Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

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Lecture - 08
Virtual Ergonomics and its Advantages

Previous course, Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation.

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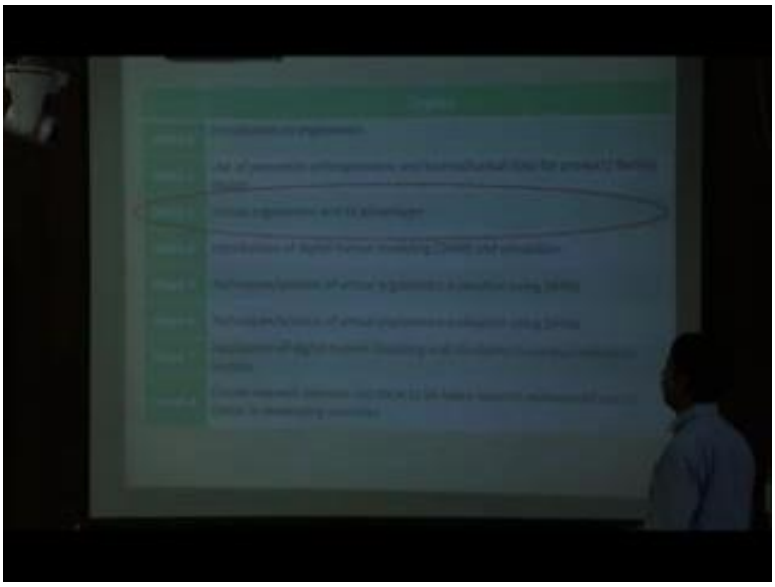

Today we are going to discuss, to our next topic; that is virtual ergonomics and its advantages

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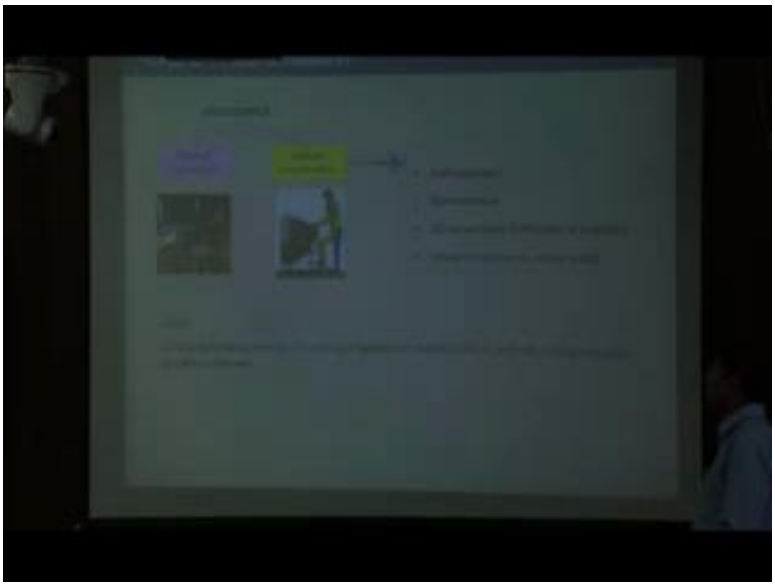

In this module three, we are going to discuss, mainly these two areas; digital 3 D evaluation and principle of projection. Next virtual simulation versus virtual (Refer Time: 00:43). So, in our earlier modules we have learnt; what is ergonomics. And also we defined; what is the difference between physical ergonomics and virtual ergonomics. So, we mentioned that in physical ergonomics there is, we study physical compatibility between real human being and real product.

On the other hand in virtual ergonomics, we evaluate the compatibility between virtual human and virtual product means CAD generated human model and CAD generated product model. So, we study the compatibility, between these two in CAD generated environment. So, in our earlier module, module one and module two we have covered ergonomics, and in module specifically module two what is anthropometric, percentile anthropometric data and its use, similarly biomechanics and biometry biomechanical data, and its use for products and various other facility design.

Now, today we are moving to this first topic; that is CAD and virtual simulation. So, first you want to know what is cad. CAD is, its full form is computer aided design. Somewhere it is also mentioned as CAD is computer aided drafting, but in our presentation, with this word cad, WE would actually mention people this abbreviation cad; that is a computer aided design. So, CAD is defined as the process of creating geometric model, surface solid etcetera, using computer graphic software. So, this is the

CAD computer aided design, is a process for a various types of computer graphic softwares are used for developing, for giving representation of product, using surface or solid modeling.

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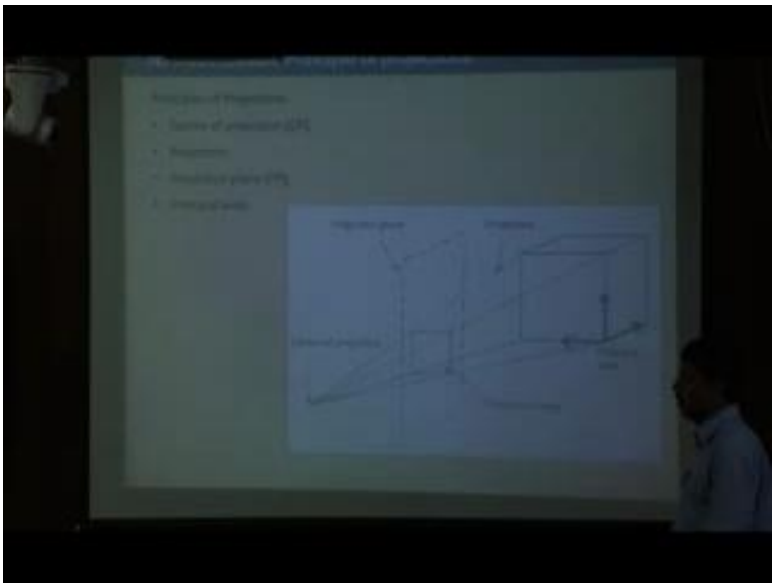

Now, we are moving to 3 D visualization. While we are discussing about CAD then 3 D visualization is very important, because you have to understand, in this CAD software, or specific CAD software as you will later on discuss about digital human modeling. So, this in this software, while you are looking at the product, or evaluating that virtual product 3 D visualization is very important. For understanding the product and compatibility with digital human model, first you should know about principle of projection. How projection happens, and how it is perceived by human eyes. So, generally if we want to define, if we discuss about principle of projection few points are there; centre of projection, projectors, and projection pane and principle axis

So, first if we mention about these four points, first one; see this is an object, three dimensional object, for that particular object obviously there will be height, weight, depth, mean x y z relations are there these three axis are called principle axis; three main axis for the particular product. Now, from that object or product, lighter are coming and falling on a plane, where image is formed, this image is called image of that object, which is formed on this particular page that plane is known as projector plane, and the image which is formed on the projection plane is called projector image. So, this is the

object with its principle axis is now that is projected on projection plane, and these light rays are converging at a particular point, that point is called centre of projection. So, basic understanding of these variables is very important for moving further.

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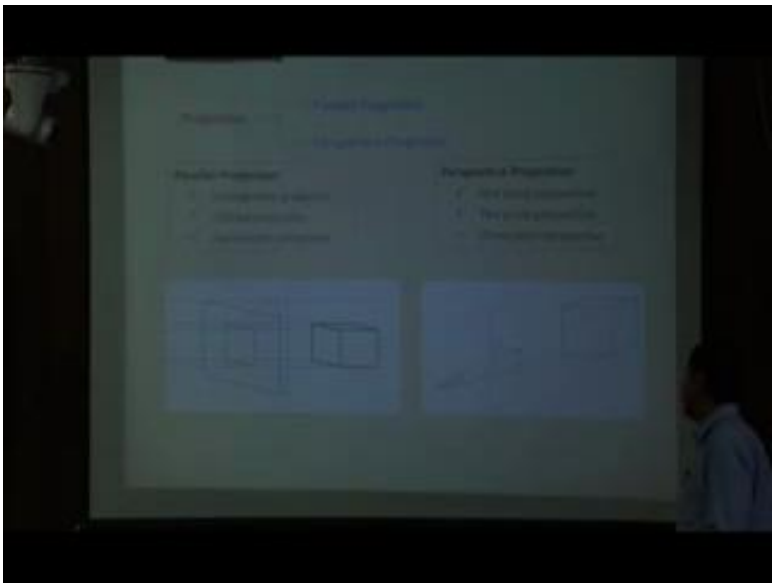

Now, projection is of two types; parallel projection, and perspective projection. In under parallel projection, we categorize this parallel projection in three categories; orthographic projection, oblique projection and axonometric projection. On the other hand perspective projections are categorized in three categories; one is, one point, second two points, and other is a three point perspective. So, what is parallel projection? Parallel projection, in case of parallel projection, this is the object; generally object is an infinite decision. From the infinite decisions, parallel light rays from the objects are coming and falling on the projection plane, and image is formed. So, in case of parallel projection, projectors from the objects are parallel. these lines, these projectors are (Refer Time: 06:38) this those are parallel to each other that is why it is called parallel projections, but in case of perspective projections, object is nearby, means within the finite distance from that object converging light rays are coming.

These are light rays of projector, projectors are coming and it is falling on a projection plane, and smaller size uniform here. Here image size is almost same, but here image size is smaller in parallel projection, always image is its side or all these thing is similar to the actual object, but in this case, it is always smaller in size, the projector image in

comparison to the object. So, the main basic differences between parallel projection and perspective projection projectors or light rays are parallel projectors, or light rays are in this case, it is convective. Another is objectives at far away in infinite distance and here object is nearby or finite distance.

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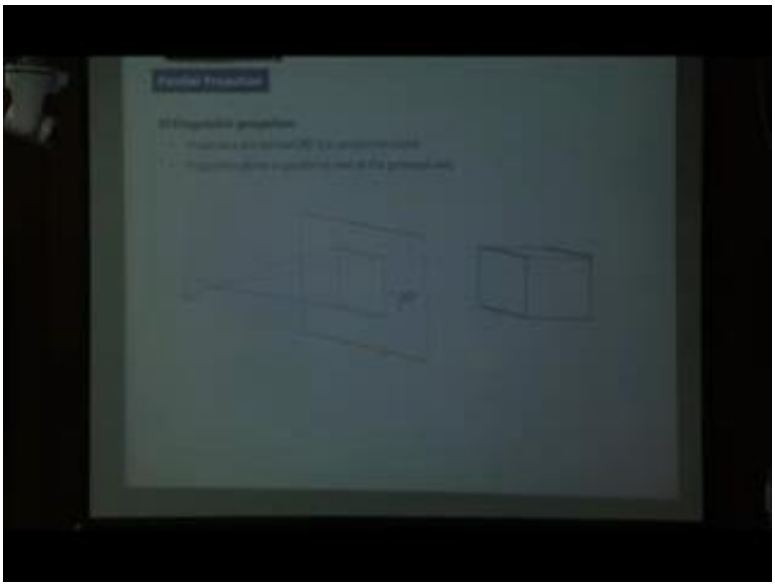

Now, first one is parallel projection. Parallel projection will be already categorized in three; orthographic, oblique and axonometric. First we are going to discuss about orthographic projection. In orthographic projection what happens. This is the object, from the object parallel light rays are coming falling on the projection plane and image is formed, and image is visualized by us. So, parallel light rays are coming from the object falling on the projection plane. Now these light rays on projectors coming from the object, falling on the projection plane at an angle of 90 degree, this is one condition. Another is one of the projection planes is parallel to the one of the principle axis. This projection plane is parallel with this one; projection plane is parallel with one of the principle axis. So, this is one of the principle axes, and this is the one line on the projection plane. So, these two are parallel.

So, two conditions to achieve orthographic projection, two conditions should be fulfilled; one projectors or light rays falling on the projection plane; that is 90 degree, and one of the principle axis is parallel with the projection plane. Then we will get this type of image, and now that image is visualized (Refer Time: 09:37). So, while we are looking at

that projected image, then light rays, here it is the converging light rays, so this is not and coming under parallel projection. So, what is parallel projection? It is shown how human perceives that projected unit. So, from the object parallel light rays are coming, and falling on the projection plane and making an image; that is called orthographic projection, condition is these two. The same thing we can draw. It will be much easier to understand in that case.

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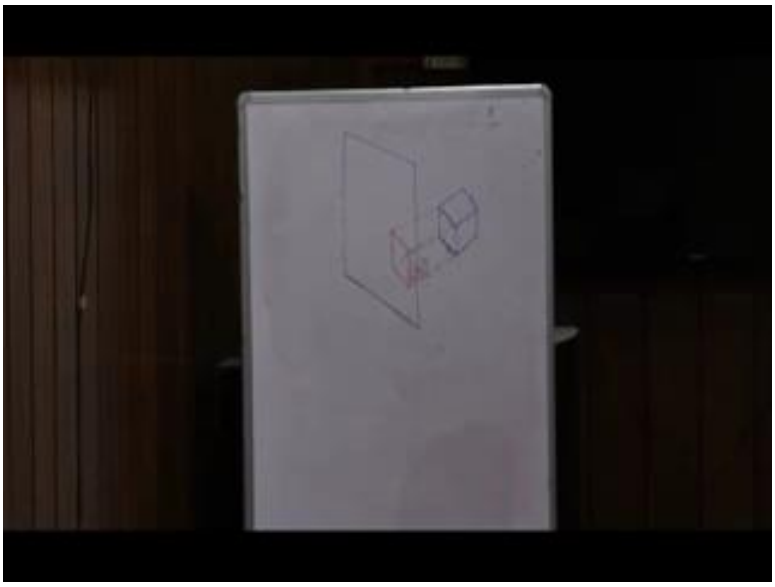

So, if this is the object. If you consider this so; obviously, this is the object. From this object and this is the projection plane. So, projection plane should be parallel with this one, one of the principle axis. So, this is parallel. Now, we are drawing the projection plane, so one criteria is fulfilled. One of the principal axis; that is this one, this principle axis is parallel with this one, first criteria. Second criteria, that light rays coming from the objects parallel light rays, coming from the objects, falling on the projection plane. This angle is 90 degree. So, this projector or light rays, falling on projection plane at an angle of 90 degree, then we are assuming orthographic projection.

Next oblique projection, in case of parallel projection what is happening. If you consider this is an object. So, parallel light rays from these objects are falling on a projection plane which is, if you consider this plane, and this is the principle axis then projection plane is here and image is formed, so we can see only this particular phase. It may be

side view, top view, any of the view, but while we are going to oblique projection then what happens. This is the light rays are coming falling on the projection plane.

And in this case, the earlier condition; that is one of the. In this case projectors are inclined to the projection plane at an angle other than 90 degree. Projection plane is parallel to one of the principle axis. So, in this case also, if we consider this particular principle axis, this axis, is parallel with the projection plane, but the projectors or light rays, which are coming from the object, and falling on the projection plane, those light rays falling on the projection plane other than 90 degree. It is not 90 degree. In earlier case in the case of orthographic projection then this angle was 90 degree, but in case of oblique projection the earlier condition is fixed, that is this one is same like; one of the principle axis is parallel with the projection plane; that is also present here, but the angle created by the light rays or projectors, on the projection plane, here it is 90 degree.

Not other than 90 degree, but in case of orthographic projection it was 90 degree. In case of oblique projection, it is other than any other angle, but not 90 degree. So, in this case what happens the image which is formed; that is both the front face, as well as this top face both are being projected. This top portion is projected here, with this area, and the front face is projected here, so we get this type of image. the overall area, of the projected image is more, but if you consider the total height, from this point to this point, if we consider this side; that is actually remain same, but the projected area is more in this case, because two faces of the object is visible here, in this type of projection.

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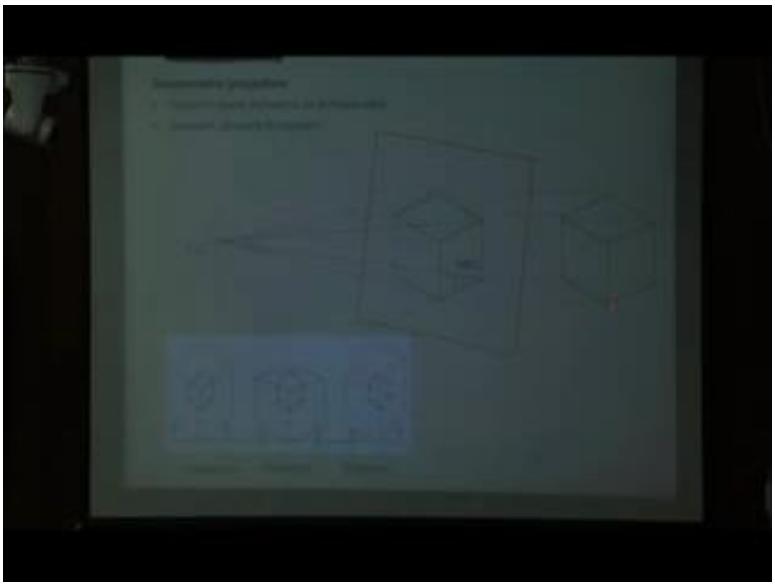

Now, if we move to axonometric projection what happens? In this case, none of the principle axis is parallel with the projection plane. If we consider this one, this principle axis, it is not parallel with this one. If we consider this one, this principle axis, is also not parallel with this one. If we consider this one; obviously, that is also not parallel with any of the principle axis, in case of axonometric projection. This is one type of parallel projection, where parallel light rays are coming from the object, falling on the projection plane, but how it is creating that image.

None of the principle axis out of these three principle axis, none of the principle axis, is parallel with the projection plane. Neither this one is parallel with this one, nor this one is parallel with this one, and; obviously, the r one (Refer Time: 16:16) is also not parallel. So, in this case, none of the principle axis is parallel with the projection plane, at the same time light rays falling on the projection plane that is other than 90 degree. What is visible here, all the three faces that is front top or side all the three faces are projected on the projection plane, and this type of image is formed. The axonometric projection is of three types; isometric, diametric, and trimetric. Based on what type of image has been formed, if this is the position different angle if this is the same image if we drawn here.

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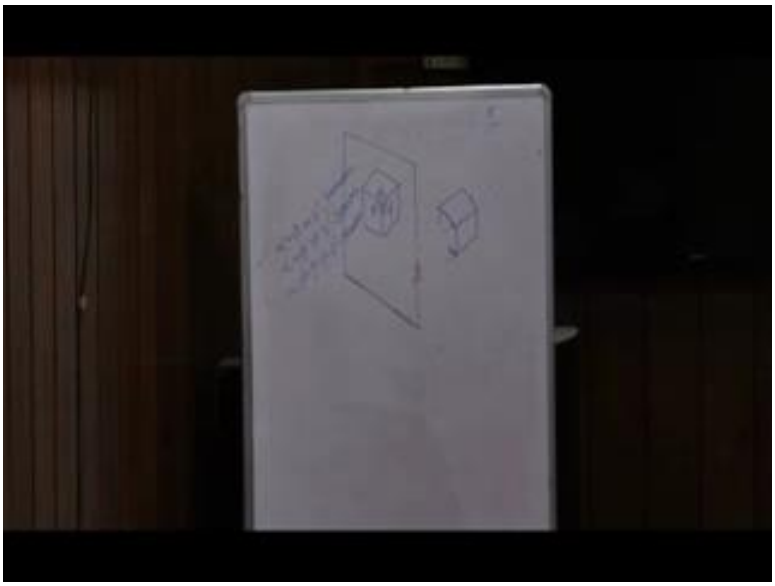

So, one image has been formed, this is that object, and if one axonometric, after axonometric projection if this type of image is formed, on the projection plane in this (Refer Time: 17:32) this angle we mentioned alpha, if this angle is beta, and if this angle is gamma, then if alpha equal to beta equal to gamma. Then we can mention this is an isometric axonometric projection. If these three angles are equal to each other, then this is projection isometric. Not only one type of axonometric projection. If alpha equal to beta, but not equal to gamma, then it is diametric; first one is isometric projection, second one is diametric projection, and third one, if alpha not equal to beta, and; obviously, not equal to gamma, then that is called trimetric projection. So, based on these angles at this point, if these three angles are equal, alpha equal to beta equal to gamma, then that is called isometric projection.

If alpha, if two angle, these two angles are same, but the third one is different, then that is diametric. If three angles are completely different, then that is called trimetric. So, we covered three types of parallel projection, orthographic projection, where projectors are falling at an angle of 90 degree, and projectors are falling at 90 degree. At the same time one of the principle axis, is one of the principle axis, is parallel with the projection plane. Second oblique projection what happened in case of oblique projection. In case of oblique projection, one of the principle axis is parallel with the projection plane, but projectors are falling at an angle, other than 90 degree. In the third case, in case of

axonometric projection none of the principle axis is parallel with the projection plane and projectors are falling on the projection plane, other than 90 degree angle.

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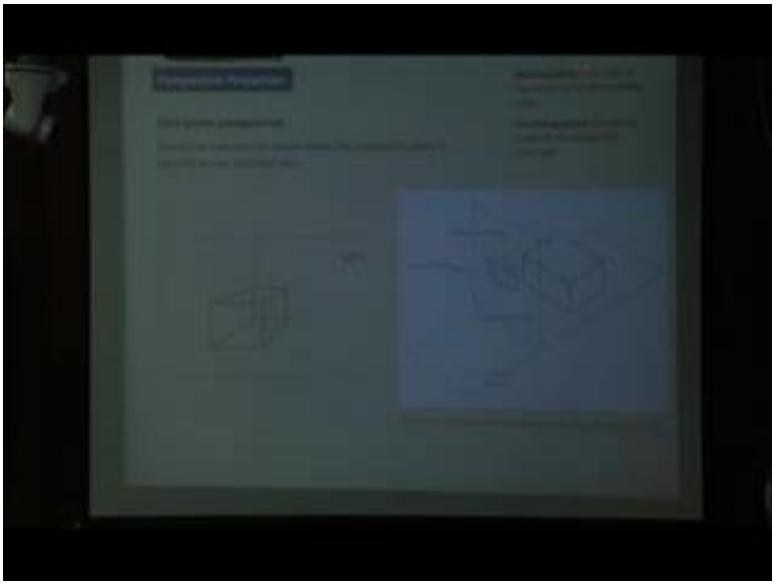

Now, moving to the next one, perspective projection, in case of perspective projection, as we mentioned earlier, here light rays are not, or projectors are not parallel, because this is converging light rays. This is the object from the object converging light rays, are coming and falling on the projection plane, and making the projected image. In that projected image, we find station point and vanishing point which is the station point. The height of the observer, I have found that observer is looking at the projected image; that is the station point, and what is vanishing point. Vanishing point is the point at which depth line converge. If this is the depth of the object, this is one depth, and similarly there will be all, the depth lines are gradually at this point, it is vanishing. If we consider as the dimension, then if we consider this particular, if we mention this is the width then if we say gradually it is moving, if we move towards this direction gradually, its dimension is reducing.

And at a particular point this dimension will be this dimension will be moving in this direction gradually reducing at a particular point this dimension will be vanished. So, this point is called vanishing point. Now, this where we will find this vanishing point, the object, from the object converging light rays are coming and image is formed, image is formed on where image is formed on the projection plane, where is station point, station

point from where that observer is looking at the projected image, but vanishing point is always on the projection plane. Location of the vanishing point, because what is vanishing point is related to the projected image, whatever the projected image is here that projected image actually two d. Although there is perception of 3 d, but this is on the 2 D plane that is projection plane. If we converge, if we connect these two line then it is merging at a particular point. So, that vanishing point is present on the projection plane here. Also we can see this is the vanishing point one. In case of one point perspective the image, which is formed is that a specific characteristics that characteristic is, it creates only one vanishing point.

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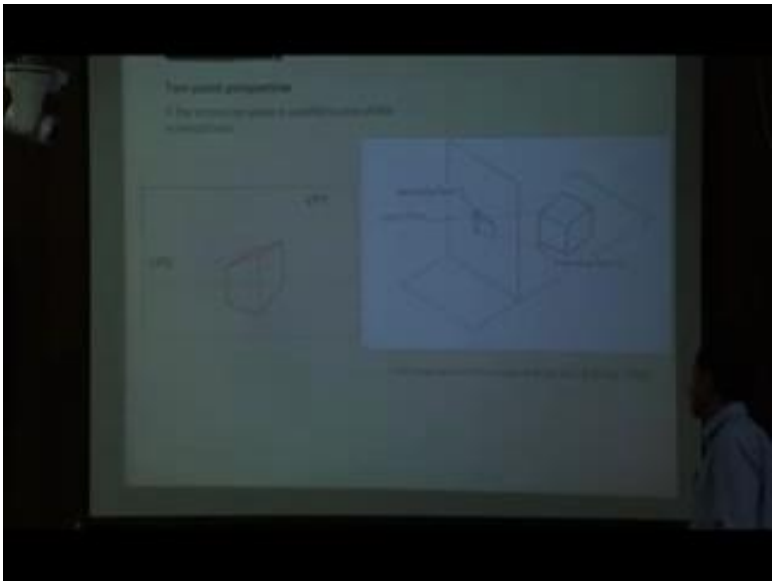

Next if it is two point perspectives then object whose image on the projection plane, where we find two vanishing points. If we see this dimension this dimension is gradually reducing, and ultimately it is moving towards the particular point. Similarly if we look at this dimension, then it is reducing. Ultimately it is moving towards a particular point, means at this particular point this dimension is vanished. Similarly at this particular point this dimension is vanishing. So, if we find this type of two vanishing points, vanishing point one and vanishing point two for that projected image, then that type of projection is called two point perspective.

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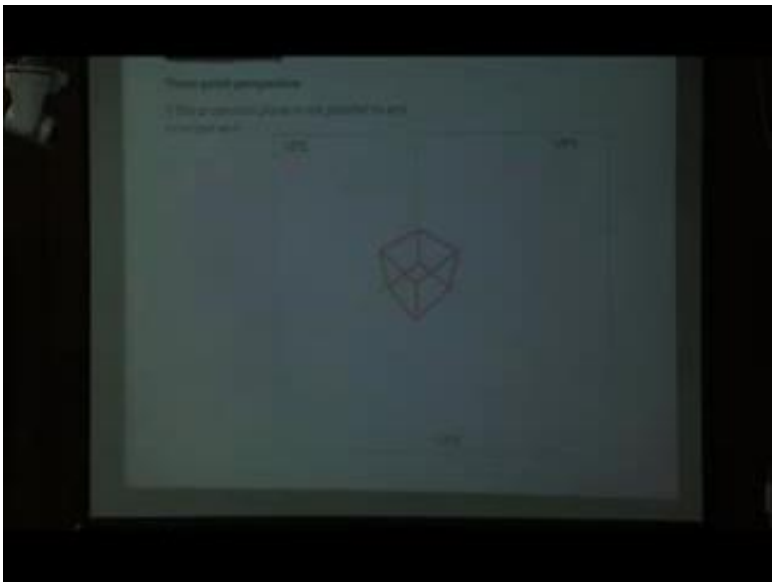

Now, moving to three point's perspective in perspective projection, if we find if the projected image which is formed on the projection plane. If it provides three vanishing points, vanishing point one, vanishing point two, and vanishing point three, then that projection is called three point perspective. In this case this particular dimension gradually reducing in this direction, if we consider three axis, if we consider this axis, this axis is gradually reducing, and ultimately moving to its value, is gradually reducing, and ultimately it is vanishing this axis, gradually reducing this particular axis moving in this direction, and meeting at the vanishing point. So, in that way all the three directions, all the three dimensions are actually moving towards vanishing point. If we find this type of three vanishing points for that projected image, then that type of image projection is called three points perspective

So, here we discussed about 3D visualization, while we are looking at that any object, from that object light rays come and fall actually. It is coming to our eyes and we perceive that object only, without singular. we observe image which is actually two dimensional, but with two eyes we both individual eyes, we get 2 D image, and the 2 D image actually superimposed and interpreted by our wave, and we perceive as a 3 d. Now, this 3D visualization of any object is important in case of digital human modeling, because digital human model at a large extent is depending on the visualization of the object, in the CAD environment, and how digital human model is interacting with that virtual product in that environment for that purpose. We need to move that environment

from various angle, and we will have to study various types of, say clearance dimension, whether there is proper interference or not, and different types of evaluation while we perform, then this visualization and understanding various types of projections parallel, and perspective will be required for using digital human modeling software for virtual ergonomic evaluation.

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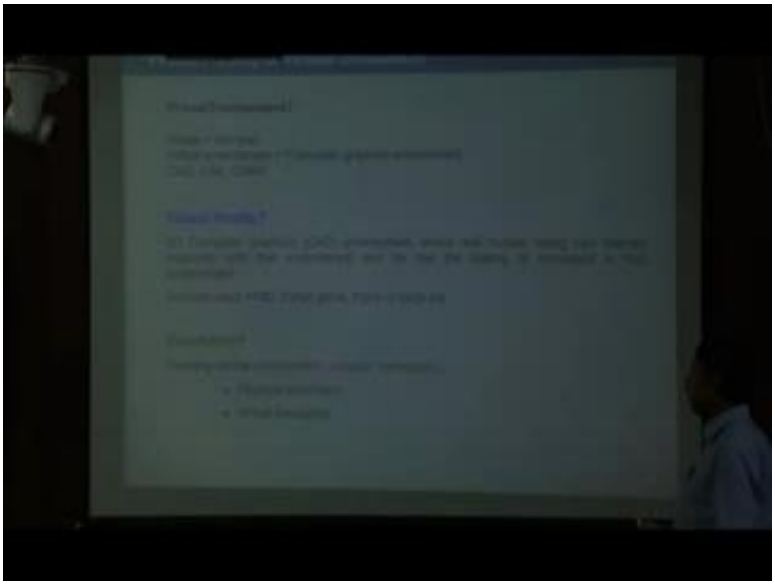

Now, next we are moving towards our topic virtual reality and virtual simulation. So, while we are discussing about virtual reality and virtual simulation, so it came to our mind that is, what is virtual? Virtual means which is not real means artificial something artificial. And what is virtual environment. Virtual environment actually computer graphics generated environment. If we take the example of class room, then if the class room environment is made up of CAD graphics, means whatever in front of me if there is a CAD generated computer graphics, generated environment of the classroom, then we can mention that this environment is virtual environment, because real product, real classroom object are not there. The whole CAD classroom environment is actually made up of computer graphics.

Now, there are different types of, this type of works CAD, CAE, Cam. So, CAD is generally as we have already discussed computer aided designing. Similarly computer aided engineering is also there. Computer aided modeling is also there, CAD is also used for computer aided manufacturing also. So, in our case only we use CAD and cam to

mention computer aided computer aided design, computer aided engineering, and computer aided modeling. Now, what is virtual reality, because many a times while we discuss about digital human modeling. Students get confused, whether this digital human modeling software or evaluation in virtual environment, is actually a virtual reality or not.

So, for that purpose we need to understand; what is virtual reality? Virtual reality if we see, this is actually computer graphics environment. in that computer graphics environment, the real human is present, and real human being has the feeling that he or she is emerging that environment, and he and she or she can interact with that environment intuitively plus continuously.

Means the environment is not real; that is virtual means CAD generated environment in that environment a real human is present. He or she is interacting with that environment, and he mastered the feeling that he or she is immersed in that environment. Then we can mention that experience as a virtual reality experience. And for that purpose, different types of hardware is also required; those are like face mounted display cyber club (Refer Time: 29:15) different types of hardware is required.

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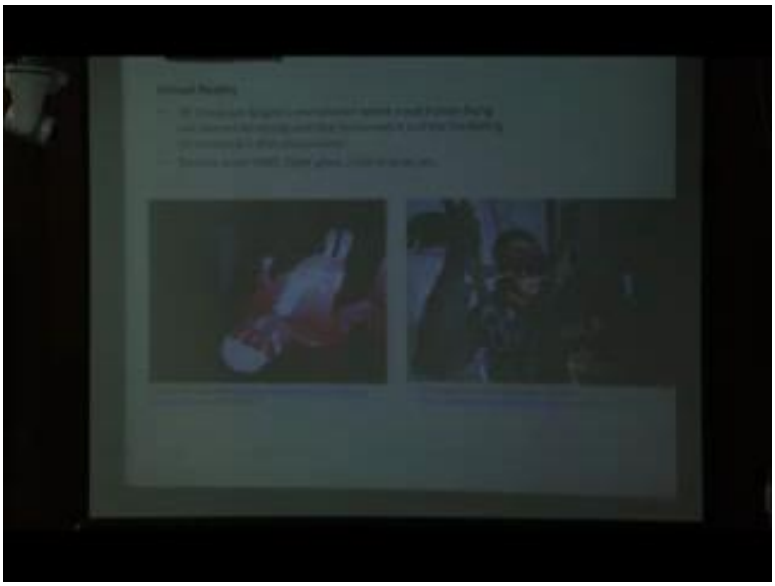

Now, we are moving to next slide. So, here are some examples of virtual reality applications. So, if you see in this case, this is the head mounted display, while that person is wearing that head mounted display, and this type of. This is from U S Navy

person spaceship trainer. So, this is just a simulation. So, with in this head mounted display, he can see the external environment, which is CAD generated. He mastered the feeling that he is actually getting down, using that or in other examples; say for example, if in front of me there is some, I am using head mounted display.

And on the head mounted display if some information image is coming, like some tiger is coming towards me, then what will happen. I must have that feeling that only, when I have that feeling from that image or from that video, that really some tiger or some other object is coming towards me and I am afraid, and I am living in that place or I am running away. So, this feeling is very important in this case. In virtual reality application; although is CAD generated which is provided to the human, but human being has the feeling that he is really in that environment. He is really present in that environment, and is interactive accordingly with that environment. Another important is simulation. So, what is simulation? Simulation is creating similar environment process or network. This simulation can be categorized in two; one is physical simulation, another is virtual simulation.

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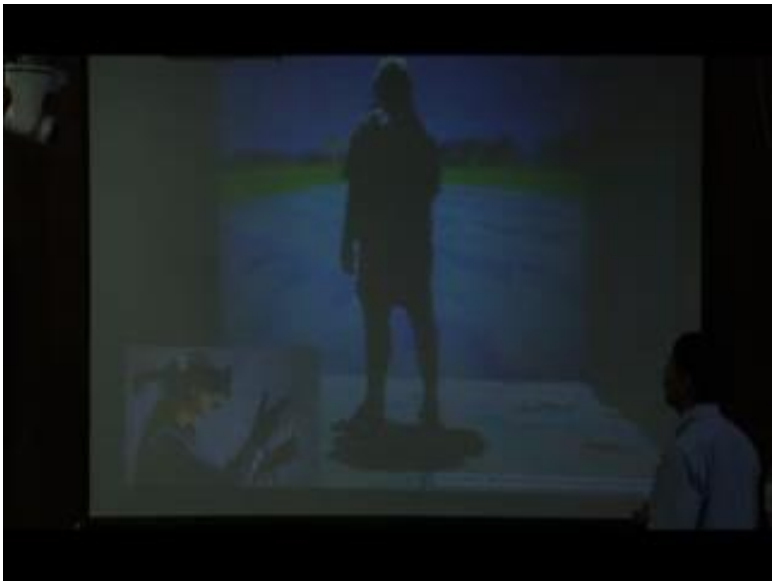

Now, this is also the example of virtual reality, where the person has the feeling that she is looking at this particular head mounted display, and in that display this type of environment he or she can see, and accordingly she is interacting, or he is interacting with the environment. So, this is an example of virtual reality.

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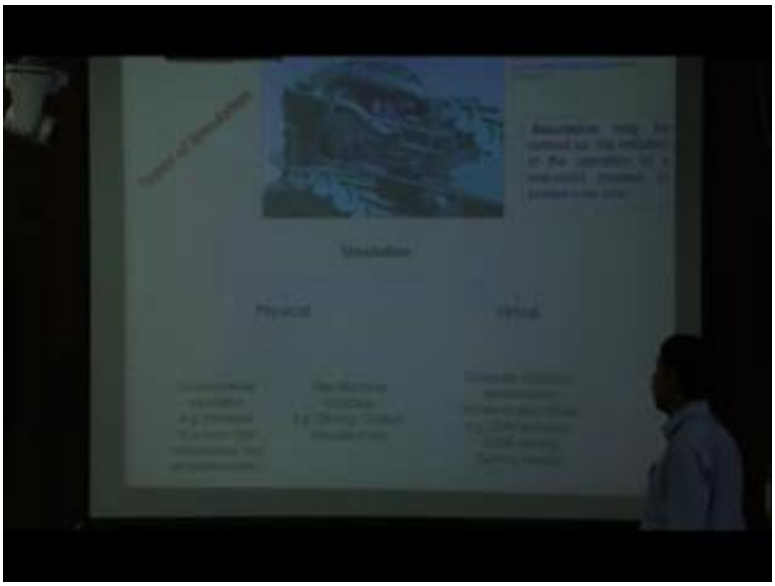

Now, I am moving to simulation and types of simulation. Already mentioned two types of simulations are there; physical simulation, and virtual simulation. Physical simulation again can be divided into two categories; one is environmental simulation, another is man machine interface simulation. In environmental simulation, one example; say in this particular room we can create the environment of the means or high altitude. So, here is low temperature, low magnetic pressure. Then glare with all these physical parameters in a particular room or particular location, we can give the feeling of Himalayan environment.

So, that is the example of environmental simulation, then next man machine interface driving cockpit simulation. All these are coming under man machine interface simulation. So, this is physical simulation, where physical object or physical products, or real human being and physical objects are present, but in case of virtual simulation the object or environment, is virtual in CAD generated, at the same time human being is also virtual, then that is also CAD generated human.

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Now, here is some examples physical simulation, environmental simulation, and so here in nature. So, this is from this source. So, what they have created here, this is snowfall. So, snowfall is happening to the same environment, they are physically created here and people who are there. On the other hand in physical man machine interface simulation that this is the characteristic dummy model, that dummy model is positioned in that car, then there is a real accident are called impact and we can test that how that impact force is affecting the various parts of the dummy model. So, this is physical. All these things are physical object and real analyses.

Similarly we can also go for man machine interface by different types of simulator cockpit, simulator driving simulator, and human being is real, but the environment which he or she is interacting that environment, is actually CAD generated, this type of driving simulator actually coming under man machine simulation.

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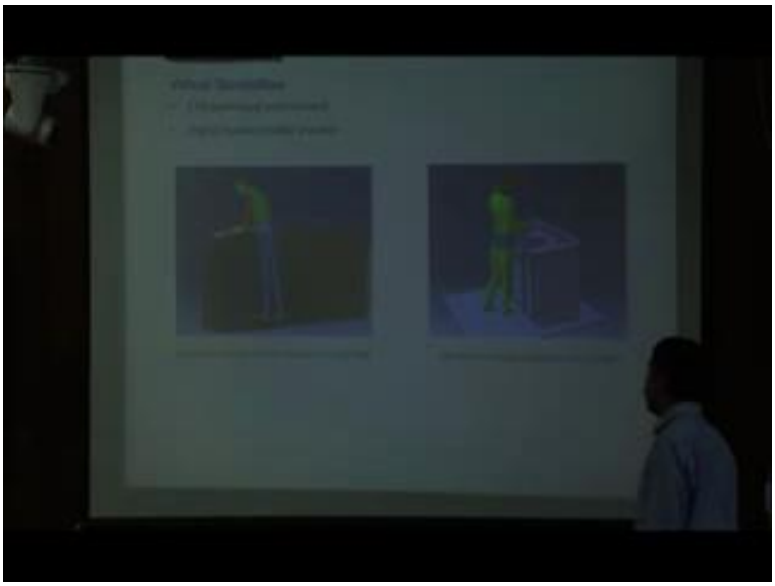

Now, virtual simulation, after (Refer Time: 34:40) between virtual simulation. So, digital human modeling software is actually used for virtual simulation. In this case we have two examples are shown, that if we want to design an evaluator wash basin, then we can design in such a way, and this simulation that human being interacting with the facility, that can be simulated in virtual simulation, where human model is CAD generated, at the same time product or facility is also CAD generated. So, this type of simulation is coming under virtual simulation.

So, we need to particularly notice that, digital human model, using digital human modeling software or digital human model, or various types of virtual ergonomic evaluation, is actually coming under virtual simulation. It is not virtual reality, because there is no real human being, who is interacting with the product. this is CAD generated human being, at the same time it is CAD generated human model or the operator even, who is using this software he or she never has that feeling, that he or she is environment is immersed in that environment that type of feeling, is not there, because this is CAD generated human being. So, this is the digital human modeling is, virtual simulation, which is not virtual reality. So, in concise part, it is not virtual reality, first point human being is not real, second that human being either this CAD model or the operator, none have that feeling of immersion.

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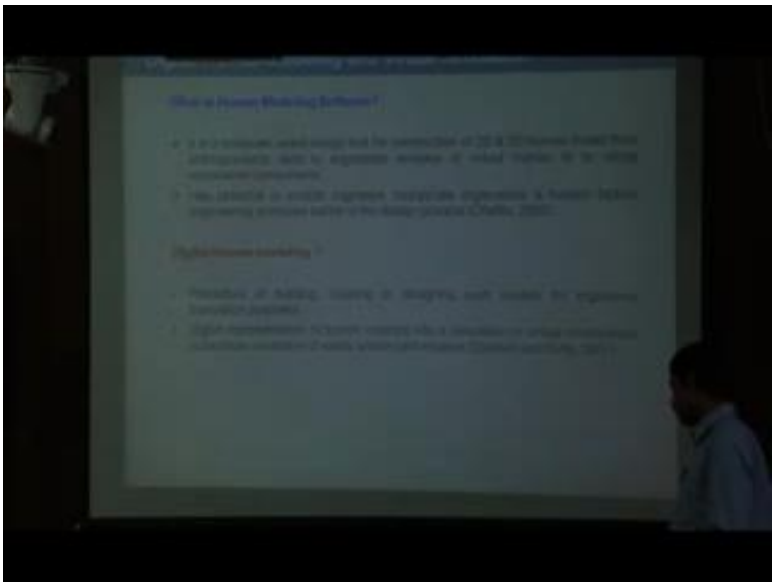

Next, so far we discussed about virtual simulation. Now specifically we are discussing about digital human model, and digital human modeling software. So, first, what is digital human modeling software? So; obviously, digital human modeling softwares are CAD softwares. So, for what purpose those CAD softwares are used. Those CAD software generally used for creating two dimensional or three dimensional human models from anthropometric or biomechanical data basis, for studying various virtual ergonomic evaluation (Refer Time: 37:16) 2005 mentioned, this software has potential to enable engineers, to incorporate ergonomic and human factor engineering principles earlier in the design process. So, this is very good software, with that software engineers or designers can consider various ergonomics and human factor issues, or they can incorporate those ergonomic and human factor principle in their design.

Next what is digital human modeling it is a software, next is a modeling. Modeling is the process. Now, process of using digital human modeling software for creating various types of products as well as digital human modeling, so two we can define as procedure to build, creating designing such digital human models or products model in that virtual environment, for various types of ergonomic evaluation purposes. So, (Refer Time: 38:18) 2007 mentioned digital representation of human. What is digital human modeling? This is the digital representation of a human or human, representation of human into a simulation or virtual environment to facilitate prediction of safety, and

what you call performance. So, this is the process of digital representation of human being in virtual environment.

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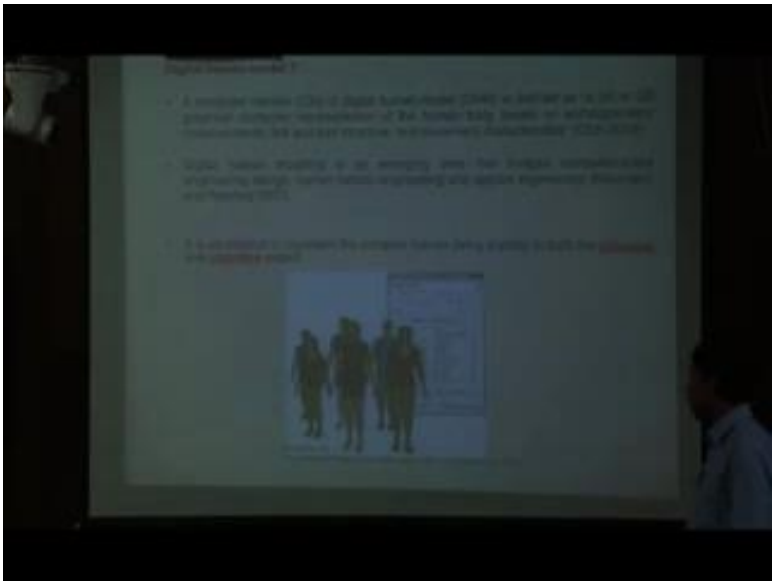

Now, what is digital human modeling? Digital human model, first we discussed digital human modeling software that is the CAD software. Digital human modeling that is the process. And third what is digital human model. Digital human model is the two dimensional or three dimensional representation of human body form, based on anthropometric and biomechanical data (Refer Time: 39:20) 2003 defined a computer manikin or digital human model, as the two dimensional or three dimensional graphical computer representation of human body, based on anthropometric measurements link and joints fracture and movement characteristics. Digital human modeling is an emerging field, and emerging field which deal in computer graphics engineering, computer aided engineering design, human factor engineering and apply (Refer Time: 39:51). So, with digital human modeling what we can do. We are actually (Refer Time: 40:00) the requirement of engineering design by incorporating various ergonomic issues in the designing.

So, digital human is here, for example you saw different types of male female children or adult, different types of human model, we can create using this type of digital human modeling softwares, and in various softwares, there is this type of database from, for different population of different countries, we can create the digital human model as per

those databases and also, but different parts of the human model p 50th 90 percentile or any other percentile, digital human model from different anthropometric and biomechanical database, from different countries we can create. Generally this digital human model is of two types; physical digital human model and cognitive digital human model. So, we will discuss about physical ergonomics digital human modeling and cognitive digital human modeling in our next module.

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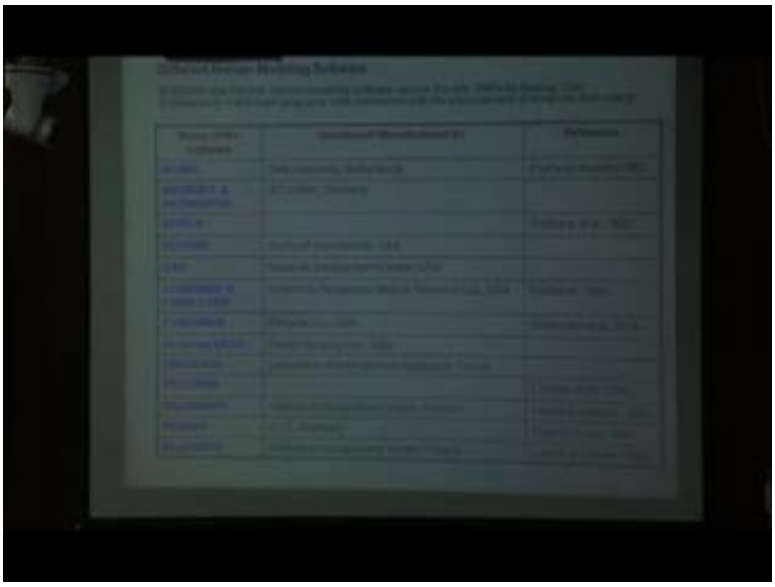

Now, different digital human modeling softwares available in the market; if we see in 1960, long back 1960 Boeing Corporation U S A, they first developed digital human modeling that was called Boeman. So, after 1960s down the line, so many software came in the market, some are still present and some abolished or obsolete from the market. in this table these are the name of various softwares, developed or manufactured by different companies or universities or institutions; that is listed here, and here some references, have information is available regarding this software. So, all of you can go through this slide. I will find these references, and at the end of the presentation all these references are given. So, you can again go through those references to know more about these softwares.

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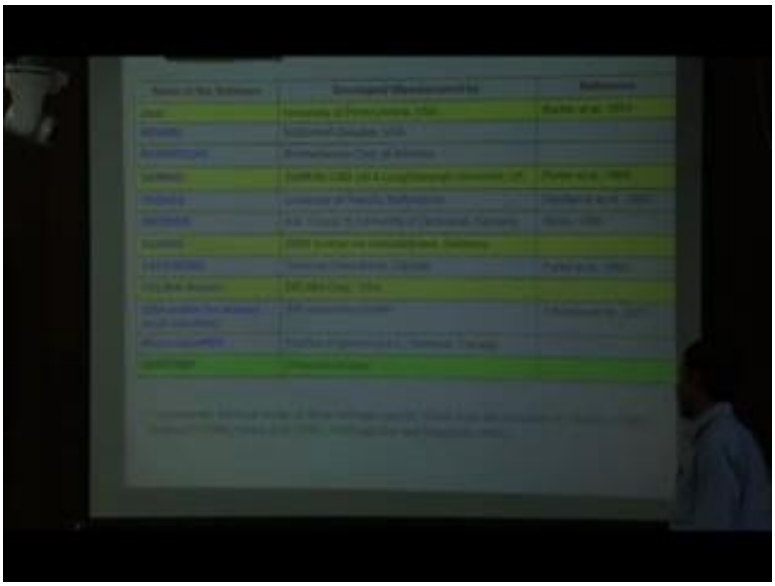

Now, in this slide also the same thing, but these are some other softwares. You have to color with the color yellow and green, some softwares have been highlighted, because these softwares are popular. I have highlighted to indicate these two softwares, which are right now used by industries, as well as various academic and research institution for various types of design and ergonomic evaluation purposes. So, among these softwares, to mention few one is Jack, Jack Developer University of Pennsylvania to U S A.

Similarly there are other softwares Sami (Refer Time: 43:05) Delmia Human, Sandoz. Among this popular software Sandoz is recently developed, and it is developed as a result of virtual soldier research of U S Army, and this is very sophisticated software, and not only anthropometric and biomechanical data has been incorporated, accurate biomechanical motion, then skin deformation. Then so many other aspects have been incorporated in that. So, among the available software, most advanced software is Sandoz. About these softwares, few authors in their article they are compared the capabilities of various softwares. So, these are few references where you will find such comparison of various softwares.

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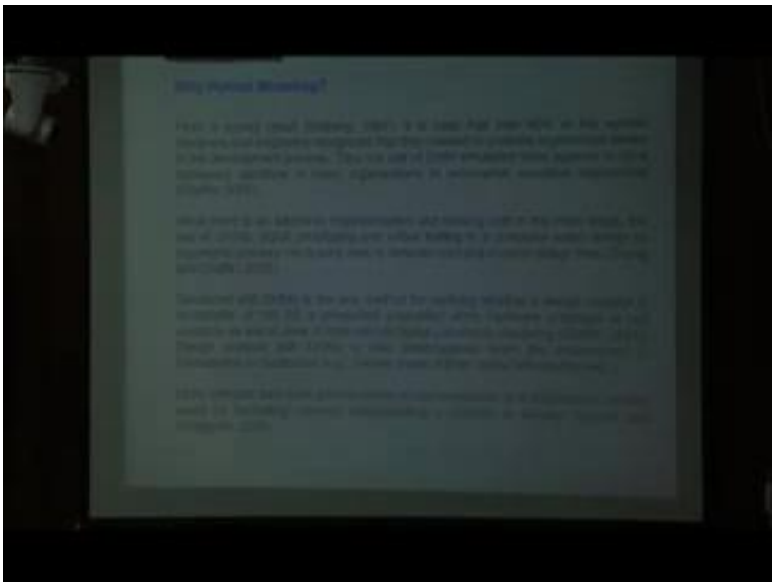

Now, why digital human modeling? Various authors in their research, they have mentioned that why digital modeling software, or use of the digital human model for ergonomics design, is important, and how that can be used. So, from a survey result Roberg 1997 mentioned, it is clear that over 90 percent of the system designers, and engineers recognize that they need consider some of ergonomics in their earlier design development stage, and if you want to do that for that purpose, digital human modeling is the best way, because digital human modeling is providing us, or helping us in proactive ergonomic evaluation, or proactive ergonomic consideration in the overall design process. While there is an additional implementation and training cost in the initial stage, the use of digital human model, digital prototyping and virtual testing in a computer aided design or ergonomic process, can quickly lead to reduce the cost shorten design time. These have been mentioned by Jan and Chaffin, 2005. They mentioned, we will discuss it in details. They mentioned although there is initial cost or investment for digital ergonomic software, but in the long run, it helps in product development and evaluation, because they reduce the cost and shorten the design time.

Simulation with digital human model is the only method for verifying, whether the design concept is acceptable or not for. Digital human modeling is the only method for verifying, whether a design concept is acceptable or not for a best type of relation, while harder prototype is not available, as in case of international space laboratory Chaffin 2001. So, Chaffin in 2001 in their research paper, they mentioned digital human

modeling is very important, in some situation where real hardware or real prototype is (Refer Time: 46:47), but we have created the virtual representation of that environment. If we want to evaluate that facility or product in virtual environment, then digital human model is the best way. So, digital human modeling software can be used for this type of environment.

Next digital human modeling software also has positive effect on communication, and collaboration among users by facilitating common understanding problem or solution. While people are working using digital human modeling software for given ergonomic inputs, in their design, then designers engineers or other stakeholders they can sit together they can understand, that how design process is going on, and how various human factor issues, is actually consider in developing that product or facility concept, digital human modeling and this CAD software actually helping in this reaction.

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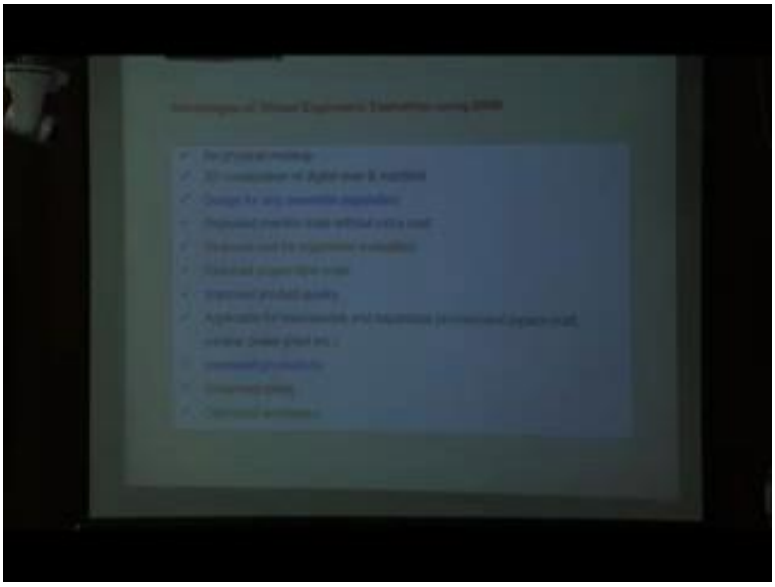

Now, there are various advantages of digital human modeling softwares are listed. So, among these various advantages, most important advantages of digital human modeling software is that, while you are using digital human model for virtual ergonomic evaluation, we can provide anthropometric and biomechanical support to the product or facility design, because in that digital human model, while we are creating the digital human model anthropometric and biomechanical data have been incorporated.

With the digital human model while we are evaluating some object, then automatically we are considering that anthropometric and biomechanical issues. Second with digital human model we can create different types of human model, in customized human. We can create male model, female model, then means sex variation as per the age variation children adult, agent or ethnographic variation Indian population, American population, Japanese population. So, different types of customized human model, if whatever human model or which population we want to repair, according to we can get digital human modeling. So, very important feature of digital human model that, this human modeling softwares can create customized human model, as per the anthropometric database percentile data, as per age variation, sex variation, nationality variation we can create.

We need not already. So, we need not to go for physical mock up, because whole evaluation is being performed in the virtual or CAD generated environment, real human CAD is not required. And we can go for repeated trial and modification, because already we have that CAD software, CAD model of the product CAD model of the human. We can interface, we can go for n number of tiers if we (Refer Time: 50:40) the concept for the product, whatever you have developed that is not good enough, or that is not accommodating or intended population, accordingly we can modify the design, for that purpose, no extra cost, not extra materials is required. Also there is no requirement of extra manpower, because all the evaluation is being performed in the virtual environment. physical mock up is not required, real human values is also not required, real material or real manufacturing, nothing is required in place of this virtual ergonomic evaluation process.

Next as we mentioned in the earlier slide also, digital human modeling software is very effective, in case of inaccessible environment while that environment cannot be accessed easily. So, if it space (Refer Time: 51:40) first space station we cannot go for a real human evaluation, while when the facility is not ready. So, for that purpose what we can do. we can create that space craft or space station in CAD environment, and whether that facility is compatible or usable or user friendly, or that astronaut, or the Euler's. All these things we can evaluate in CAD software using digital human modeling. So, in such environment which is not easily accessible, means inaccessible environment digital human modeling is very helpful for evaluation.

Next hazardous environment nuclear power plant, chemical weapon station, in this case we cannot go for real human tier. In this scenario also virtual human representation, using digital human model will be very much effective. So, first people mention, most first important benefit of using digital human model that is, we can create customized human model. Second we can go for repeated trial and modification without extra cost, extra time or extra material manpower or all these. Third we can go for evaluation of inaccessible environment. Next we can go for evaluation of hazardous environment. Then; obviously, while we are using this type of virtual evaluation using digital human model, there is reduced project time scale improved quality, increased productivity and safety, all these benefits we actually achieve.

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Now, why digital human modeling software or virtual ergonomic evaluation is beneficial over the traditional process, where physical mock up or physical prototype is made, and evaluated with real human being. If we look at this graph, there are y axis development cost is there, and of x axis, typical product or process development phases are there. So, in a product or process development there are various phases - starting from concept conceptual phase, then design, engineering, prototyping, testing, redesign and others, in an initial phase that is the conceptual phase or design phase, if you see the traditional process.

For traditional process need not CAD cam phase; that is a mockup phase, physical mockup and real human (Refer Time: 54:46) mockup, in that case in conceptual phase and design phase, the initial cost is less, but in case of digital human model based virtual evaluation,, computer aided engineering or digital mockup digital mockup study. This is physical mockup, this value is digital mockup. While we are using digital mockup computer aided engineering or digital human modeling, in that case, in the initial phases in conceptual phase or design phase, cost is high. Why this cost is high. During the initial phases extra cost is required for that infrastructure facility. We need to buy that computer or digital human modeling software, that facility we have to develop initially, and then it is also required for using this type of software. So, initial investment is high in the initial phases; that is conceptual and design phase, but one step facility is ready.

Then; that means, in the next phases later stages for redesign and modification, we can go for n number of trial and modification, in the CAD environment, for that purpose extra cost extra manpower extra material nothing is required, but in the traditional process; although the initial cost is low, but in the later phases, in these stages prototyping testing redesign the cost is high. Why cost is high in these cases, because in these cases it will go for redesign and modification, then we need to go for making new prototype, new mockup in for making those separate mockup, or separate prototype, material is required, manpower is required for that purpose, cost is required, time is required.

So, in the later phases in traditional design process the cost is high, this phases means test redesign phases cost is high, overall if we look at this graph. So, initial extra cost is required for CAD cam based process, in comparison to that additional one, is only this much high, but at the final stages or later stages we can find, the overall reduction cost reduction in the phase redesign phases, the reduction is, cost reduction is too high. So, comparing this difference we can easily understand that, if we use CAD cam based process using digital human modeling, for virtual ergonomic evaluation then in the design process, and then it is very much beneficial in terms of cost also.

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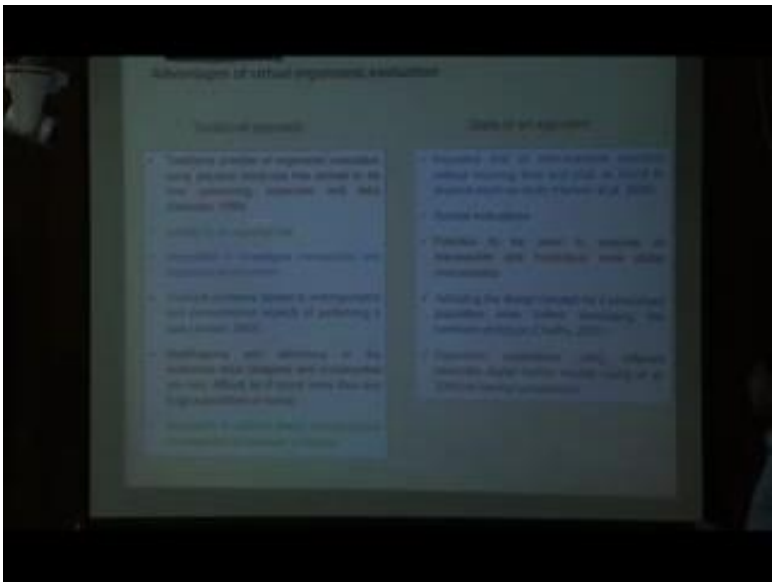

After that graph same thing, if we can discuss here in tabular form, the traditional approach. in traditional approach what happens, and in state of the art approach means with using digital human model for virtual ergonomic evaluation. While we are using the traditional method in mockup phase real human (Refer Time: 58:00) method, then what is happening? Traditional practice of ergonomic evaluation, using physical mockup has provided, as proved to be time consuming, expensive and risky. So, this is a drawback of traditional method. It is time consuming, because you have to make a physical mockup or prototype, and then you have to go for real human trial, which is one time consuming costly. inability to do repeated trial repeated trial in many cases repeated trial is not possible, because for subjective evaluation while we are calling back real human being, may not be available every time.

Impersonal to investigate in case of inaccessible and hazardous environment, because we cannot put real human wealth, human being for this type of trial and evaluation, overdo problems related to anthropometric and biomechanical aspects apart from their particular task. It is mentioned by Jansen, 2002. So, this is many a times these aspects or overlooked in case of traditional process, but if we use digital human modeling software. In the digital human model already anthropometric and biomechanical data is incorporated. So, there that is already taken care of, that anthropometric and biomechanical aspect in that design.

Modification and alteration in the workplace once designed and implemented is very difficult, because for that purpose redesign and modification, we need again new material cloth manpower, and for that purpose cost is incurred, impossible to validate design concept given developing the hardware. In traditional process only you can go for human trial, when the prototype or mockup is ready, but otherwise it is not possible, go for human evaluation, but in this case, ergonomic evaluation with real human, it is not possible without creating the hardware facility, but in case of digital human modeling software what we can do. We can go for repeated trial and modification. Evaluation, we can do the evaluation quicker, for evaluation very less time is required. Potential to be used in analysis of inaccessible; like space craft or space station hazardous (Refer Time: 60:37) environment like nuclear power plant, validating the design concept for tested population even.

Before developing the hardware, before developing the actual prototype, actual hardware, actual facility, whether that facility will be compatible at a particular population or intended user, we can evaluate that in the virtual environment. Next ergonomic evaluation using different percentile of digital human model, we can create customized human model, and our facility and product and evaluated in virtual environment or CAD generated environment, using those human model. So, from this comparison, it is very evident that the use of digital human modeling, for virtual evaluation, ergonomic evaluation of product or facility, is always beneficial in comparison to the traditional mockup test real human trial.

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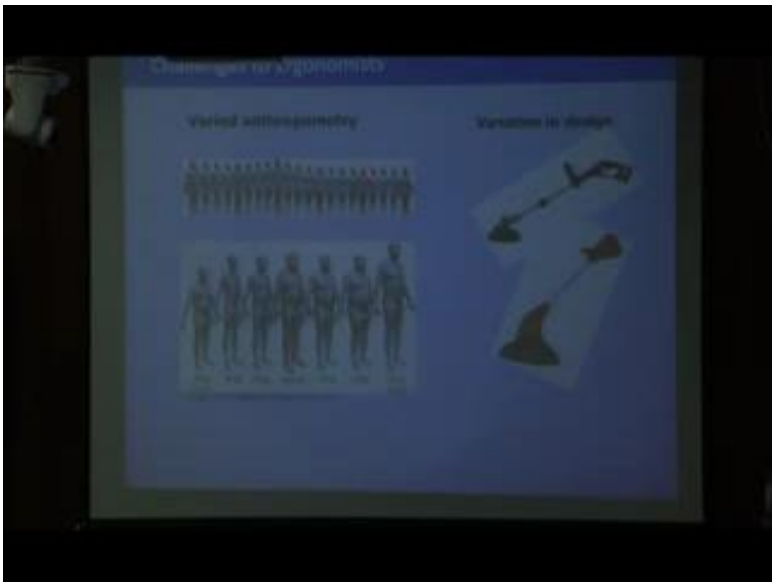

Now, already we discussed this one in our module one also, that what is the real challenge to the ergonomist or designer. In the population, there is huge variation of human body in terms of body weight, in terms of body shape and sizes. So, here this example is given, if this is the original body, shape and sizes. If this is 20 kg, it is changing like this if here we have 40 Kg, it is changing like this, and at the same time if you reduce the body weight accordingly body is becoming like this. Here increasing 20 kg of weight and 20 centimeter the body structure is like this.

Similarly, if we go for reduction of 20 kg body weight and reduction of height also, then body structure is like this. So, this type of huge variation exists in our population. Then how we can design product of this population, which will be compatible with wide range of this people. In the market also different types of products are available, or while you are designing this type of product or facility, how do we ensure that that product or facility will be comfortable for a wide range of people, whose body dimension and anthropometric variability is also used.

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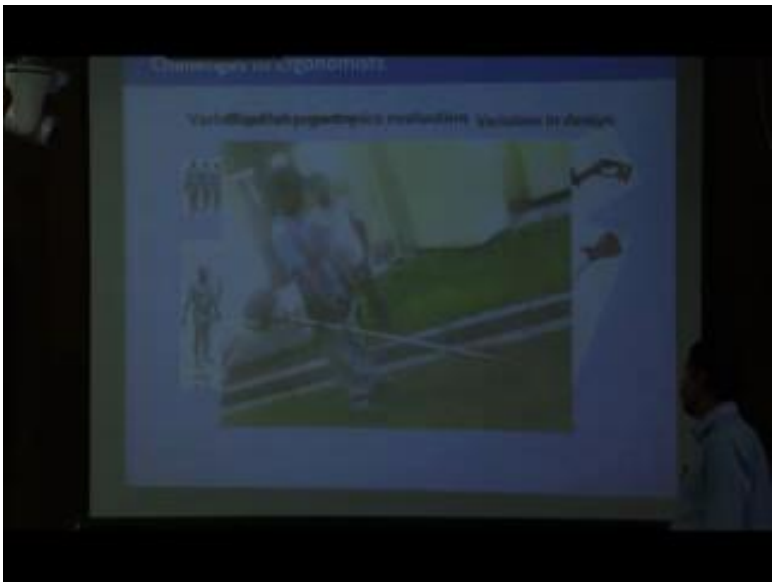

So, traditional approach is there. In the traditional approach we can go for real human trial. in real human trial that real product is been operated by the real human, and while that person is using the product, we can go for various ergonomic evaluation, in terms of operation of that instrument or device, but for this purpose if you want to accommodate a wide range of operation, we have to call people of defined anthropometric and some other type variation. We have to call some fat person, thin person, smaller, larger people with smaller larger body dimension, and we have to ask them to operate that equipment or device; otherwise which is not possible. Then if we this same equipment is, where is intended to be operated by both male and female, then later we have to call human personnel also. So, for this type of trial, it is very difficult time consuming and costly.

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But if we use digital human modeling software, if we have this type of digital human model, or we can create customizing the model, as per our requirement any sort of anthropometric variation, age variation, biomechanical variation we can create, and we can also create this type of product or facility in that CAD environment. After developing these two we can go for interfacing these two, in digital human model with appropriate working posture we are interfacing with the product model.

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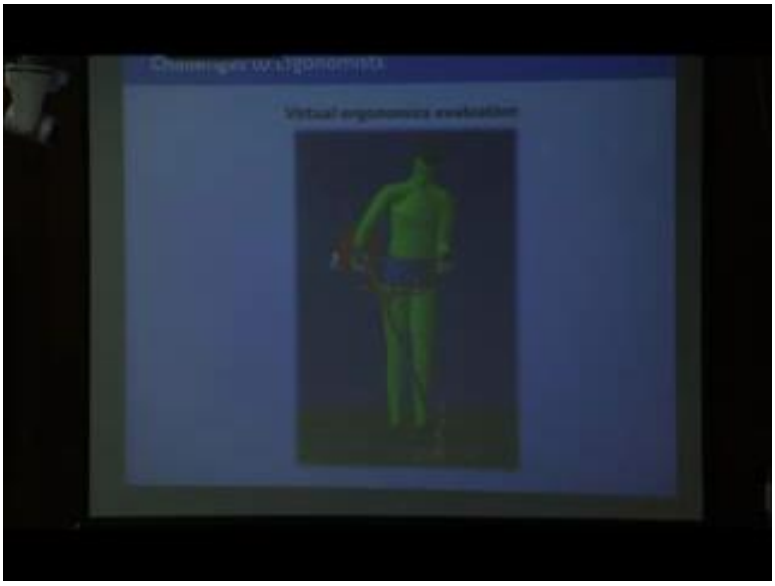

Then we are going for various types of ergonomic evaluation in terms of reach, clearance, vision, whatever is required this type of evaluation. Now we can change this human model as per the anthropometric variation of various percentile data, we can make this model from male to female; if we want to go for age variation we can do the same thing also. For that purpose we are not requiring, following that people find type of this product is needed to be modified, then we can do that modification in the CAD software, for that purpose as this is not a physical mockup or physical prototype. So, in this case we do not require any material or are not requiring manpower for making those product or mockup. So, for this reason, use of digital human modeling, is very beneficial for designers.

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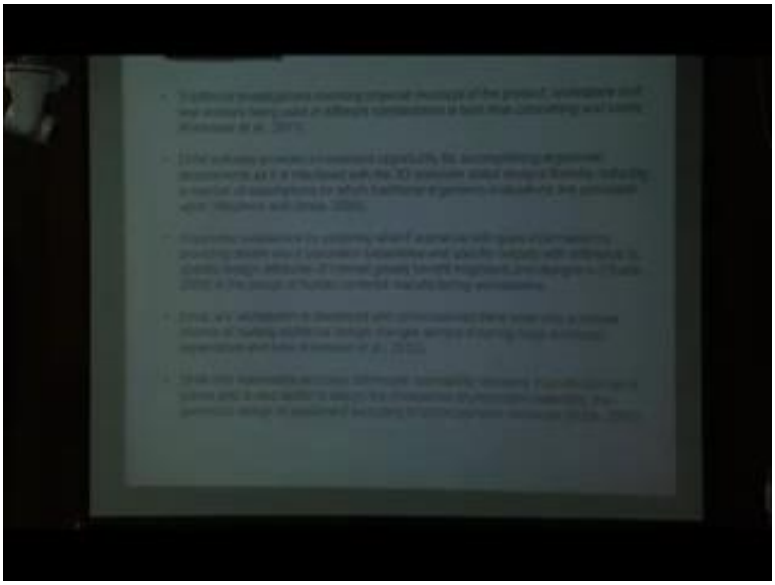

Now, various authors in the research paper they have mentioned, that why digital human modeling software is beneficial, and useful for considering various ergonomic and human factor issues in design. So, (Refer Time: 66:53) Et Al 2011 stated that the additional investigation informing physical mockup of the product, work space, and real workers being used in different combination, is both time consuming and costly.

Similarly, Stephens and Jones 2009, they mentioned digital human model software provide some excellent opportunity for accomplishing ergonomics assessments, as it is interfacing with three d computer aided designs. Thereby, reducing the number of assumptions on which traditional ergonomic evaluation is grounded up. Chaffin 2009

mentioned that ergonomic evaluation by (Refer Time: 67:44), what its scenario with quick information by providing, details about population capabilities and specific outputs, with reference to specific design, attributes of interest greatly benefits, engineers and designers, in the design of human centre manufacturing workstation.

In another paper (Refer Time: 68:12) Et Al 2011 mentioned, once any workstation is developed and commissioned, there exist only a (Refer Time: 68:24) chance of making addition design changes without incurring huge additional expenditure and time. So, if once the facility is ready, then we have very limited chance, to modify that product and facility. So, if we want to redesign and modify our concept of product, it has to be done, before making the actual prototype. So, that evaluation of man machine compatibility should be performed before making the actual prototype, and that should be performed in CAD software using D H M. D H M with reasonable accuracy, addresses reach ability concerns in production work places, and also useful to design the dimensions of production assembly, the geometric design of equipment according to the anthropometric human that actually is developed by D H M.

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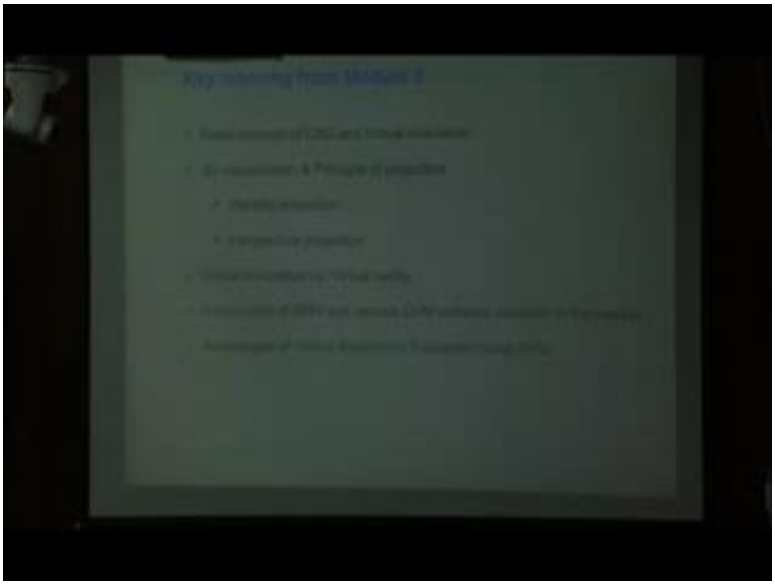

Now, key learnings from this module three, we have discussed about basic concepts of CAD virtual simulation. Then we move to 3 D visualization, and principle of projection, where we discussed about parallel projection, perspective projection, and different types of parallel projection; like orthographic, oblique, axonometric, then, various types of

perspective projection; one point perspective, two point perspectives, or three point's perspective. We also discussed about virtual simulation versus virtual reality, and we clearly mentioned that for digital human modeling, or using this type of CAD software, is not virtual reality application, this is actually a virtual simulation

Next we discussed about what is digital human model, digital human modeling, and then various types of digital human modeling softwares, which were available in the market, or which presently available in the market. We have provided that list then various advantages of digital human modeling software. Why digital human modeling software is beneficial over the traditional mock up or prototype based real human trail or ergonomic evaluation. So, all these topics we have covered in this module three.

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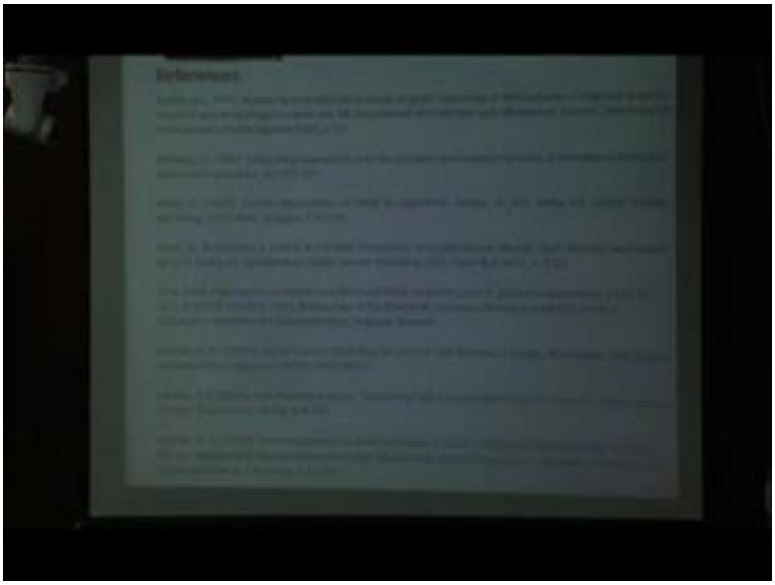

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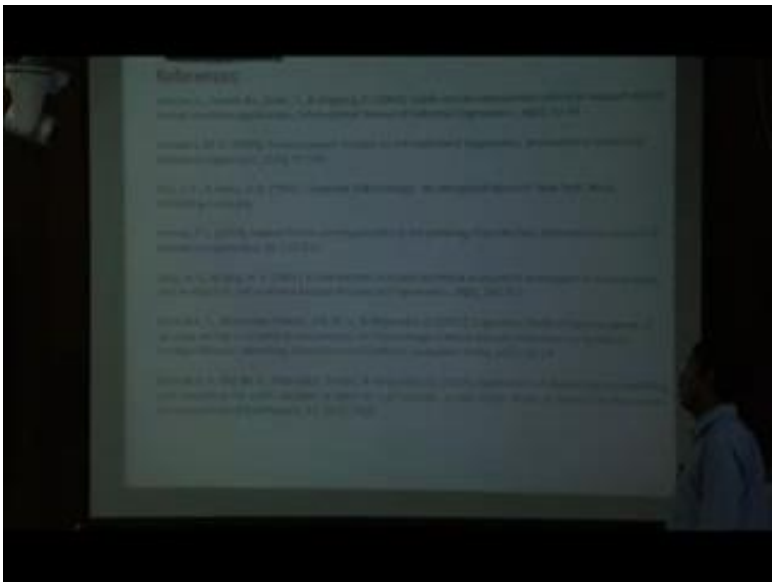

So, this is the list of references, which has been used, for this in various slides of this presentation. So, all of you can go through these references then, you will get more information, more idea about this digital human modeling and its use for ergonomic design purposes. So, this is the list, this is continued. So, I suggest all of you to explore all these references.

Thank you all, this is the end of Module 3.