

FEET IN THE CLOUD

Digital Orthopaedics is developing cloud-enabled modeling and simulation tools for foot surgeons and their patients

The résumés of surgeons Bruno Ferré and Thibaut Leemrijse demonstrate an impressive mastery of orthopedic surgery focused on the highly complex foot and ankle. Their extensive research and academic credentials, in their native France and Belgium as well as internationally, clearly identify them as leaders in their field. Both of them remain full-time orthopedic surgeons (Dr Ferré in a private hospital in Monaco, Dr. Leemrijse at the Foot and Ankle Institute he co-founded in Brussels). Yet not content to rest on their laurels, the two joined forces in 2016 to create a startup company called Digital Orthopaedics. Their CEO is Eric Halioua, a serial entrepreneur in the Life Sciences industry who holds Masters Degrees in pharmacology, biology and business administration. The young company's goal is to develop a cloud-based, comprehensive Clinical Decision Support System that will enable orthopedic surgeons to personalize the planning and execution of orthopedic surgeries for patients anywhere in the world.

When the Digital Orthopaedics team reached out to SIMULIA for an Abaqus license, they learned about the 3DEXPERIENCE Lab, applied, and were accepted into the Dassault Systèmes' accelerator program. Their company is currently developing models of healthy and diseased feet using CATIA, Simpack, and Abaqus and building the algorithms that will power their proprietary decision-support system through the 3DEXPERIENCE platform on the cloud.

SCN interviewed Dr. Ferré and Mr. Halioua separately; the following Q&A brings together some of their comments about their exiting new venture.

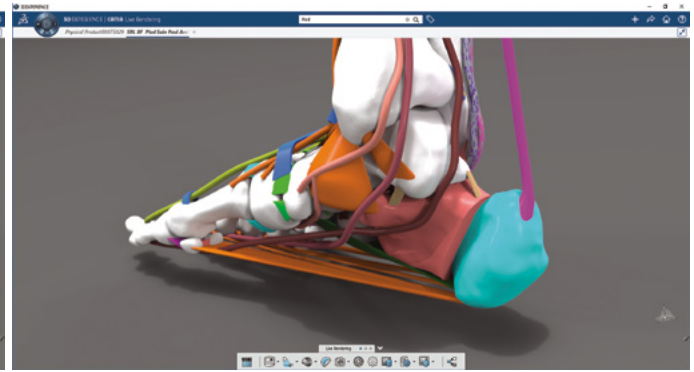
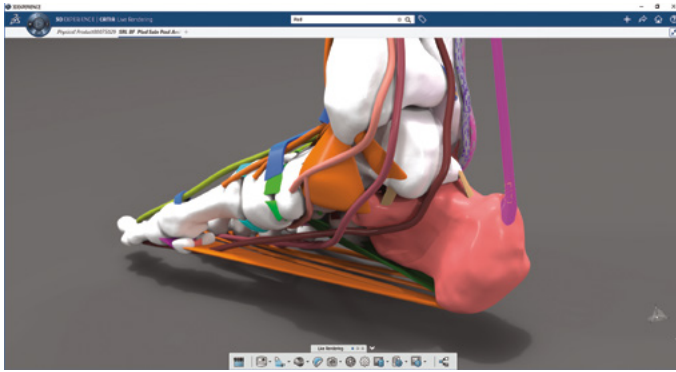
Why the focus on the foot?

Ferré: About ten years ago I switched to feet—after decades of performing lower-limb surgery and implanting thousands of hip and knee prostheses—because I saw the foot as an exciting intellectual challenge. It's a highly complex structure, both anatomically and functionally. Anatomically there are 28 bones interfacing with cartilages around 40 joints defined by more than 100 ligaments and driven by more than 30 tendons. Functionally, foot movement varies a lot depending on the muscular activation of each patient for every gait scenario—walking, running, jumping and so on. I'd been studying

digital modeling for a number of years and I realized that the complexity of the foot could be best interpreted using realistic simulation.

What made you and Dr. Leemrijse decide to create your company?

Ferré: Dr. Leemrijse and I have known each other for a long time. He's an extremely brilliant spirit who shares the same curiosity as I do and an understanding of the critical importance of shared knowledge. Together we realized that imaging, modeling and simulation presented an opportunity to truly advance diagnosis and treatment for foot surgeons and their patients. It just seemed natural to join together to form a company to achieve this!



What is the long-term goal of Digital Orthopaedics?

Halioua: We are on a journey to transform the planning and execution of orthopedic surgeries and treatment by personalizing Precision Medicine. This disruptive technology will change current one-type-treatment-suits-all thinking to a personalized therapeutic approach that takes into account the patient's unique anatomy and functional entities. We are creating the framework necessary for developing CT- and MRI-scan based, patient-specific, 3D digital models to be used to diagnose injuries and abnormalities, identify optimum treatments for every patient, and simulate surgery in silico in each patient's virtual 3D twin. We'll provide this framework in the form of a three-part platform offering of Knowledge Base and Diagnosis Support, Personalized 3D Surgical Simulation, and Machine Learning and Clinical Cases.

We are in the middle stages of development, not commercialized yet, but we have already received ISO 13485 certification for quality assurance of our services, which are considered a medical device. We've filed for a patent, will apply for European CE certification, and are in the process of preparing an FDA application as well.

So how does the 3DEXPERIENCE on the cloud help your company achieve its objectives?

Halioua: Our vision is to offer all our services completely on the cloud—which is really mandatory in order to be fully functional, and cost-effective, with the amount of HPC capacity required. Close collaboration between engineers and medical teams in an interdisciplinary group is key to success in this area. In order to share tools and techniques among surgeons and hospitals worldwide, we have to be on the cloud.

We are in the process of adapting our services to the **3DEXPERIENCE** platform on the cloud, which will be a key enabler to our success because it offers:

- The framework necessary to capture and automate the “medical image to 3D model to realistic simulation” workflow
- The potential to connect to hospital imaging systems and enable a clinical decision-making service to orthopedic surgeons worldwide
- Efficient development, testing and deployment of custom solutions for clinical services
- Collaboration and sharing of ideas and feedback within our user community of physicians and engineers

For us, being on the cloud is the only way to reach the surgeons, who don't want to invest in a machine or device—they just want quick access to solutions via a web interface that is easy to use and very ergonomic.

Talk about what Dassault Systèmes tools you're using to develop your own offerings and how these capabilities can help advance medicine in general.

Ferré: The existing medical treatises on physiology and biomechanics of the foot are not sufficient to capture the dynamic phenomena of everything the foot of a living human being can do. Dassault Systèmes helps us organize our accumulated knowledge with algorithms that work inside that knowledge.

In the capabilities of Dassault Systèmes are all the processes of physics needed to simulate the actions of cars, aircraft, and other products. This accumulated intelligence now provides my team with many tools that we can apply to simulations that can help with planning and performing orthopedic surgery.

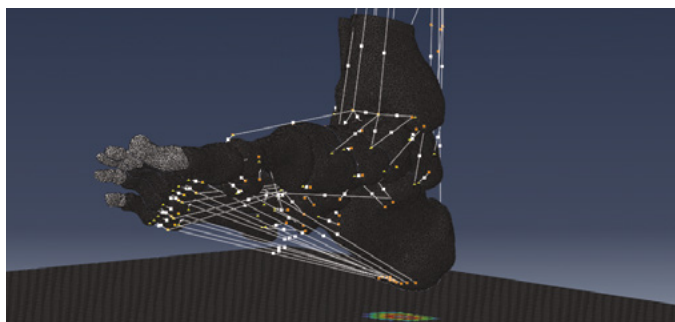
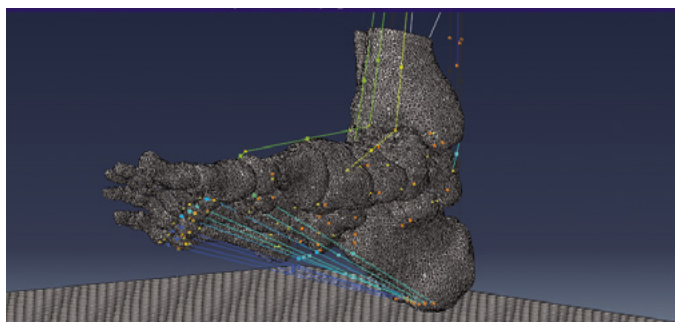
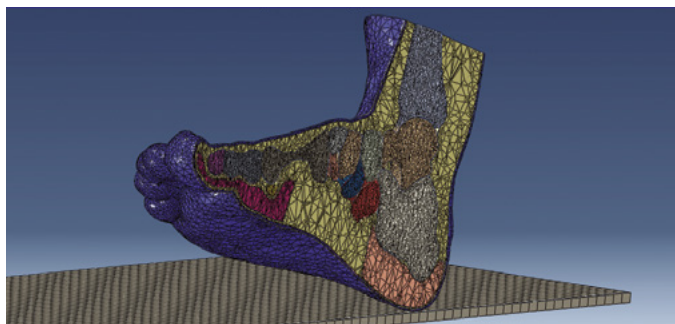
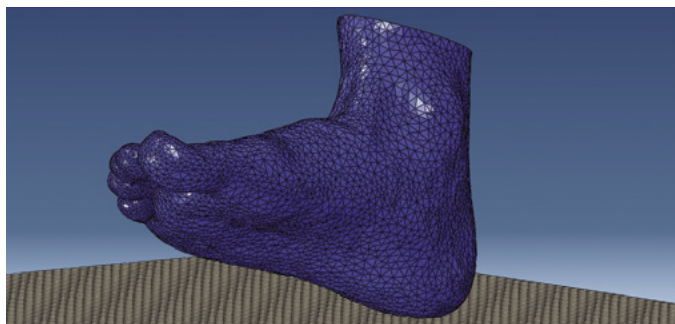
I've just recently started working with CATIA and it is really magic for creating geometries! Simpack allows us to model entire multibody systems, which helps us understand the kinematics and global displacement of the foot. That reaction force and joint kinematics data can then be used as input for FE modeling with Abaqus of the complex contact behavior between the foot and the ground, and the simulation of internal foot quantities such as joint cartilage contact pressures and tissue stress levels. For full comprehension of the entire foot, you need patient data.

Halioua: Dassault Systèmes and SIMULIA offer the entire breadth and width of solutions we need.

Ferré: Looking at the big picture, we are a simple actor within the profound change that is taking place in medicine. We're only at the beginning of this digital era of serving patients. We must continue to develop our techniques but also ensure the transmission of our knowledge and enthusiasm to the generations that follow.

We've found a similar state of mind at Dassault Systèmes and we believe they will be one of the great players of this medicine of tomorrow, just as they have been in the automotive and aviation industries.

Cover Story



What do doctors think of your vision?

Ferré: A lot of surgeons still don't fully understand the power of simulation and part of my role is to convince them of how essential it is to the advancement of medicine overall. As a surgeon myself I can explain to them how predictive simulation can help them identify the correct diagnosis for each patient, and then custom-design the best treatment for the problem.

For 2,000 years medicine has been more of an art, with doctors almost in the role of sorcerers. The influence of hard science has been accelerating in recent decades and we are now at a point where the power of data can be focused onto evidence-based medicine. While being careful to protect the proprietary biology of each patient, you can use digital data to reach a much more precise analysis of that patient's particular problem in order to come up with the appropriate solution.

Halioua: Yes, this represents a major change for many doctors, using simulation within a clinical decision support system. But these surgeons are first of all scientists, so we need to convince them that the model we're developing provides value—meaning, for example, that you will identify exactly how many millimeters of tendon you need to cut in order to remove specific constraints on the motion of the foot. Once they grasp that, they become more open to the idea. And then you need to discuss training, the right economics, user-friendliness, and speed, in order for them to reach a decision. At the end of the day in the operating room, the decision is still in the hands of the surgeons; we can help them consider surgical options, but they make the final choice.

Ferré: One thing we are seeing is that those surgeons who are already performing advanced surgeries and methodologies—piloting surgical robots, helping develop devices, and so on—are very interested in what we are doing. They already

understand that you can prepare and rehearse surgery ahead of time through simulation.

And how do patients feel about this?

Halioua: In the future healthcare system the role of the patient will be more and more important. The level of education of patients, thanks largely to the Internet, can be extremely high these days. Using simulation, the surgeon can show the patients specifically what is wrong and how they will fix it.

Ferré: When you explain this predictive medicine concept to patients, they really want this, they understand the value of treatment that is specific to their own body, and it gives them confidence in their surgeons. Everyone wants to be able to predict the good or bad consequences of a medical intervention. Modeling and simulation are essential for achieving this and are the foundation of the medicine of tomorrow.

For More Information

<http://www.digital-orthopaedics.com/>

The **3DEXPERIENCE** Lab from Dassault Systèmes is a new open innovation laboratory that merges collective intelligence with a cross-collaborative approach to foster entrepreneurship and innovation. Entrepreneurs, makers, and innovators everywhere are invited to join the **3DEXPERIENCE** Lab, a community of intelligent, creative and passionate people, focused on positively impacting society, through the creation of disruptive, groundbreaking projects. Dassault Systèmes is committed to helping them bring those projects to life, with the hopes of unleashing further progress and growth for tomorrow's world.

For More Information

<https://3dexperiencelab.3ds.com/en/homepage>