About Me

Education:

B.S., M.S and Ph.D (2015) in Purdue University

Research Interests:

• Design Theory and Methods
• Digital Human Modeling
• Human Factors Engineering
• Systems Engineering
• Product Design and Development
• Industrial Design

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About Me

Design Theory and Methods
Systems Engineering

Human Factors Engineering

Digital Human Modeling

http://www.onandemirel.com/3-research-2/3-2-themes/3-2-2-design-theory-and-methods/
http://www.onandemirel.com/3-research-2/3-2-themes/3-2-3-human-factors-engineering/
http://www.onandemirel.com/project/human-in-the-loop-vehicle-design/
WHAT IS DIGITAL HUMAN MODELING?
Digital Human Modeling

*What is it?*

**What is DHM?**

- is digital representation of the human inserted into a simulation or a virtual environment to facilitate prediction of **safety** and/or **performance**.

- includes:
  - visualization (**form**)  
  - math/science (**function**)  

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Digital Human Modeling

What is it?

What is DHM used for?

- Safety and performance assessments via biomechanics and ergonomics
Digital Human Modeling

*What is it?*

*Why is it important?*

- can incorporate Human Factors Engineering design principles earlier in the product development

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http://www.onandemirel.com/7-projects/
THE DEVELOPMENT OF DIGITAL HUMAN MODELS
Digital Human Modeling

Brief Research Background

- Early Models - (1960 - 1980):
  - Cockpit packaging and pilot ergonomics of military aircraft
  - Prediction of center of gravity, principal moments, product of inertia
  - Design of cockpit consoles, seats and seat belts

[Image: Vision envelope in a cockpit]
[Image: Unobscured rotation check]

Early Models - (1960s):
- Mostly in 2D - some in 3D
- Basic mathematical formulation (e.g., center of mass)
- Not focusing on design but mostly analysis of postures

The segmental method

Adapted from Hamil & Knutzen, 1995, Biomechanical basis of human movement, Baltimore, MD: Williams & Wilkins.
Digital Human Modeling

*Brief Research Background*

- Biomechanics Models - (1960 - 1980s):
  - Generic biomechanics models for predicting strength capabilities
  - Manual/occupational tasks represented: lifting, pushing, pulling
  - Anthropometry, posture and force parameters

![Digital Human Modeling](image-url)
Digital Human Modeling

Brief Research Background

- Biomechanics Models - (1960 - 1980s):
  - Static models - no consideration of dynamics human postures
  - Variations of people from military and limited civilian data base
  - Anthropometry, posture and force parameters

Digital Human Modeling

Brief Research Background

- **Biomechanics Models - (1960 - 1980s):**
  - Anthropometry: people are different!
  - Considering variation in design process.


- Statistical DHM models bring anthropometry, motion and ergonomics capabilities to design of workplaces and product design.
- CAD integration
Digital Human Modeling

Brief Research Background

  - Advanced 3D models with higher visual and physical realism.
  - Motion Capture
Digital Human Modeling

Brief Research Background

- Models with Technology Integration - (2000 - now):
  - Beyond traditional statistical biomechanics and ergonomics
  - Technology integration:
    • markerless motion capture,
    • haptic devices and feedback,
    • immersive and virtual reality
    • digital twins
    • .....

Digital Human Modeling

Brief Research Background

- Models with Technology Integration - (2000 - now):
  - Computer driven models
  - High-fidelity postures and motion

Fig. 2 Skin rigging: (a) Automatic rigging; (b) manual rigging

Fig. 6 Snapshots of Santos throwing an object

Fig. 8 Sequential snapshots of Santos moving a 10-lb box from a lower shelf to a higher shelf. (a) without any torque limits on the spine, and (b) with torque limit on the spine (time progression from left to right)
Digital Human Modeling

Brief Research Background

- Towards Multi-physics Model (2020s and beyond):
  - Realistic Visualization
  - Anthropometry
  - Predictive Posture
  - Micro - Macro Motion
  - Cognitive Aspects
  - Analysis Modules
  - Quick Modeling
  - Segmentation - DOF

Multi-physics Integration

Human-in-the-loop vehicle development (Parametric modeling, Fluid dynamics, biomechanics analysis and virtual reality integration)

http://www.onandemirel.com/project/human-in-the-loop-vehicle-design/
DIGITAL HUMAN MODELING
&
ENGINEERING DESIGN
Designing with DHM:

- Before *physical prototypes* are built, engineering can:
  - implement proactive ergonomics in product design
  - evaluate human-product/environment interactions

- Working on *digital prototypes* via DHM has the potential to reduce:
  - design costs
  - time-to-market
  - the risk of injury
  - design errors
Digital Human Modeling

Design Connection

How Humans Factors Typically Considered?

Reactive Approach

Societal Need
Clarify Problem
Develop Concepts
Embody Design
Detail Design
Product that meets need

CAD → CAE → Prototype → Human Subject

Digital Human Modeling

Design Connection

An Alternative Approach?

Proactive Approach

Societal Need

Clarify Problem

Develop Concepts

Embody Design

Detail Design

Product that meets need

https://www.caricos.com/cars/vw/2012_volkswagen_up/images/76.html
https://i.ytimg.com/vi/eHUfeJE0k_c/maxresdefault.jpg
http://www.supercarreviewonline.com/cars/new-car-reviews/1502-new-audi-r8-prototype-first-drive/
Why DHM?

*Detailed Computational Human Factors Engineering*

<table>
<thead>
<tr>
<th>Reactive - Physical Human Studies</th>
<th>vs.</th>
<th>Proactive - Digital Human Modeling</th>
</tr>
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<tbody>
<tr>
<td>expensive (time &amp; finances)</td>
<td></td>
<td>cheap(er)</td>
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<tr>
<td>slow</td>
<td></td>
<td>fast(er)</td>
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<tr>
<td>sequential / one at a time</td>
<td></td>
<td>parallel</td>
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<tr>
<td>only few-parameters to check</td>
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<td>multi-purpose</td>
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https://www.caricos.com/cars/v/ww/2012_volkswagen_up/images/76.html
Why DHM?
Overall Design Cost and Time Reduction!

DIGITAL HUMAN MODELING & ENGINEERING DESIGN OF COMPLEX SYSTEMS
Why is this important?

*Developing better products*

- Especially for design that are hard to "prototype"

Humans are not replaceable!

*Human Factors in Complex Systems*

**Biodynamic Responses**

- Underwater shock produced by an underwater explosion remains one of the biggest threats to ships and shipboard personnel.

- What is an underwater shock?
  - Extremely high acceleration
  - Very short duration.

- Each ship hull, engine, superstructure needs to pass this test

- Internal structure including crew space needs to provide safe working environment.
Humans are not replaceable!

*Human Factors in Complex Systems*

**Predicting Biodynamic Responses**

- What are the options here?

- Relatively simplified version:

![Diagram](image)

*Fig. 1. Simplified mechanical system representing the human body sitting upright in a chair subjected to vertical shock.*

Humans are not replaceable!

*Human Factors in Complex Systems*

**Predicting Biodynamic Responses**

- What are the options here?

  - Actual data collection via crash test dummies:

Warrior Injury Assessment Manikin (WIAMan)
https://www.aerodefensetech.com/component/content/article/adt/features/articles/27963
Humans are not replaceable!

*Human Factors in Complex Systems*

**Predicting Biodynamic Responses**

- What are the other options here?
  
  - Digital Human Models with Multi-Physics Simulations

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https://altairhyperworks.com/partner/hubyx