When Animation Meets Simulation

Movie-making tools help drive a virtual product evaluation using Abaqus FEA

As film animators know all too well, the human face is one of the most difficult objects to model realistically. A flexible layer of skin covers a complex array of muscles and bones, producing a seemingly endless number of subtle facial expressions.

These subtleties come alive onscreen due to the blending of live action with special effects that is pushing the animation envelope forward: Animators now use computer-based physics in much the same way that design engineers use realistic simulation.

Figure 2. Kimberly-Clark Professional Duckbill® dust mask (real and simulated).

Modeling Facial Features

Motion capture animation isn't just for making movies. "Representing the positions and movements of the human face is a big challenge in designing some of our products," says Chris Pieper, Associate Research Fellow at Kimberly-Clark Corporation, a leading global health and hygiene company.

Although the company is most known for household brands such as KLEENEX® and HUGGIES®, they also manufacture dust masks, or particle respirators, that are worn by professionals and do-it-yourselfers who are involved in woodworking, machining, and other activities that create by-products that are unhealthy to breathe. The design challenge is to make a mask that's comfortable and at the same time maintains an airtight seal against the changing shape of the face.

For Pieper and his engineering team, the simulation problem was to represent a moving deformable surface—a face—in contact with a flexible object—a dust mask. "It's crucial that the mask conform to the face," says Pieper. "The contact pressure between the mask and the face is very important to the proper function of the product and the comfort of the user." Pieper, who was familiar with motion-capture methodologies, thought that he could adapt techniques from the entertainment industry to the product development process.

From Motion Capture to Simulation

Pieper and his group looked to SIMULIA to explore how high-resolution motion-capture data could be used for virtual product design. "Abaqus FEA is well-suited for studying soft, flexible structures with complex geometry in contact," says Pieper. "The general contact feature makes problem setup easy and solutions stable."

For his analysis, Pieper drew from the computer-generated animation world. He selected Contour™ Reality Capture, a high-fidelity performance capture technology from Mova, LLC. The California-based company recently used its technology to capture the facial movements of actor Edward Norton to animate the face of the green superhero in the 2008 release The Incredible Hulk. The Mova system utilizes an array of cameras—much like contemporary marker-based systems—but also incorporates a stroboscopic fluorescent lighting set-up. The result is 100,000 3D points at 0.1mm accuracy—high resolution that realistically recreates human facial movements as well as a photographic image of the face at the same time.

The first step in creating a moving facial model for the dust mask study involved extracting surface point positions from a lower-resolution set of facial motion capture data, in an open source format called C3D used by biomechanics, animation, and gait analysis laboratories. The engineering team took the initial positions of the surface points, defined them as nodes, and completed finite element definitions using Geomagic—a surfacing software—to establish nodal connectivity. The team used a Python program to write the nodes and elements to an Abaqus input file so that they could be imported as an orphan mesh part. Using the orphan mesh as the basis for a minimal model definition, they then added a step definition and generated a sparse output database (ODB).

"The Abaqus ODB served as a kind of containment bucket for us," Pieper says. "We added all the displacement data to it to create a global model." They then used the global model to drive a submodel representing a human face undergoing a range of expressions and motions. The global ODB was completed by adding nodal displacements using the Abaqus Python scripting interface. To verify that all data was converted correctly, the team viewed the updated ODB as an animation using Abaqus (Figure 1). "Completing the global facial model was a big step all by itself," Pieper notes.

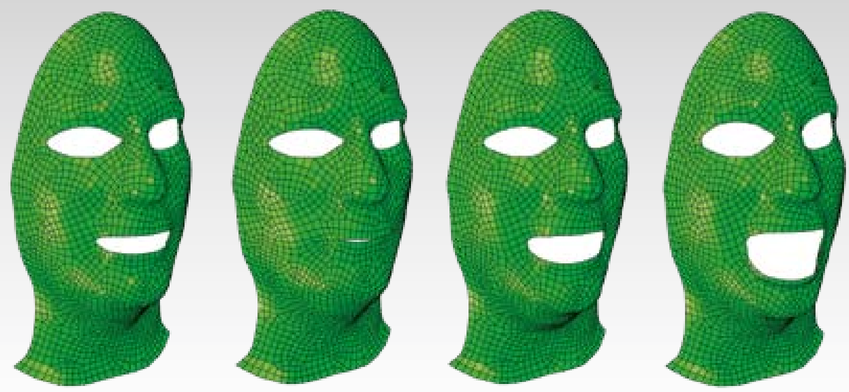

Figure 1. Visualizations of several frames from the updated output database (ODB), showing deformed shapes of the deformable surface (face) at points in time.

Figure 3. Contact pressure contours as an estimate of sealing effectiveness of dust mask on face at various points in time.

The engineering team next used the global model to drive the moving surface portion of the submodel, which included both the face and the virtual representation of the dust mask (Figure 2). As a final step in creating the finite element model, they added a submodel boundary condition and additional loads (including a pressure load on the nose piece and an inhaling load on the inner surfaces of the mask). Now the model was ready to run.

Results Get Rave Reviews

Postprocessing revealed several regions that exhibited gapping between the mask and the face—such as the areas of greatest curvature around the nose. This was evidenced by gaps in contact pressure contours (Figure 3), suggesting the need for design changes. "This type of product evaluation is extremely difficult using real human subjects and physical measurements," Pieper points out. "This demonstrates how simulation gives designers the means to rapidly evaluate the benefits of each alternative. We look to these simulations to help us narrow the field of design possibilities, so that when we do testing with human subjects, we are only looking at the design finalists," says Pieper. "That can really shrink the product design cycle."

While the dust mask simulation was a feasibility study and has not yet been fully validated, Pieper sees the value of marrying motion-capture with simulation to model what he calls "living surfaces"—complex moving surfaces that are not easily described mathematically. "The technique provides a new way of representing a complex moving surface as a boundary condition or constraint in a simulation," he concludes. "This methodology will certainly be useful and feasible for applications that haven't even been considered yet."

Chris Pieper is an Associate Research Fellow for Kimberly-Clark (K-C) corporation in their Corporate Research and Engineering group. Chris joined K-C in 1987 and started using Abaqus in 1995. Since that time he has been devoted to virtual product simulation and is responsible for developing and automating simulation processes. Chris earned his BS and MS in Mechanical Engineering at the University of Wisconsin - Madison.

For More Information

www.kimberly-clark.com
www.simulia.com/cust_ref