

IN FOCUS

VOLUME 2

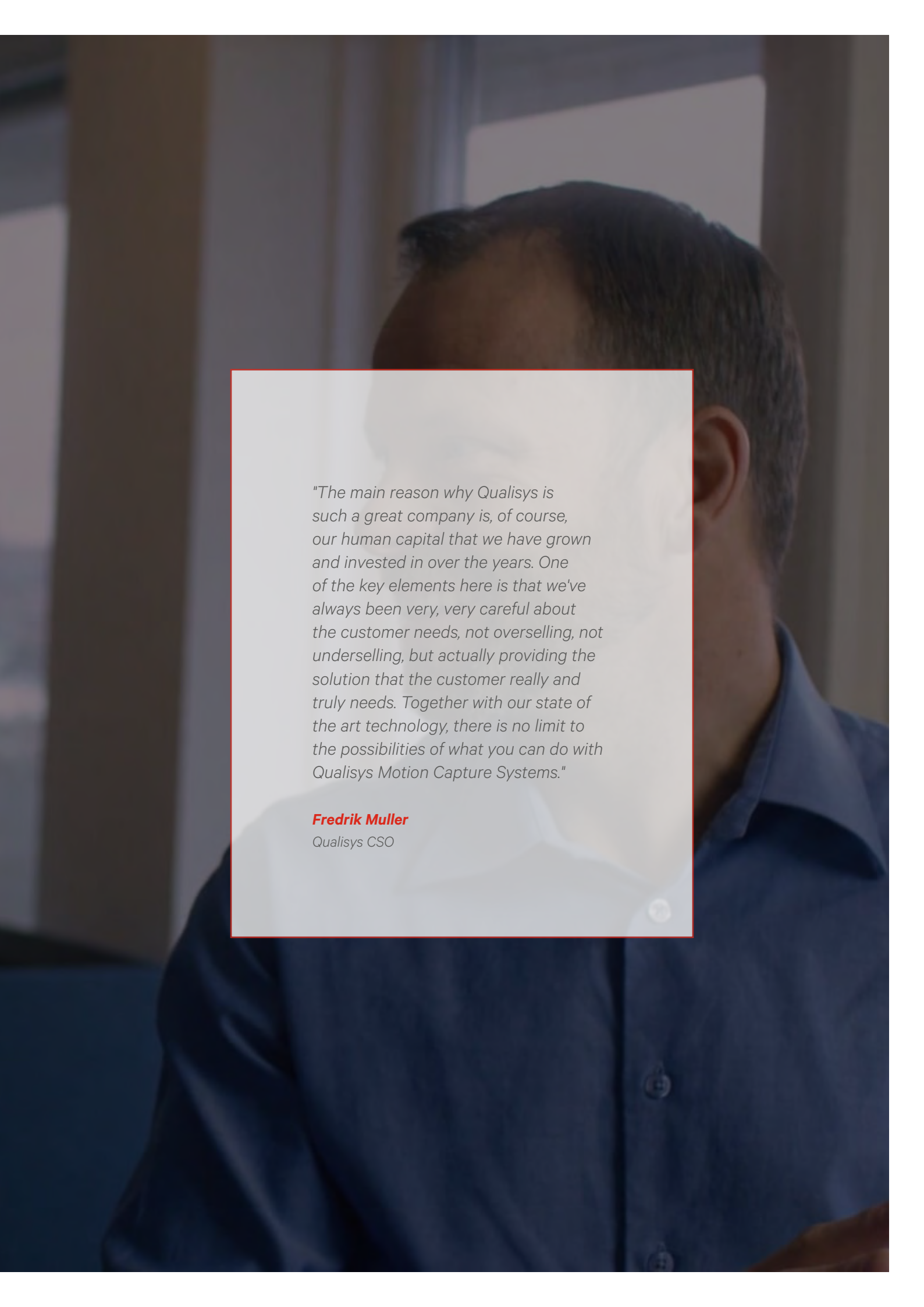
CONTENT

Qualisys and Qualisys Customers

The writings expressed in this document are those submitted by Qualisys customers writing in their individual capacities.

Qualisys assumes no responsibility or liability for any errors or omissions in the content of the customer stories. The information contained in the stories provided by the writers describes their views with no guarantees of completeness, accuracy, usefulness, or timeliness.



A man with dark hair, wearing a blue button-down shirt, is shown from the chest up, looking towards a laptop screen. The background is slightly blurred, showing what appears to be an office or meeting room setting. A white rectangular box with a thin red border is overlaid on the image, containing a quote and the man's name and title.

"The main reason why Qualisys is such a great company is, of course, our human capital that we have grown and invested in over the years. One of the key elements here is that we've always been very, very careful about the customer needs, not overselling, not underselling, but actually providing the solution that the customer really and truly needs. Together with our state of the art technology, there is no limit to the possibilities of what you can do with Qualisys Motion Capture Systems."

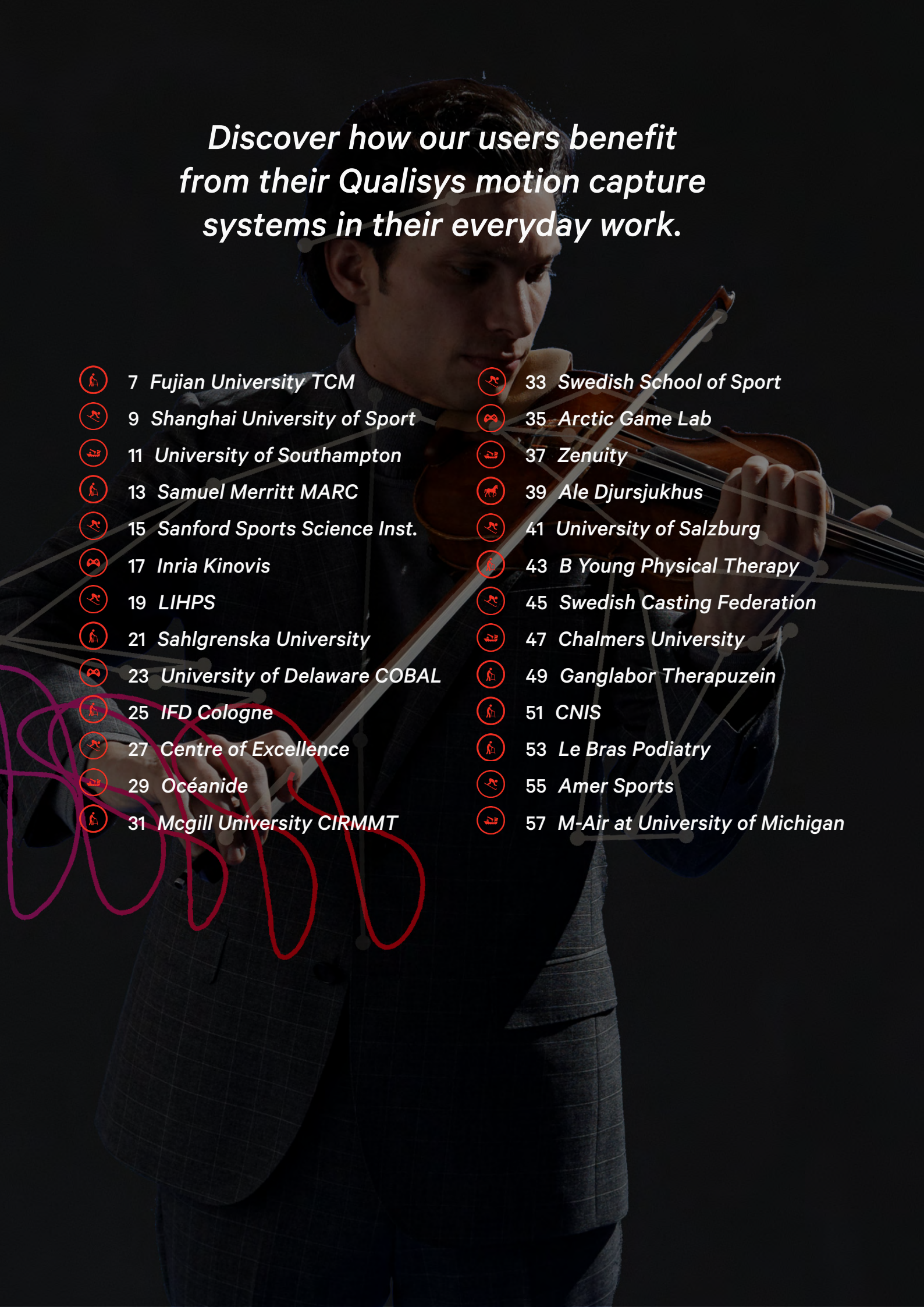

Fredrik Muller

Qualisys CSO



CONTENTS

*Discover how our users benefit
from their Qualisys motion capture
systems in their everyday work.*

- 
- 
- 7 Fujian University TCM
 - 9 Shanghai University of Sport
 - 11 University of Southampton
 - 13 Samuel Merritt MARC
 - 15 Sanford Sports Science Inst.
 - 17 Inria Kinovis
 - 19 LIHPS
 - 21 Sahlgrenska University
 - 23 University of Delaware COBAL
 - 25 IFD Cologne
 - 27 Centre of Excellence
 - 29 Océanide
 - 31 McGill University CIRMMT
 - 33 Swedish School of Sport
 - 35 Arctic Game Lab
 - 37 Zenuity
 - 39 Ale Djursjukhus
 - 41 University of Salzburg
 - 43 B Young Physical Therapy
 - 45 Swedish Casting Federation
 - 47 Chalmers University
 - 49 Ganglabor Therapuzein
 - 51 CNIS
 - 53 Le Bras Podiatry
 - 55 Amer Sports
 - 57 M-Air at University of Michigan



Traditional Chinese Medicine Using Motion Capture

The 3D Motion Analysis Lab at Fujian University of Traditional Chinese Medicine is an essential part of the National & Local Joint Engineering Research Center of Rehabilitation Medical Technology in Fujian University of Traditional Chinese Medicine.

In addition to the mainstream research performed at the facility, they also focus on the biomechanical mechanism of bone and joint diseases. For example, joint pain becomes severe during stair climbing in patients with knee osteoarthritis (KOA). Therefore, they independently developed and designed a three-axis adjustable stair apparatus to simulate climbing movement in the lab.

Along with the motion capture system, movement characteristics of patients with KOA were analyzed using and the 3D force measuring platform installed on the stairs and in the ground and stairs. Traditional Chinese medicine therapy, such as electroacupuncture and



Taijiqian, was also used to treat the patients with KOA, then analyze the effects on musculoskeletal system and motor control.

The lab works with hospitals to translate scientific research results into clinical treatments, such as the development of the spine stretching bed, and its application for scoliosis patients, appropriate use of orthosis upper and lower extremity support. Through a large amount of data collection, the laboratory will construct a database and collect normative data of human gait and stair climbing and develop the rehabilitation scale.

The lab is also responsible for teaching gait analysis and biomechanics for rehabilitation graduates and undergraduates. It conducts teaching experiments for roughly 120 students a year. Students master advanced sports evaluation skills through practical training or improve vocational skills.

As a university of traditional Chinese medicine, the lab has used the Qualisys motion capture system to quantify the movement control mechanism of TaiChi, which could help people understand TaiChi more scientifically and allow them to practice TaiChi effectively and harmlessly.



The Ballistics of Pole Vaulting

Shanghai University of Sport (SUS) is a public university in Yangpu District, Shanghai, China. Its Sport Performance Research Center (SPRC) is a state-of-the-art facility that includes a large Experiment Hall, Movement Control and Learning Lab, Muscle Strength Test Lab, Sport Biomechanical Analysis Lab, and Sports Equipment Lab.

AN OLYMPIC APPROACH

The SPRC is a substantial scientific research base for the doctoral and master's program, a postdoctoral mobile station. Researchers within pursue sport biomechanics research to improve Olympic Game skills, such as track and field, swimming, ball sports, and winter games.

Within the sport of pole vaulting, the experimental method is to capture both Kinematic and Kinetic data of pole vaulters' movement, including run-up, take-off, swing up, turn, extension, fly-away. The technical analysis results and training suggestions provide to coaches. Meanwhile, it will establish musculoskeletal system modeling and simulation system and energy model of pole vaulters.

TOTAL COVERAGE

The experiment needs to capture 3D movement in a large volume. The SPRC is equipped with 22 Qualisys 7+ cameras, installed on the ground and in the air. The researchers leverage the Qualisys system to capture all movements of joints,

gravity path, pace and stride rate of the run-up's final three steps. The group also use three Kistler force plates and one Kistler pole vault force plate with integrated electronics to get the force applied to the pole and the force of the pole pressing against the planting box.

NIKE GLOBAL RESEARCH PARTNERS

Since 2006, SPRC has been one of Nike Global Research Partners. During the program, researchers carried out many research projects such as:

- Research of badminton step method and development of badminton shoes
- Development of tennis shoes for the Beijing Olympic Games
- High and low-top sneakers, ankle injuries
- Basketball shoes and sport performance
- Metatarsophalangeal joint features and athletic shoe development

"Pole vault is a highly technical and very complicated sport. We successfully leverage the Qualisys 3D Motion Capture System to capture pole vaulters' 3D movements in a large volume."

Yu Liu

Professor - Human Movement







Applications of Motion Capture in a Towing Tank

The Boldrewood Towing Tank at the University of Southampton was designed in-house and built to be at the forefront of physical testing for many years to come. It features a combination of conventional proven systems and the latest technology.

Model tracking is an essential element of vessel maneuvering tests, and motion capture has become the method of choice for tracking free running models in large maneuvering basins. The limited availability of large ocean basins for research and education has led the University of Southampton to purchase two Qualisys motion capture systems for its Boldrewood towing



tank: one for above water measurements and one for underwater measurements. The two systems can also be coupled for hybrid measurements.

COMBINING ABOVE-WATER WITH UNDERWATER

The versatility of the Qualisys motion capture technology has allowed the university to develop new experimental methods used for education, research and commercial projects. The above-water system consists of 4 wide-angle cameras (70°) and 4 narrow angle cameras (49°), offering an infinity of combinations, but experience shows that three different arrangements cover most of the work undertaken in the Boldrewood towing tank. The flexibility of the setup enables model dynamics to be measured in air, in water and across the water surface.

Not only does the Qualisys motion capture system provide motion data for analysis, but it also can be used in real time as an input for a control algorithm. The system calculates real-time six degrees of freedom (6DOF) data from rigid bodies that can be accessed by using Qualisys' SDK and translated into a NMEA compatible format. The obtained data can then be forwarded to a model computer via WiFi. The data is processed on the model computer with the appropriate algorithm depending on the experiment.

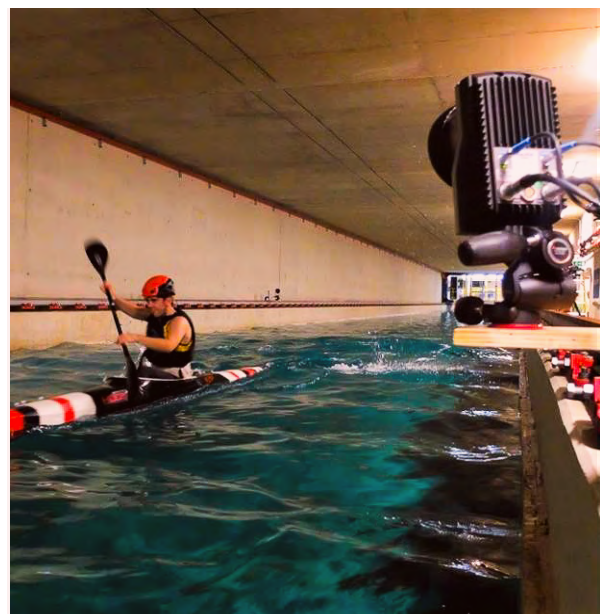
A BIOMECHANICAL APPROACH

Both motion capture systems have also been used in a swimming pool to capture kayak stroke motion and kinematics of a freestyle swimmer's body above and below the water. This allowed arm velocities and orientations to be determined throughout the entire stroke cycle.



SYSTEM SETUP

- 6 7+ Underwater Cameras
- 4 Qualisys 5+ Cameras
- 4 5+ Wide-Angle Cameras





The MARC at Samuel Merritt University

The Motion Analysis Research Center (MARC) at Samuel Merritt University (SMU) is among the best equipped healthcare sciences teaching and research laboratories in northern California.

THE SPACE

The capture space is a 2,100 ft² / 195 m² state-of-the-art laboratory designed to advance the study of human movement in education, research, and patient care. The MARC serves as a teaching center on motion analysis for faculty and students from SMU's California School of Podiatric Medicine (CSPM), Department of Occupational Therapy, Department of Physical Therapy, and Department of Nursing.

THE SYSTEM

The centerpiece of the MARC is its nine Qualisys 5+ camera system, which is integrated with six in-floor force platforms and 16-channel wireless EMG system.

The facility also boasts a dual force platform instrumented treadmill, computerized posturography, portable metabolic exercise testing, an isokinetic dynamometer, two different plantar pressure measurement systems, and an instrumented gait walkway.

THE SYMPOSIUM

Each year, the MARC hosts an annual symposium, known as the Motion Analysis Research Center Symposium, offering faculty, students, and community members an opportunity to actively participate in a forum that includes tutorials, workshops, and presentations, interacting with invited speakers from a variety of fields, all with interests in clinical biomechanics, sports medicine, and rehabilitation.

The symposium draws its audience from occupational therapists, physician assistants, physical therapists, and podiatrists from the Bay Area and Pacific Northwest Area of the United States.

"Performers' flexibility and dynamic body positions will be no threat to the tracking capabilities of the Qualisys 5+ cameras."

Drew Smith

Director, SMU MARC





Biomechanics without Boundaries!

Nestled in Sioux Falls, South Dakota and Fargo, North Dakota is a state-of-the-art facility known as the Sanford Sports Science Institute (SSSI). The SSSI is leading scientific advancements in athletic health and performance through research, development, education, and elite athlete testing services.

The Sanford Sports Science Institute leverages motion capture in and out of the laboratory to help athletes with performance and to conduct state-of-the-art research. The usage of motion capture technology to study human movement at SSSI is nothing new to this team of highly-skilled sports science specialists. The importance of having the most accurate and advanced technology remains a absolute necessity for the Human Performance department.

The facility manifests Qualisys motion capture capabilities that know no physical boundaries! The SSSI has biomechanics labs in the Sanford Pentagon - home of the Miami Heat's National Basketball Association G League, otherwise known as the Sioux Falls SkyForce, a sixty-bay outdoor golf entertainment facility, and the 80,000 ft² / 500 m² Sanford Fieldhouse.

The SSSI houses a Qualisys motion capture system consisting of twelve 7+ and eight Miquis M3 motion capture cameras, two 210c and two Miquis color video cameras.

Numerous software modules also supplement their athletic performance reporting needs, including golf, running, baseball, and custom analysis modules.

RESEARCH AND DEVELOPMENT

Researchers at the SSSI leverage their motion-capture system to understand athlete development, musculoskeletal injuries, rehabilitation, and for performance with focus on golf, baseball, and running. The SSSI also develops custom analyses leveraging motion capture to provide athletes and clinicians with reports to diagnose areas for performance improvement and inform clinical treatment plans.

PERFORMANCE TESTING

The SSSI regularly works with athletes of all ages and abilities, from elite professional and college

athletes to local youth athletes. Assessments commonly conducted include golf swing evaluations, gait and running assessments, and baseball pitching analyses, analyses though are certainly not limited to those applications.

Testing has been conducted in the SSSI runner's clinic and sports science and biomechanics lab, and outside on the driving range!

EDUCATION

The team at the SSSI have been active participants in National Biomechanics Day, a worldwide initiative to introduce high school students to biomechanics and the career opportunities in the field. Hundreds of students visit the lab during events, inspiring future scientists and engineers.









The Climb of a Model Athlete

The French National Research Institute for Digital Science and Technology, otherwise known as Inria, covers a large scope of domains in Computer Science, encompassing engineering, human biomechanics, and animation motion capture practices for full analysis of athletes and the structures on which they perform.

THE PLATFORM KINOVIS

Researchers use Qualisys motion capture with a video system to evaluate physical performance and structural optimization. The platform Kinovis makes a great use of the combination of a 68 cameras video-based system for 3D moving surface reconstruction and a 20 Qualisys 7+ marker-based mocap system. It is intended to capture shapes in motion, typically a moving human body. To this purpose the practical acquisition space is approximately 8m x 5m (25ft x 15ft) and surrounded by two acquisition systems.

The color video camera system provides full shape and appearance information with 3D textured meshes while a standard Qualisys Motion capture system provide infrared reflective marker trajectories for analysis of the subjects' movement data.

Speed climbing involves an optimization of the velocity of the ascent and the trajectory path

during performance. Consequently, any energy spent in the two other directions than vertical, namely the lateral direction and the direction perpendicular to the wall plane, is a potential loss of performance.

To assess this principle, Research Scientist, Lionel Reveret, presented a study on 3D motion analysis and its 3D visualization for a subject during a speed climbing performance. The fundamentals of geometrical measurement in 3D require to integrate multiple 2D cues, at least two, in order to extract 3D information. First results with two drones following an athlete's ascent show that a 3D velocity profile can be provided from the tracking of a marker on the harness, pointing critical phases in the ascent vertical speed is no longer dominant.

A TRAINED MODEL

Further investigation is performed using video-based tracking, in which a full body 3D avatar model of the climber is represented as a 3D mesh. The model and its deformation are learned in a lab studio resulting as a manifold embedding of the 3D mesh and its deformations, used afterwards to perform registration onto video of performance of speed climbing.

The group inspires many to take full advantage of all uses of the mocap system as their Champion subjects compete in the 2021 Olympics.



“The Qualisys system allows us to carry out very precise running analysis of Luxembourg’s elite athletes, offering a fast response to their technique questions and providing state-of-the-art and easy-to-understand reports in the discussion with their coaches.”

Eric Besenius

Performance Services Coordinator (LIHPS)

Optimizing Performance with Motion Capture

The Human Motion Lab is located in the basement of the Centre Hospitalier de Luxembourg (CHL) Sports Medicine Clinic, and is the result of a fruitful collaboration between CHL, the Luxembourg Institute of Health (LIH), the Luxembourg Institute of Research in Orthopedics, Sports Medicine and Science (LIROMS) and the Luxembourg Institute for High Performance in Sports (LIHPS).

The LIHPS aims to develop high-performance sport in Luxembourg by creating a structure for specialized services for elite athletes and promoting the transfer

of knowledge to Luxembourg’s stakeholders in high-performance sport. It offers its services to elite athletes who are members of the Luxembourg Olympic and Sports Committee (COSL) squads, the army’s elite sports section or any other COSL support measure. For sports science research and highly specialized expertise in the field of biomechanical analysis, the LIHPS can build on one of its essential pillars, the LIROMS.

The Human Motion Lab is equipped with an instrumented treadmill, two force plates and a Qualisys system with 9 Miquis M5 cameras and 2 Miquis Video cameras. As the athletes undergo an assessment, a simulated track is placed in front of them on a large screen to replicate natural performing conditions, rather than a projection of the movements tracked in QTM, which may opt the athlete to pay too much attention on their form, skewing the results of what would instinctively occur in practice.

Paving the Way for Gait



Roy Tranberg and Ronald Zügner facilitate investigations that occur at the Sahlgrenska University Hospital gait laboratory in Gothenburg, Sweden, allowing more patients receive the help they need whilst ensuring the quality of care is maintained for those who have already been treated for other gait disorders.

IMPROVING QUALITY OF LIFE

The gait laboratory houses a Qualisys motion capture system, by which patients with different conditions are examined using gait analysis, which influences the treatment of patients with walking difficulties and overall quality of life.

Patients referred for gait analysis have symptoms such as cerebral palsy, diabetes, hip arthrosis, Achilles

tendon ruptures or have suffered strokes. All patients have gait-related difficulties and might need advanced surgery, botulinum toxin injection, orthosis or physiotherapy in order to alleviate gait difficulties in hip, knee or ankle joints.

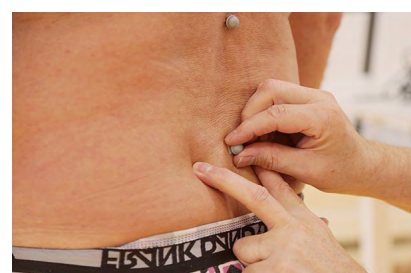
A DEEPER ANALYSIS

The facility carries out a far deeper analysis, which gives more information than a regular medical visit, and, in turn enables them to make a more accurate assessment of upcoming treatments and/or interventions. It is not only beneficial for the patients, but for the patient's family too.

The patient's movement patterns are captured by attaching reflective markers to the skin and tracking their motion using 16 cameras. Force plates that are built into the floor

measure ground reaction forces simultaneously with the motion and provide calculations of forces produced as the patient walks.

Not even clinically trained eyes can note the rapid movement that occurs between the joint segments when an individual takes a step. They can see tendencies, but it's impossible to see in detail how a knee joint is stressed in one footstep. Thanks to the technology, Roy and Ronald can see fifteen times faster than the eye, thus giving patients a more accurate and complete assessment.



"We have chosen to invest in new equipment from Qualisys, which will help us to grow to be bigger and better within clinical gait analysis, and carry out research and development at the hospital just as we have done for the last 20 years."

Roy Tranberg

*Physical Therapist -
Sahlgrenska University Hospital*





Neurological & Biomechanical Fusion

The bipedal human is inherently unstable and needs a sophisticated control system to remain upright. Researchers at the University of Delaware Science, Technology and Advanced Research campus' CoBal Lab strive to understand biomechanical and neurological components of balance.

The researchers use a Virtual Reality (VR) Dome to simulate a variety of scenes that manipulate a subject's senses as human motion is investigated to better facilitate rehabilitation practices in patients with neurological disease and injury that lead to balance problems.

MULTI-SENSORY FUSION

The CoBal Lab team performed a study on Multi Sensory Fusion and sensory re-weighting in college athletes to investigate potential mechanisms underlying brain injury due to mild mechanical impact. Participants stand in front the virtual reality Dome as researchers perturb the three sensory systems:

Some subjects walk on the treadmill as the VR environment is rotated, creating a perceived visual fall to the side. The same thing is done with the GVS by inducing artificial fall sensations. These tactics replicate stress levels experienced in sports/ recreational activities to isolate underlying concussion symptoms.

Another project focuses on characterizing neural control strategies while walking in children with Cerebral Palsy (CP), to recognize relationships between sensory processing and functional mobility in children with CP. By collecting movement data, EMG activity, and ground reaction force data, the group is able to get a larger context of function and rehab.

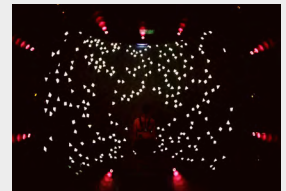
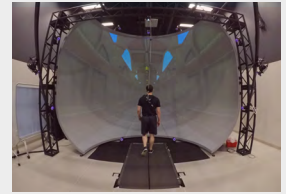
CONTROLLED SIMULATION

Stochastic Resonance stimulation is used to study possible deficits in the dynamic integration of the sensory system's modalities, in which the Qualisys system is mounted around the VR dome to track movement patterns and responses to the controlled stimulation.

In studies involving Parkinson's disease, subjects are immersed into a virtual scene while electrical currents stimulate the Vestibular system, posing an extreme challenge for the subject's sense of balance.

SYSTEM SETUP

- 13 Miquis M3 cameras
- 1 Miquis Video camera
- 1 instrumented treadmill
- EMG
- VR Dome System
- Oculus Rift
- GVS system



The group uses various techniques to manipulate the 3 sensory systems:

VESTIBULAR SYSTEM is controlled by a Galvanic Vestibular Stimulation (GVS) in which an electric current is sent to the vestibular complex biasing the signal.

VISION is engineered with the VR Dome System

PROPRIOCEPTION is conducted with vibrators on the Aquilles tendon



The Front Line of Back to Sport Operations

Institut für Funktionelle Diagnostik (IFD) Cologne was founded in 2014 as an initiative between Professor Peter Bruggeman, the Head of the Institute for Biomechanics and Orthopedics at the German Sport University – Cologne, and a group of doctors that have a connection to the analysis of elite German athletes. The idea was to take methods which are typically used in research applications and use it towards patient assessment.

Experts are all driven towards a common goal, which is to uncover the origin of the movement related problem in their patients. A patient can be anyone suffering from joint pain, ranging from the common public to elite professional athletes. For each patient, the assessment process is individualized based on to the injury's limitation, history, physical aptitude, or motivational factors for quick recovery.

THE PATIENT PROCESS

To start, all patients go through a preliminary interview for the IFD expert to better understand what problems they are suffering from. The team then designs a plan for which tasks will be performed during assessment.

Next, testing is performed, which can incorporate strength tests, plantar pressure measurements, whole body

scans, EMG measurements, and movement analysis. This is where the Qualisys motion capture comes into play, giving the team the ability to measure and analyze various different functional movements.

Movements are specific to the patient being assessed, for instance, elite football/soccer players perform more dynamic trials such as change of direction, stopping, and jumping tasks, while elderly undergo slower movement assessment as in typical gait analysis.

"PLAYING DETECTIVE"

Data collected from all of the testing gives heed to what Dr. Steffen Willwacher (IFD Sport Scientist), refers to as "playing detective" – analyzing the results. An analysis is performed on all tested activities, isolating abnormalities and linking them to others which may cater to the overall deficiency of the patient. Lastly, recommendations are delivered based on the reported results.

Before IFD had acquired the Qualisys motion capture systems in 2017, analyzing functional movements and limitations was a much more laborious task. Programs had been built within MATLAB to streamline data processing, however, improvements were still needed to support report comprehensibility for the patient's understanding and continuous practice.





FUNCTIONAL ASSESSMENT

IFD assesses functional performance to designate a path to rehabilitation, a concept often referred to as *Back to Sport*. Collaboration between IFD and Qualisys was initiated, aimed at the delivery of immediate and comprehensive results a patient. The outcome was the Qualisys Functional Assessment Module - product that others can use when working with injured and rehabilitating patients, for efficient occupational practices and a faster means of getting an athlete *Back to Sport*.



Badminton 3D Testing

Qualisys motion capture was used for intensive and unique testing, of badminton players, at The Centre of Excellence in Holbæk, Denmark. Researchers from Aalborg University visited Stenhus Gymnasium, where the center is located to perform tests on the COE players.

The focus of the tests was a new product called Spraino®



that is designed to prevent ankle sprains, but also the center of mass and whether the height influences the speed of badminton players. Reflective markers were attached to the body.

Qualisys cameras track and register the complex movement of the markers and translates them into an extremely accurate, computer-generated 3D wire frame model that show the way the body moves on court.

“

"Tracking worked immediately such that we could show the 3D animations to the players shortly after the recordings. This offers incredible opportunities for athlete feedback."

Uwe G. Kersting

Professor, PhD at Aalborg University

Offshore Mechanics and Arctic Engineering

Océanide is comprised of various aquatic test facilities that examine the performance of model marine vehicles as they are launched into simulated environments. The test facilities are located in France and include the BGO deep water basin (waves, wind, current), a wave flume tank, and a shallow water wave tank.

In the test facilities, conditions are replicated to measure the performance of the vessels when undergoing environmental and other associated impacts as the vehicles respond to obstacles such as marine renewable energy converters, oil and gas platforms, ship traffic, seafloor topography, pipelines, and beaches.

RULING INDUSTRY STANDARDS

During the 2018 International Conference on Offshore Mechanics and Arctic Engineering, a project was presented containing a review of the industry standards on both experimental and Computational Fluid Dynamic (CFD) approaches, which used Qualisys motion capture to track the vessel model and measure its performance when certain conditions were replicated.

The study involved the analysis of Vortex-Induced Vibrations (VIV) on spool and jumper geometries, which are known to present several drawbacks when approached with conventional engineering. The complex, 3D form of the spools and jumpers makes the fluid three-

dimensional and the vibratory response can exhibit a complex, non-linear, multi-modal response due to the structural form.

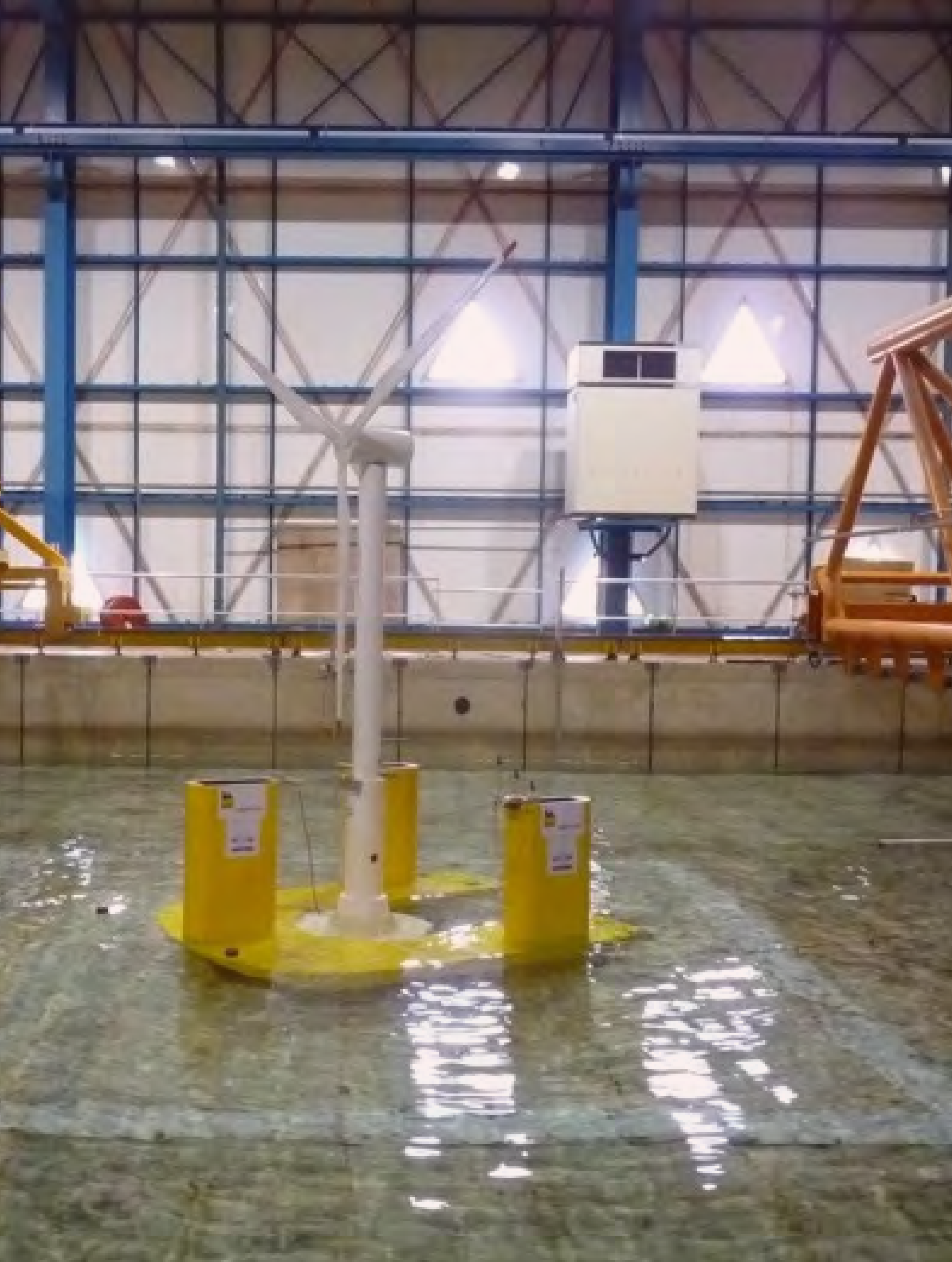
To prove the success of the CFD-based fluid-structure interaction (FSI) method, experiments were carried out in Océanide's BGO FIRST wave, current and wind basin. The tank is 16m (52 ft) wide and 40m (131ft) long, and a movable floor creates a water depth that varies between 5m (16ft) down to a few centimeters.

MEASURING DISPLACEMENT

The group collected measurements at both anchorage points to determine displacement using a 4-camera Qualisys underwater system to track the position of 6 markers affixed to the model, and the mean current velocity checked downstream of the model and out of its wake.

Tests were conducted with several current velocities, and several spool headings. The measurement of the 6 marker positions allowed the group to quantify the VIV's amplitudes and frequencies, leading to a great experimental database of numerical tools for reliability assessment.



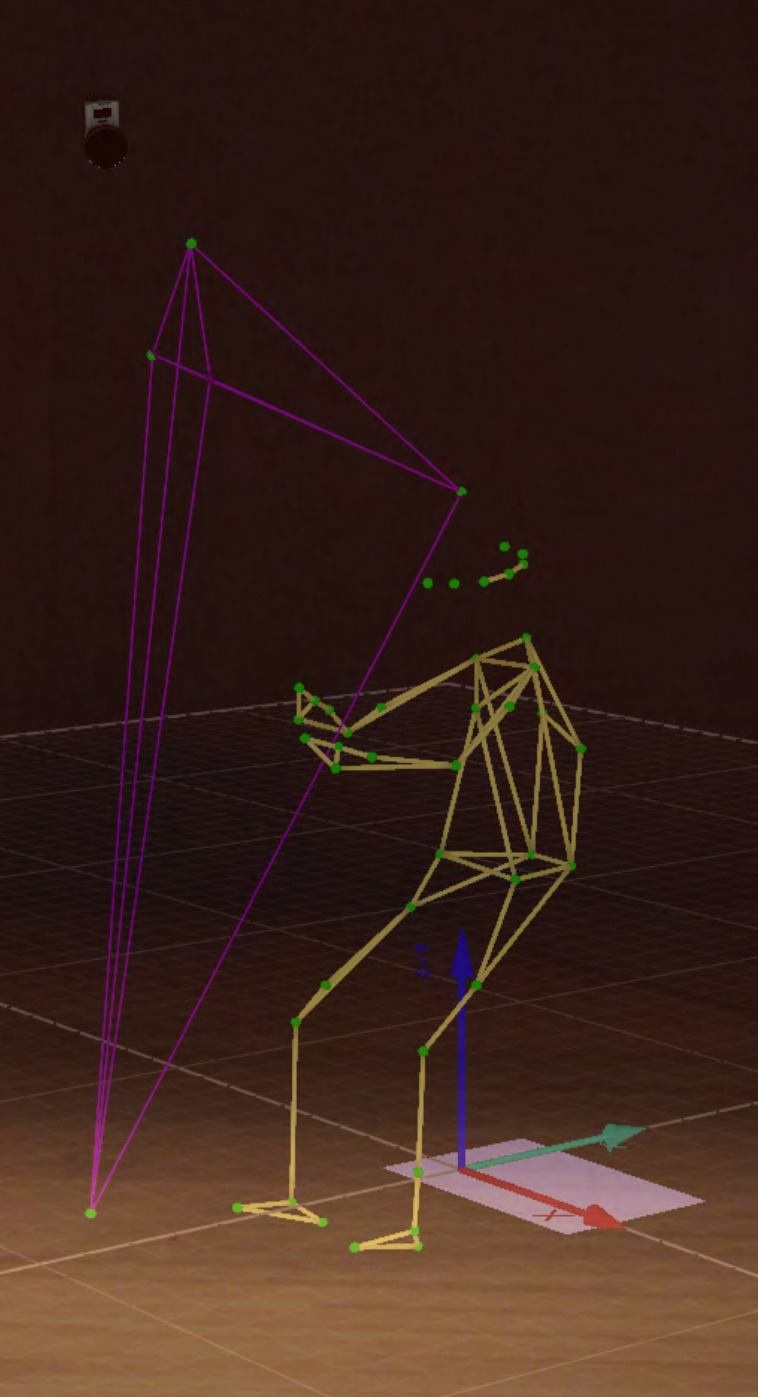




Music Media & Technology

The Centre of Interdisciplinary Research Music Media and Technology (CIRMMT) is a multi-disciplinary research group that seeks to develop innovative approaches to the scientific study of music media and technology, promoting the application of new technologies in science and creative arts and providing an advanced research training environment.

The CIRMMT is centered in Montréal, Canada at the Schulich School of Music of McGill University, uniting researchers and students from several Quebec institutions. Students study movement kinematics in order to distinguish recurrent motion patterns that are related to the musical structure from those



that are part of their personal signature. A 12-camera 4+ active/passive Qualisys system is set up in the Performance and Recording Lab while the Immersive Presence Lab contains 8 Qualisys 7+ 8 Qualisys 3+ cameras, and a Qualisys Video camera. The facility is home to 66 Qualisys motion capture cameras in total, “check out” to student and faculty projects.

NON-INTRUSIVE MEASUREMENTS

The high precision of the 3D motion capture Qualisys system along with non-intrusive reflective markers allowed researchers to track with great accuracy a musicians’ fast and skillful movements in order to understand the relationships between their movements and the sound parameters.

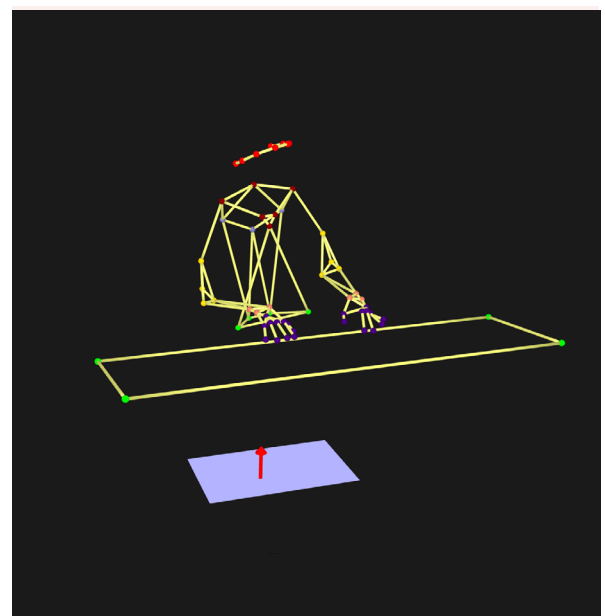
The system is used to analyze the body movements of performing musicians, which offers an insight into how they rely on movements to convey expressive information, and create a motion database that can help design new pedagogical tools. This software could be used in the context of instrumental lessons to help student-musicians develop accurate awareness of their movements and make relationships between their gestures and the sound.

Motion data are collected with a 17-camera Qualisys motion capture system. The data streams of MIDI piano keyboard, the video camera, and of the mocap cameras are synchronized and time stamped.

FINGER MOTION TRACKING

Fine and precise movements such as finger motion can also be measured with several cameras angled toward the piano keyboard. QTM allows you to display force data. Reflective markers are placed on every musician according to a definite Plug in Gait with arms, hands and upper body model, which gives a precise description of the musicians’ body posture.

Harp Gesture Acquisition for the Control of Audiovisual Synthesis used a motion capture analysis of concert harpists to create a vocabulary of performative gestures. These gestures were mapped to input from wireless motion acquisition devices worn by performer, allowing them to use natural body movement to control external audio and visual processes during a live performance.





A New Sport for the Paralympic Games

Researchers at Swedish School of Sport and Health Sciences (GIH) have conducted biomechanical research to create evidence-based classification systems for athletes competing in paracanoe. The research used motion capture and allowed the group to further study the details of sport performance.

The International Paralympic Committee (IPC) requires that sports included in the Paralympic games must have an evidence-based classification system. Paracanoe is a relatively new sport in which athletes with physical impairments compete in either Para-kayak or Para Va'a. Para-kayak is contested in a kayak propelled with a double-blade paddle; Para Va'a is in a Polynesian outrigger canoe and is propelled using a single-blade paddle.

AN INTERNATIONAL EFFORT

Dr. Anna Bjerkefors from GIH was contacted by the International Canoe Federation (ICF) to lead the scientific work in creating an evidence-based classification

system for Para-kayak and Para Va'a. Together with GIH members Johanna Rosén, Toni Arndt and Olga Tarassova, 3D motion data and paddling power output was collected using Qualisys motion capture on 33 able-bodied kayak and Va'a athletes and 130 Paracanoe athletes from 20 different countries.

The Qualisys equipment was shipped to different global sites, where "pop-up labs" were created to collect data on top athletes at five Canoe Sprint and Paracanoe World Championships, including GIH in Stockholm, the Centre for Disability Sport at Loughborough University (UK), George Fox University (USA), and National Center of Sport Training (Russia).

Information of how athletes with different impairments paddle compared to able-bodied athletes and compared to other impairment types was then used as a basis for creating evidence-based classification systems for Para-kayak and Para Va'a in collaboration with international classifiers from the ICF.

"It feels great to be able to help more people have the opportunity to compete in the Paralympic Games in two new disciplines"

Johanna Rosén
PhD student, GIH





Arctic Game Lab

Arctic Game Lab is Northern Europe's fastest growing game industry cluster. Situated in northern Sweden, the group works to strengthen the regional game industry in the municipalities Umeå, Skellefteå, Piteå, Luleå and Boden.

Together they create meeting places, Game Jams, lectures, business development, collaborations between game development companies and educations/students – in order to build a stronger gaming industry, with more game companies and better selling games.

MOCAP AS A SERVICE

As a service to the game companies in the region, Arctic Game Lab has built a Motion Capture studio at Campus Skellefteå using Qualisys M3 cameras. In order to cut rental costs, the space is shared with one of the best martial arts centers outside Japan: Skellefteå Budokan, where six clubs provide more than ten traditional Japanese Budo sports.

One of their dojos (for aikido, jujutsu and judo) has been modified with truss, M3 cameras and a 23 square meters or 250 square feet, Virtual Production LED wall so that it can work as a motion capture studio during business hours (budo practice is done only on evenings and weekends). This way the utilization rate is now much higher, benefiting all parties.

The studio itself is a 160 square meter / 1,700 square foot mocap recording area of 11 x 8 m (35 x 25 ft) and 3 meters (10 ft) in height. In total Skellefteå Budokan is around 1000 m² or 11,000 ft², so there are plenty of additional rooms for storage, recreation, rehearsal, review, rest, dressing, post-mocap sauna, etc.

INSPIRING EDUCATION

The group focuses on educating key personnel and providing access to educations. One of the first projects that put the system to the test was having students from the local VFX-artist education "Visual Magic" documenting aikido, kendo, iaido and karate with the help of martial artists from Skellefteå Budokan – further linking the two tenants.

Together with local companies such as North Kingdom, Seize the

Frame, Autotech Teknikinformation, Tarvalley and Hello Future, Arctic Lab has started a few smaller projects that examines the synergies between mocap and different technologies such as Volumetric Capture (using Ouster lidar radar sensors), Virtual Production and multiuser XR.

"Qualisys delivered a system that exceeds our expectations, both in terms of hassle-free setup and quality of output. The sales and support from Qualisys was extremely helpful, tailoring it to our needs and helping us get the studio up and running - a scalable system that just works."

Magnus Johansson
Project Manager









Driving Towards Intelligent & Safe Mobility

Zenuity is an advanced driver assistance systems and autonomous drive technology developer and was formed in 2017 as a joint venture between Volvo Cars and automotive safety supplier, Autoliv – an industry first, where an OEM and Tier-1 supplier, both recognized as pioneers in automotive safety, formed a company to develop the software and solutions required to create a global connected automotive ecosystem.

Since the launch of Zenuity, Autoliv has divided itself into the passive safety department, which focuses on airbags and seat belts, and the active safety department, which includes functions such as Autonomous Emergency Braking, Adaptive Cruise Control, Traffic Jam Assist Highway Assist, among others.

IMPROVING ACTIVE SAFETY

With an ambition to make safe and intelligent mobility available to as many people as possible, the company sought out technology that would aid to the localization vehicles. Location-based services require positioning systems, which can estimate the user location. Global Positioning System (GPS) is commonly used in navigation, tracking, and public safety. However, in indoor environments, signals from the GPS satellites are obstructed, delivering limited

coverage and inaccurate results. Recognizing that optical motion capture technology provides a solution for indoor vehicle localization and automation, Zenuity's Gothenburg, Munich, and Detroit sites were provided with 12 Qualisys 7+ cameras to support their work in the development of autonomous driving solutions.

The Qualisys system is set up in a 170m²/ 1800ft² ring which exists in each facility and is used to localize vehicles for indoor applications. For instance, by tracking the location of a vehicle performing its regular tests, developers may use the vehicle's positional and orientational data collected to determine traffic gaps and time instances to perform maneuvers and calculate algorithms to apply in automated testing.

WEATHERPROOF CAMERAS

The protected Qualisys 7+ cameras allows work to continue outdoors to test specific maneuvers in various scenarios. Another critical component is QTM's open source real-time software development kit, which gives the testing team the ability to use the system in cohesion with their own systems. Algorithms determined in earlier stages can be used to control vehicular movement in real-time when performing maneuvers on a test track. The higher degree of automation significantly minimizes manual labor.



"It is the best aid during my 30 years as a veterinarian. The cameras document what the eye does not see, and an objective scientific assessment is obtained. It's a huge help and it helps me as a veterinarian to think and see new critical eyes."

Lotta Månsby
Owner, Ale Djursjukhus



Detecting Equine Abnormalities

Dr. Lotta Månsby, owner of Ale Djursjukhus, has had much involvement with health diagnostics in movement analysis of equines and is particularly fond of her Qualisys equipment.

Qualisys motion capture is becoming increasingly well-known in the horse industry, and after a visit with the entire staff at Swedish University of Agricultural Sciences, the owners of Ale Djursjukhus purchased a Qualisys system for themselves, becoming one of the first of its kind with this high-performance motion analysis system.

In one case, a seventeen-year-old horse, Tessan, had been studied due to a chronic problem in the foot's radial bone area. She came to the clinic because the owner had seen a similar injury pattern previously

and thought it might be the same problem again and was worth paying a little extra to get a precise picture of the situation. As an electronics and computer engineer, she also wanted to see how the system worked in practice, and in the end, she hoped to get her horse back on track again.

Tessan was described as a good ride, but very difficult to handle. In preparation for the test, reflective markers were attached to the horse's head, withers and pelvis before the test began. As she trotted, the cameras captured everything and made it easier to see if the ailment was in the landing or mid-stride as the horse shows a possible deviation from normal gait. Anesthesia was applied to witness any differences.

From the captured results, the team could see the asymmetry which surprised them—Tessan was unhealthy on her right forefoot, though she previously experienced and was treated for an injury on the left forefoot.

Science on the Slopes



In the town of Windischgarsten, Austria, there exists an integrated training and learning environment for the development of young winter sport athletes in a school environment, known as the Ski Mittelschule Windischgarsten.

AN INFINITE SKI SLOPE

The site includes a specially designed ski treadmill with a carpet overlay, allowing for athletes to train year-round on the ski carpet simulator while researchers at the University of Salzburg to study the complex kinematics of Alpine skiing in a hyper-controlled scenario.

The 9.5 x 5 meter (31 x 16 ft) “infinite ski slope” is used by the coaches and athletes to develop and practice skiing specific skills off the snow. The ski carpet can be adjusted in speed from 0

– 25 km/h (0 – 15 mph) and inclination from 9 – 20 degrees

DIGITAL MOTION PROJECT

One study was undertaken as part of the Digital Motion Project, a joint project between the Biomechanics, Training & Movement Science, and Sports Psychology groups within the Department of Sport and Exercise Science at University of Salzburg.

This group of researchers from along with the École Polytechnique Fédéral de Lausanne took to the “slopes” of the ski carpet at the Ski Mittelschule Windischgarsten, Austria. The firm Salzburg Research was an collaborating scientific partner in this project, as well. The purpose was to:

1. Validate all previously reported methodologies to detect turns during alpine skiing.

2. Validate a wearable system to estimate kinematic and kinetic parameters during alpine skiing.
3. Develop a model for detecting fatigue during Alpine Skiing.

While the main scope of this project is to develop wearable technologies for sport, these technologies must be both valid and repeatable, in which the Qualisys system plays a massively important role.

Results not only aid in the development and improvement of training practices for athletes, but also feed the development and validation of algorithms to estimate motion quality parameters during alpine skiing, such as segment or ski orientation, estimated “g-force”, center of mass trajectory, load quantification, fatigue detection, and other parameters.

"The Qualisys system was absolutely a focal point of this study. The ability to set-up and adapt the system to a measurement environment as complex as the ski carpet was invaluable."

Cory Snyder, MS
University of Salzburg





The 8 Cylinders of Pitching

Several factors make B Young Physical Therapy (PT) unique like specialized one-on-one treatment given to the patients. But the biggest separating factor from their competitors is the state-of-the-art Qualisys motion capture system.

A SPECIALTY IN BASEBALL

Brandon is a licensed Physical Therapist who specializes in shoulder and elbow treatment especially in baseball pitchers. Brandon has worked with baseball pitchers of all levels, from youth to professional, to help them return to competition after major injuries. The inclusion of 3D motion capture has dramatically improved treatment techniques used to help pitchers return to prior level of competition and beyond following injury.

His methods also aid to the improvement of pitch velocity following 3D analysis and biomechanical movement correction. Baseball pitchers who dedicate themselves to B Young Physical Therapy's offseason program, known as The 8 Cylinders of Pitching, typically see an average velocity improvement of greater than 10 MPH or 16.2 km/h on their fastball.

DEFINING A TREATMENT PLAN

The Physical Therapy work is dedicated to providing the most direct and effective treatment plan possible with today's technology. In order to provide the best treatment

plan, one must understand what is driving the athletes pain or dysfunction. Many times, it is flawed movement patterns causing the pain or dysfunction.

In order to sufficiently evaluate high speed athletic movements and suggest corrective movement strategies the facility relies on their Qualisys Motion Capture System, which consists of 8 5+ cameras surrounding a 1,000ft² / 93m² warehouse space.

The motion capture space houses an authentic clay mound built to major league specs. The professional clay mound allows pitchers to use their cleats which allows for much more realistic pitching conditions. In 2020, BYoung took on a second location for more capture opportunities.

RUNNING THE BUSINESS

Brandon's partner, Lee Welch, uses 10 Miquis M3 and 4 Miquis Video cameras for running and sprinting in addition to baseball analysis. By incorporating 3D motion capture in his treatment, Lee has rehabilitated many runners back to running, who failed traditional therapy treatment or surgical intervention.



"From the time the foot lands you have a tenth of a second to release the ball, you cannot see this with the naked eye, you cannot evaluate a pitcher with high speed video cameras"

Brandon Young

Founder - B Young Physical Therapy





Movement Analysis of Fly Casting

At the Swedish Casting Federation, research is conducted linked to “The Perfect Cast” endeavor - a broad venture aimed at all who want to learn or develop their ability and performance in casting with fishing rods. This includes all ages, gender, background etc., that is, from the beginner fishermen to the elite casters, with the purpose of raising awareness of the sport and to develop it on all levels.

MOVECAST

This particular project is referred to as MOVECAST and is a pilot project focusing on elite casters in the Swedish Casting Federation's two disciplines, Fly Casting and Casting. The goal of MOVECAST is to develop methods for analyzing movement. The project was coordinated in part by Ulrik Röijezon, PhD, Associate Professor at Luleå University of Technology, board member the Swedish Casting Federation and active elite fly caster.

Different rods and lines are used in the various events of the two disciplines of Fly Casting and Casting. The Fly Casting discipline has six events with different fly rods and fly lines, whereas the Casting discipline has nine events, three of which with fly rods and fly lines. Some events use single-hand rods

and others use double-hand rods. Some events are cast only on water while others can be cast also on land or indoors.

At Luleå University of Technology (LTU), individuals have access to equipment that measures movement behaviors, such as the IMU system and the EMG system are portable and feasible to use in both indoor and outdoor settings. They also have Qualisys motion capture system in the Human Health and Performance Lab – Movement Science at LTU. The accuracy of the Qualisys system allows certain movement measurements that we cannot do with the IMU system, for example measurements of the rod tip, the fly line and even the small fly during fly casting.

LARGE VOLUME COVERAGE

The motion lab is too small to assess max-distance fly casting, so the project was moved to Bosön, Stockholm at the Swedish Sports Confederation for further and deepened investigations into the movement behavior in fly casting.

These methods can then be used in future larger research projects to increase the knowledge about the movement behavior of the caster, rod, line and fly during fly casting among expert casters as well as less experienced casters.





Elite casters in Fly Casting and Casting participated in an elite camp at Bosön in Stockholm, Sweden. 12 cameras were placed on tripods on the ground and 6 cameras were fixed to the roof approximately 15 meters / 45 feet above ground covering a large measurement volume for assessment of the caster as well as the rod, fly line and the fly during maximum distance casting with both single-hand and double hand fly rods.

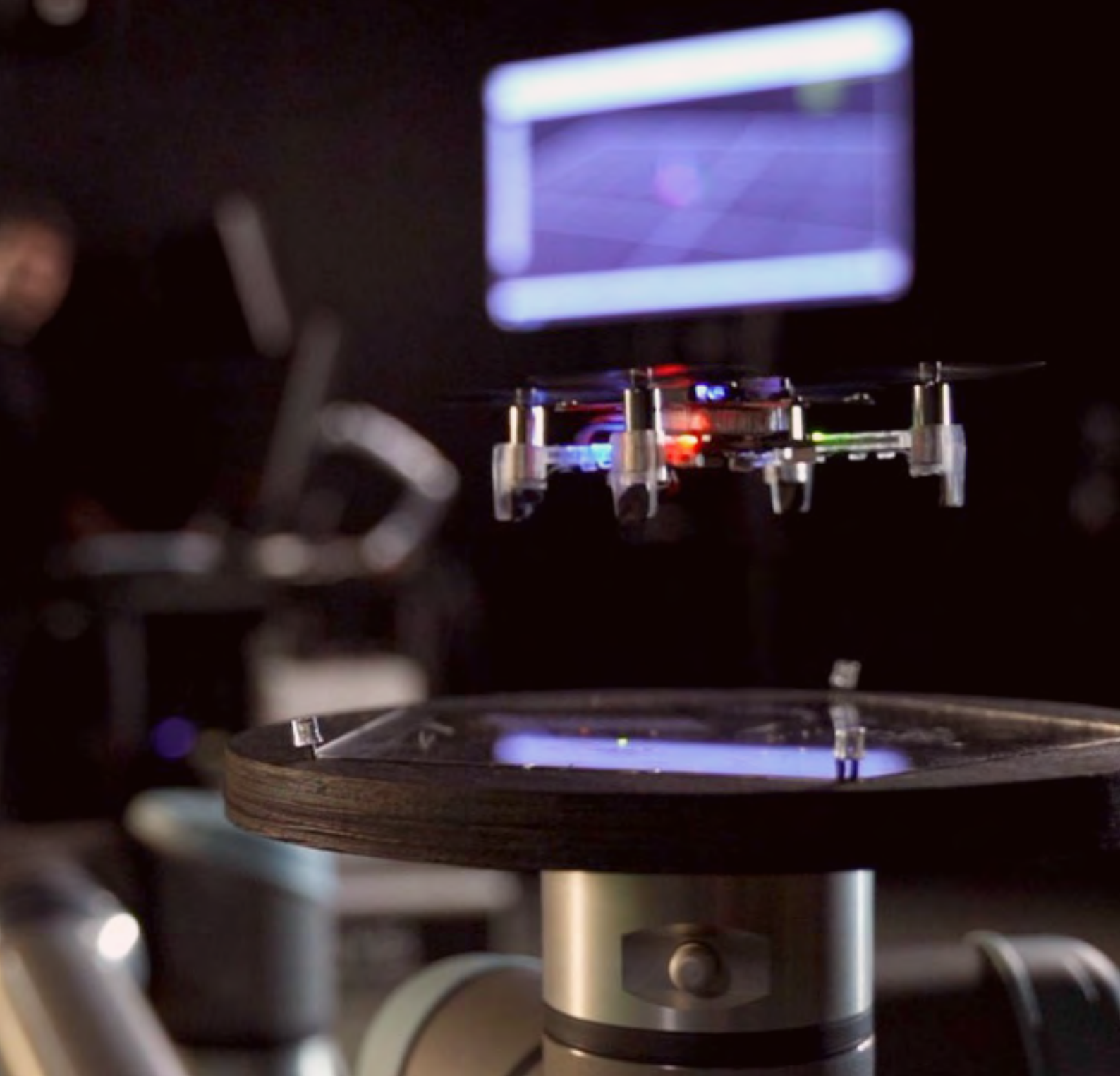


Human-Robot Interaction & Social Drones

At Chalmers University in Gothenburg, Sweden, within the Computer Science department, interaction design researchers use Qualisys motion capture as they practice the methods and philosophy of design within computer science and run research through design projects on social drones.

Social drones, a term coined by the researchers themselves, describes the application of autonomous drones flying in environments with humans.

What the Chalmers researchers are specifically curious about is the environment and people that are interacting with the drone in some way – an area known as human-drone interaction. It includes fields, such as sports, using drones as training devices or enhancing the spectator's experience. Others use drones to bring physical touch into virtual reality. The Qualisys motion capture system is used to capture the motion of both humans and drones as the group designs experiences with digital and robotic



materials embodying the essence of these practices.

One example is a project called Drone Chi, which is a system for movement exercises performed together with a drone, inspired by Tai Chi, meant to be a meditative experience for cultivating focus and calm. The researchers used marker-based tracking to follow and control the drone in 3D space and follow the user's hands via custom-designed 3D-printed hand pads.

Another is the prototype Wisp, in which wearable sensors can detect breathing as a drone moves with the breath in real-time. It investigates how a drone-based interactive

experience might motivate people of all ages to take up meditation and breathwork, and how a drone's movement can be used to guide and enhance the experience.

The group uses motion capture to both control and analyze motions of the drone, and capture human movement. Using real-time and recording functions in tandem, the motion capture data is used to build an interactive experience, as well as a source of information on how these interactions happen, and how we might design better ones in the future. They also experiment with positioning systems and AI-based algorithms to eventually turn the prototypes into products.



A Hybrid Solution for Gait Analysis

The gait lab at Ganglabor Therapuzein is based in a clinical rehab center for orthopedic patients. As a patient-driven facility, the main focus is not particularly on research, but instead based on therapy – trying to get patients closer to normal movement patterns, trying to develop new gait movement so that they can walk again without pain, and ultimately trying to reduce pain.

The members at Ganglabor turned to Qualisys, because time is a highly valuable factor when it comes to working with patients. Often times with optical motion capture systems, too much time goes into adhering markers to a patient's body. Investing in a Qualisys Hybrid system would ultimately increase the productivity and one-to-one time with patients without sacrificing precision or the option to pursue in-depth studies.

With the Hybrid system, the group can switch between video mode and infrared mode and decide to perform either the marker-based measurements, as in the past, or they can choose to go markerless.

MARKERLESS CAPTURES

10 Miqu Hybrid cameras surround the capture volume of the gait lab at Ganglabor Therapuzein. Their patients range in all ages; from youths becoming acclimated to a gait pattern, to high-level athletes who perform running analysis and functional assessment tests as

a back-to-sport service, as well as older, more senior individuals recovering from a procedure or rebuilding strength in places in which it was lost.

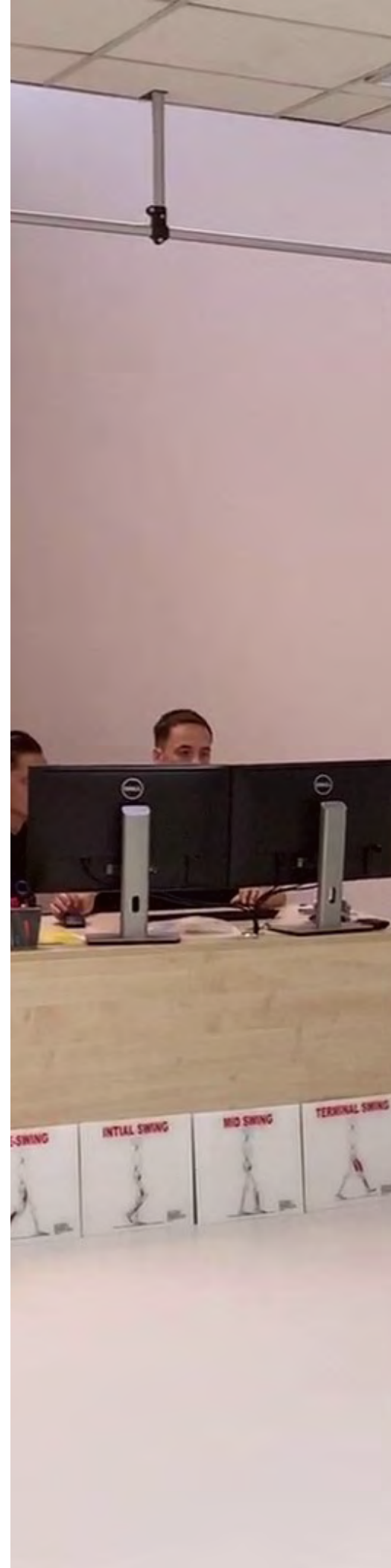
The primary measurement method is markerless, because of the time it saves. It also allows the group to use it as a feedback tool for the patients; it is easier for patients to comprehend and recognize themselves when seeing video rather than tracked markers.

MARKER-BASED CAPTURES

Yet, the ability to switch back and forth is extremely valuable to the team. If there is a particular topic revealed in studies and literature, then the group has the opportunity to go more in-depth using the marker-based method. They can also be more thorough with their patients to address a specific concern that they witness in the markerless measurements, such as the application of a specific foot model for added data analysis.

SYSTEM SETUP

- 10 Miqu Hybrid cameras
- Gait Analysis Module
- Function Assessment Module
- Theia 3D
- Visual 3D
- EMG
- Force Plates



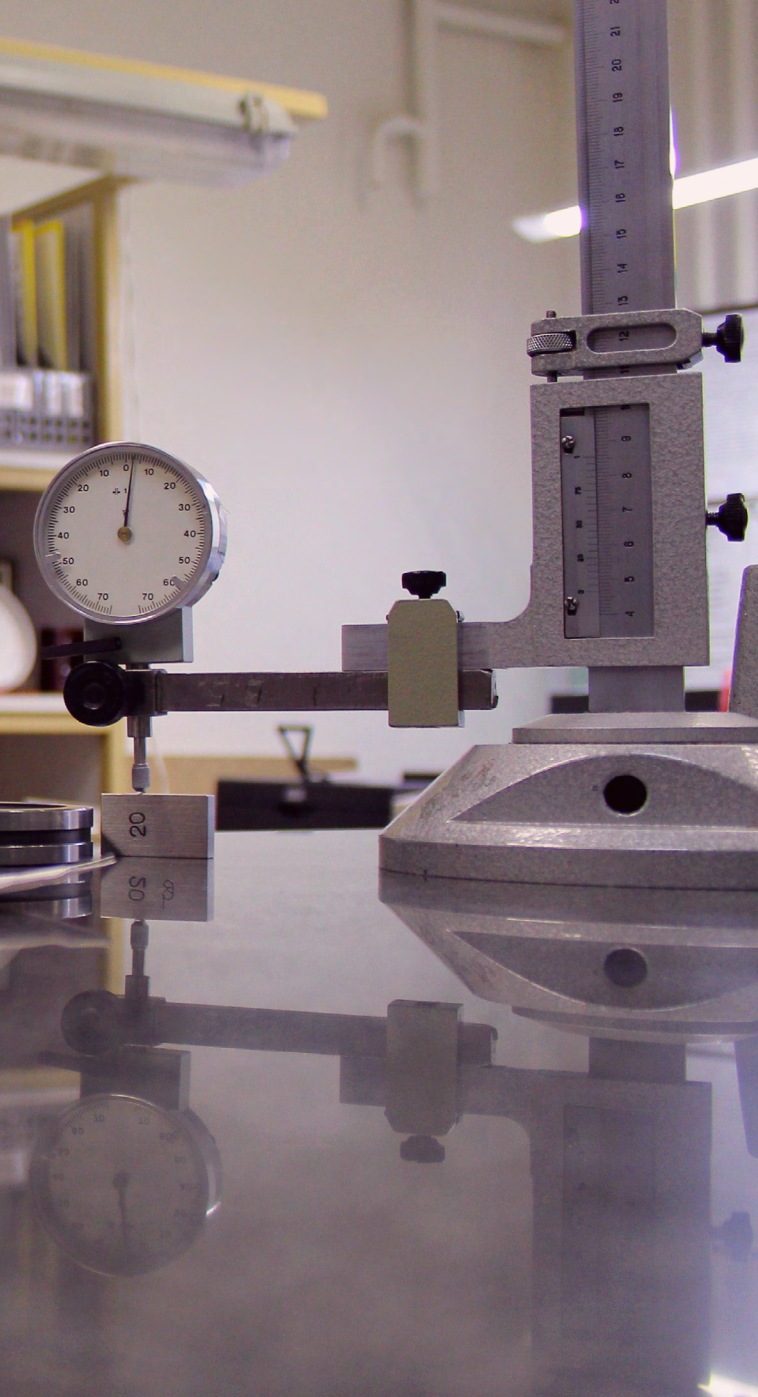




Regulating Standardized Measurements

In a world where competition forces us to go faster, these enthusiasts can rely on an effective system to meet deadlines without sacrificing innovation, performance and safety for their new products.

The China National Institute of Standardization (CNIS), established since 1963, is directly subordinate to the State Administration of Market Regulation (SAMR). As a national social service institution dedicated to standardization researches, it mainly addresses the global, strategic and comprehensive standardization issues in the national economy and social development of China.



BIOMECHANICS LAB

The Biomechanics Lab is based on human biomechanical problems in work and daily life, using research methods to develop a model of human biomechanical characteristics. Moreover, mass data and technical support are provided for product design, workspace layout, work task design, and evaluation. Human manipulation force, such as push and pull force, grip strength, torsion force, pressing force and pedaling force, is also measured. The Qualisys system is used for product evaluation for subject wearing various shoe types with different backpacks. The lab also pursues gait analysis for children and elderly.

- 15 Qualisys 7+ cameras
- 2 210c video cameras

ERGONOMICS LABORATORY

The Ergonomics Laboratory of CNIS has been established since 1980. It focuses on fundamental and applied research in ergonomics and standardization, providing technical and data support. The lab includes eight experimental platforms, covering fields such as usability evaluation, biomechanics, anthropometry, Virtual Reality, environment ergonomics, human-system interaction, usability and user experience.

- 8 Qualisys 5+ cameras
- 4 210c Video cameras

USABILITY EVALUATION LAB

This lab is aimed to measure the most intangible behaviors for user experience detection using research methods in physiology, psychological and cognitive neuroscience are applied here. Through continuous research and data accumulation, the standards have been developed for usability tests and user experience evaluation. For instance, the product operation for home appliances is captured for evaluation purposes.

- 8 Qualisys 5+ cameras
- 4 210c Video cameras



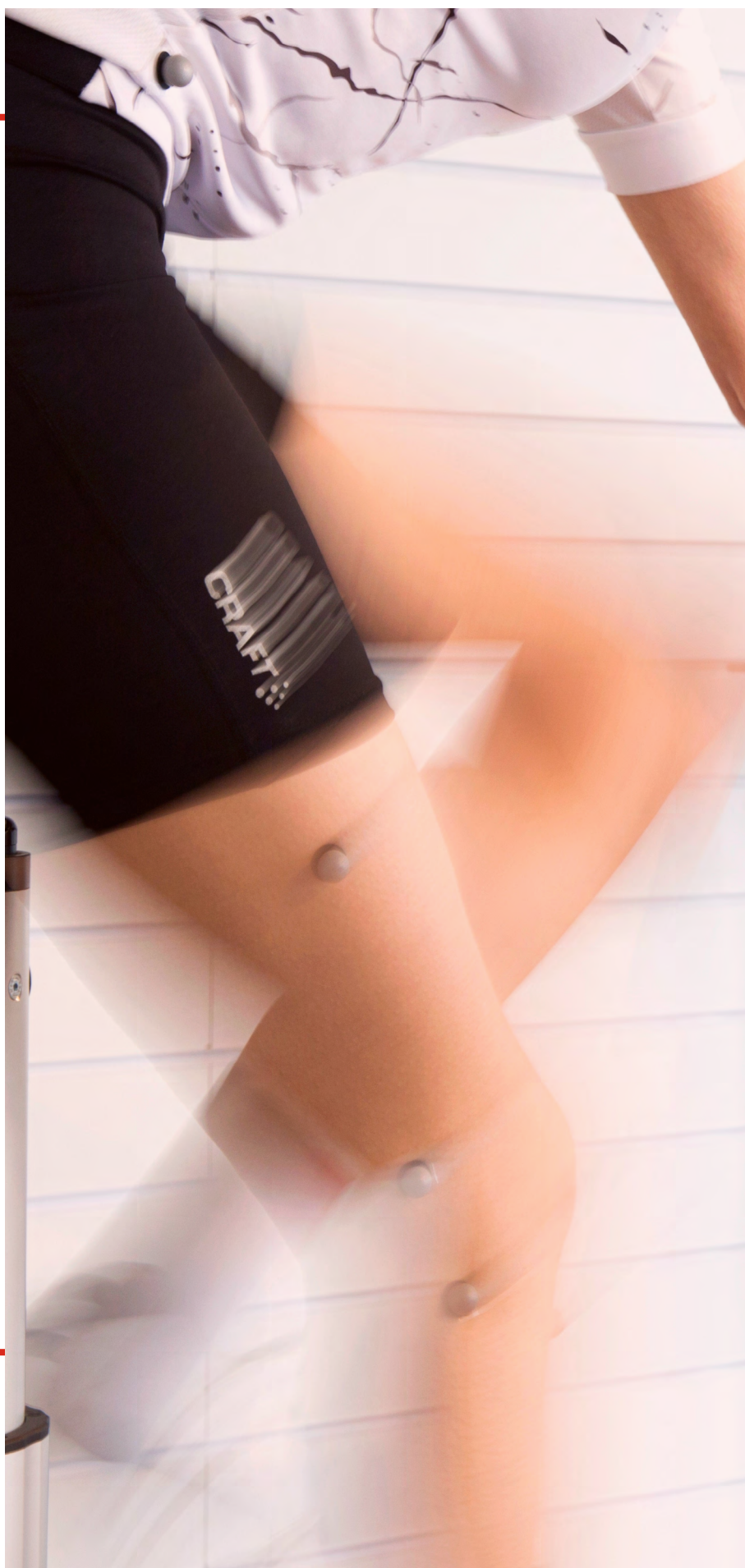
"I have used Qualisys for many studies, such as gait analysis and product ergonomics design evaluation, for example, tracking finger movement when operating mobile apps. Qualisys is an accurate and efficient measurement tool."

Terry Liu

Associate Professor – CNIS



中国标准化研究院
CHINA NATIONAL INSTITUTE OF STANDARDIZATION



The Evolution of Bike Fitting

In the past, a podiatry practice, although commonly equipped with some instrumentation such as pressure plates or 2D video, would not have been the most common candidate for investing in a fully-featured motion capture system.

However, owner of Le Bras podiatry, Sébastien Le Bras, is not your ordinary podiatrist and Qualisys is not your average motion capture system. Thanks to the Qualisys sport modules and their web report format, capture and analysis can be an easy and automated practice and the evaluation is comprehensive and in depth with its findings. With the cycling module especially, Sébastien has been able to expand his business and fit athletes from various regions of France.

PIONEER OF CYCLING ANALYSIS

A seasoned expert in all aspects of lower limb biomechanics, Sébastien has been investing in his clinic for years together with his business partners, to turn it into a pioneering

biomechanical evaluation center. In addition to the usual pathologies and annoyances dealt with in similar clinics, Sébastien has built an amazing expertise in the field of human movement, which he is using to support a wide variety of patients.

Among his visitors, professional and semi-professional athletes have become quite common, especially in the cycling community in the French region of Brittany, where the clinic is located, and where cycling is a religion.

DATA-DRIVEN RESULTS

The outcome can be training advice, custom-made insoles manufactured on-site, adjustments to a bike or pair of running shoes, physical therapy – also provided on site, or coaching sessions offered at the clinic. The most rewarding of all is when he receives a phone call from MDs about a patient, who had been through every single treatment and medicine, but continued showing a history of repeated injuries before visiting.

“Investing in a Qualisys motion capture system was a natural evolution of my assessment arsenal.”

Sébastien Le Bras

Owner, Le Bras podiatry



A Need for Speed and Efficiency

Amer Sports, a global corporation and one of the global leaders in the sports gear industry, has installed the HQ of one of its iconic brands, Salomon, as well as R&D for others like Mavic and Wilson.

The facility decided to invest in the R & D sector and construct a new lab equipped with the best instrumentation. To achieve this, they initiated a collaboration with Trinoma (Qualisys' French distributor), to select the right equipment and software, install it and train the team.

RESEARCH & DEVELOPMENT

It is now possible for the group to study the movements of the human body in real-time. Of course, the lower extremity is of specific importance when designing elite performance shoes and protecting runners from injuries. Every new concept and every modification to a product can be tested quickly, objectively and accurately with the Qualisys system, combined with Delsys EMG, force plates and Visual 3D software.

The advanced technical support and training, combined with highly automated processes implemented in Qualisys Track Manager and Visual3D offer essential efficiency to the Amer Sports team. Their approach is the same as in academic research, therefore the team is composed of doctoral students and PhDs, many of which have

completed their PhD coursework at Amer Sports together with University partners.

Once the athlete is up and running on the treadmill, 8 Qualisys 7+ cameras that surround the subject determine the 3D position of the markers placed on the athlete's body. An image of the action is then rendered in real time. The collected data allows the modeling of his skeleton in 3D and the visualization of the stress suffered by his body during the activity. The team is able to, for instance, define the position of flexion lines under the sole of the runner's shoe.

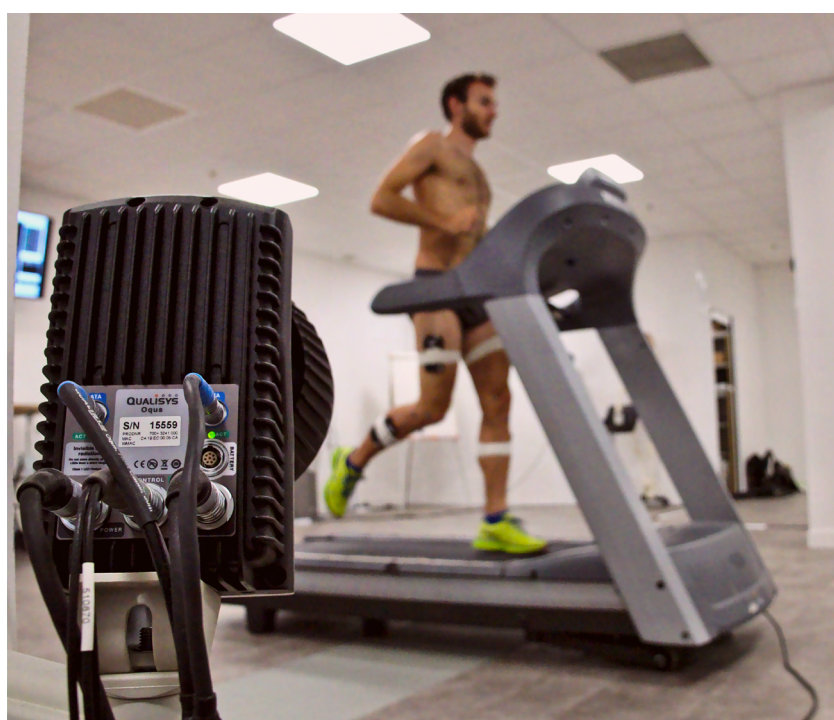
MORE THAN JUST A RUNNING ANALYSIS

Thanks to the system, research in the field of cycling can also be performed efficiently to improve or

validate new sport equipment. Other activities offered by some of the group's products, such as walking with the Salomon trekking range or tennis gear from the Wilson product line also benefit from the Qualisys technology. In a world where competition forces us to go faster, these enthusiasts can rely on an effective system to meet deadlines without sacrificing innovation, performance and safety for their upcoming products.

SYSTEM SETUP

- 8 Qualisys 7+ cameras
- Qualisys Track Manager
- Running PAF Module
- Visual 3D
- Delsys EMG
- Force Plates









A Space for Robotic Discovery

M-Air is a four-story, outdoor netted facility that enables the scientific study of autonomy and collaborative robotics in the complete range of Michigan weather, from below 0°F /-18°C winters to high humidity summers with all the snow, rain, hail, and sleet that comes throughout the year. Qualisys' protected cameras allow the group to study outdoors and in extreme weather conditions.

Research at M-Air involves resilient algorithms, which preserve the safety and security of multi-agent systems. They study algorithms which allow robots to achieve certain goals even if some of the robots are hacked, faulty, or broken. The lab space itself is too small to use very many agents simultaneously, so M-Air provides more space for performing complex tasks with multi-agent teams.

Located next door to the new Ford Robotics Building, it offers a home to roboticists from across the the University of Michigan to collaborate and contribute to one another's work, enhancing and accelerating the robotic solutions that can serve society.



FACING EXTREME WEATHER

The Qualisys 7+ cameras allow the group to study outdoors and in the extreme weather condition. The space holds 36 Qualisys 7+ IP67 Protected cameras, for extensive autonomous flight and vehicular tracking experiences.

The outdoor location allows the group to test algorithms in more realistic environments than can be simulated indoors, including testing quadrotors in windy conditions and ground robots on outdoor surfaces for realistic ground and air patterns.

GROUND TRUTH DATA

One particular experiment analyzed the accuracy of a state estimator running on the robot. Motion capture from M-Air served as ground truth. As the subject walked, the system estimated the robot's 3D orientation, position, and velocity using IMU, joint encoder, and contact measurements, presented with several plots attached comparing the state estimates vs. ground truth from the Qualisys motion capture system.

"The large outdoor space in which the robots can operate allows us to test longer experiments without having to worry about accidentally leaving the area - all covered by the Qualisys system."

Ross Hartley

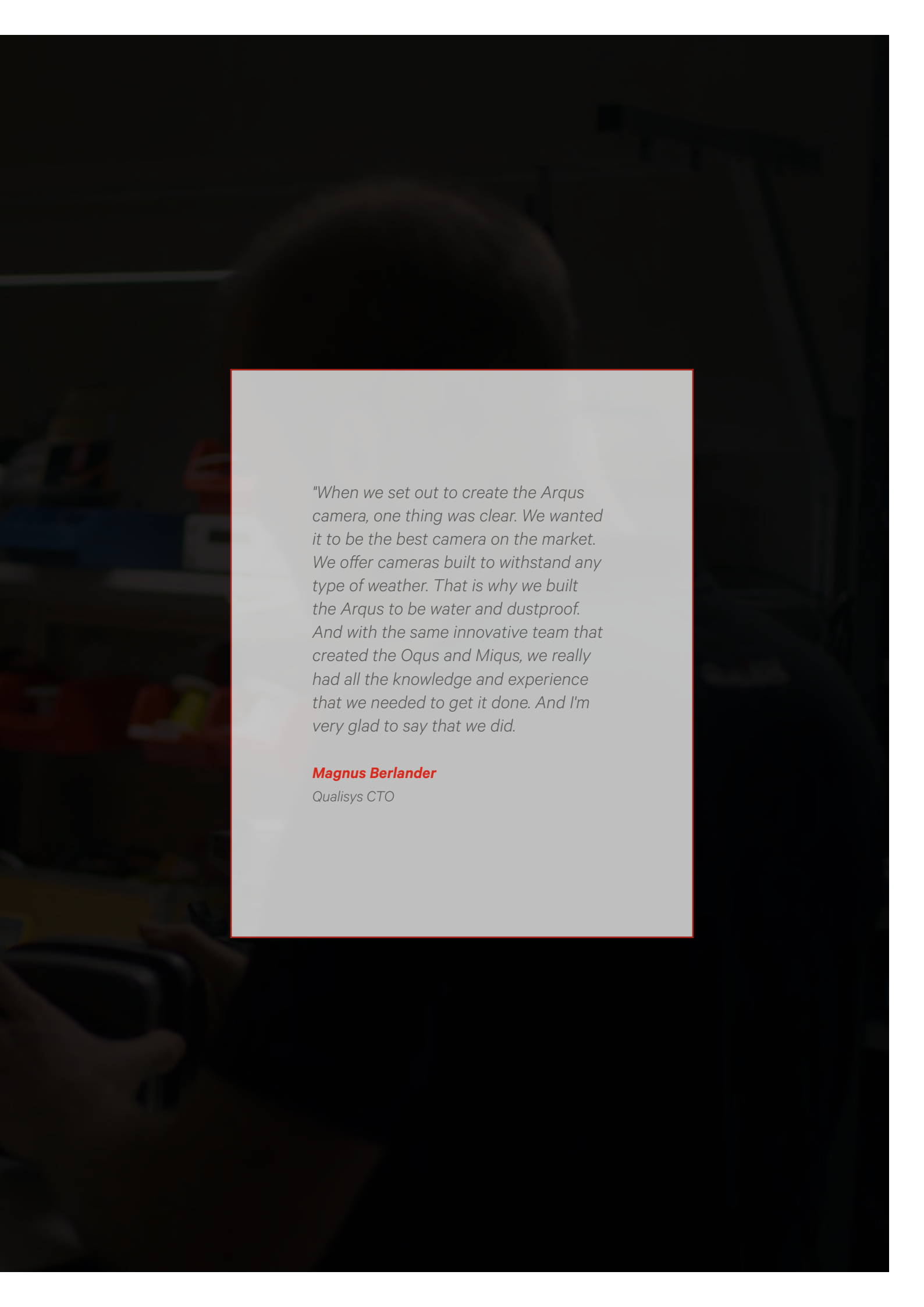
University of Michigan, M-Air

FUTURE WORK

The stories enclosed stories are customer cases submitted prior to the launch of our newest camera platform, the Arqus. Stay tuned for our next volume, which will feature customers that work with the Arqus motion camera platform, and read about the industry's highest performing motion capture camera by visiting

www.qualisys.com/hardware/arqus.





"When we set out to create the Arqus camera, one thing was clear. We wanted it to be the best camera on the market. We offer cameras built to withstand any type of weather. That is why we built the Arqus to be water and dustproof. And with the same innovative team that created the Oqus and Miquis, we really had all the knowledge and experience that we needed to get it done. And I'm very glad to say that we did."

Magnus Berlander

Qualisys CTO

**Qualisys**

www.qualisys.com
sales@qualisys.com

**Qualisys Europe (HQ)**

Kvarnbergsgatan 2
411 05 Gothenburg
Sweden

Qualisys Americas

1603 Barclay Blvd
Buffalo Grove Illinois
60089 USA

Qualisys Asia Pacific

Suite 2611, 26F New Town Center Bldg
83 Lou Shan Guan Road
Shanghai PRC, 200336