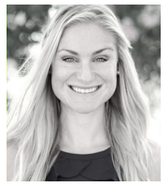
BRIDGING BIOMEDICAL RESEARCH WITH AEROSPACE ENGINEERING IN THE LAB OF TOMORROW

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



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

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

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

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

To facilitate the dual purposes of the lab, Walck has two Vicon systems running in parallel within the same space. "We have two separate lock boxes, so they're two separate systems, but they can act as one," explains Walck. "There are 12 Vantage cameras all along the perimeter of the ceiling which we use for flight testing and robotics. There are eight Veros on the tripods for human clinical trials and small robotics. We have two video recorders and then we have the AMTI force plates and Delsys EMG system. Our back bay door opens up all the way, so you could study sports movements like pitching."

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

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

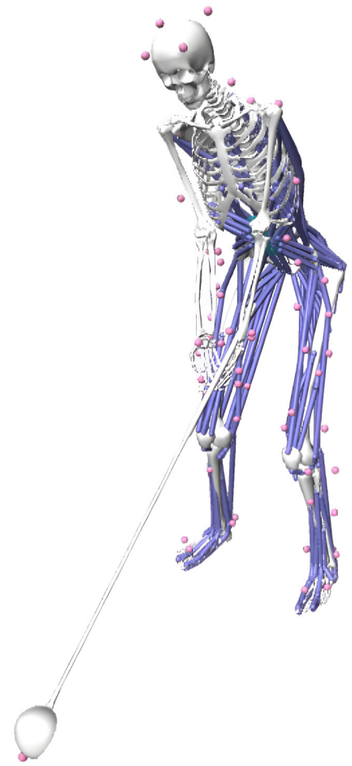
Another key element of the lab's success is the support Walck receives from Vicon. "University professors tend not to learn hardware or software. Their students do," says Walck.

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

THE PROJECTS

PHYSIOLOGICAL RESPONSES TO MICROGRAVITY

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



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

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

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

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

ASSISTIVE KAYAKING DEVICE

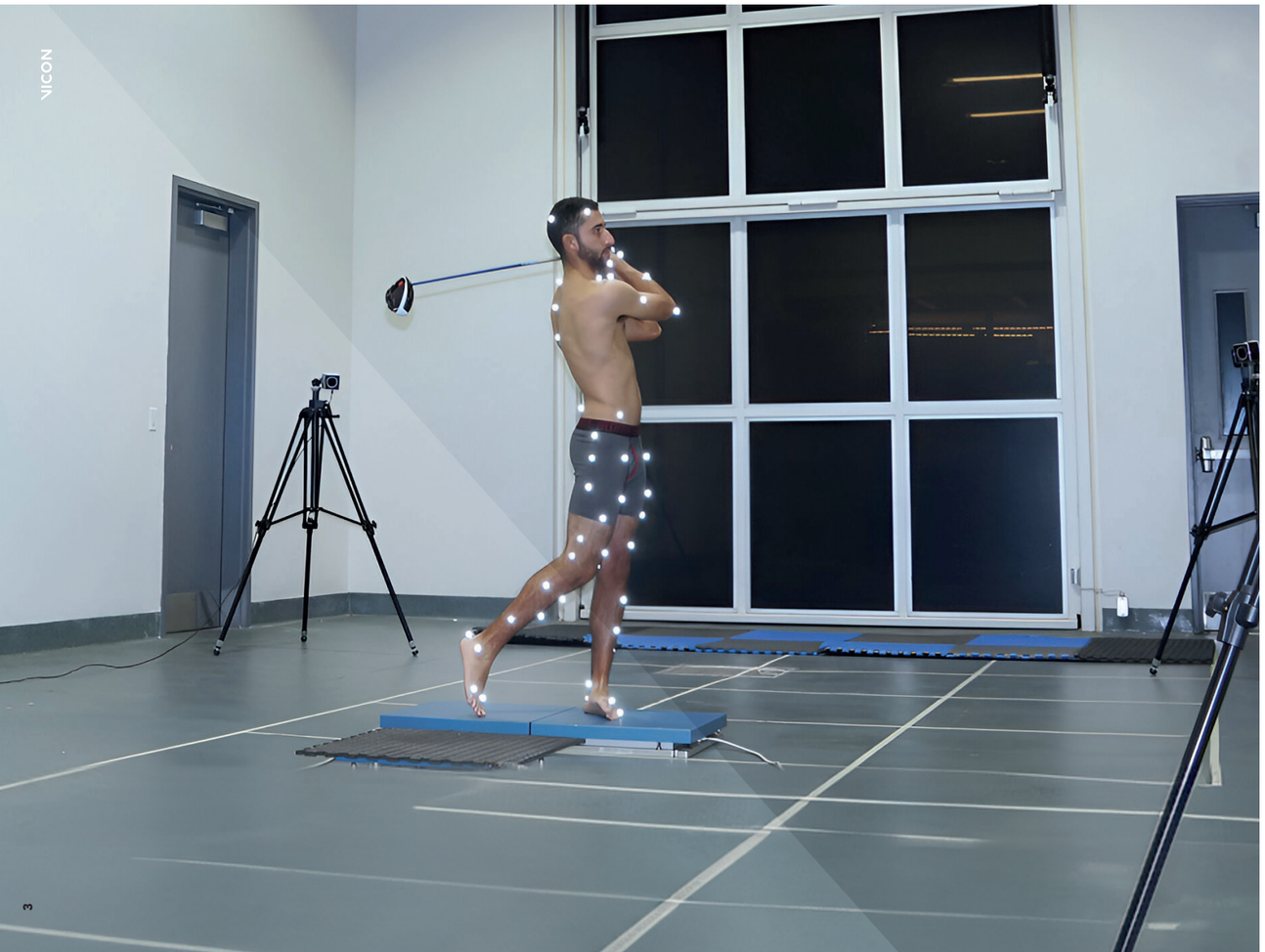
"We also have our smart assistive devices, which I call adaptive devices. Currently, we are focusing on an adaptive device for kayaking as our case study," says Walck. "We work with Oceans of Hope Foundation, a nonprofit which organizes watersports for people with disabilities. A lot of their members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

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

Embry-Riddle's senior design students decided that they could improve on the device mechanically and add an AI component. The thinking was to make the device capable of adjusting to imperfect inputs and still fulfill its intended function successfully. Dr. Walck is also investigating how this device affects the cognitive responses, if at all.

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

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



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

EXOSKELETONS

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

QUADCOPTERS

One of the more conventionally aeronautical applications that the Embry-Riddle lab is used for is drones. "We're investigating the performance of multiple off-the-shelf quadrotors to see if we can build one that surpasses them," says Walck. "So we got the main ones and are looking at the data for each. Then ranking a few parameters we will see if ours can beat them.

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

EQUINE THERAPY

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

"So I want a way to quantify what the muscles are doing and how it is having a therapeutic effect. And, then, find a way to create an adaptable saddle that can help with balance, but that will gradually lower the level of assistance as the rider progresses.

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

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

For more on the motion analysis lab at Embry-Riddle, visit: ***https://erbal.mystrikingly.com/***