KEYNOTE TALK

Tuesday, October 22, 2024 at 9am

Anatomically-Based Hand Simulation

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Abstract: I will present the multi-year efforts on modeling and animating human hands, performed in my laboratory at USC. Hands are important in many applications, such as computer games, film, ergonomic design, tracking, and medical treatment. I will discuss how to acquire complete human hand anatomy in multiple poses using magnetic resonance imaging (MRI). Acquiring human hand anatomy in multiple poses was previously difficult because MRI scans must be long for high-precision results (over 10 minutes), and because humans cannot hold their hands perfectly still in non-trivial and badly supported poses. We invented a manufacturing process whereby lifecasting materials commonly employed in film special effects industry are used to stabilize the hand during MRI scanning. We demonstrate how to efficiently segment the MRI scans into individual bone, muscle, tendon, ligament, fat and skin meshes in all poses, and how to correspond each organ's mesh to the same mesh connectivity across all scanned poses. Next, we give a method to simulate the volumetric shape of the organs to any pose in the hand's range of motion, producing both external skin shapes and internal organ shapes that match ground truth optical scans and medical images (MRI) in multiple scanned poses. We achieve this by combining MRI images in multiple hand poses with FEM multibody nonlinear elasto-plastic simulation. This enables us to start with an arbitrary animation of the hand joint hierarchy, and produce a matching high-quality skin and internal organ animation of the hand. Our system models bones, muscles, tendons, ligaments and fat as separate volumetric organs that mechanically interact through contact and attachments, and whose shape matches medical images (MRI) in the MRI-scanned hand poses. We use our method to produce volumetric renders of the internal anatomy of the human hand in motion, and to compute and render highly realistic hand surface shapes.

Speaker Bio-Sketch: Jernej Barbic is a Full Professor of Computer Science at USC. His interests include computer graphics, animation, interactive physics, haptic rendering, visual effects for film, medical simulation and imaging, deformable objects, biomechanics, sound simulation, model reduction, intellectual property law and startup companies. He has published over 50 publications in computer graphics and related fields. He was also a co-founder and CTO of a successful computer animation startup company "Ziva Dynamics" (acquired by Unity Technologies), whereby he contributed technical and business leadership on real-time character deformation, anatomically based modeling, nonlinear elasticity and digital humans. In 2014, he was named a Sloan Research Fellow. In 2011, MIT Technology Review named him one of the Top 35 Innovators under the age of 35 in the world (TR35). Jernej is also the author of Vega FEM, a free C/C++ software physics library for deformable object simulation. He received his Ph.D. from CMU, followed by Postdoctoral Research at MIT.