VIRTUAL SOLDIER RESEARCH

HUMAN FACTORS ENGINEERING

THE UNIVERSITY OF IOWA
College of Engineering
Virtual Soldier Research

WHO WE ARE

Virtual Soldier Research (VSR) is a world-class research organization comprised of a multi-disciplinary team of faculty, professional staff, and students. Our expertise spans a variety of fields, including computer science, computer graphics, physiology, engineering, biomechanics, robotics, and optimization. VSR balances cutting-edge research with customer-driven product development in the field of digital human modeling (DHM). As an independent research group within the University of Iowa College of Engineering’s Center for Computer-Aided Design (CCAD), VSR was established to develop new technologies in digital human modeling and simulation.

VSR has pushed forward the field of DHM by conducting novel research and creating new technology that predicts human posture, motion, and other functions in a high-fidelity, physics-based, three-dimensional, real-time environment. The inclusion of real-world constraints such as gravity, muscle fatigue, muscle strength, clothing restrictions, material properties, and physical restrictions in all of our models allows us to create the most realistic pre-production test environment. However, VSR’s digital human model, Santos™, is not just an independent software tool; it is a platform for growth, integration, and collaboration.

In addition, VSR has successfully secured long-term strategic partnerships with Department of Defense (DoD) agencies as well as private industries that work with us in our development and deployment of technologies designed to test products and manufacturing processes from a human-centric perspective. Our success has led to the spin-off of an innovative private company, Santos Human, Inc., specifically focused on product development.
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Cutting-Edge Research

VSR creates technologies that provide a virtual environment for physics-based digital human modeling and simulation at the highest level of fidelity and realism. Our research efforts have made us world leaders in the areas of:

- Human Performance/Human Systems Integration
- Posture Prediction
- Predictive Dynamics (motion prediction)
- Multi-Scale Modeling
- Task Simulation and Analysis
- Physical Gait, both walking and running
- Muscle and Physiological Modeling
- Dynamic Strength and Fatigue
- Whole-Body Vibration
- Body Armor Design and Analysis
- Warfighter Fightability and Survivability
- Clothing and Fabric Modeling
- Hand Modeling
- Intuitive Interfaces
- Motion Capture Technology
- Real-Time Simulation and Virtual Reality
- Validation
What Makes Us Unique

The Virtual Soldier Research Program combines leading scientists, engineers, and programmers within the ideal multi-disciplinary and collaborative environment for sustained cutting-edge research and development in the field of digital human modeling.

OUR PEOPLE

Linking industry to some of the brightest minds in academia, VSR is able to advance the limits of digital human modeling and simulation on an ever-increasing scale, and our people are our greatest asset:

- Dr. Karim Abdel-Malek, Founder and Director of the Virtual Soldier Research Program, serves as the director of the Center for Computer-Aided Design. Dr. Abdel-Malek’s basic research in robotic manipulator kinematics/dynamics has led to the underlying formulations for human prediction. In conjunction with Professor Jasbir Arora and their students, the basic science of predictive dynamics was developed and has made a significant impact on how digital humans predict physics-based motion.

- Dr. Jasbir Arora, Co-founder, Associate Director of the Virtual Soldier Research Program, and F. Wendell Miller Professor of Civil, Mechanical, and Industrial Engineering, is an international expert in numerical optimization, numerical analysis, and real-time implementation. Dr. Arora leads the efforts to develop numerical algorithms for implementation in digital human models and provides leadership for the entire VSR research enterprise.

- Dr. Timothy Marler, VSR’s Senior Research Scientist, works with predictive human models, developing optimization-based posture prediction capabilities and new methods and techniques for multi-objective optimization. Dr. Marler is the Program Manager for several industry- and military-funded programs. He coordinates and develops large-scale projects to advance the VSR research portfolio and state-of-the-art research.

VSR History

VSR is one of seven groups within the Center for Computer-Aided Design, which was founded at The University of Iowa in 1981 by Prof. Edward J. Haug and is currently under the direction of Dr. Karim Abdel-Malek. CCAD is a world-class modeling and simulation research center with almost 30 years of success working with DoD, other government agencies, and public companies. With over 100 researchers, CCAD is a well-established, dynamic, multifaceted research environment that encompasses not only VSR, but also the Operator Performance Lab (OPL), the Biomechanical Soft Tissue Lab (BioMost), the Reliability and Sensory Prognostic Systems Lab (RSPS), the Musculoskeletal Imaging Modeling and Experimentation Lab (MimX), the 3D-Biomotion Research Lab (3DBMRL), and the National Advanced Driving Simulator (NADS), all of which focus on modeling and simulation of complex 3D, physics-based challenges.

VSR was founded in 2003 through external funding from the US Army Tank Automotive Command (TACOM) to put the Warfighter at the center of US Army product designs. Using this initial research and funding as a foundation, VSR continues to cultivate and develop research programs in digital human modeling and simulation with those who share our vision.
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- Dr. Salam Rahmatalla, an expert in structural optimization and human motion, has brought his expertise in optimization, structural analysis and control, and human motion analysis and validation for human response to whole-body vibration.

- Dr. Laura Frey Law, with her background in engineering and physical therapy, contributes expertise in human physiological assessment and modeling, developing joint-level models of dynamic strength and fatigue.

- Dr. Jia Lu, an expert in computational mechanics and biomechanics, brings to the team expertise in modeling skeletal muscle, flesh, and cloth, as well as advanced simulation technologies for the mechanical analysis of such systems.

- Mr. Rich Lineback, Program Advisor for VSR with 25-plus years of industry experience in software development and deployment in support of government and commercial clients, works with prospective clients to envision mutually beneficial research and development efforts that leverage VSR capabilities and technology to address client needs.

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Our Approach

VSR focuses on predictive capabilities that provide significant feedback in the use of DHM and have resulted in the creation of technology that predicts human posture and motion for digital humans in a high-fidelity, physics-based, three-dimensional environment. Our approach to DHM allows us to answer questions such as, how long can a human perform a given task, how many humans are needed to complete a task, is a particular task safe, what effects will increased protective clothing have on human effectiveness, and what is the level of fatigue, energy, oxygen consumption, etc. to perform a task? Consequently, one can see the results of trade-off analyses with altered parameters and conditions, in terms of visual simulations and in terms of numerical metrics. While much of this research focuses on Warfighter effectiveness, this state-of-the-art digital human modeling and simulation tool is also providing our civilian partners with the ability to reveal deficiencies and envision improvements for products and processes that are not typically evident until after extensive time and resources have already been expended on production and deployment.

Our methodology for DHM is physics-based, meaning the laws of physics are inherently considered in all of our predictive models. In addition, our approach is task-based, meaning we can model and study the behavior that stems from different types of tasks. Furthermore, these studies can be conducted in real time on a standard PC. Finally, the fidelity is superior with respect to musculoskeletal models and visualization. Essentially, our virtual human, Santos™, has been specifically designed for human-centric trade-off analysis.

Our Product

While Santos™ is the most visually realistic and highest-fidelity digital human model available, what makes Santos™ unique compared to all other currently available human models is the suite of interconnected, real-time, validated, physics-based, predictive capabilities, as well as the foundation it provides for the most comprehensive multi-scale digital human. The use of these novel optimization-based modeling and simulation techniques allows our digital humans to predict how and why humans perform.

In addition, VSR is unique as an academic lab in its ability to balance cutting-edge, multi-disciplinary research in a highly collaborative environment with customer-driven, easy-to-use, intuitive software interfaces. The Santos™ environment has been meticulously designed and developed by a dedicated team of professional software engineers and developers with over 30 years of combined experience in the computer games industry. Consequently, VSR provides a software foundation that is scalable, extensible, and future-proof. This, coupled with our joint- and physics-based, predictive approach to DHM and the optimization structure used in the research, provides an ideal platform for creating a complete multi-scale human model as a system of systems that saves time, saves money, and saves lives.

Partnering with VSR

The benefits to partnering with VSR go beyond the novel research and the products that this research fuels. As an integral part of The University of Iowa, VSR draws on expertise from other university groups such as the Center for Computer-Aided Design, which houses multiple modeling and simulation groups, and the University of Iowa Hospitals and Clinics (one of the largest teaching hospitals in the nation). In addition, VSR brings with it a long history of industry and military research partners, meaning that new efforts are able to leverage previously funded work. Given that the majority of the funded work ultimately integrates with the Santos™ software, our partners play a role in shaping the human modeling software, providing input on the ground floor.

Our research partners take advantage of over $35 million in prior research and development, key University of Iowa faculty and staff who continue to develop the Santos technology, and a broad network of experienced medical researchers. Work is focused on extending, developing, and applying tools and technology to address each research partner’s specific problems. Through their involvement, our research partners help shape the future of the world’s most advanced digital human modeling and simulation environment, while VSR develops in-house expertise and future corporate resources fully versed in the use of our technology applied to the research partner’s domain.

VSR’s partners include:

- US Army TARDEC
- US Army Natick Soldier Research, Development, and Engineering Center (NSRDEC)
- Office of Naval Research
- Naval Health Research Center
- Naval Air Systems Command
- Caterpillar Corp.
- Medtronic, Inc.
- Rockwell Collins, Inc.
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“The next generation of human modeling and simulation begins when you’re ready.”

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