Digital Human Modeling and Simuation in Ergonomics

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Introduction

- DHM

Simulations

- Modeling and a simulation

Software

Jack, Safework, RAMSIS ,Anthropose , Opensim , SAMMIE , 3DSSPP , Catia

3DSSPP

- Practical course

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Introduction

10%

DHM :

Difinition

Application

Simulations

10%

Modeling simulation

Software

10%

Jack, Safework, RAMSIS Anthropose , Opensim , SAMMIE , 3DSSPP , Catia

3DSSPP

70%

Software environment

Practical training

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Ergonomics assessments

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- SAFTY AND HEALTH
- COMFORT
- WORK QUALITY OF LIFE

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Observational Methods:

Direct Observation: Observing workers in their natural work environment to identify ergonomic risk factors and potential areas for improvement.

Checklists: Using standardized checklists to systematically evaluate workstations and tasks for ergonomic factors.

Task Analysis:

Hierarchical Task Analysis (HTA): Breaking down complex tasks into a hierarchy of subtasks to identify potential ergonomic issues at each level.

Job Safety Analysis (JSA): Examining each step of a job to identify potential hazards and recommend ergonomic improvements.

Subjective Feedback:

Surveys and Questionnaires: Gathering feedback from workers about their comfort, fatigue, and any discomfort they may experience during work.

Interviews: Conducting one-on-one or group interviews to understand workers' perspectives on ergonomic issues.

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Anthropometric Measurements:

Body Measurements: Collecting data on body dimensions to ensure that workspaces and tools accommodate a diverse range of body sizes.

Reach Envelopes: Assessing the comfortable reach zones for various tasks to optimize the placement of tools and equipment.

Biomechanical Analysis:

Motion Capture: Using technology to record and analyze the movement of workers during tasks to identify awkward postures and potential sources of strain.

Force Measurement: Measuring the force exerted by workers during various tasks to ensure that it falls within safe limits.

Environmental Factors:

Lighting Assessment: Evaluating the lighting conditions in a workspace to ensure proper visibility and reduce eye strain.

Noise Assessment: Identifying and mitigating sources of excessive noise that may contribute to stress and fatigue.

Workstation Design Guidelines:

Applying Ergonomic Principles: Designing workstations and tools based on established ergonomic principles, such as proper chair and desk height, monitor placement, and keyboard position.

Ergonomic Software Tools: Utilizing computer-based tools to simulate and analyze ergonomic conditions in virtual environments.

Feedback and Continuous Improvement:

Post-Implementation Evaluation: Assessing the effectiveness of ergonomic interventions after they have been implemented to ensure improvements and make further adjustments if necessary

The ergonomic design of the work environment reduces postural stress, improves organizational productivity, enhances job satisfaction, and results in a better quality of work-life.

- **Digital human modeling** software is a **Computer-aided Design** **CAD** tool for the construction of 2D and 3D human models from anthropometric data of targeted users/population for ergonomic analysis of virtual human fit to **virtual workstation** components

- A few popular DHM software, which is commercially available include **JACK, SAMMIE, RAMSIS, DELMIA, SANTOS, etc**

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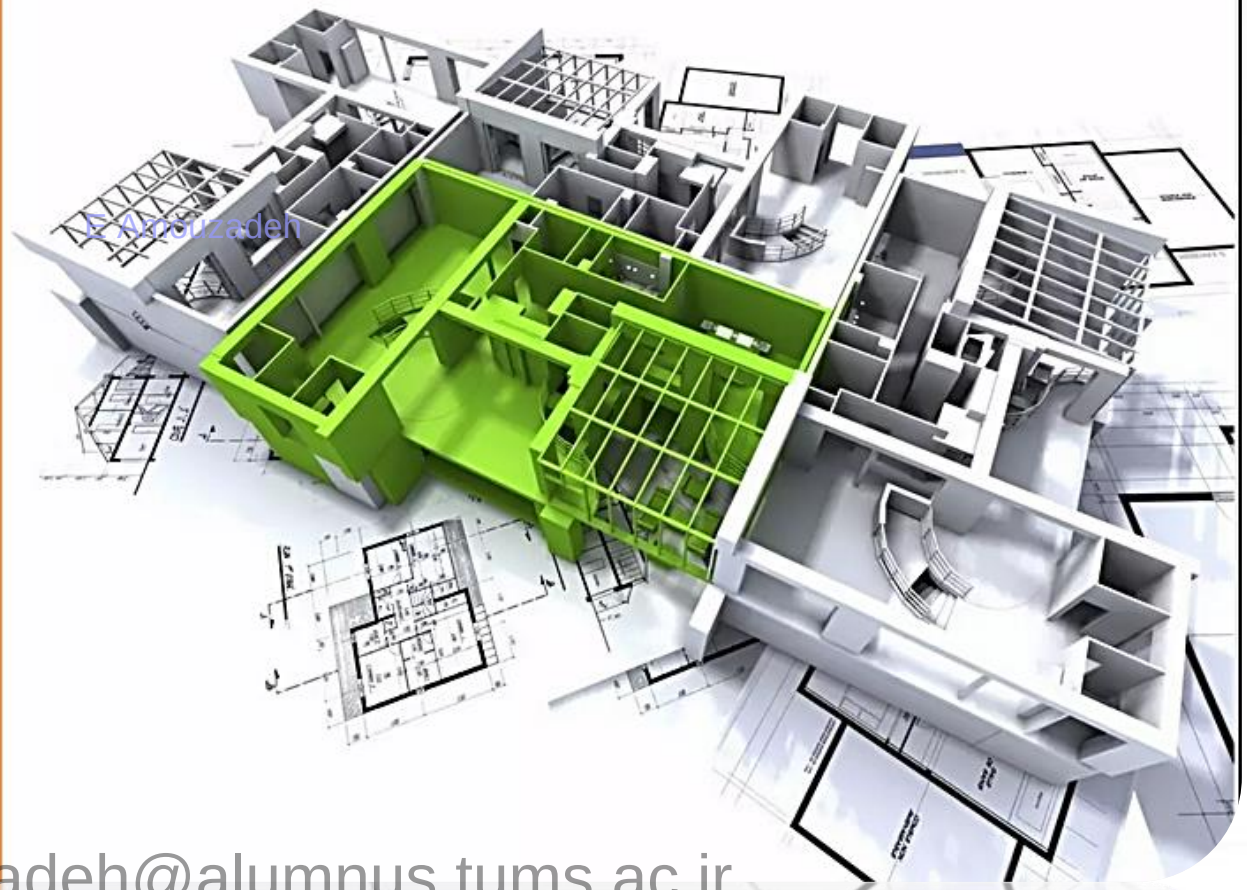
CAD

Computer Aided Design (CAD) is a form of design in which people work with computers to create ideas, models, and prototypes.

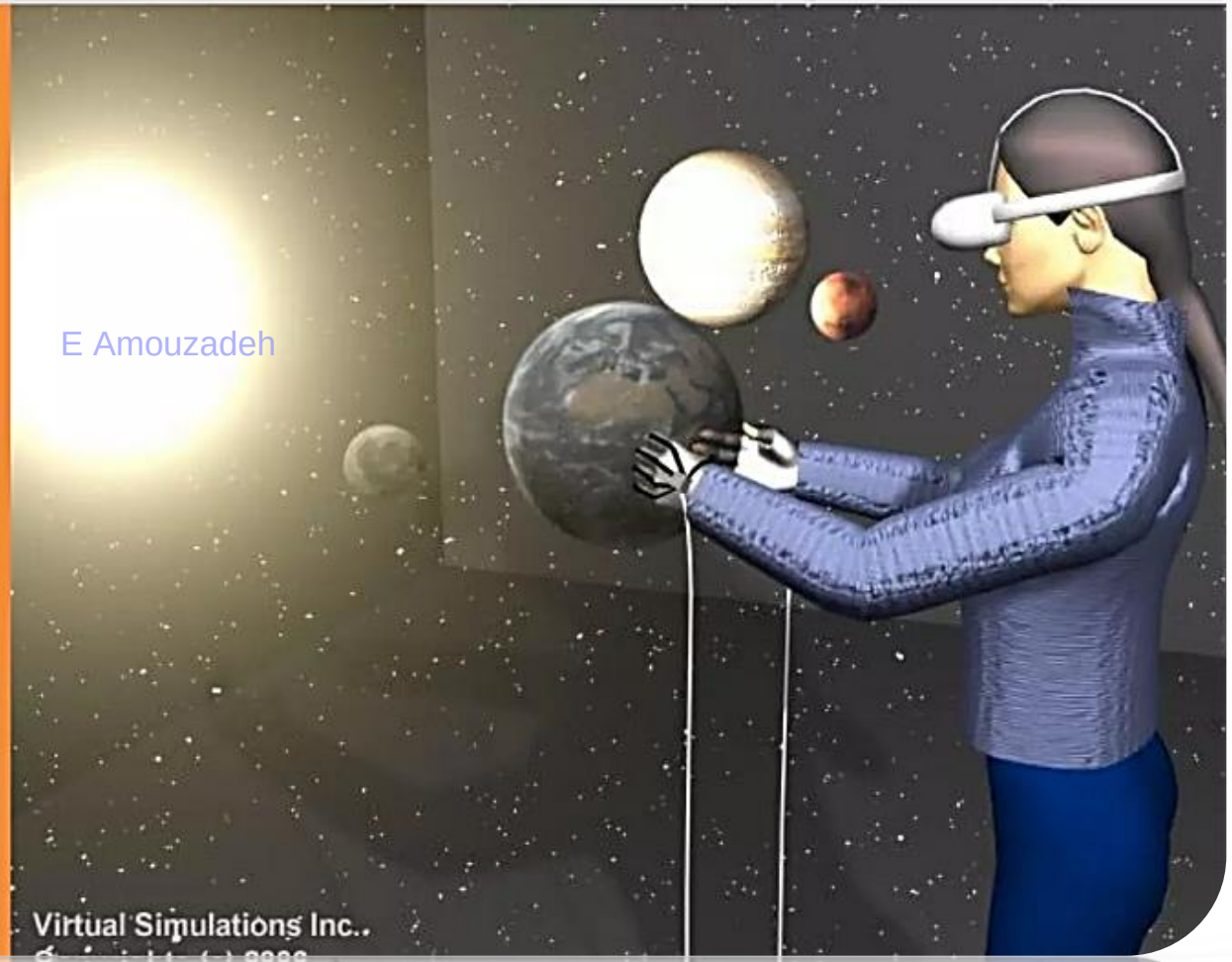
CAD was originally developed to assist people with technical drawing and drafting, but it has expanded to include numerous other potential uses.



Simulation

Simulation is the imitation of the operation of a real-world process or system over time.

The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors of the selected physical or abstract system or process



Digtal Human Modeling - Definition

Digital Human Modeling is the process of developing digital human models using anthropometric and biomechanical database, for ergonomic evaluation of product and workstation in virtual environment, using 2D or 3D CAD softwares.

Method:
1. Make human model.
2. Make workstation.
3. Fit human model into workstation.

Development of DHM

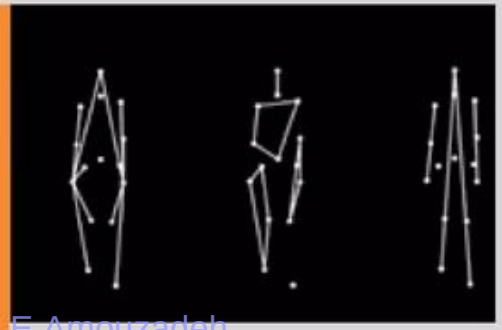
1. Started with only stick figures.

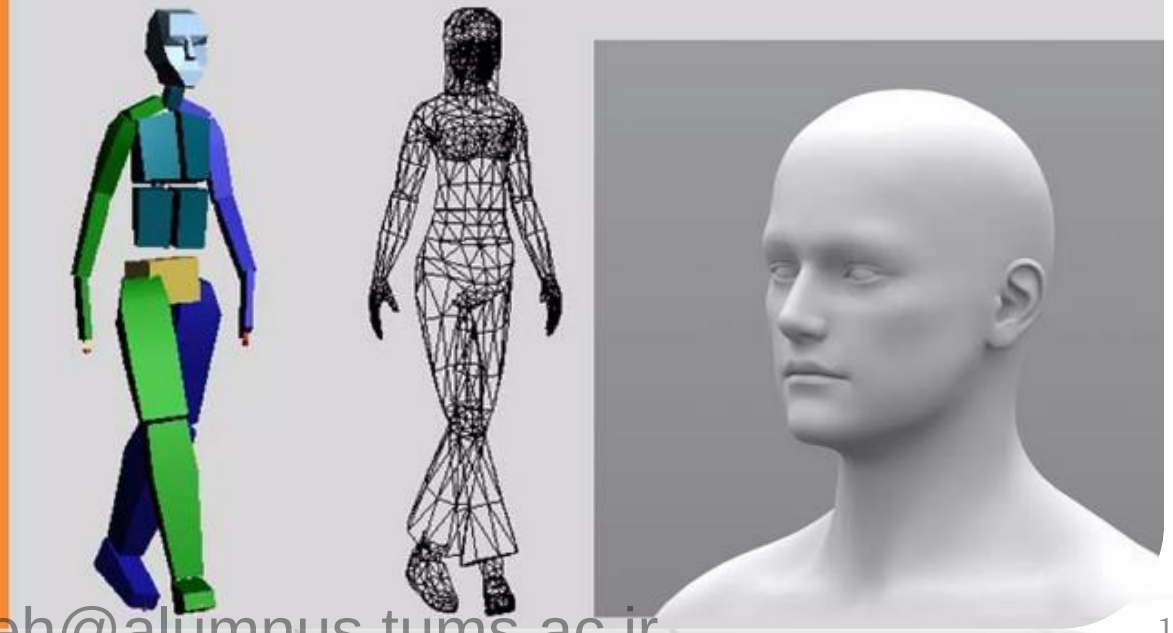
2. Robot like appearance (Geometric primitives - sphere, rectangle).

3. More complex representation of body segments with finer details.

4. Surface Modeling - applying smoothing algorithms.

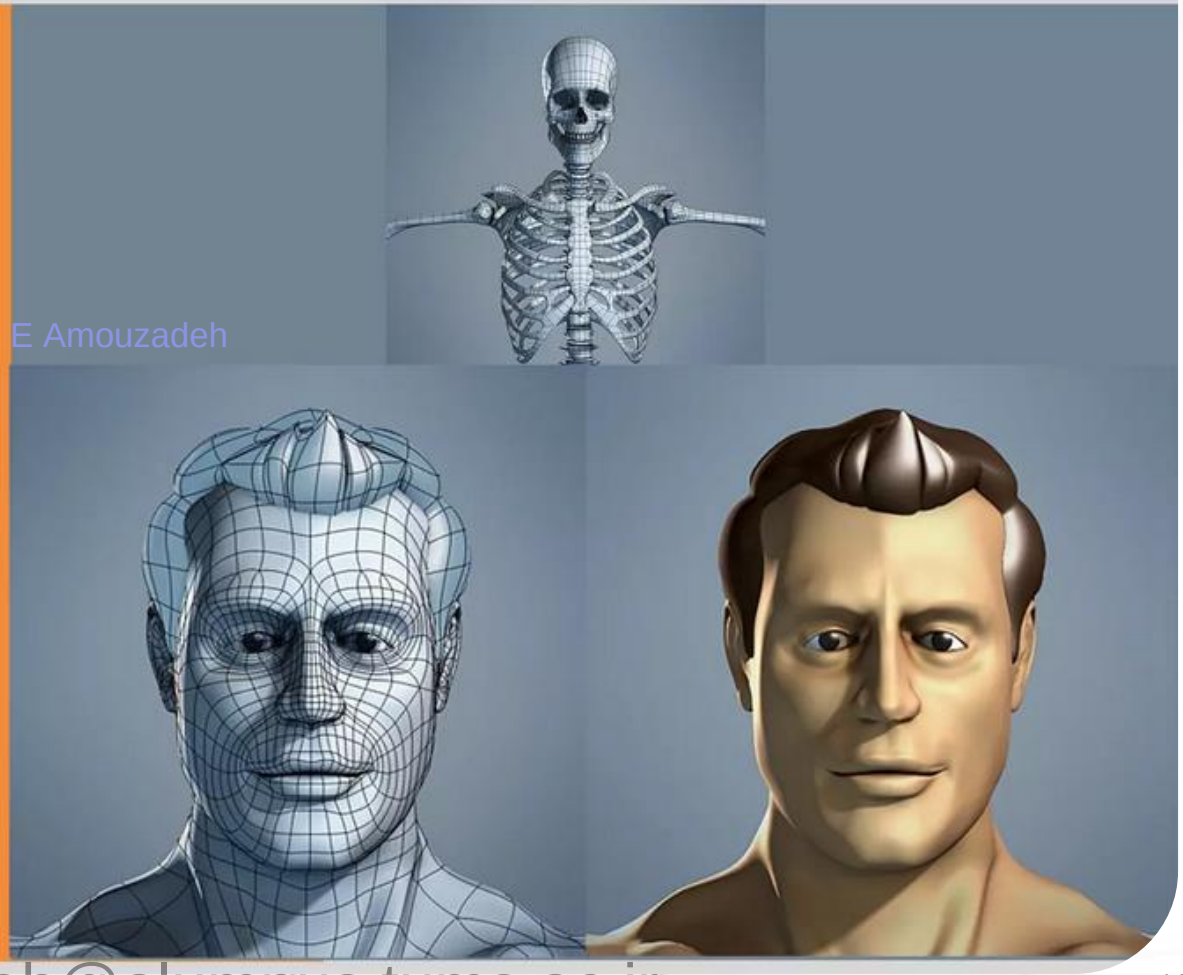
5. Now, realistic skin deformation and contracting muscles.





Construction of DHM

1. Stick figure
2. Skeletal Model
3. Wireframe Model
4. Shaded Model
5. Presentation Model



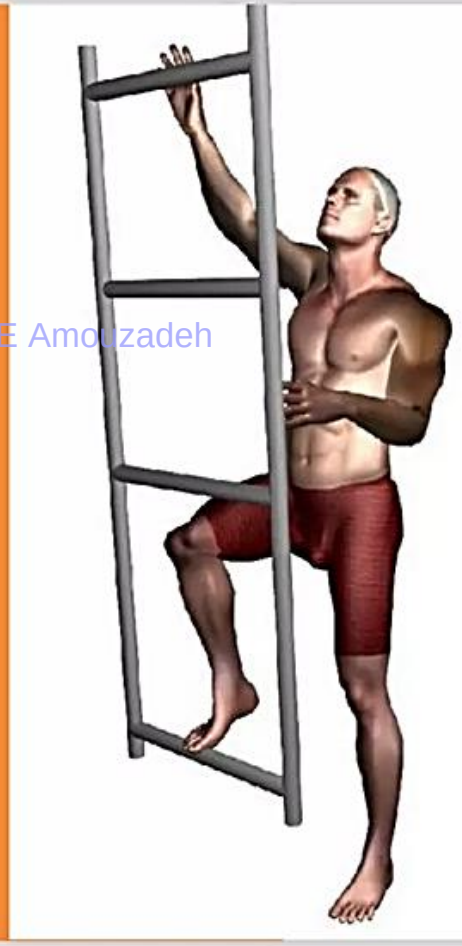
DHM Softwares in Market (Popular)

JACK

RAMSIS

DELMIA

SANTOS



Other DHM Softwares in Market

ADAPS

ANYBODY & ANTHROPODS

APOLIN

BUFORD

CAR

COMBIMAN & CREW CHIEF

CYBERMAN

ENVISION/ERGO

EGRODATA

Types of DHM Softwares

1. Physical : It includes anatomical shape or reaction/performance under different conditions. Eg:- Reach, interference, Collision Detection.

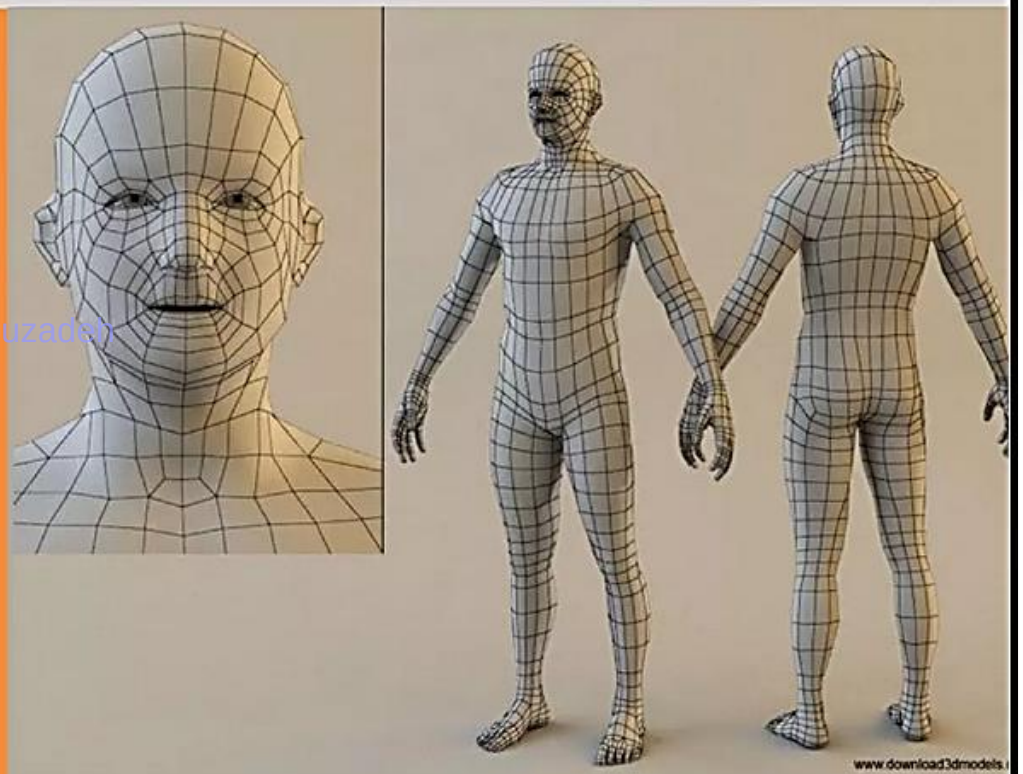
Softwares : JACK, RAMSIS

2. Cognitive : It includes human behavioral aspect, artificial intelligence, interactivity of synthetic agents.

Softwares : REBA, CASHE

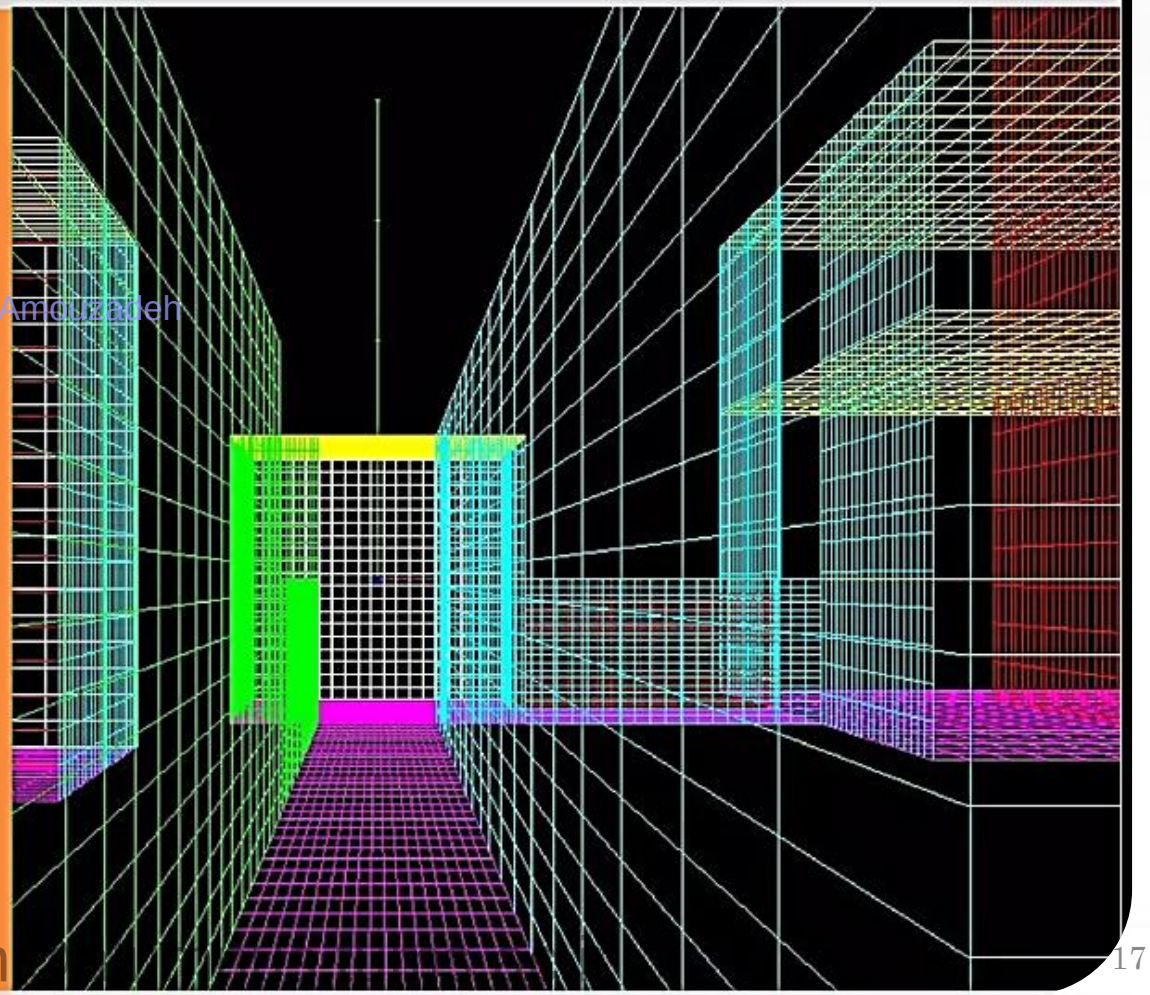
Basic Functionality of DHM softwares

Creating a virtual human.



Basic Functionality of DHM softwares

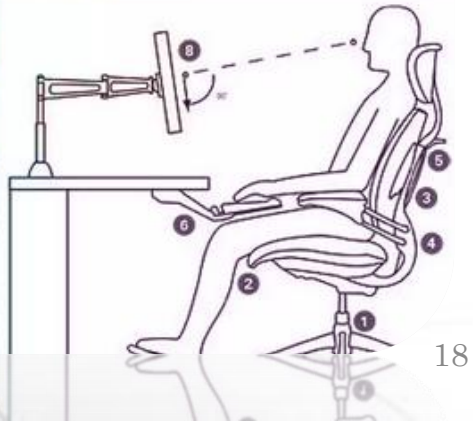
Building a virtual environment.



Basic Functionality of DHM softwares

Vision Analysis

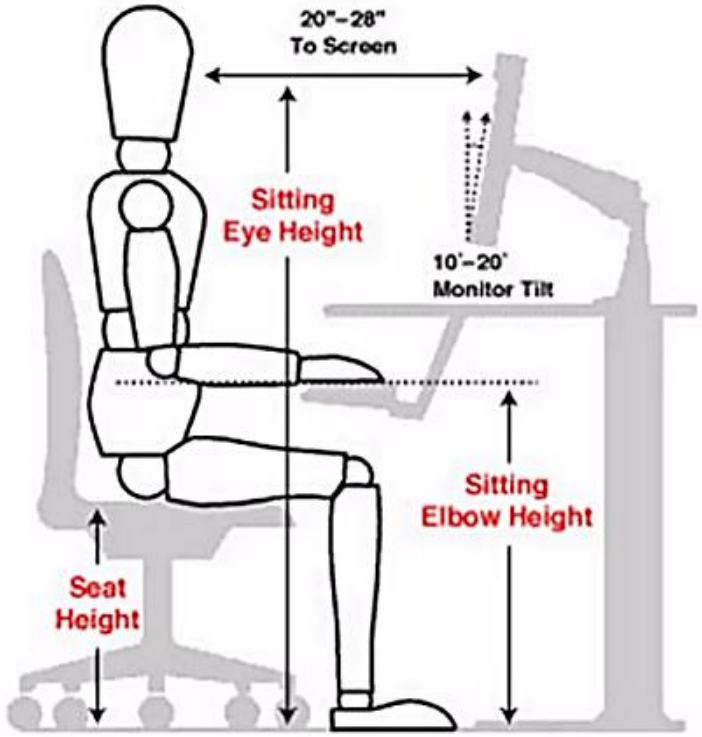
1. View Cone
2. Analysis of blind spot
3. Reflection zone
4. Eye view window
5. Obscuration zone



Basic Functionality of DHM softwares

Seating Accomodation

Seat height
Seat depth
Seat width
Position of headrest



Basic Functionality of DHM softwares

Seating Accomodation for workstations

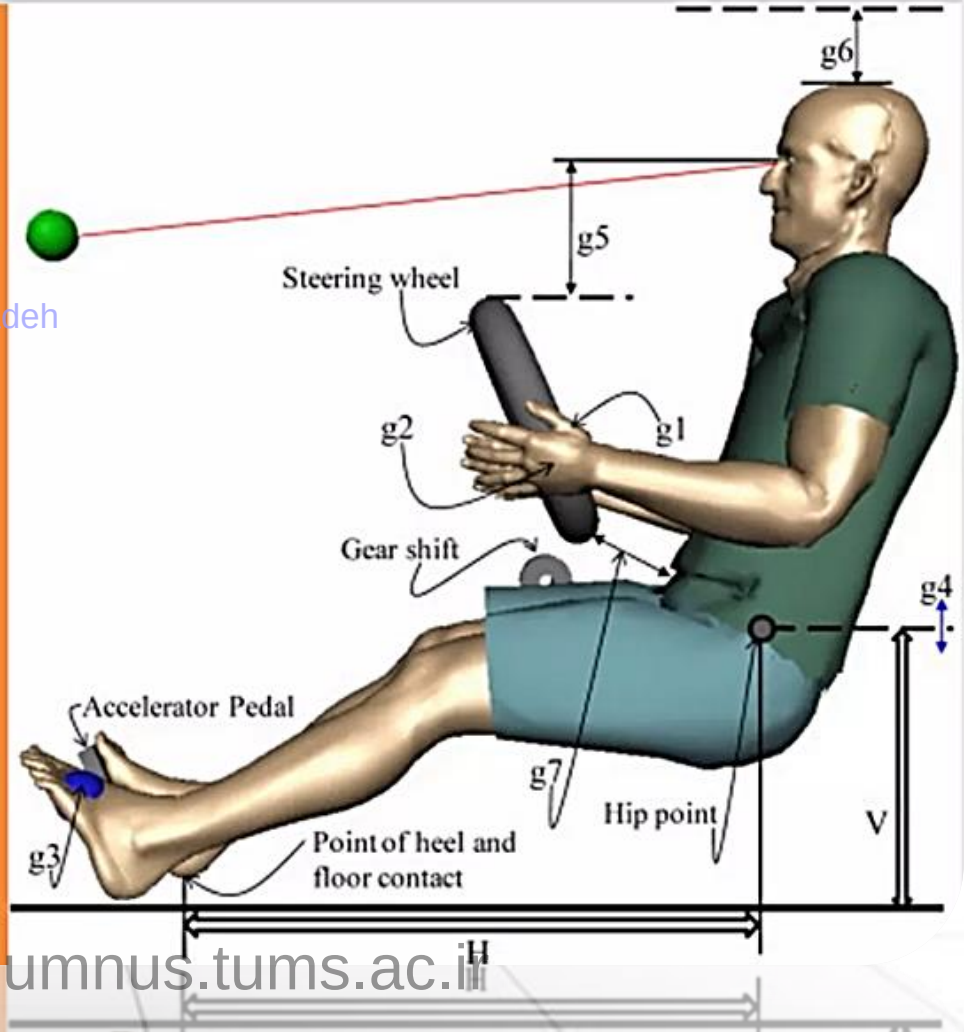
SRP (Seat Reference Point) - For Bikes

SgRP (Seating Reference Point) - SRP of 95th percentile

NSRP (Neutral Seat Reference Point) - SRP of 50th percentile

AHP (Accelerator Heel Point) - For Car design

DEP (Design Eye Point) - For Cockpit design



Basic Functionality of DHM softwares

Other functions of DHM softwares include:

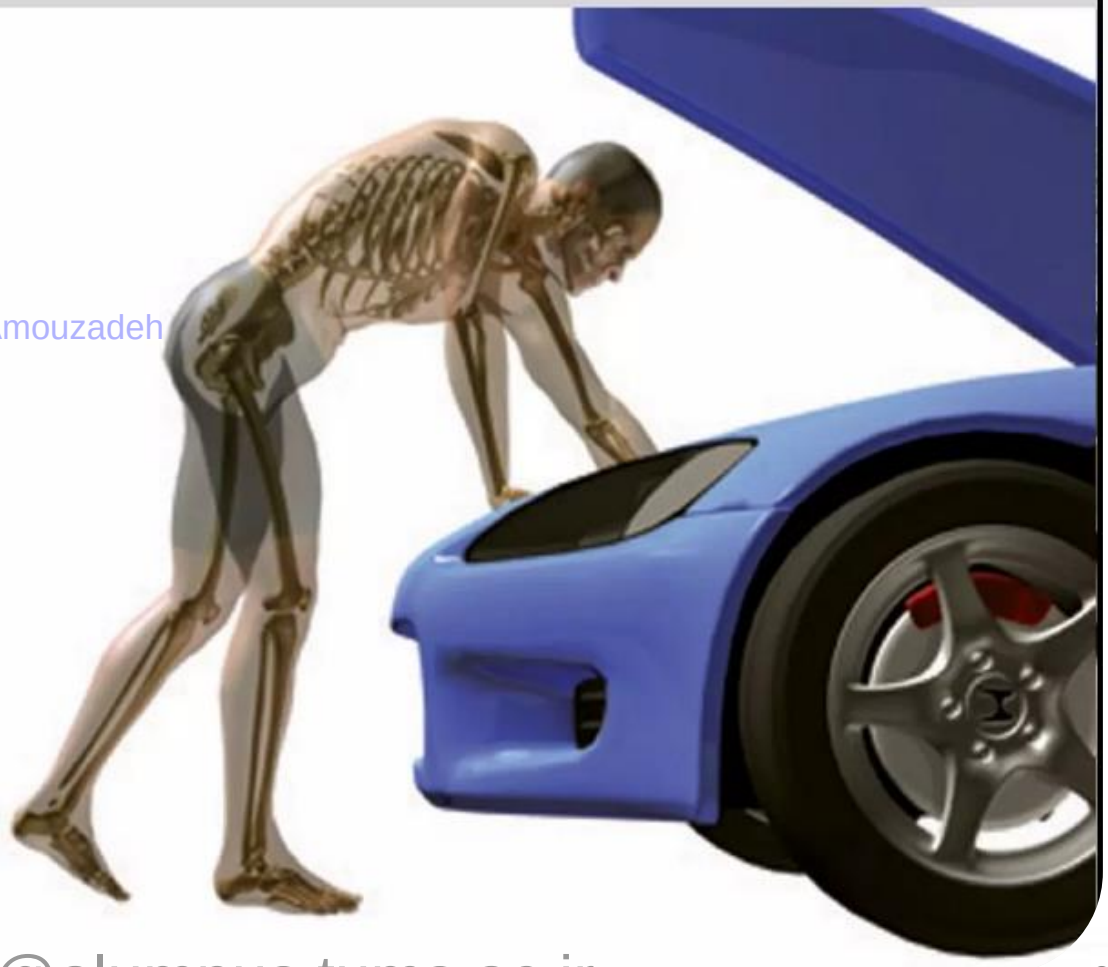
- Comfort/discomfort analysis
- Fatigue analysis
- Posture analysis
- Lower Back analysis
- Metabolic energy expenditure
- Predetermined time standards
- Static strength prediction

DHM in Scientific Research Fields

Automobile Industry

As a driving force for DHM development, the automotive industry has traditionally used human models in the **manufacturing sector** (production ergonomics, e.g. assembly) and the **engineering sector** (product ergonomics, e.g. safety, packaging).

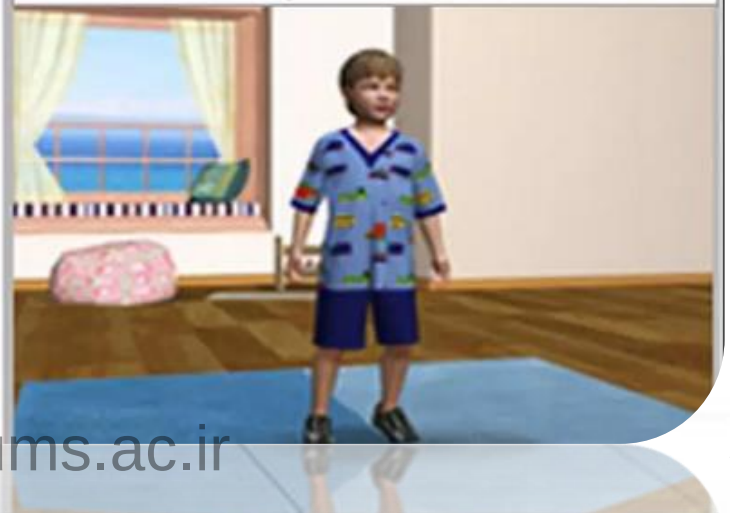
These models are optimised for a **seated posture, interface to a vehicle seat through standardised methods and provide linkages to vehicle controls.**



DHM in Scientific Research Fields

Textile

DHM is used to **set up the dimensions of human bodies, the color of the skin and hair, shapes** thereof, etc., to create original 3D models. **By fixing patterns in three dimensions on the model,** considering the characteristics of the material and synthesizing the materials on it, real finished images, including the silhouette of the product, etc. can be examined by rotating the image 360 degrees.



DHM in Scientific Research Fields

Sports

DHM forms a very useful tool for **sports performance analysis.**

DHM in Scientific Research Fields

Human Anatomy

DHM helps in understanding the **complex structure of human body** in an easy and descriptive manner.


SIMULATION
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MODELING
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Typical simulation modeling workflow

Simulation modeling follows a process much like this:

- **Use a 2D or 3D CAD tool to develop a virtual model, also known as a digital prototype, to represent a design.**
- **Generate a 2D or 3D mesh for analysis calculations. Automatic algorithms can create finite element meshes, or users can create structured meshes to maintain control over element quality.**

Modeling

A **model** is a product (physical or digital) that represents a system of interest

Simulation modeling is the process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world. Simulation modeling is used to help designers and engineers understand whether, under what conditions, and in which ways a part could fail and what loads it can withstand. Simulation modeling can also help to predict fluid flow and heat transfer patterns. It analyses the approximate working conditions by applying the simulation software.

Simulation modeling i

Simulation

A **simulation** is the process of using a model to study the behavior and performance of an actual or theoretical system

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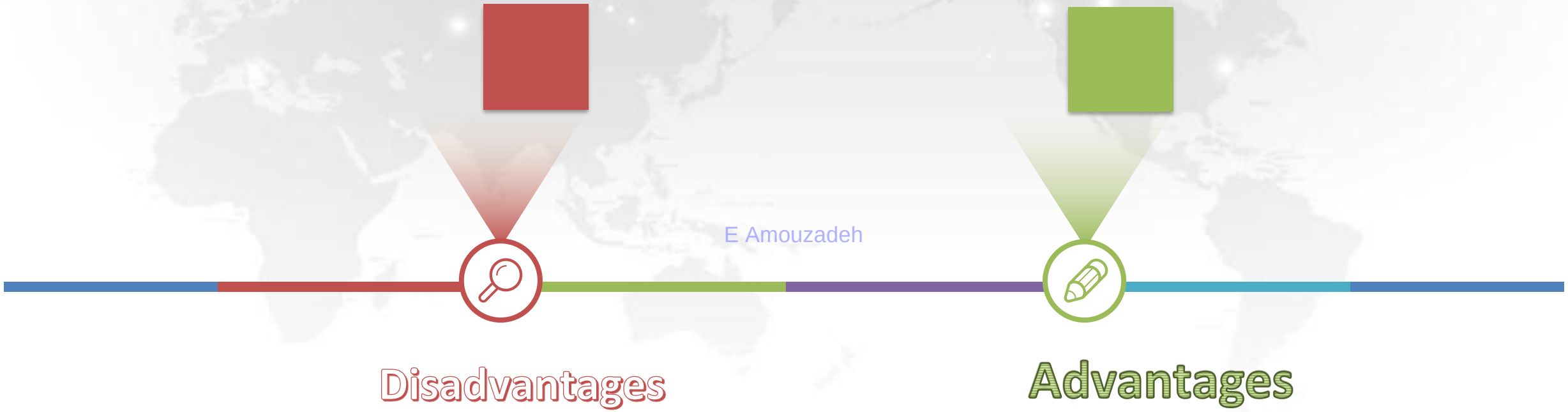
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Disadvantages
Advantages

1 **DHM** allows designers to explore the potential advantages and disadvantages of different design configurations without the need for physical prototypes

2 **Simulation of human interaction:**
DHM enables designers to simulate human-workplace interaction by inserting a digital human model in the CAD generated work environment

3 This allows designers **to assess accessibility** inside a working cabin or cockpit, evaluate positioning and comfort, visibility, ingress and egress, reaching and grasping, foot pedal operation, multi-person **interaction**, **strength assessment**, and **ergonomic evaluations**

4 **Reduction of design time and cost**

5 **Proactive design and ergonomic evaluation**: DHM is widely used in diverse fields that include manufacturing industry, healthcare sectors, transportation, agriculture, defense research and development, aerospace-aviation sectors.

6 **Replacement of physical mockups:** DHM is used in vehicle design, where expensive physical mockups are being replaced with virtual prototypes that are assessed using virtual drivers, passengers, and maintainers

In **summary**, DHM is a valuable tool for designers and engineers as it allows them to explore design configurations, simulate human interaction, reduce design time and cost, perform proactive design and ergonomic evaluation, and replace physical mockups

1 Time-consuming: One of the primary disadvantages of DHM is that it can be time-consuming to gather the information necessary to develop the simulations and communicate those simulations to the design team3

2 This can slow down the design process and increase development costs.

Limited accuracy:

DHM is limited by the accuracy of the anthropometric data used to create the digital human models

3 If the data is inaccurate or incomplete, the resulting simulations may not **accurately** represent the human **population** being modeled.

Limited range of motion: DHM is also limited by the range of motion of the digital human models

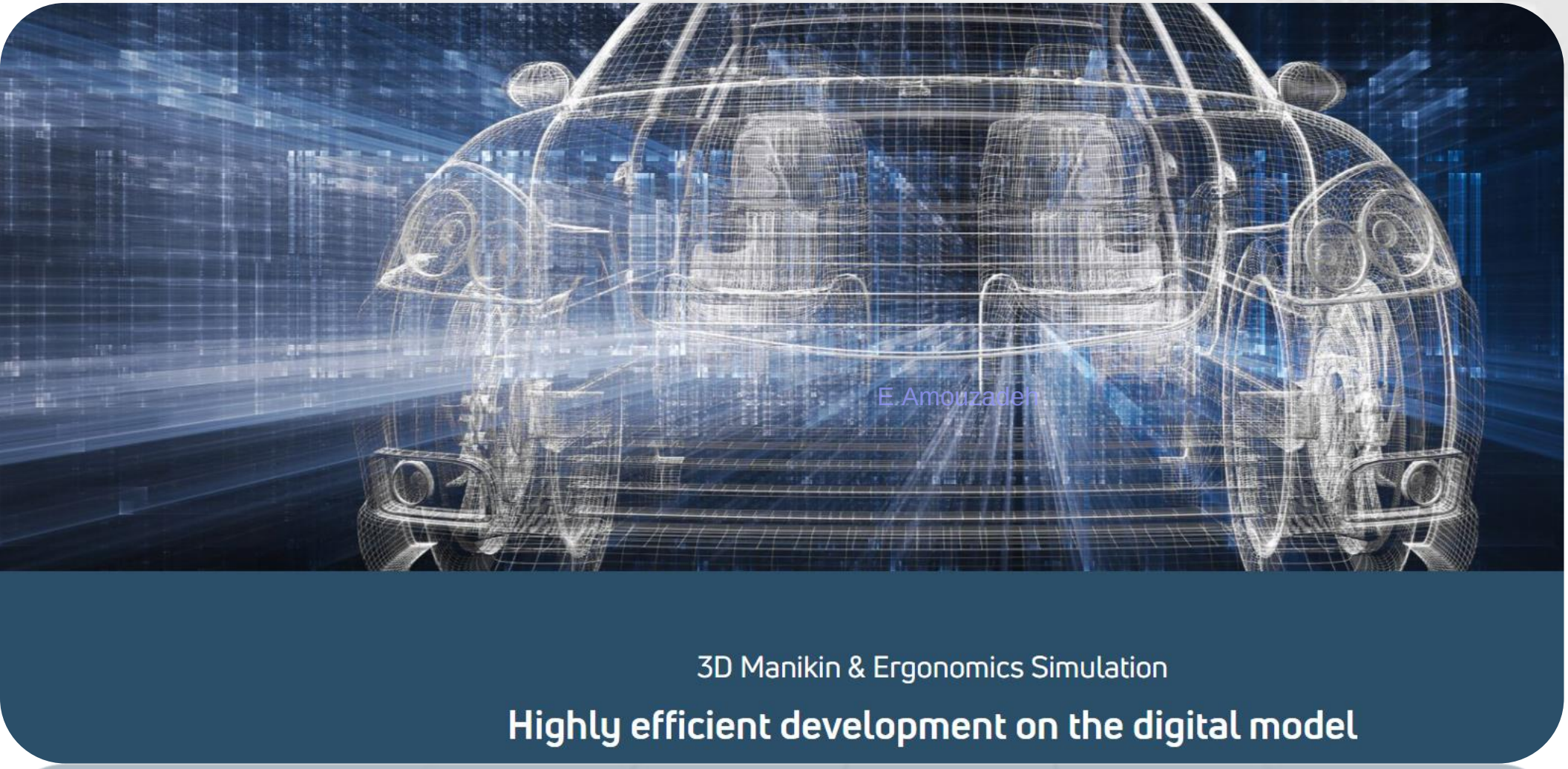
4 If the models cannot accurately simulate the full range of human motion, the resulting simulations may not be accurate

5 While there has been progress in this area, there is still much work to be done to accurately model human interaction with products and work environments.

In **summary**,

DHM has some limitations, **including being time-consuming, limited accuracy, limited range of motion, and limited interaction modeling**. However, these limitations can be addressed through continued research and development in the field.

Software



1. Jack
2. Safework
3. RAMSIS
4. Anthropose
5. Opensim
6. SAMMIE
7. 3DSSPP
8. Catia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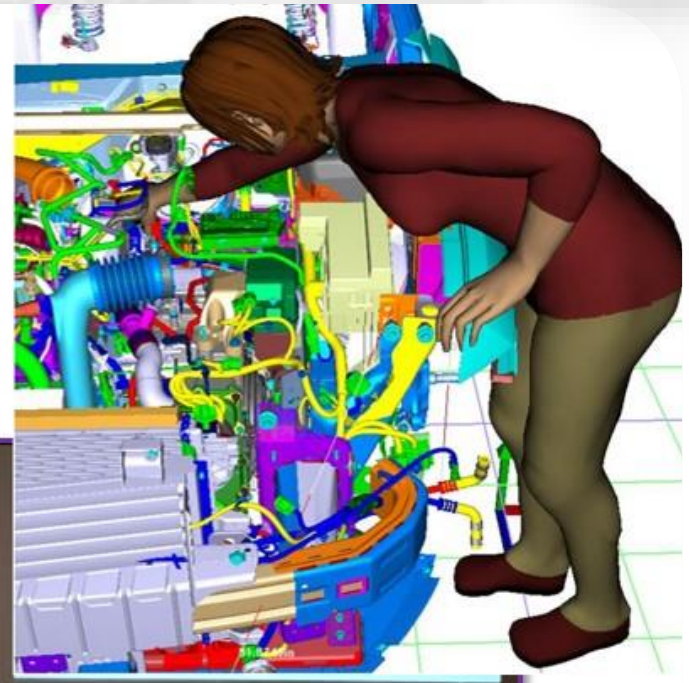
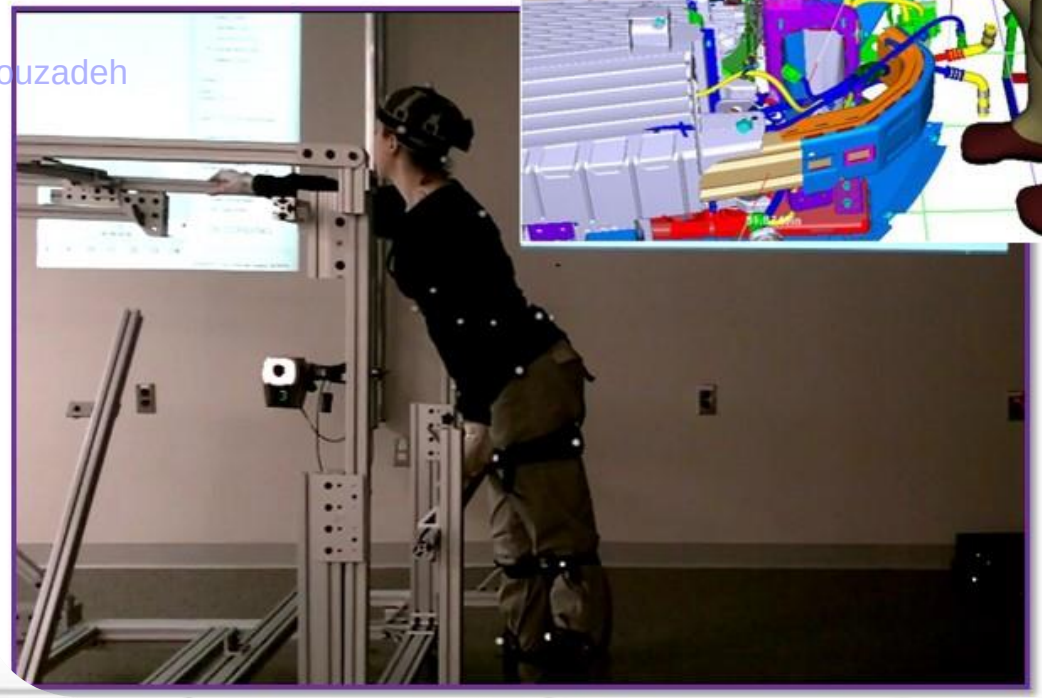
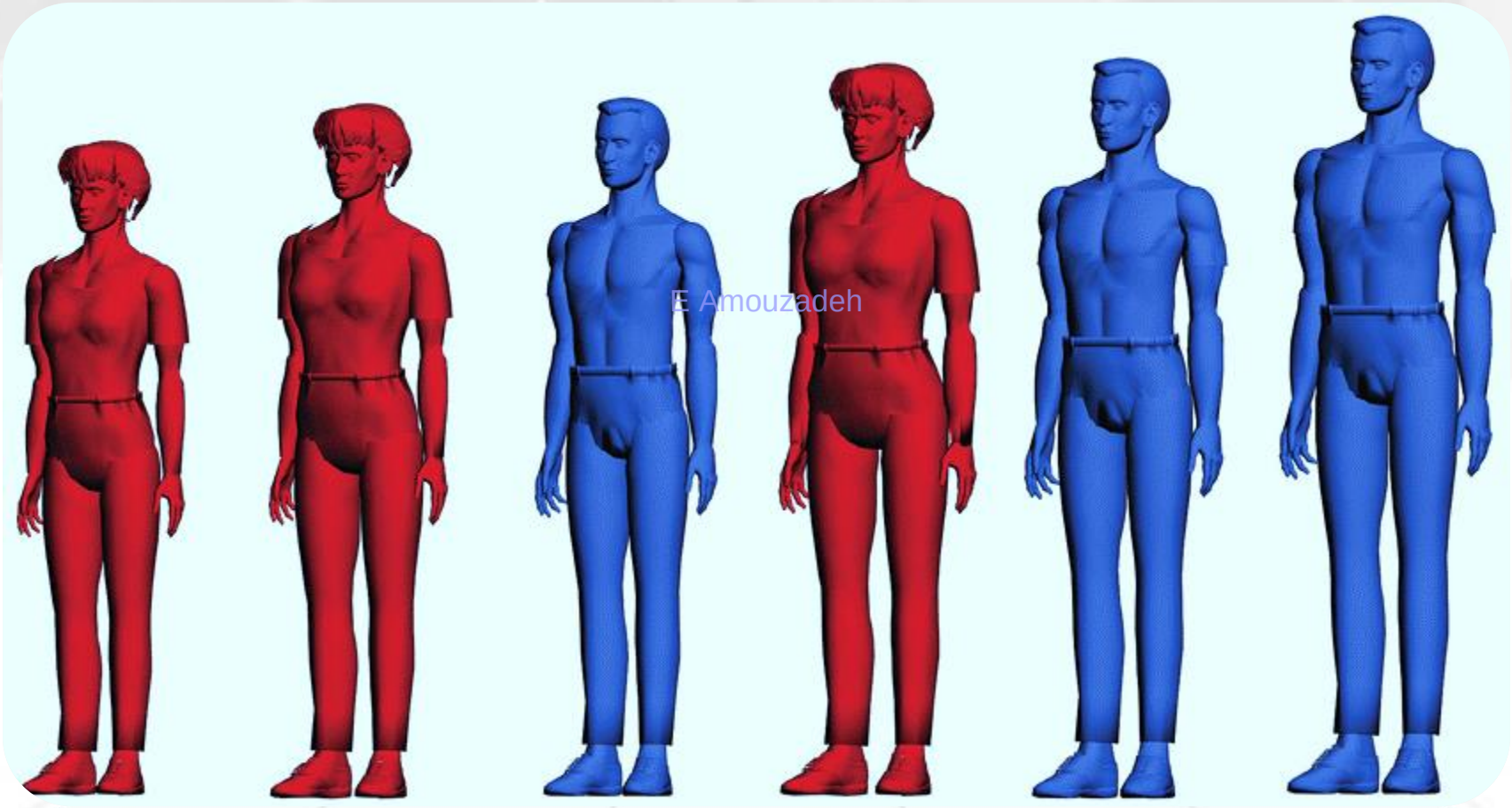


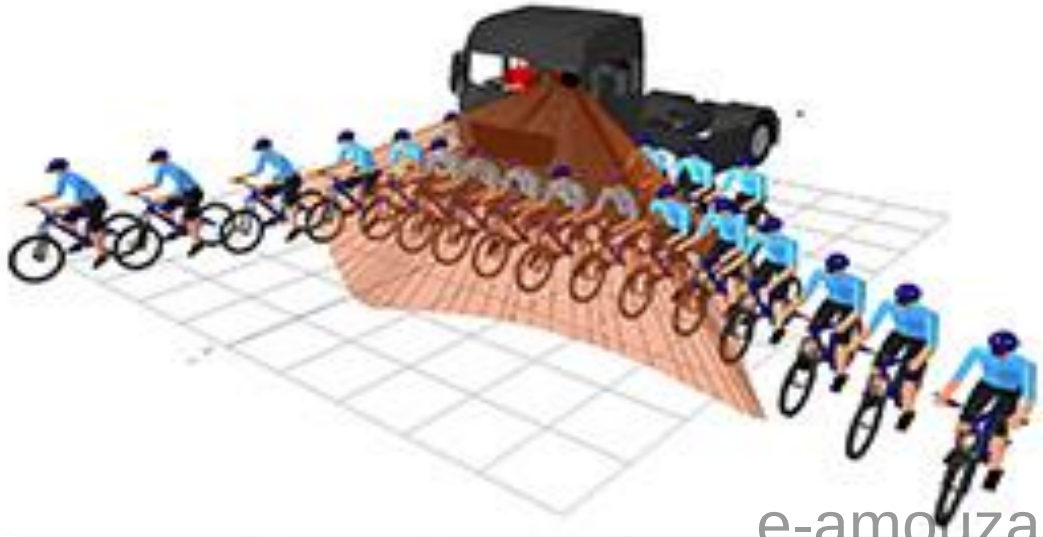


Anthropodse :



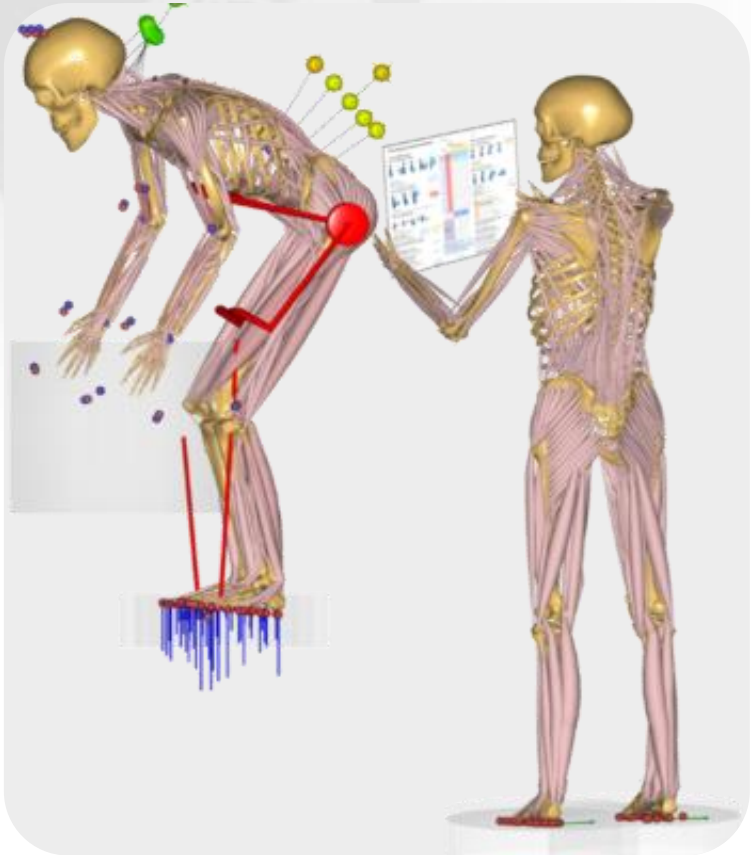
SAMMIE

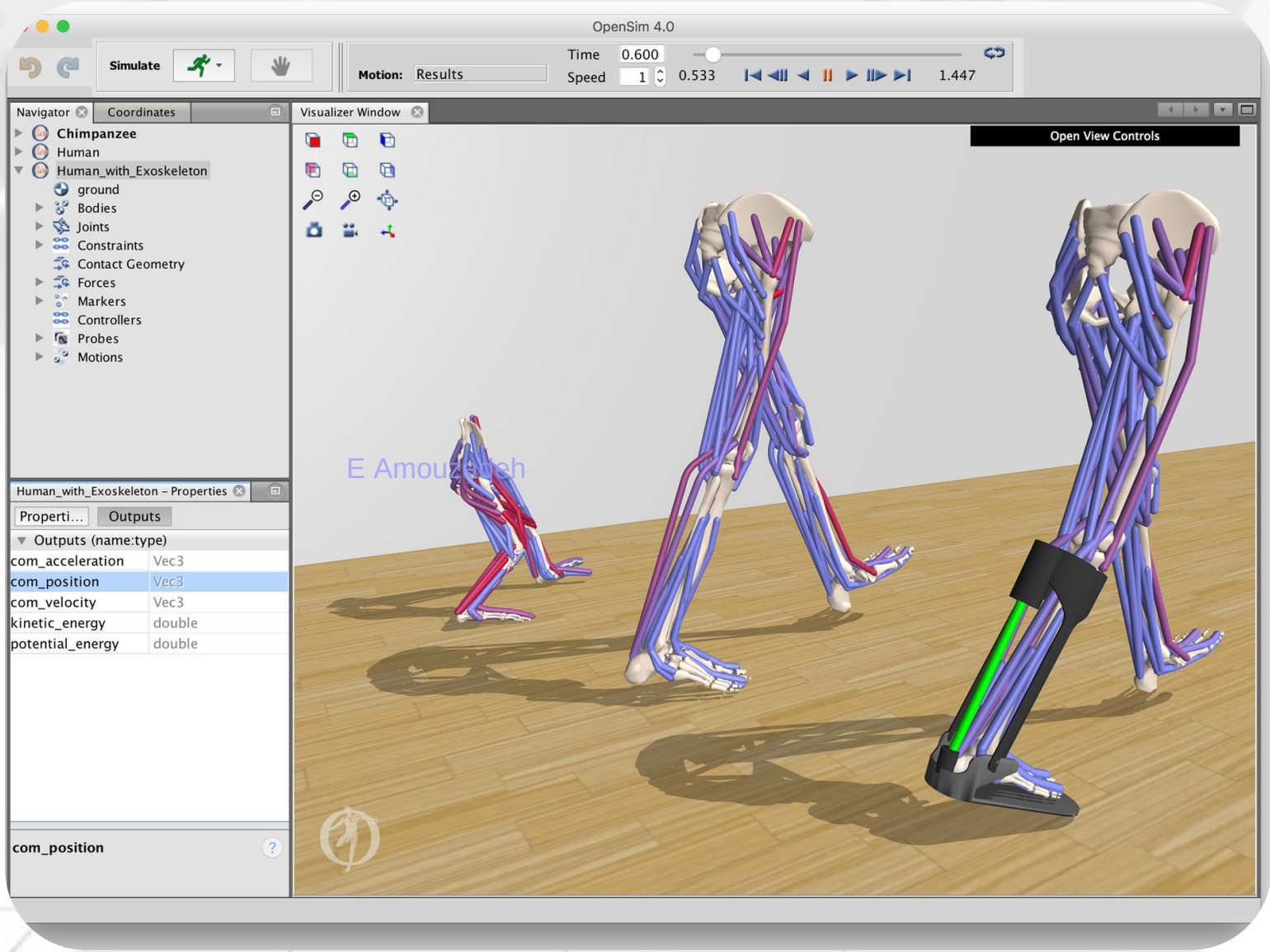
SAMMIE



AnyBody For Ergonomics

Extend conventional ergonomic assessment **standards (e.g., Rapid Upper Limb Assessment – RULA)** with **biomechanical** parameters as muscle activity and forces, joint reaction forces, and metabolism. Compare subjects, scenarios, trends, and statistics to understand the biomechanical factors affecting the health and identify the risk of musculoskeletal injuries.





https://opensim.stanford.edu/

3DSSPP

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About People Research Academic Programs Continuing Education Software/Services Get Involved Contact Us
3DSSPP Software
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IMPORTANT ANNOUNCEMENT: Effective October 7, 2020
Effective October 7, 2020 the University of Michigan has entered into an exclusive licensing arrangement with VelocityEHS | Humantech for forward licensing, support and development of the 3D Static Strength Prediction Program (3DSSPP). All forward sales, support and development of the program will be managed by the VelocityEHS | Humantech team. Additional information is available through their website and through their associated support channels including via e-mail at help@ehs.com.
If you are an existing licensee of Version 7 and are looking to upgrade to the latest version please contact the VelocityEHS | Humantech team via e-mail at help@ehs.com.
Software/Services
3DSSPP Software
3DSSPP: Background Information
3DSSPP: Example Applications
3DSSPP: Features
3DSSPP: Training & Video Tutorials
3DSSPP: References
3DSSPP: Purchasing Information
3DSSPP: Download
EEPP Software – No longer supported

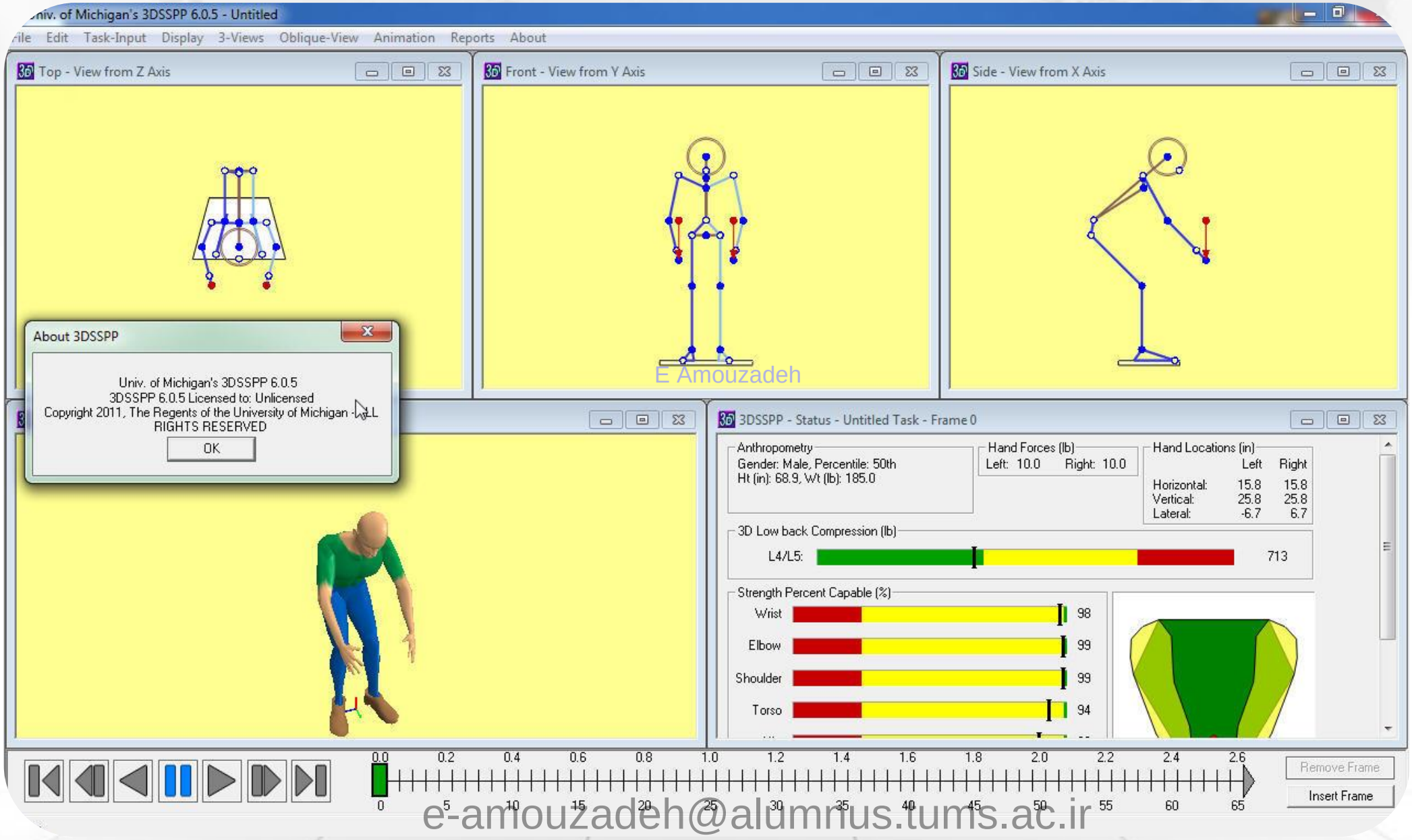
3DSSPP :

What is 3D SSPP?

3D SSPP software predicts static strength requirements for tasks such as lifts, presses, pushes, and pulls. The program provides an approximate job simulation that includes posture data, force parameters and male/ female anthropometry. Output includes the percentage of men and women who have the strength to perform the described job, spinal compression forces, and data comparisons to NIOSH guidelines. The user can analyze torso twists and bends and make complex hand force entries. Analysis is aided by an automatic posture generation feature and three-dimensional human graphic illustrations.

How can 3D SSPP help you?

3D SSPP can be used as an aid in the evaluation of the physical demands of a prescribed job. Furthermore, the 3D SSPP can aid the analyst in evaluating proposed workplace designs and redesigns prior to the actual construction or reconstruction of the workplace or task. The program is applicable to worker motions in three dimensional space. 3D SSPP is most useful in the analysis of the "slow" movements used in heavy materials handling tasks since the biomechanical computations assume that the effects of acceleration and momentum are negligible. Such tasks can be evaluated best by breaking the activity down into a sequence of static postures and analyzing each individual posture. The 3D SSPP assumes the analyst understands the application of the NIOSH design and upper limit criteria for strength and disc compression forces (refer to Appendix III for details). The program should not be used as the sole determinant of worker strength performance or job designs based on that performance. Other criteria and professional judgement are required to properly design a safe and productive job.


Univ. of Michigan's 3DSSPP 6.0.5 - Untitled
File Edit Task-Input Display 3-Views Oblique-View Animation Reports About
Top - View from Z Axis
Front - View from Y Axis
Side - View from X Axis
About 3DSSPP
Univ. of Michigan's 3DSSPP 6.0.5
3DSSPP 6.0.5 Licensed to: Unlicensed
Copyright 2011, The Regents of the University of Michigan - ALL RIGHTS RESERVED
OK
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3DSSPP - Status - Untitled Task - Frame 0
Anthropometry
Gender: Male, Percentile: 50th
Ht (in): 68.9, Wt (lb): 185.0
Hand Forces (lb)
Left: 10.0 Right: 10.0
Hand Locations (in)
Left Right
Horizontal: 15.8 15.8
Vertical: 25.8 25.8
Lateral: -6.7 6.7
3D Low back Compression (lb)
L4/L5: 713
Strength Percent Capable (%)
Wrist 98
Elbow 99
Shoulder 99
Torso 94
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Remove Frame
Insert Frame

PART 2

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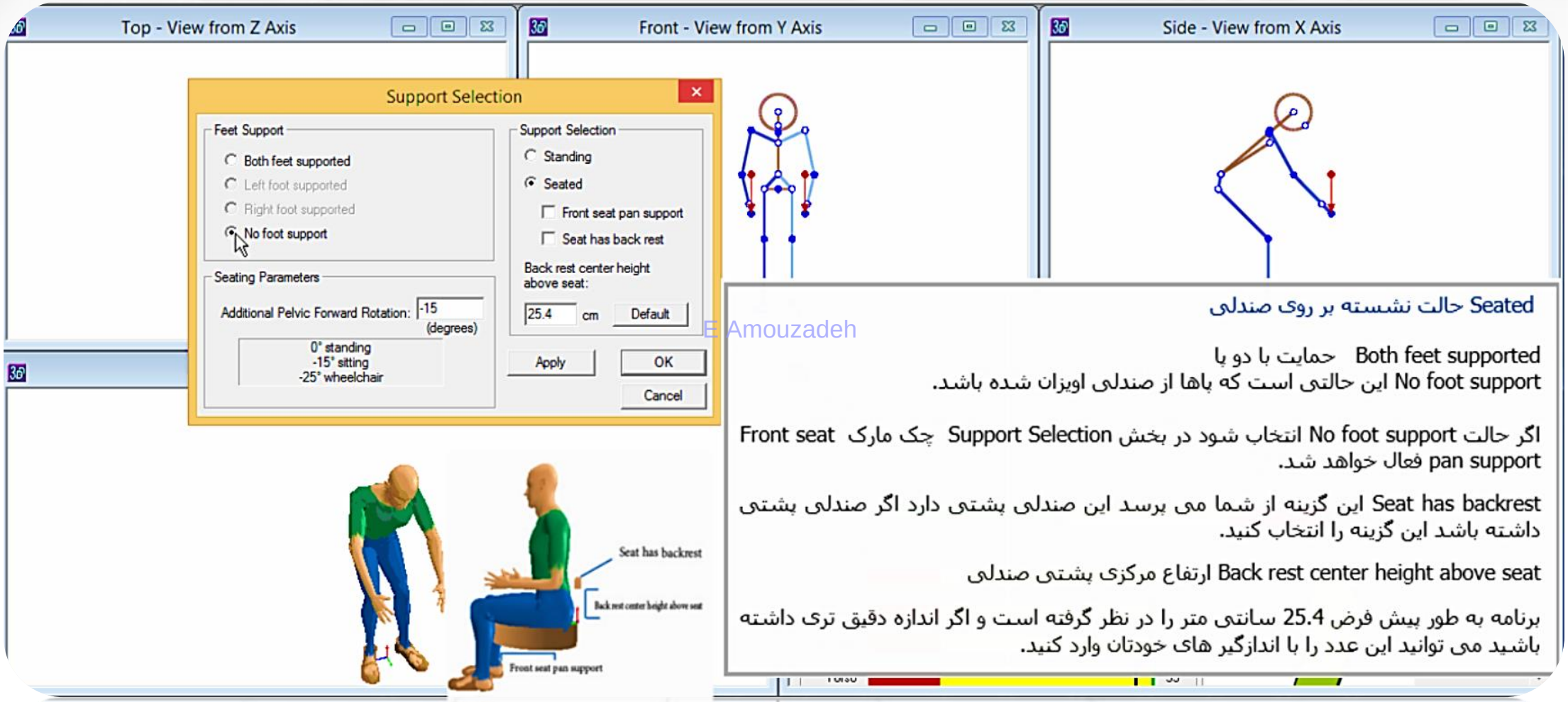

Seated حالت نشسته بر روی صندلی

Both feet supported حمایت با دو پا

No foot support این حالتی است که پاها از صندلی اویزان شده باشد.

اگر حالت No foot support انتخاب شود در بخش Support Selection چک مارک Front seat pan support فعال خواهد شد.

Seat has backrest این گزینه از شما می پرسد این صندلی پشتی دارد اگر صندلی پشتی داشته باشد این گزینه را انتخاب کنید.

Back rest center height above seat ارتفاع مرکزی پشتی صندلی

برنامه به طور پیش فرض 25.4 سانتی متر را در نظر گرفته است و اگر اندازه دقیق تری داشته باشید می توانید این عدد را با اندازگیر های خودتان وارد کنید.


60°
60°
60°
90°
120°
120°
130°
50°
50°
50°
-150°
-150°
-40°
-40°
90°
50°
Horizontal angle measurements
اندازه گیرهای زاویه افقی
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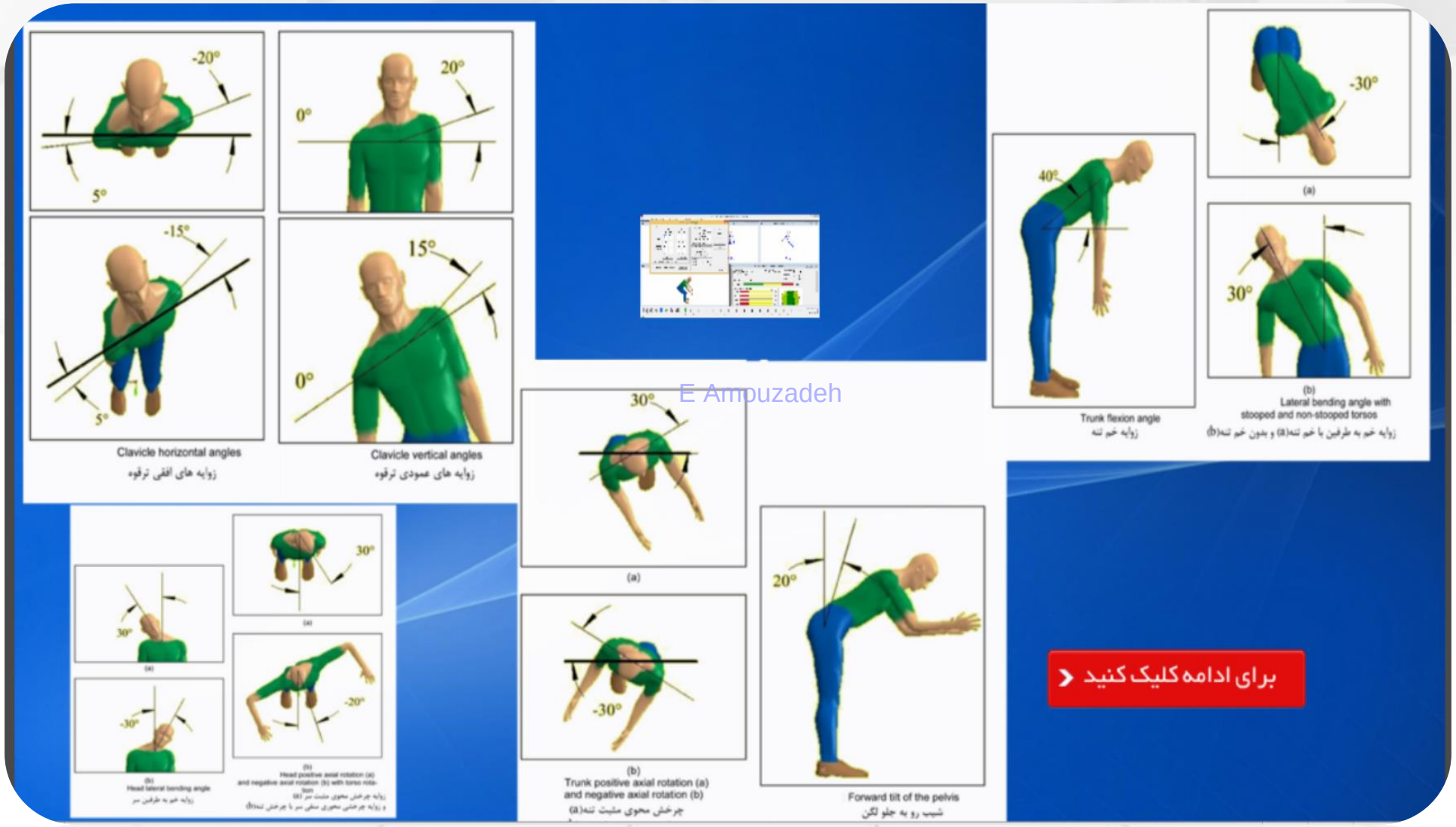
برای ادامه کلیک کنید
60°
-60°
-60°
-55°
35°
40°
40°
-60°
-45°
45°
-50°
60°
-55°
Vertical angle measurements
اندازه گیری های زاویه عمودی


-20°
5°
20°
0°
-15°
5°
15°
0°
Clavicle horizontal angles
زوایه های افقی ترقوه
Clavicle vertical angles
زوایه های عمودی ترقوه
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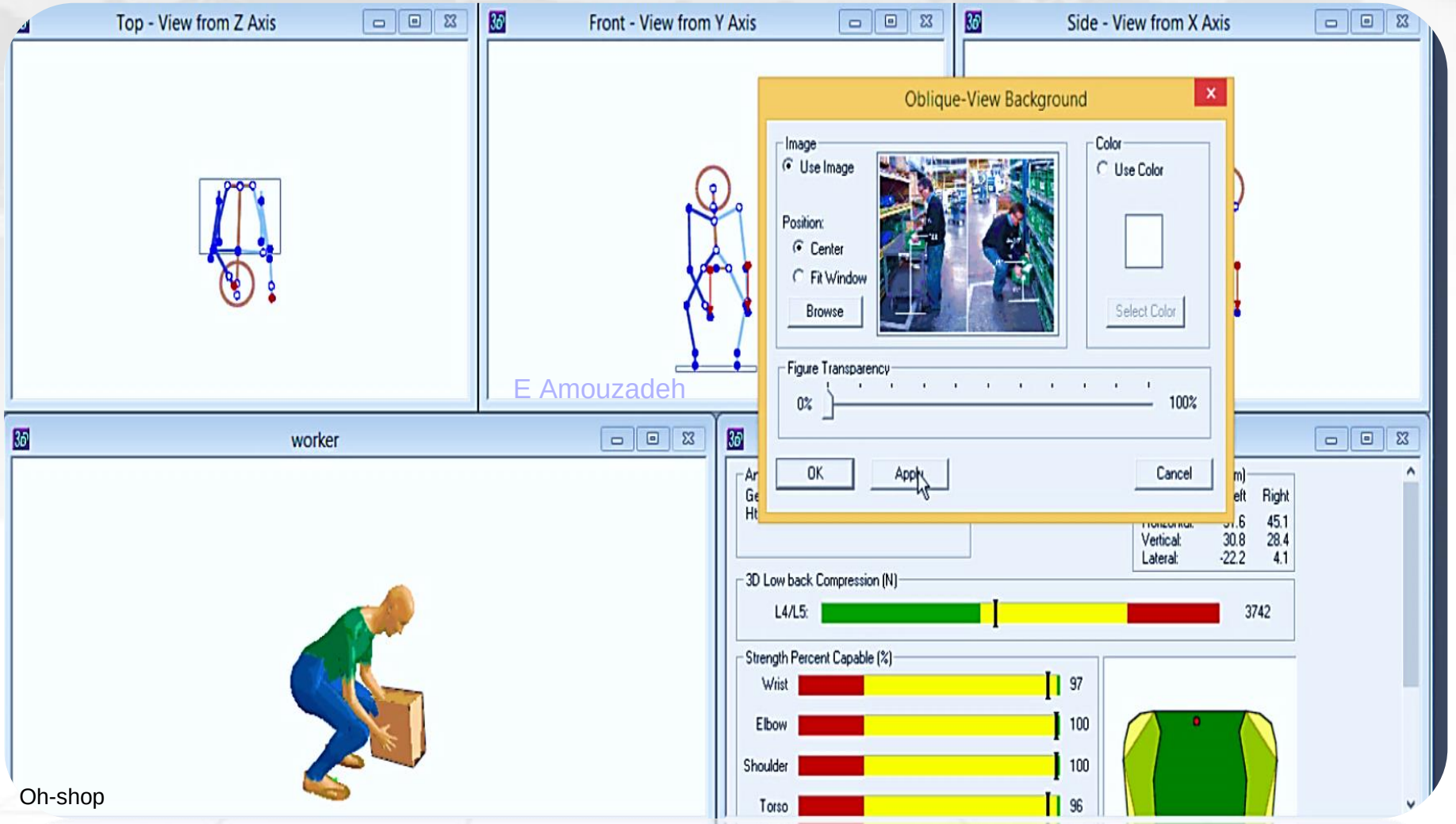
30°
(a)
-30°
(b)
Trunk positive axial rotation (a) and negative axial rotation (b)
چرخش محوری مثبت تنه(a) و منفی تنه(b)
20°
Forward tilt of the pelvis
شیب رو به جلو لگن
40°
Trunk flexion angle
زوایه خم تنه
-30°
(a)
30°
(b)
Lateral bending angle with stooped and non-stooped torsos
زوایه خم به طرفین با خم تنه(a) و بدون خم تنه(b)
30°
30°
-30°
(b)
Head lateral bending angle
زوایه خم به طرفین سر
30°
(a)
-20°
(b)
Head positive axial rotation (a) and negative axial rotation (b) with torso rotation
زوایه چرخش محوری مثبت سر (a) و زوایه چرخشی محوری منفی سر با چرخش تنه(b)
برای ادامه کلیک کنید


-20°
5°
20°
0°
-15°
5°
15°
0°
Clavicle horizontal angles
زوایه های افقی ترقوه
Clavicle vertical angles
زوایه های عمودی ترقوه
E Amouzadeh
30°
(a)
-30°
(b)
Trunk positive axial rotation (a) and negative axial rotation (b)
چرخش محوری مثبت تنه(a)
40°
Trunk flexion angle
زوایه خم تنه
-30°
(a)
30°
(b)
Lateral bending angle with stooped and non-stooped torsos
زوایه خم به طرفین با خم تنه(a) و بدون خم تنه(b)
20°
Forward tilt of the pelvis
شیب رو به جلو لگن
برای ادامه کلیک کنید

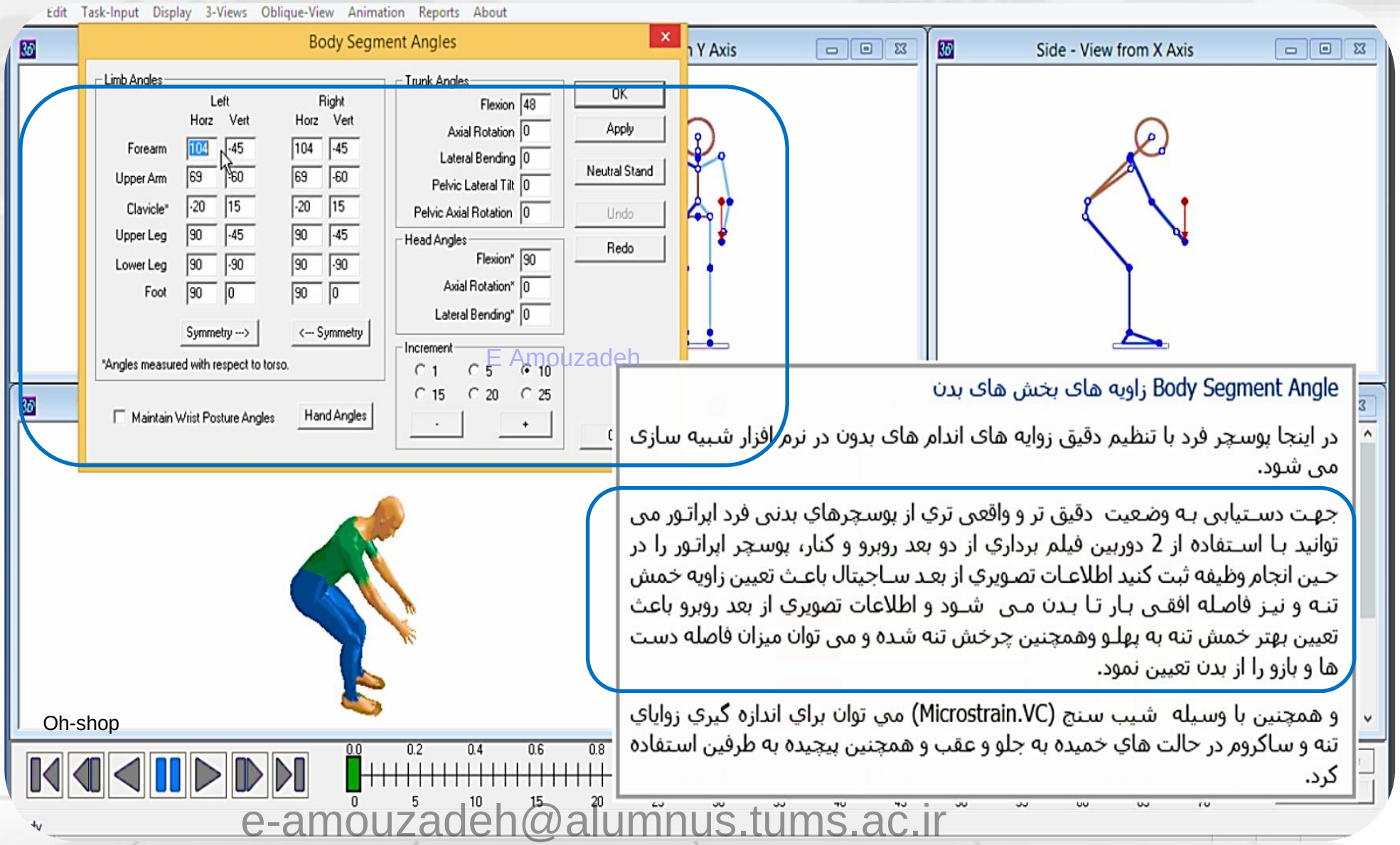
sample

sample

کلیک راست بر روی پنجره Hominoid **و از قسمت** Background **عکس محیط کار را فراخوانی کنید.**



sample



Body Segment Angle زاویه های بخش های بدن

در اینجا پوسچر فرد با تنظیم دقیق زوایه های اندام های بدون در نرم افزار شبیه سازی می شود.

جهت دستیابی به وضعیت دقیق تر و واقعی تري از پوسچرهاي بدنی فرد اپراتور می توانید با استفاده از 2 دوربین فیلم برداري از دو بعد روبرو و کنار، پوسچر اپراتور را در حین انجام وظیفه ثبت کنید اطلاعات تصویري از بعد ساجیتال باعث تعیین زاویه خمش تنه و نیز فاصله افقی بار تا بدن می شود و اطلاعات تصویري از بعد روبرو باعث تعیین بهتر خمش تنه به پهلو وهمچنین چرخش تنه شده و می توان میزان فاصله دست ها و بازو را از بدن تعیین نمود.

و همچنین با وسیله شیب سنج (Microstrain.VC) مي توان براي اندازه گیري زواياي تنه و ساکروم در حالت هاي خمیده به جلو و عقب و همچنین پیچیده به طرفین استفاده کرد.

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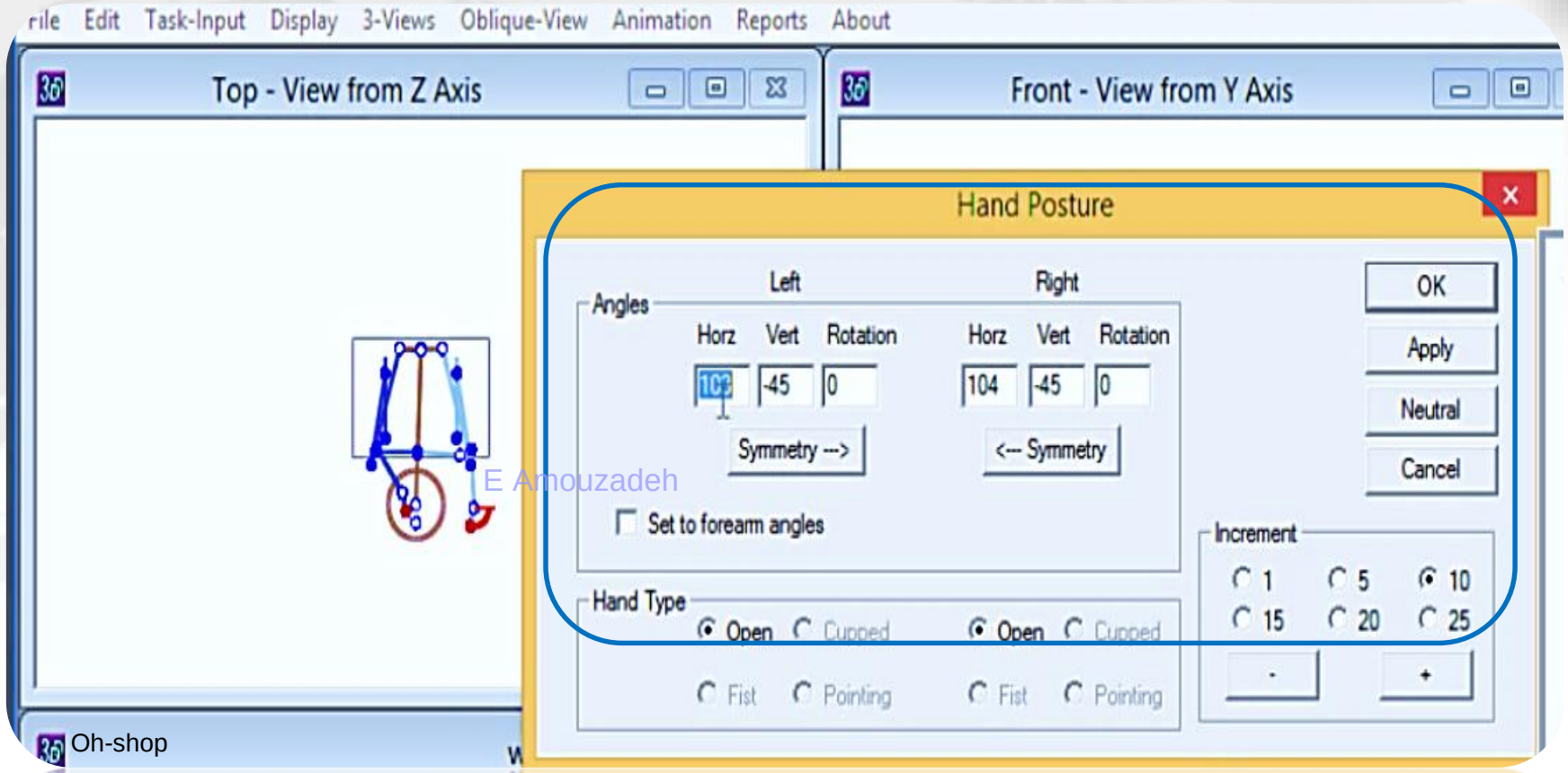
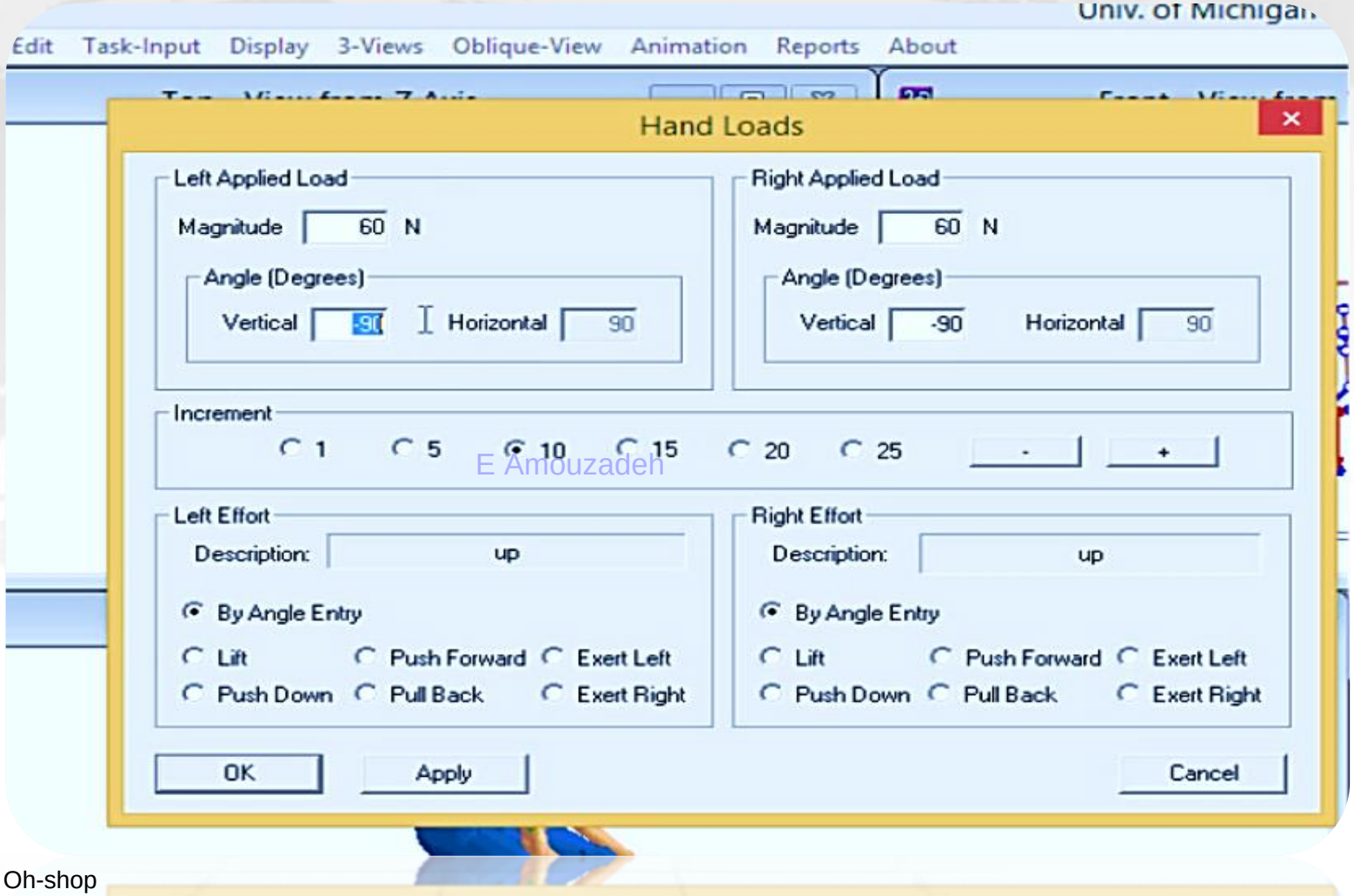
sample



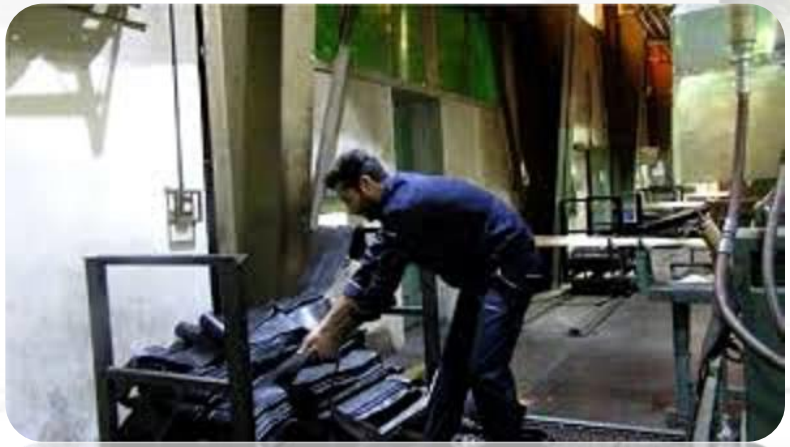
sample

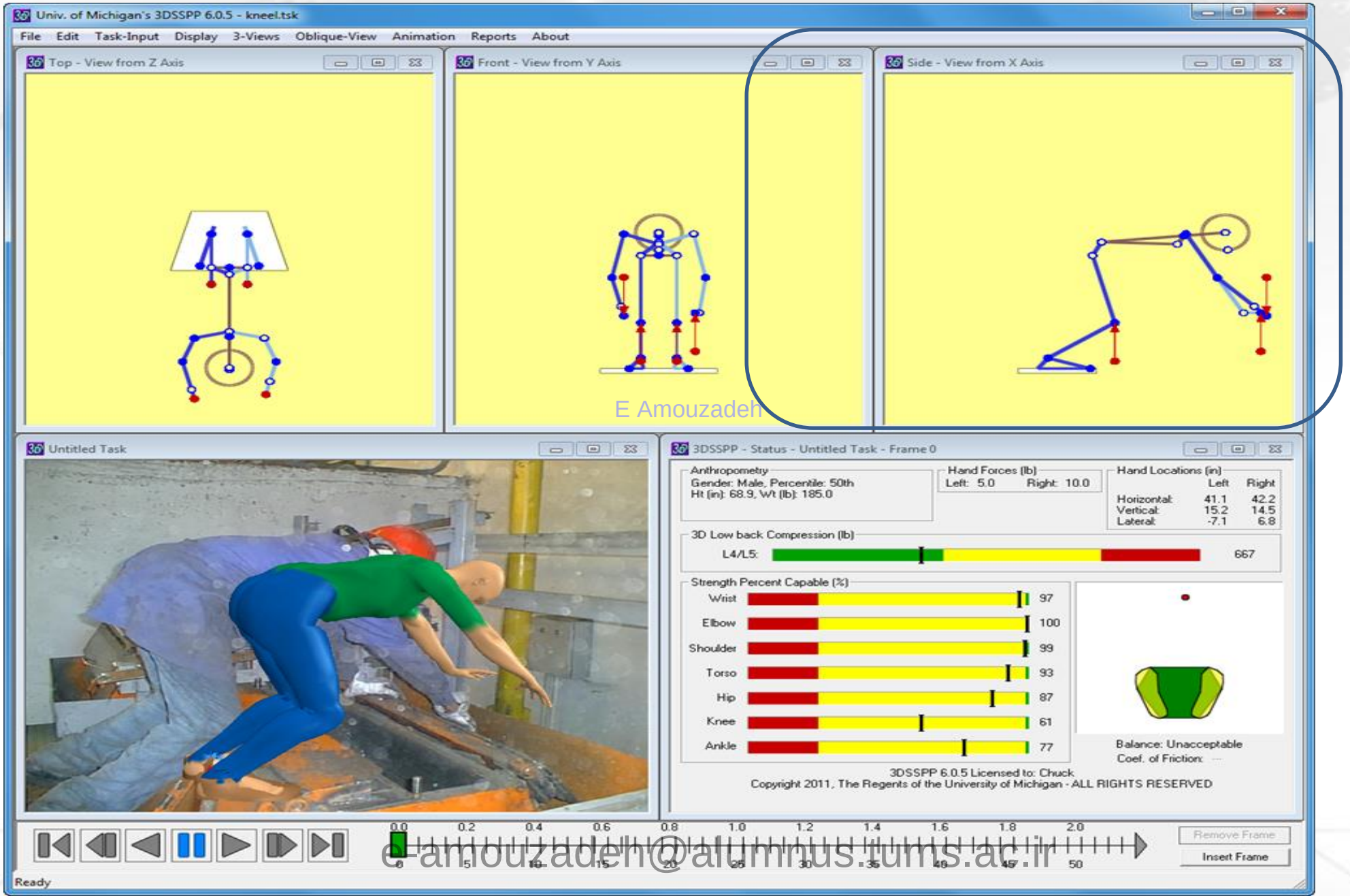


Oh-shop

exercise

Insert One Picture In 3DSSPP And Simulate The Position!





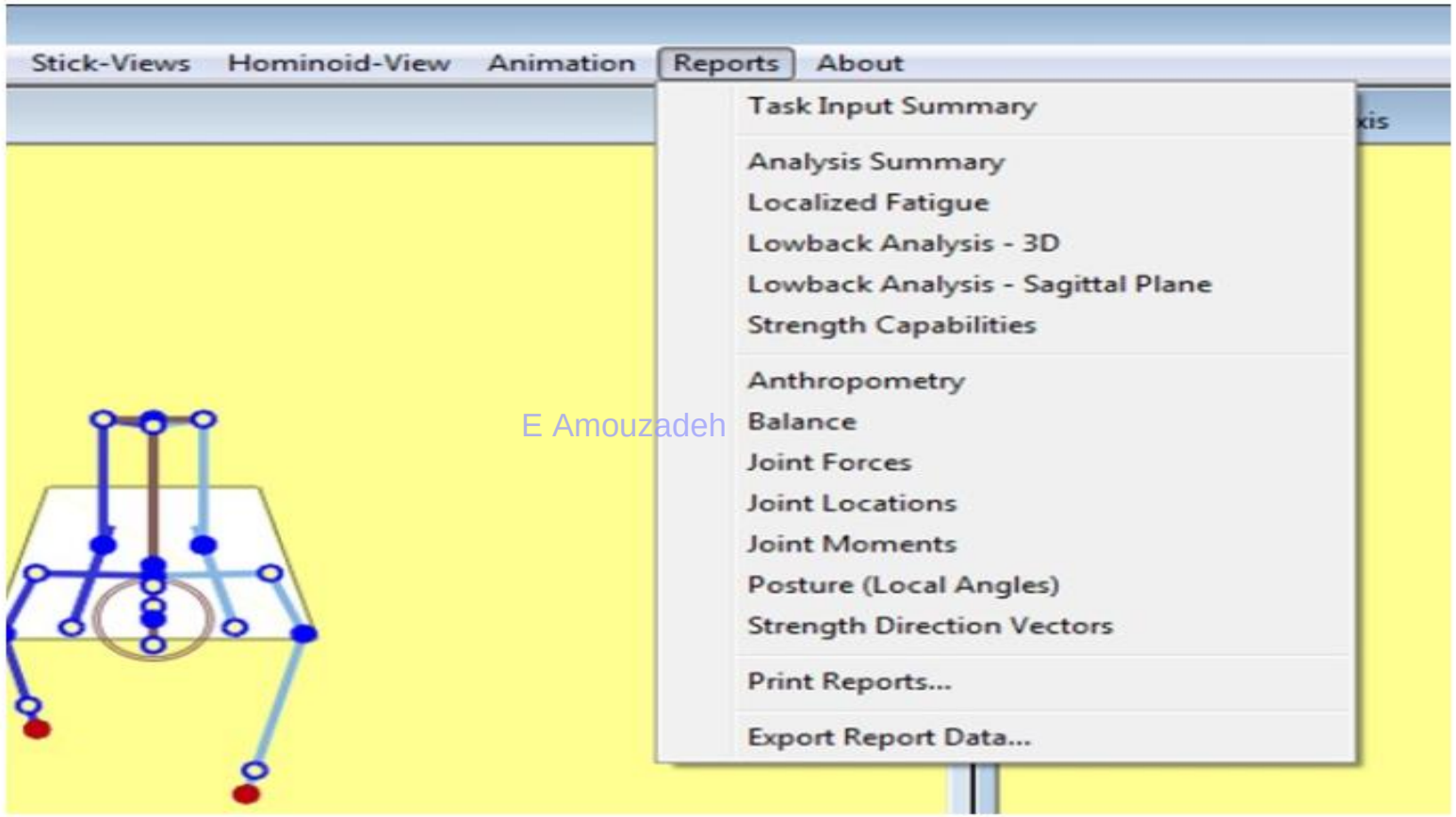


Figure 11.1: Reports Menu

3DSSPP - Task Input Summary

Description
Company: Unknown Company, Analyst: Unknown, Date: 06/23/16
Task: Untitled Task - Frame 0
Gender: Male, Percentile: 50th -- UNIQUE, Height: 69.4 in, Weight: 190.5 lb
Comment:

Hand Forces (lb)
Left: 10.0 Right: 10.0

Hand Locations (in)

	Left	Right
Horizontal:	15.8	15.8
Vertical:	24.4	24.4
Lateral:	-8.4	8.4

Limb Angles (Deg)

	Left			Right		
	Horz	Vert	Rot	Horz	Vert	Rot
Hand:	104	-45	0	104	-45	0
Forearm:	104	-45		104	-45	
Upper Arm:	69	-60		69	-60	
Clavicle:	-20	0		-20	0	
Upper Leg:	90	-45		90	-45	
Lower Leg:	90	-90		90	-90	
Foot:	75	0		75	0	

Trunk

Angles	(Degrees)
Flexion:	48
Rotation:	0
Bending:	0
Pelvic Lateral Tilt:	0
Pelvic Axial Rotation:	0

Head/Neck

Flexion:	90
Rotation:	Static
Bending:	Static

Hands

	Left			Right		
Neutral	Horz	Vert	Lat	Horz	Vert	Lat
Location(in):	15.8	24.4	-8.4	15.8	24.4	8.4
	Horz(Deg)	Vert(Deg)	Mag(lb)	Horz(Deg)	Vert(Deg)	Mag(lb)
Force:	90	-90	10.0	90	-90	10.0

3DSSPP 7.0.0 Licensed to: Unprotected
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Figure 11.2: Task Input Summary report

- **گزارش خلاصه ورودی وظیفه**

خلاصه ای از داده های وارد شده در Task-Input **آیتم های منو شامل موارد زیر است:**

۱. زوایای مفصلی،
۲. مکان های دست،
۳. بزرگی و جهت نیروی دست و
۴. نیروهای مشترک اضافی.

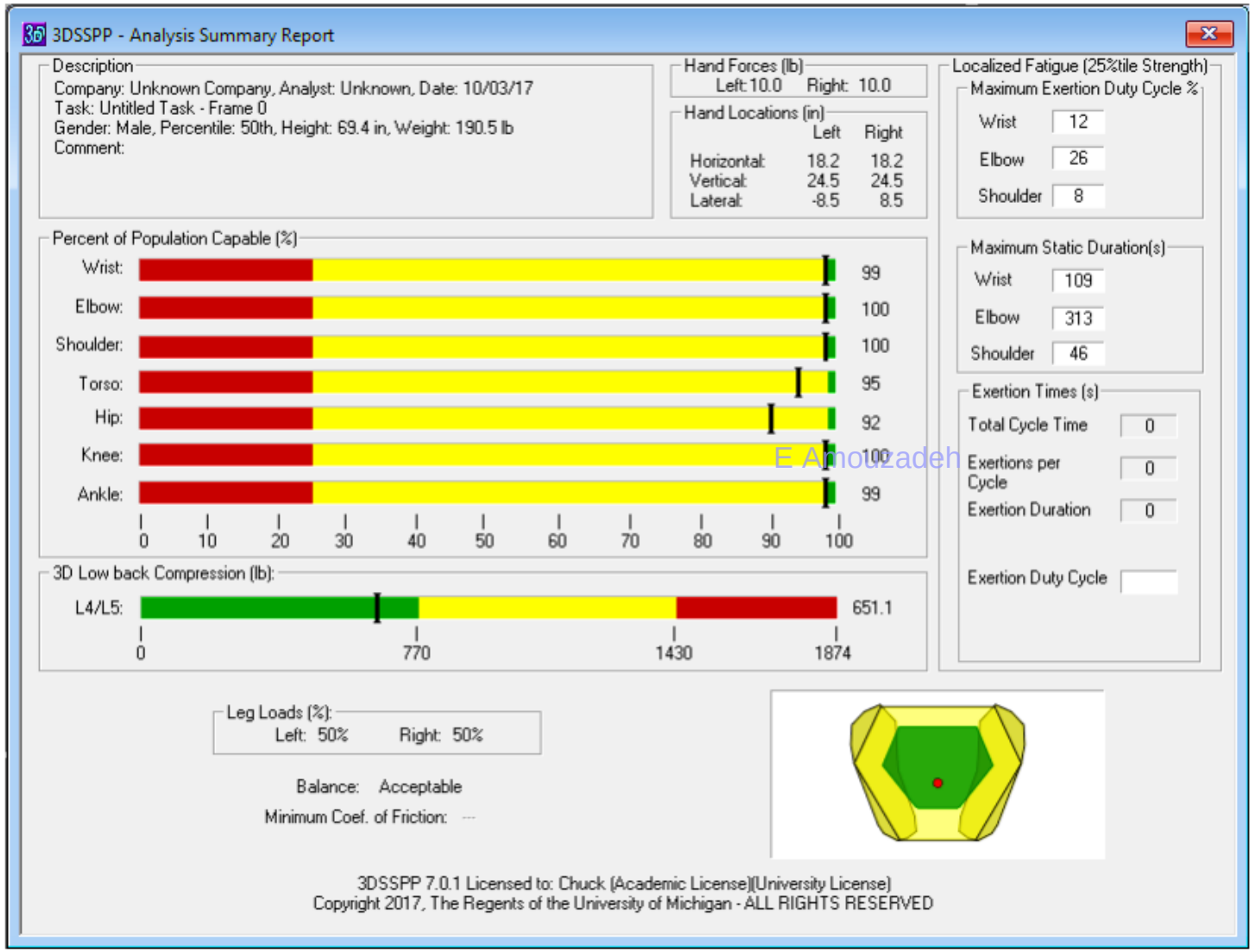

Figure 11.3: Analysis Summary report

- گزارش خلاصه تحلیل

- پنج حوزه اطلاعاتی را نشان می دهد:
- نیروهای دست،
- فشرده سازی پشت دیسک،
- درصد قابلیت،
- تعادل،
- ضریب اصطکاک
- و خستگی موضعی

برخی از نرم افزارهای تعیین زوایای بدن

در حال حاضر، برخی از نرم‌افزارهای تعیین زوایای بدن از روی ویدئو و عکس در حوزه‌های مختلفی مورد استفاده قرار می‌گیرند، از جمله:

- **OpenPose:**

یک نرم‌افزار متن‌باز برای تشخیص و تعیین موقعیت اجزای بدن از ویدئو و تصاویر.

وب‌سایت: OpenPose

- **Microsoft Azure Kinect Body Tracking:**

یک سرویس ابری از مایکروسافت برای تعقیب و تشخیص حرکات بدن از طریق دوربین‌های سنسور .Azure Kinect

وب‌سایت: Azure Kinect Body Tracking

- **DeepLabCut:**

یک ابزار متن‌باز برای تعیین موقعیت اجزای بدن با استفاده از شبکه‌های عصبی عمیق.

وب‌سایت: DeepLabCut

- **Laban Movement Analysis (LMA) Tools:**

ابزارهایی که بر اساس تحلیل حرکات لابان ایجاد شده‌اند.

وب‌سایت: Laban Movement Analysis

- **Posenet:**

یک مدل عصبی کوچک برای تشخیص موقعیت اجزای بدن از تصاویر با استفاده از .TensorFlow.js

وب‌سایت: Posenet

ایمیل :

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e-amouzadeh@alumnus.tums.ac.ir

Thank You

E.Amouzadeh

2023 December

ترادرس ارگونومی-۲۹ آذر ماه-۱۴۰۲

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