SANTOSHUMAN®

Virtual Human-in-the-Loop Solutions

Santos® AFF Plug-In

A New Method for Predicting Manual Arm Strength

Given that most tasks are performed with the hands, manual arm strength (MAS) is relevant for most task analyses, and is the limiting factor for many of them. Current ergonomics software packages generally predict strength demands in a similar way. First, they estimate the reaction moments required about three axes at the shoulder, one axis at the elbow and up to three axes at the forearm/wrist, to balance the moments caused by the weights of arm segments and the external force applied at the hand. Then, the required moments are compared to the selected population's strength values, which are estimated for each joint axis with equations based on empirical strength data. However, this current method has substantial limitations that can adversely affect the validity of its MAS estimates, including:

- The strength equations are based on empirical data that are typically from old studies, particularly for the shoulder
- The errors from multiple strength prediction equations (up to 7 axes), can be compounded when predicting a single MAS value
- The strength, produced about any axis at a joint, is assumed to be independent of the strength requirements about any of the other two axes
- For the shoulder and wrist joints, it assumes that the changes in strength resulting from a rotation about one axis, do not interact with the rotations about the other two axes.

The Arm Force Field (AFF) method was developed by Nick La Delfa and Jim Potvin (one of SantosHuman Inc.'s Technical Consultants) at McMaster University, as an alternative to current methods. The AFF uses an artificial neural network to predict manual arm strength (MAS), based on the location of the hand with respect to the shoulder, the direction of the applied force and the orientation of the torso. **This superior method of predicting manual arm strength is currently available within Santos® Pro and will also be bundled with the soon to be available product, Santos® Lite.**

SHI's success is tied directly to our clients' success and the **Santos® AFF Plug-In** represents yet another way in which we strive to match our state of the art, human-centric, virtual product design and analysis methods, technologies, and resources with client requirements.

	All Santos® Technologies Developed Since 2003 including a Comprehensive Suite of Literature and Physics-based Analysis Capabilities	Santos® Technologies Developed Specifically for Warfighter Equipment Configuration Management	**A Basic Santos® Predictive Model that can assess the % of a population capable of performing a task at an easily affordable price**	Provides Application Developers with a key Santos® Predictive Model for Human Simulation
Santos® Pro	✓			
Santos® ETOWL		✓		
Santos® Lite			✓	
Santos® PMP SDK				✓

Potvin's lab collected MAS data in multiple studies over a ten-year period, with a total of 36 hand locations in the full reach envelope, with between 6 and 27 force directions at each hand location, for a total of 536 (average n = 25 female subjects per condition) (*Freeman & Potvin, 2008; La Delfa et al, 2014; La Delfa, 2015; La Delfa & Potvin, 2016; La Delfa & Potvin, submitted*). The AFF method predicted the MAS values very well (r^2 = 0.97, RMSD = 5.2 N, n = 456) and maintained good generalizability with external validation data (r^2 = 0.842, RMSD = 13.1 N, n = 80).

The research will be published in Applied Ergonomics in March 2017 but is available now online at:

- http://www.sciencedirect.com/science/article/pii/S0003687016302095

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