

## Can the real-life user be replaced by a digital model?

User testing with prototypes can provide invaluable ergonomic data in design. But, when the physical ergonomics of a complex or dangerous system is being considered, prototype testing, especially early in the design process, can be prohibitively complicated and expensive.

A solution proposed by US company SantosHuman Inc is to use a digital human model (DHM) such as Santos.

Santos models the human body as a kinematic system, a series of links connected by rotation degrees of freedom (DoF) that collectively represent musculoskeletal joints such as the wrist, elbow, vertebra or shoulder. Each DoF corresponds to one kinematic revolute joint and these revolute joints can be combined to model various musculoskeletal joints. In the case of Santos, it has 109 predictive DoF, as well as approximately 209 DoF for manual manipulation.

Santos was originally developed by the Virtual Soldier Research Program (VSR), an independent research group within the Center for Computer-Aided Design at the University of Iowa.

Although dynamic analysis is a broad and well developed field, Santos claims to have also developed 'predictive dynamics'. While forward dynamics provides kinematics data for given forces and inverse dynamics yields forces for given kinematics data, predictive dynamics, the company explains, uses optimisation to provide forces and kinematics data simultaneously.

The model is designed to predict dynamic human motion without pre-recorded data and while considering strength fatigue. The progress of the human model through the task can be monitored visually by way of alerts that indicate if, for example, he has fallen, and by monitoring vitals such as heartbeat, blood pressure and metabolism.

An example of how the model can be used is a project in which the force exerted on a pilot by his helmet during flight manoeuvres was investigated. The Santos environment was used to capture data showing the difference in neck strain for a range of helmet weight, centre of mass and pilot positions.

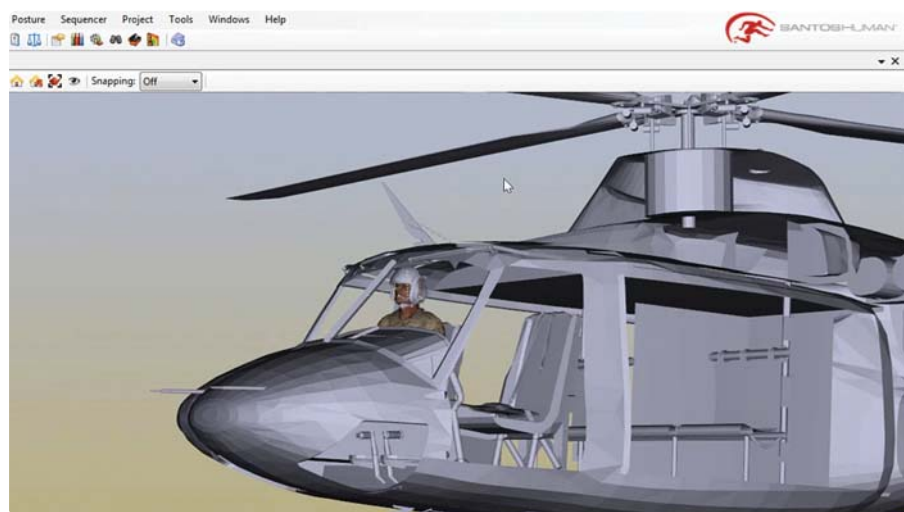
According to SantosHuman Inc., their product "offers an opportunity to conduct ergonomic and human factors studies before actual prototyping, significantly enhancing trials, accelerating assessment and providing a highly instrumented environment."

The model has so far been used for a large number of military simulations, to predict, for example, how a soldier would escape from an overturned tank. It has also been used by Chrysler, General Motors and Caterpillar, among others.

While the model generates an impressive amount of data, it cannot currently provide feedback about how difficult a task

feels in the real world. In an attempt to address this limitation, there is research underway in the VSR group to determine the relationship between human muscle strength capacity and the ability to perform given tasks.

The aim of the research is to give more realistic simulations by limiting it to reasonable human strength capabilities and providing a measure of 'perceived difficulty' by the digital human.



The process of developing models such as Santos has provided an enormous amount of insight into how the human body moves, operates and deals with physical stress and so is very useful for understanding the mechanics of particular tasks. The standard NIOSH equation, for example, allows for simple assessments of straightforward manual lifting tasks in order to identify ergonomic solutions for reducing physical stresses and preventing back pain.

There are, however, clear limitations to the usefulness of the data currently generated by DHMs like Santos. While they can tell you that a person will not be injured by a particular rollercoaster they cannot predict whether that rollercoaster will be enjoyable, or perhaps too scary for children.

The ongoing research does attempt to provide more insight into the subjective experience of a particular activity, but there are so many assumptions that go into a simulation and so many variables that can't be accounted for that any data generated can only be said to provide an approximate picture of reality.

Researchers at the VSR claim that in the future the Santos model will be able to give full insight into the lived experience of working with a particular design. But for the moment it seems that in order to understand the full, context-dependent human experience the real-life user is still hard to beat.