

# USERS MANUAL

## AN AUTOCAD BASES HUMAN MODELING PROGRAM-HUMAN

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### WHAT IS REQUIRED TO USE THIS PROGRAM

You need AutoCAD version 10 or above to run this program. Human model comes up only as a 3D model and to use it, YOU NEED TO BE QUITE PROFICIENT IN AUTOCAD 3D MODELING. You should be familiar with AutoCAD's 3D related commands such as "viewpoint", "ucs", "hide" and "vports" to use this model effectively. Also you should be familiar with typing the commands at the AutoCAD's command prompt and general conventions used for such inputs. At present there is no menu or toolbar interface for the human model.

### HOW DOES THE PROGRAM WORK

AutoCAD is a 3D CAD program, thus theoretically you can draw anything including a human model using its native commands. If you want to draw and manipulate a 3D human model using AutoCAD's native commands, it will take prohibitively long time and it would be very difficult. This program runs within the AutoCAD's drawing environment and provides you with a set of special commands to effectively generate and manipulate human models. When these special commands are typed-in at the command prompt, it acquires your inputs through command prompts and then, automates all the AutoCAD's native commands needed to create and manipulate a complex human model. This program thus provides an easy interface for human modeling in the AutoCAD environment. It helps you to generate a 3D human model according to your specification. When the human model is created, it provides you with several special human commands to help you manipulate the human model. The special human commands are described later.

The program assembles a set of human body segments, which are drawn to the 50<sup>th</sup> percentile size and are stored in a drawing "humanmodel.dwg" as blocks. If you need other percentile human model than 50<sup>th</sup> percentile, it calculates the scale factors to size the blocks accordingly. Additionally, it allows you to input individual body segment lengths for a customized human model. Once the human model is created in AutoCAD's drawing database, the program keeps track of the positions and orientations of the blocks representing each body segment. To change the joint angles of the human model in the 3D environment, the program uses AutoCAD commands "select", "ucs" "rotate" etc in the background to achieve the desired result in 3D. The program also calculates the required angles of rotations from the geometric database of the objects drawn in AutoCAD.

## PROGRAM STARTUP REQUIREMENTS

**Before you use this program, copy the humanmodel.dwg and human.lsp files in the DWG directory of AutoCAD or any other directory for which AutoCAD has a defined path.**

Run AutoCAD and either start a new file or open any drawing file on which you want to generate the human model. You should open an existing drawing of a physical environment into which you want to import the human model for human machine interaction evaluation. This existing drawing should be a 3D drawing.

After the drawing window opens, use AutoCAD's "insert" command, select the browse option and select humanmodel.dwg file as the block to be inserted and then click ok. When AutoCAD prompts you to choose insertion point of the block, simply cancel the "insert" command by pressing Escape key. This will bring all predefined blocks of humanmodel.dwg into your current drawing database, without drawing anything on your drawing window. These blocks are essential for the human model to work.

Use vpoints command or use the view menu, then choose 3D views, and then North East or North West. This will enable you to see the 3D human model in proper orientation when inserted.

Load the program by typing the following at AutoCAD's command prompt: (Load "human.lsp"). You must use the parentheses. Alternatively, you can also use the Tools menu of AutoCAD and then select Autolisp and then select the human.lsp file from the selection. You will get a confirmation the human.lsp program has been successfully loaded.

The following box shows the copy of the command prompt area of AutoCAD when I performed the above three tasks using AutoCAD's tool bar and menus. My inputs are in bold font.

```
Regenerating model.
AutoCAD menu utilities loaded.
AutoCAD Express Tools Menu loaded.
Command: _insert
Specify insertion point or [Scale/X/Y/Z/Rotate/PScale/PX/PY/PZ/PRotate]:
*Cancel*
Command:
Command:
Command: _-view Enter an option
[?/Orthographic/Delete/Restore/Save/Ucs/Window]: _neiso Regenerating model.
Command:
Command:
Command: _appload HUMAN.LSP successfully loaded.
Command:
Command:
```

Once the above five steps are completed you are ready to use the human modeling program within the existing drawing. The following special human commands are then available to you for creation and manipulation of human model. These special human commands can only be

used by typing the command at AutoCAD's command prompt. No menu or toolbar option is available at present.

The special commands will now act just like any other AutoCAD's native commands. **They are not case sensitive.** Depending on the special command, it will generate a series of prompts at the command prompt window to acquire your inputs. These prompts are enclosed within two angle brackets. The prompts will include the available choice of your responses. Similar to the native AutoCAD commands, you may type your response by typing the first few letters of the options, which are shown in capitalized letters.

SPECIAL HUMAN COMMANDS: IMPORTH, EXTRACT, HMOVE, POSTURE, REACH, ENVELOP, AND ANALYSE

**IMPORTH** – Lets you import a human model into the current AutoCAD drawing. Following is an example of interaction of importing a 25<sup>th</sup> percentile human model in a standing posture. Command prompts are shown in Arial font and my inputs are shown in **bold font**.

Command: **ImportH**

Male or Female <M F>:**f**

Gross Percentile or Limb Dimensions <G L>:**g**

Percentile <0.5 to 99.5>:**25**

SEated or STanding: **st**

Seat reference pt or mid pt of heels :

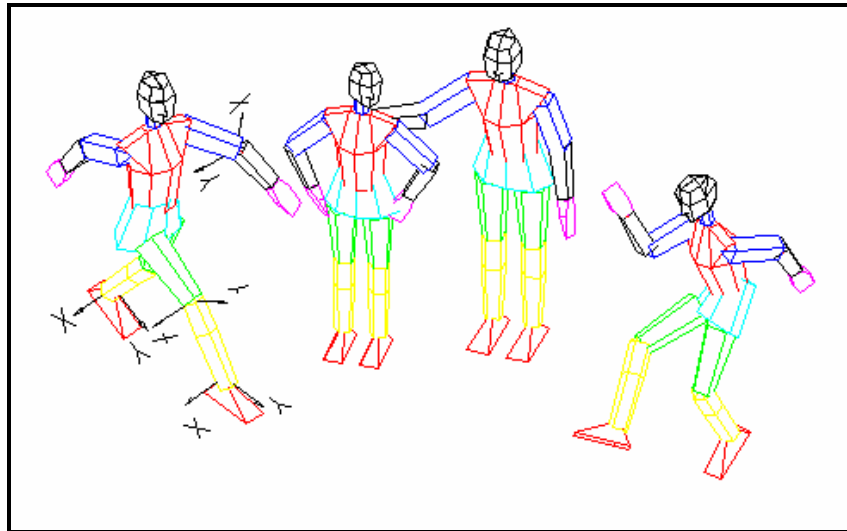
Presently only female human model is available. The female human segment blocks are drawn in the humanmodel.dwg files. Similar male segment blocks need to be drawn and saved in the above drawing before the male option in importH command will work. If you choose male model, it will give you an error message.

You can use gross percentile option or can select limb dimension option. If you choose the latter option, then the prompt will ask you to input the individual limb dimensions of the model. Using this option you can build any size model. Once the sizing data is acquired, the program can insert the human model in either seated or standing posture and prompts you to select accordingly. Once you select the initial posture, then it asks you to input the insertion point. The insertion point you can input either by providing x,y,z coordinate, or by clicking a point on the drawing area. In the latter method you can use AutoCAD's "OSNAP" modes to precisely position the model. If you import the model in seated posture, the insertion point you input will be the seat reference point. If you import it in standing posture, the insertion point you input will be the mid point between the heels.

At the completion of the command, you will see the human model facing the current y-direction of your UCS and its right side of the model towards the x-direction of UCS.

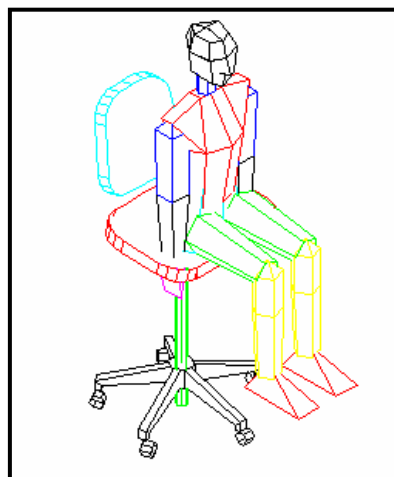
You can use importH command repeatedly to import multiple human models of different sizes into your drawing. The following four human standing models were drawn by using importH repeatedly. Then their postures were changed using "extract" and "posture" commands

repeatedly. The uses of these commands are explained later. Then AutoCAD's "hide" command was used to remove the unwanted lines.



The following diagram shows you a 95<sup>th</sup> percentile seated human model imported on an existing drawing of an office chair. Again AutoCAD's "hide" command was used to improve visualization.

Note that the human is sitting at the edge of the chair. This is because during the execution of the import command, I picked a wrong point as the seat reference point. Also the model's arm has penetrated the seat base. These can be corrected later by using "hmove" and "posture" commands, explained later.



## EXTRACT

This command is provided to activate any of the imported human models for further manipulations. Suppose you have imported 3 different human models into your drawing and want to work on the second imported model. You will use this command.

Command: **extract**

The model number to initialize <Number>: **2**

This way you can initialize any human model in your drawing database at any time and manipulate them using the following special human commands.

## HMOVE

This special command allows you to move or rotate the whole human model in your drawing space. Use this command if you need to reposition the human model after you have imported it.

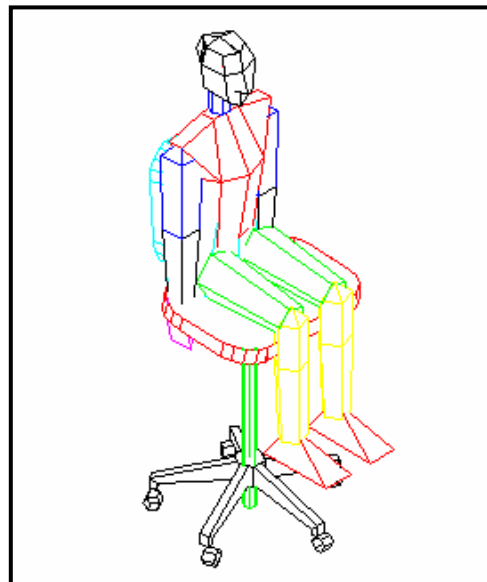
Command: **HMOVE**

Angular or Linear movement <A L>: **L**

Specify base point or displacement: **0,-10,0**

Command: **(pressed enter)**

The first prompt lets you select either Linear movement or Angular movement required. Here I have chosen linear, and then inputted a x,y,z displacement of (0,-10, 0). At the completion of this command the program moves the human model -10 units in the y direction. You can also accomplish this by using your pointing device, such as mouse.



If you select Angular option, it will ask you angular rotation required. Once you enter the angle, it will rotate the model around its vertical axis.

## POSTURE

This command allows you to change the joint angles by rotating a segment around its proximal joint. When the posture command is used, it prompts you to select the segment to be repositioned. The segments are abbreviated as Rft- right foot, Lft-left foot, RLg-right leg, LLg-left leg, RThi-right thigh, LThi-left thigh, Hip- Hip, Trs- torso, RUrm-right upper arm, LUrm-left upper arm, RArm-right arm, LArm-left arm, RPm-right palm, LPm –left palm, Nk-neck, Hd-head. Depending upon your selection, the program selects the appropriate body segment blocks. Then the program prompts you to select the direction of rotation with respect to the x, y or z direction of the segment. After this, the program asks for your input for the amount of rotation in degrees. You can also input this using your pointing device.

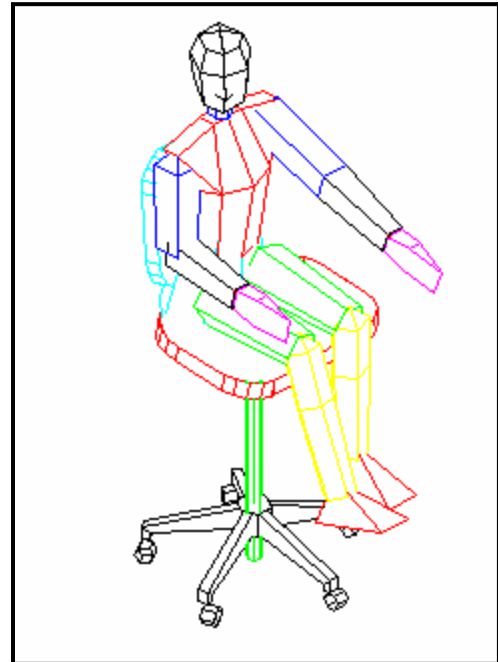
Command: **POSTURE**

Which segment <RFt LFt RLg LLg RThi LThi Hip Trs RUrm LUrm RArm LArm RPm LPm Nk Hd>: **LU**  
Movement with respect to the axis <X Y Z>:**X**  
Specify rotation angle or [Reference]:

In the above interaction, I selected the left upper arm for a rotation around X axis and inputted the angle with a mouse click. The program selects left upper arm along with other distal segments attached to it and rotates the whole segment around the shoulder joint in flexion towards the point I clicked.

By repeatedly using this command you can bring a human model to any desired posture. I changed the right arm (RA) around X, right leg (RL) around X, Left upper arm (LU) around x and y, and neck (N) around z to correct the seated human model's posture.

However, there is no restriction to the joint angles and the axis of rotation you input. Therefore, the body segments can assume unnatural posture if you provide abnormal inputs. If you do so, you can always use AutoCAD's undo command by typing "u" repeatedly.



## REACH

This command allows you to check if a point within the drawing is within the arm reach of a human model. The program uses the present arm length and current shoulder joint coordinate data of the human model to check the reach. If the point is within the reach, the program calculates the required joint angles in the shoulder and elbow joint to reach the point, and repositions the upper arm and lower arm such that the palm touches the reaching point.

Command: **reach**

Point to reach : **int**

of

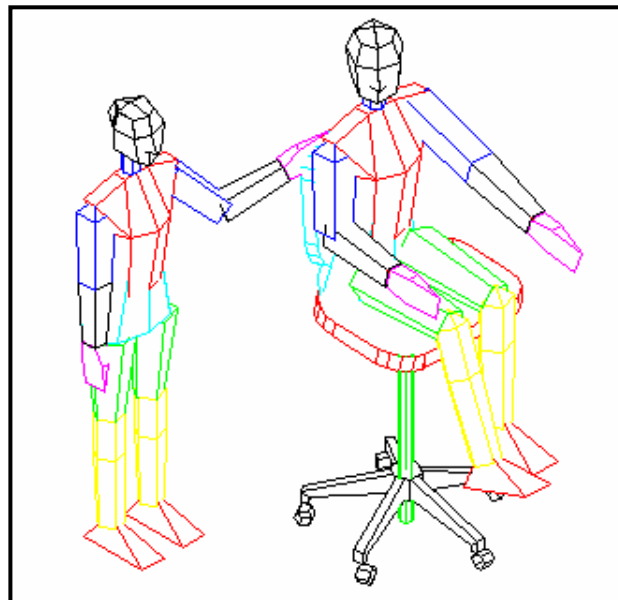
By which hand <L R>:**L**

Before executing the reach command, I imported a 5<sup>th</sup> percentile human model in standing posture into the drawing database and positioned it to the right of the existing model [refer to following diagram]. Then I used the reach command, inputted the point to reach by using the 'int' osnap and clicking on an intersection on the shoulder of the previous human model in my

drawing database. Afterwards I inputted L to indicate left hand to reach the point. I could have also inputted x,y,z coordinate of the reach point using any of the available options in AutoCAD to input the location of a point. Once all inputs are given, the program performs all calculations, and changes the posture of the left upper and lower arms to execute the reach.

If the point to reach is beyond the reach of the human model, the program will output that the point is not within the reach.

Presently the reach originates from the specified shoulder joint. The program cannot change the torso angle for performing the reach, such as leaning towards the reach point. If a point is beyond the arm reach, you can use the posture command to lean the model towards the reach direction and then execute the reach command. Also you can use Hmove to move the whole model towards the reach point to make the reach possible.



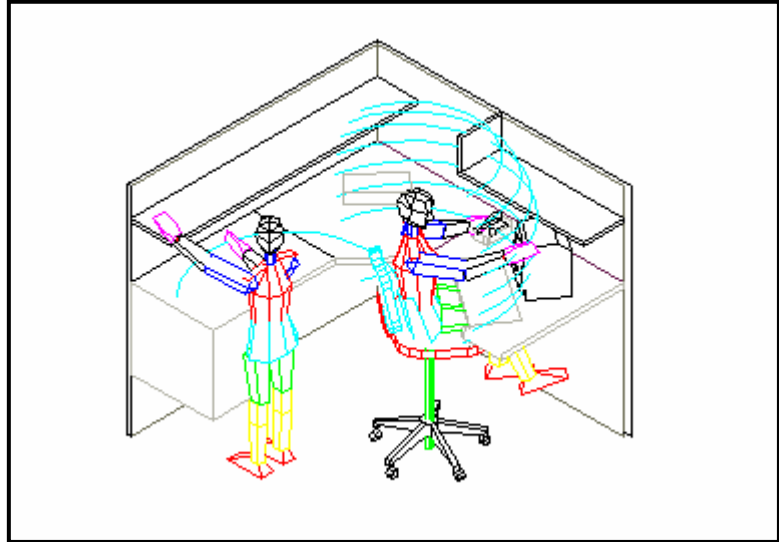
## ENVELOP

This command allows you to draw the boundary of the reach area or a reach volume. The program uses the present arm length and current shoulder joint coordinate data of the human model to draw reach envelopes. In case of reach area boundary the program needs the input for the height of the surface for which the reach boundary is to be drawn. In case of reach volume, the program simply draws curves representing the 3D envelope.

Command: **envelop**  
Hand <Right Left>: **r**  
Volume or Area <V A>: **A**  
Select any point on the  
desired surface: **end**  
of:

In the above interactions I selected the right hand by typing 'r', the reach type as reach area by typing A, then selected a point using the end osnap of AutoCAD on the table top.

I extracted the other human model and used the volume option, and selected its left hand for drawing the reach volume. Using this special command you can check the reach ability of the model at any plane.



## ANALYZE

This special command computes the joint angle of a selected joint of the human model. After positioning the model at the desired posture, you can use the command to find the numerical values of the joint angle at that posture.

Command: **analyse**  
Which segment <RFt LFt RLg LLg RThi LThi Hip Trs RUrm LUrm RArm LArm RPm LPm  
Nk Hd>: **ru**  
Command: Angle from XZ 317.684267950025 Angle from YZ 0.000000000000 Rotation  
0.000002889430

In the above interactions, I analyzed the joint angle of the right upper arm (ru), and the program computes the angles.



## WHAT NOT TO EXPECT FROM THIS PROGRAM

I wrote this AutoLISP program while I was a graduate student, about 12 years ago. This is by no means a full blown software and should be used as a building block for developing a more robust and usable human modeling program. If you are developing a human modeling program using AutoLISP, this program may be of help. This program may have some glitches and does not always perform as it should. If you wish, you may work on the AutoLISP source codes to improve upon the program. Some possible improvements arranged in an increasing order of difficulties are:

- Adding a set of 50 percentile male segments
- Improving the outer shell of the human segments to give it a better look
- Using the camera command of AutoCAD, add a special human command to show the field of view of the human model
- Adding a human modeling tool bar containing special human commands
- Incorporating a set of constraints to limit unnatural postures
- Incorporating mass and inertial properties to the body segments, to automate static and dynamic biomechanical load computations