Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

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Lecture – 10
Introduction of Digital Human Modeling (DHM) and Simulation

Welcome to the course Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation.

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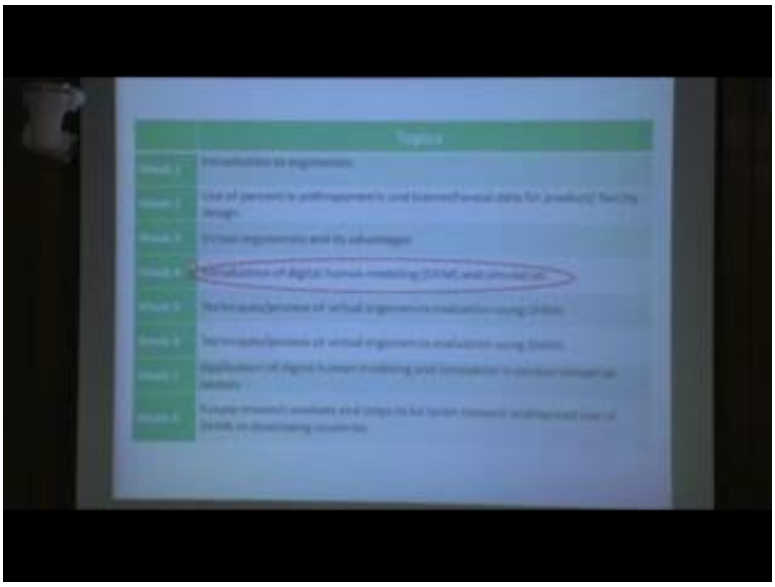

Now, we are going to discuss this module, for which work introduction to digital human modeling and simulation so in the last 3 modules, 1, 2 and 3, we discussed various aspects of design ergonomics actual ergonomics.

Now, particularly we will discuss about digital human modeling and simulation in module 4. In module 3 we mentioned what is digital human module. Just for recapitulation we are again discussing; what is digital human is modeling.

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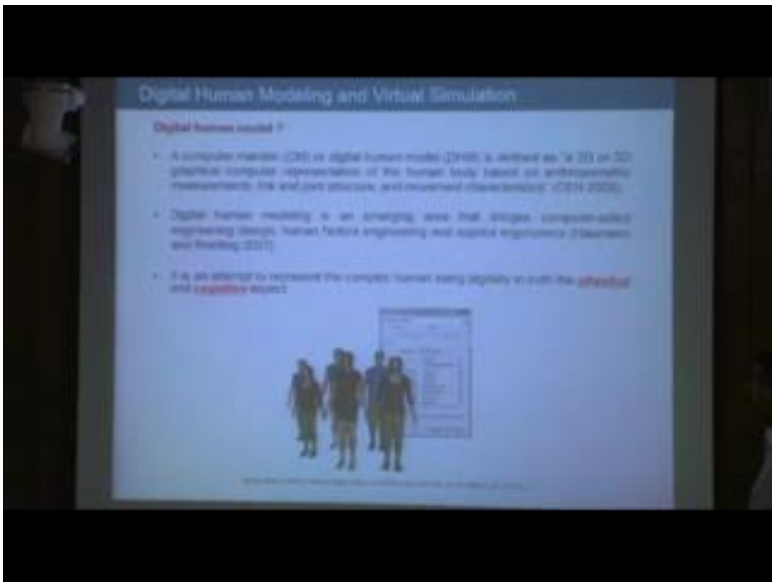

See in 2003 defined digital human model, as this is computer graphics managing or digital human model. It can be defined as a 2 dimensional or 3 dimensional graphical computer representation of human body, based on anthropometric measurements link and joint structure and movement characteristics. In other words we can define; what is digital human model. Digital human models are 2 dimensional or 3 dimensional representation of human body based on anthropometric and biological data's and those models are used for virtual organic inauguration of product and constitutions.

These digital human models are of 2 types. First one is physical and second one is cognitive so here is one example. These digital human models male models and female models created using Jack software. And we can see the different population database are already incorporated in that software and based on those databases you can create digital human model.

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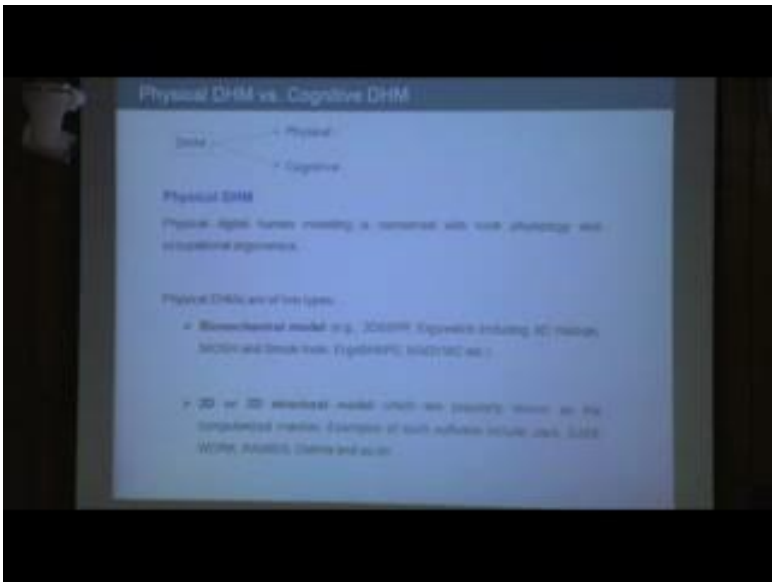

So, digital human models are of 2 types, one is physical human model another is cognitive digital human model. Now what is physical digital human model? Physical digital human modeling is concerned with physiology anatomy and various occupational ergonomics aspects. Physical digital human models again. We can categorise in 2 categories; one biochemical model biomechanical model and another is 2 dimensional or 3 dimensional structural model. This biomechanical model we discussed about various softwares is there for example, 3DSSPP, Ergowatch, NIOSH and Snook Couch so all these are coming under biomechanical model.

And under 2 dimensional or 3 dimensional structural model we discussed about various 2 dimensional or 3 dimensional representation of human model human body form and example of such softwares are Jack Sammie, RAMSIS, Safe Work, Delmia and so many others.

So, overall, this physical digital human model mainly concerned about biochemical aspect anthropometric aspect and while we are evaluating any work station, we are checking the human compatibility with the machine; we use this type of physical human model. But physical human model, which are we are discussing in the present course that is mainly related to 2 dimensional, 3 dimensional structural models.

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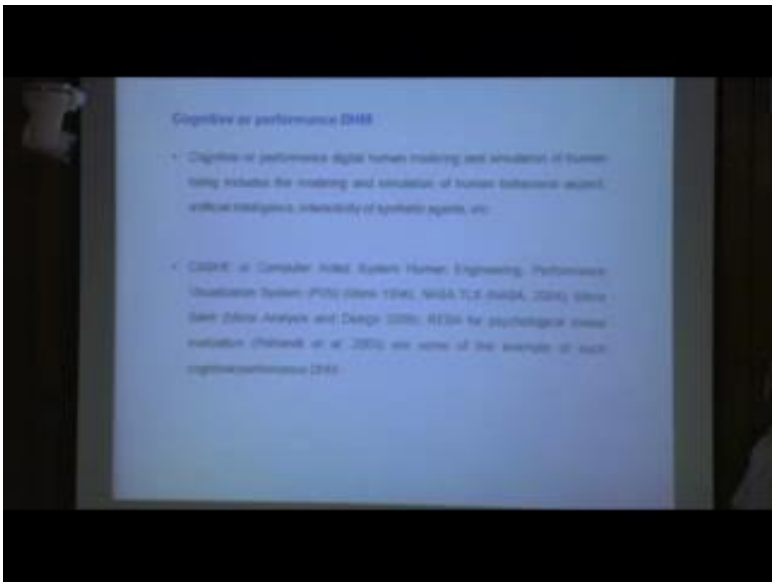

Next another type of digital human modeling is cognitive digital human model. Which is still in development phase because in many universities and research organization in this particular area research is going on and new research findings are coming out so this cognitive and or performance digital human model it wants to does it deal with cognitive and performance digital human model as only of human beings include modeling and simulation of human behavioural aspects, artificial intelligence interactivity of synthetic elements, etcetera.

So these are the areas which permit you interactive human models. Examples of such softwares are Cashe, Compu or computer aided system human engineering, performance visualization system PVS then NASA,-TLX and so many others. But these softwares as well as overall the cognitive or performance digital human model these are still in, and enough research is required for developing this particular field.

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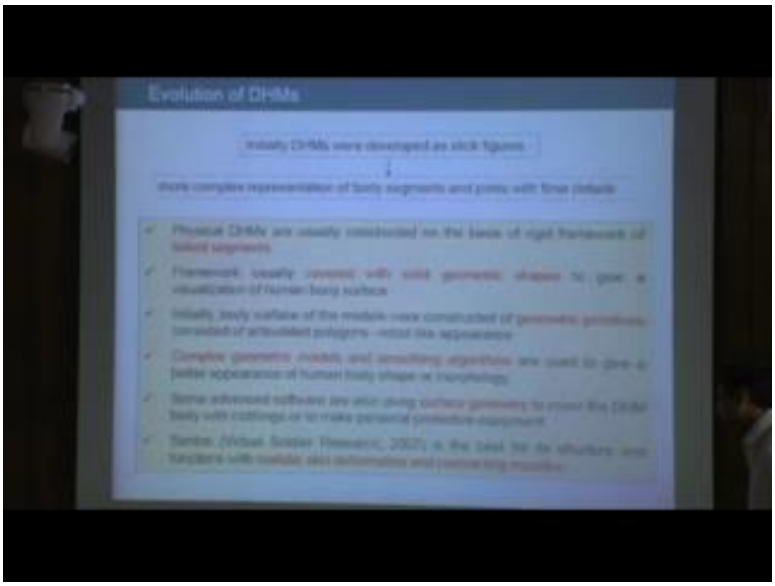

Now, evolution of digital human modeling when this digital human model started and gradually years after years how we work, if we look initially digital human models are developed as it figures, more complex representation of body segments and joints with finer details gradually came.

Next physical digital human models are usually constructed on the basis of rigid framework or linked segment. Framework usually covered with solid geometric shapes to give visualization of human body surface. So initially it is rigid framework of linked segments then gradually it is solid geometric shapes. So it is solid geometric shapes and here those models are robot live. Because in this software stack geometric primitives like cylinder then different types of polygons, then sphere all those basic forms are used. Gradually with the advancement of computer technology complex geometric models and so only algorithm came. Then it is possible to develop body shapes or morphology with surface modeling.

Later on the surface geometric were further developed which intended human scheme then various types of closings projecting equipment, those types of development happened in this field. And more recently in this software centres it is developed by virtual surgery cells, by Ivan university. In that software we can find very realistic information contracting muscle in very advanced digital human model that will came in the market. Which initially started with still figures now advanced digital human

softwares are available where, we can go for various types of actual ergonomics evolution and these models are very realistic in terms of anthropometric in terms of body motion in terms of various analysis and also as per look also.

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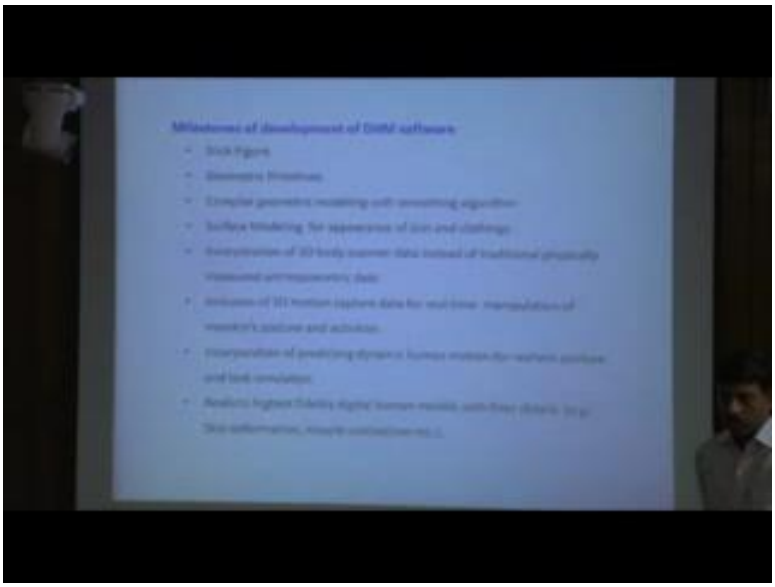

So, if the full whatever discussed in earlier slide the whole information, if you summarize, it moves like these milestones so initially it has still figure then geometric primitives are used gradually complex geometric module with smoothing algorithm came, surface modeling for appearance of clean and clothing's it was started. Then incorporation of 3D body scan, of data directly earlier for digital human model, physical anthropometric measurement and those data's data are used for this purpose. But nowadays directly we can input the data from 3D body scanner and those data is used for developing digital human model.

So, those digital humans are much more realistic. Now tell me in 3D body scanner, then 3D motion capture data. Human motion in 3D space that has also been captured with camera and that information is incorporated with our virtual prediction, various types of activities. So that is also included in this digital modeling software. So technology like 3D body scanning 3D motion analysis all those are now with incorporated in advanced digital modeling softwares.

Then incorporation of predicting dynamic human motion for realistic pasture and transculation that is also done; realistic high quality digital human models with finer

details as for example, skin reformation muscle contraction that is also going on software developer. The whole evolution can be represented like this type of diagram. So it started from still figure then geometric primitive. Then it moves towards error frame then various types of satellite representation, only for the skin and body shape or showing the body shape for not only the body shape or after that gradually moves towards this type of skeleton figure, not only skeleton on that muscles also.

For example, anybody's software there is muscle also, after that node realistic representation like skin reformation closing reformation clothing pattern. So all these thing gradually being incorporated in various digital human modeling software; so among the software one is Santosh where we can find all these realistic skin reformations then muscle movement and all.

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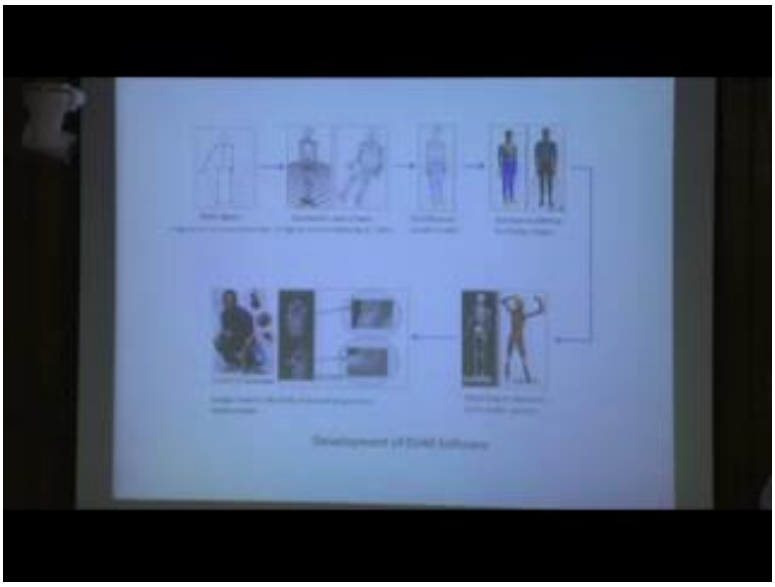

Now, next we are moving towards the history of various digital human modeling software which developed years after years started in late 1990 in the long back 1960s by Boeing Corporation USA, they developed the first digital human model, which is known as Boeing.

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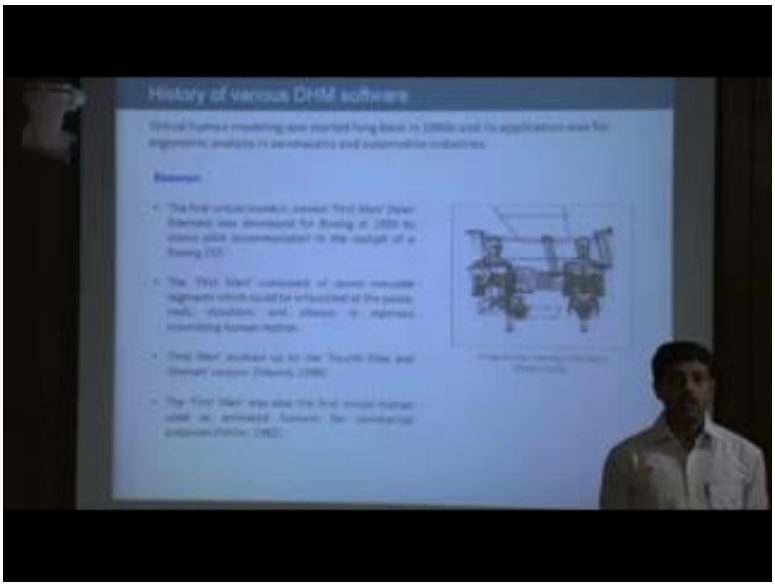

So we are starting from that software Bohemian. So if we look at those models we will understand those models are very primitive in nature. The first virtual man making name first man later on it was named as Bohemian, was developed by Boeing corporation of USA in 1959 to access file of accommodation in the corporate of a Boeing 747, the first man composed of it was composed of 7 vowels 7, which could be articulated at pelvis, neck, shoulder, elbow in manners resembling to human motion.

Now, first man even up to fourth generation that is fourth man and women version, as it is found from information provided by Novel 1998. The first man who was also the first virtual women used as animated human for commercial purpose. So this is one image from that software.

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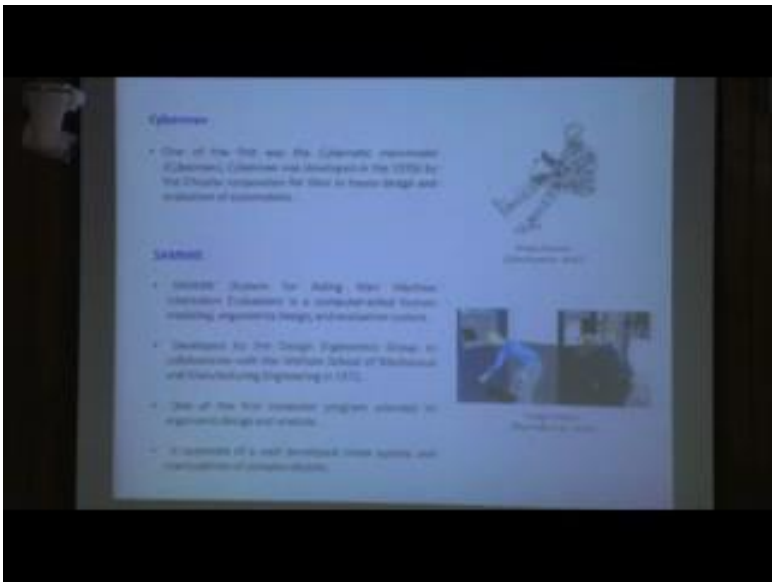

Next after Bohemian, now there are so many other software; Cylome and Sammie – so one of the first was the first digital software was Cybermatic man model cyber man. Cyber man was developed in 1970 by Chrysler Corporation, for that in house design and evolution of automobile. Then other software like Sammie came. Sammie full form system for aiding man machine intermachine interaction, evolution is a computer aided human modeling ergonomic design and evolution of system, developed by design organsmics group in collaboration with Winston school of mechanical and manufacturing engineering in 1972.

This is one of the first train computer based digital human modeling program for ergonomic evolution. It consisted of well-developed mission system and manipulation of complex object.

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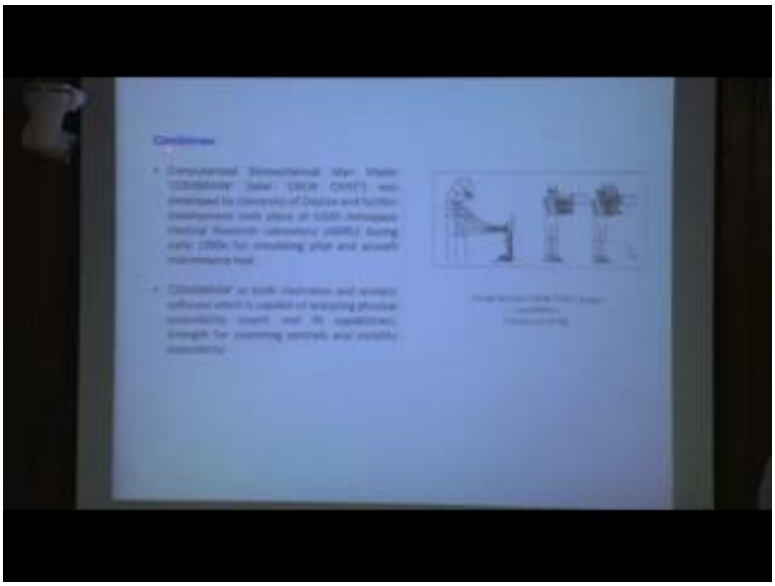

After Bohemian Cyber man Sammie, so many other softwares also came in the market one software is COMBINAN. Computerised biomechanical man model known as COMBINAN, later on it was known as ug, was developed by university of data. And further development took place in us air force, medical research laboratory Amrl during early 90s, 1980 for simulating pilot and aircraft maintenance task.

So, in 1980s, COMBINAN software came. COMBINAN has both elasthetic and analytic software which is capable of analysing physical accessibility reach and fit capabilities strength for operating control and visibility accessibility etcetera. Then gradually more advanced softwares came in mid 80s 10 burglars.

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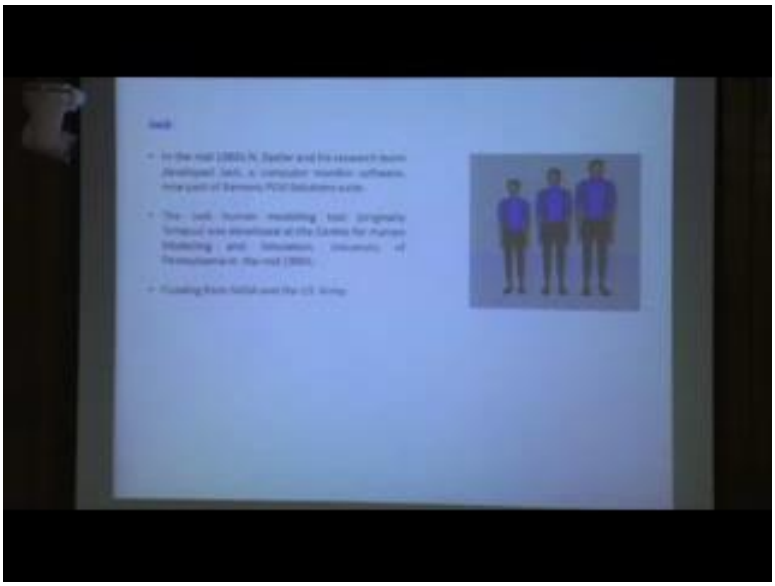

And his research team developed the software Jack. This is computer graphics software where now it is being marketed by Seimens PLM solutions. The Jack software initially it was known as 10 pass, and it was developed by human modeling and simulation group, university of Pennsylvania. And it was funded by NASA and US army. And if you look at the models, so this model relatively more realistic than the earlier models.

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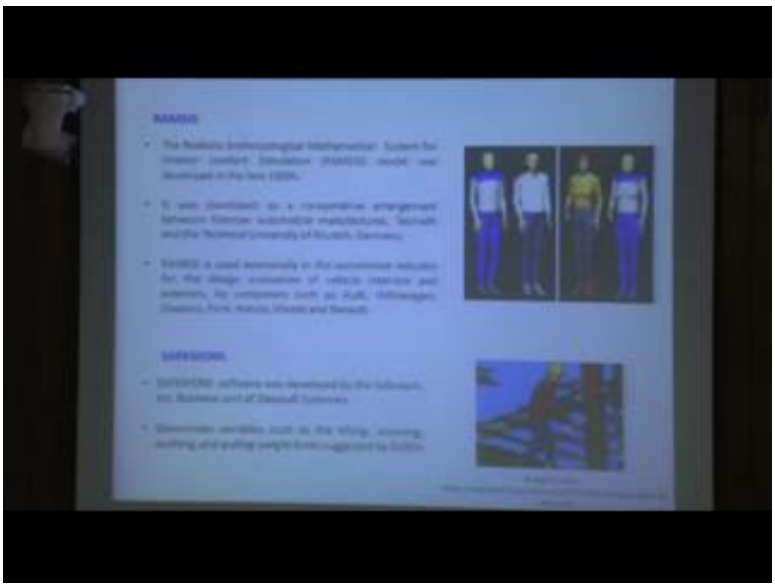

In this 1980s - 1990s, during this period other software also appeared in the market. One of such software is RAMSIS. The realistic anthropological mathematical system for

interior compute simulation known as RAMSIS; model and it was developed in 1980s. It was developed as a cooperative arrangement between German automotive by manufacturer and technical university of moonlit German, so by collaboration of this tech mark and university of moonlit this software came.

RAMSIS is used extensively in automotive industry, from various types of passengers starting from passengers curve to heavy vehicle, as well as even for aerospace industry this software is being widely used nowadays. Another software SAFEFWORK; SAFEFWORK software was developed by Safewore Inc. Business unit of Dafoll system it can determine various variables such as, lifting, lowering, pushing, and pulling suggested by NAS lifting position.

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Some other software, as it is mentioned here, ManupruingPro. ManupruingPro is a pc based human modeling software it was available it is available since 1990. ManupruingPro was used by air operations division in late 90s to assist in the evolution of pilot in a graph hop helicopter. So how these models can be used for helicopter optic simulation. It has been shown by authors as in case, of you can through this reference you will get more information.

Another software known as LifeMOD; it came to existence around 90s. 1990s with constant development over 2 decades, it can be integrated with other software like MD ADAMS. LifeMOD has powerful post processing capabilities, to produce template lots

of force, displacements, velocities, accelerations, torques, and using a 3D motion capture system, we can also incorporate even changing motion in data to this software. And we can create life the motion of digital human models.

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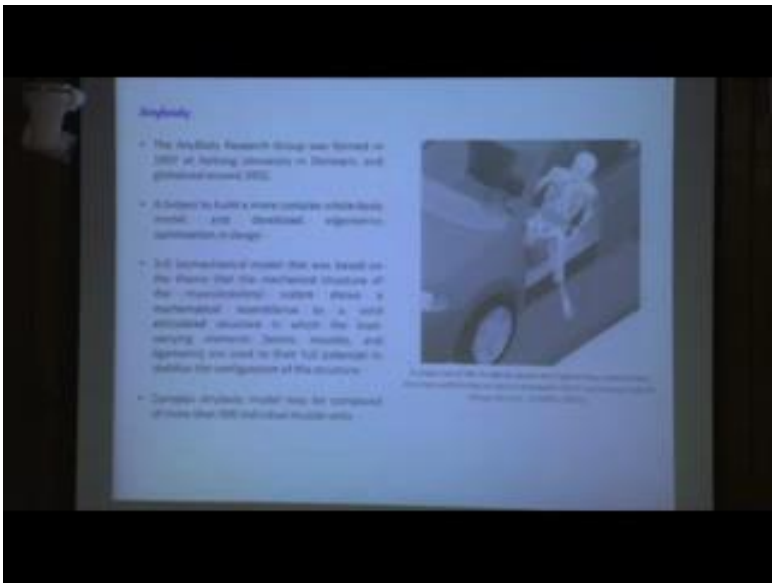

So, down the line, another software this any anybody, it, it came into existence and become popular during 2000. Anybody research group was formed in 1997 at Albert university in Denmark, and globalised around 2002. It yet to be more complex for whole body model and developed ergonomic optimization and design see the biomechanical model that was based on the theory of mechanical structure of the muscular structure system.

So, was the mathematical resemblance, plus solid articulated structure in which the local elements, bones, muscles and ligaments are used to their full potential? To stabilize the configuration of the structure, since earlier models what do we find, earlier models you find that is mainly either linked segment or linked segments or skeleton structures is with surface modeling to represent the human skin or shaded model. But in this first model we can find, with the anatomical bones structure is covered skeletal structure is covered with various muscles.

Even with this software we can create models anybody models that may be composed more than 500 immunity muscles. So when we are discussing or when we are going to analogy various types of biomechanical analysis, then this software is very much helpful.

Because there we can analyse the full potential to where we can analyse the motion of bones, then muscle contraction activity of ligaments so all these things can be analysed using this type of software.

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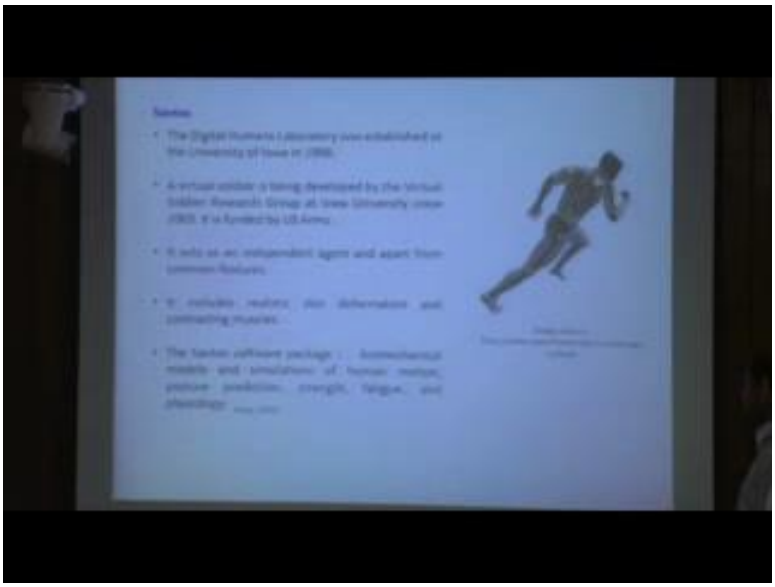

Most advanced among this available software, what we find that is in terms of features the software is called samples. The samples were developed by university of Iva, and the in 1998, and this it was funded by virtual soldier research by us army, and university of at Iva under the project virtual soldier research group, they developed this software. This software right now among those available softwares, it is considered as one of the best software. Because in this software we can find the skeletal structure covered with the surface model, and it includes realistic skin reformation, contracting muscle all these thing we can go for physiologically biomechanical reformation, various environment variables those can also be studied with this software.

So, this is a, v lm advanced software. The software practices Santo software, that it includes biomechanical models and simulation of human motion posture predictions strength fatigue and also physiology. So this information you can get more information from this reference Richie 2011.

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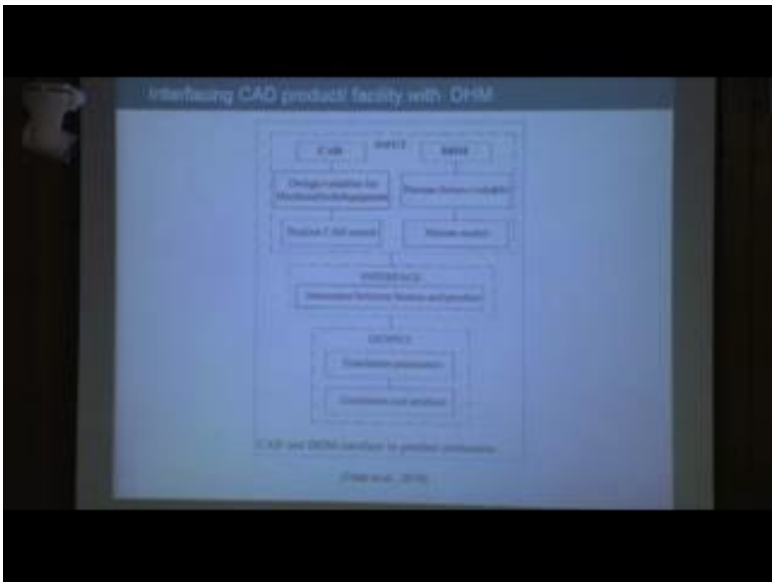

Now, so what we discussed so far. We discussed about how the digital human modeling software evolve starting from 1960s still today, and regular digital human modeling softwares which came in the market in different time period.

Now, we are moving to interfacing CAD product or facility with digital human model. How we can do that one. So this schematic diagram proposed by, in 2016. So what they proposed what input is required CAD, from CAD software, where we can consider various design variables for machine tools or any other equipment or different design and all those considering, all those variables we can create the CAD model of the product or any other facility. So in this site using CAD software we are developing CAD model.

On the other hand, we are developing digital human model. Using digital human modeling software various human softwares variable related to anthropometric related to biomechanics we can consider and we can create human model. When this product CAD model or facility CAD model is ready and human CAD models are also ready then we can go for interfacing those. Interaction between human and product, after that we go for various output simulation parameters and simulation analysis. So after analysing you can go so this step is called virtual ergonomic simulation of that product or work station or any other facility which we are developing.

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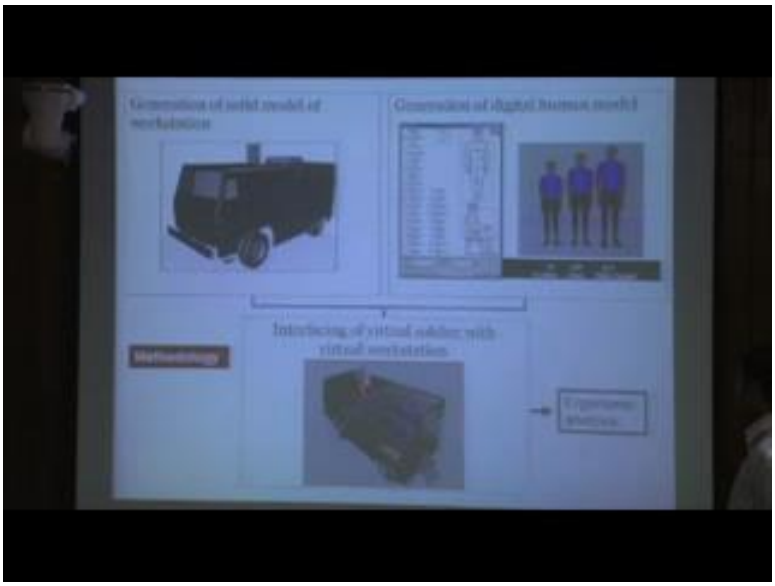

So, details information regarding this reference we will get at the end slide. Now if we represent the same thing in schematic diagram. So what you will do with digital human modeling software, where we can use anthropometric data as well as biomechanical data or initially it is used anthropometric data, we can create this type of digital human modeling even we can change various biomechanical also like range of motion comfort range also those data we can fit in this types of digital human model. And when the digital human model, we can earlier also we discussed, we can create customized human model customized human model means, we can create an age variation self-variation anthropometric variation as per various percentile data.

So, here it is shown in the 5th percentage vocal soldiers from in India, then 58 percentile whole data of army and 96 percentage ship and navy soldiers from Indian army. So these are the representative of smaller Indian army personnel, average Indian army personnel, and larger Indian army personnel. Well this models are may be then what we have gained, we can generate solid model of this type of productive facility. Here it is an army vehicle in army vehicle this type of army vehicle period or any other product or facility we can develop using either with the help of this type of digital human modeling software, but many digital human modeling software does not have such capabilities to develop very complex CAD model of the productive facility of the purpose.

What we do we developed this type of product model from other CAD software, like Solid works, CATIA, Unigraphics. Now this type of various software I will give also various softwares of CAD softwares are available. With those CAD softwares we can create this type of product of facility model, and we can import those models in detail modeling software. Then what we do. We go for interfacing this digital human model with the product of facility or vehicle model or work station model. For that purpose, what is required, we will have to give appropriate working posture, in that work station in that facility what is the activity required activities, those human models are required to do that, type of posture we have to give, and we have to position those human models inside the workstation of the facility.

While human models are properly positioned, then we can go for various types of virtual ergonomic evolution. We will discuss what type of ergonomic evolution we can do with this type of software, with this type of digital human modeling and CAD software. So if we retreat so first you are creating digital human model of various percentile or even we can create as per individual data, at the centre we are either creating this type of product model using digital human modeling software, or we are importing this type of CAD model of the product from made from other software. Like say Unigraphics, CATIA, Solid works. After that you are importing that model to the digital modeling software interface. And we are putting those human models with appropriate working posture. Then we are moving towards ergonomic evolution.

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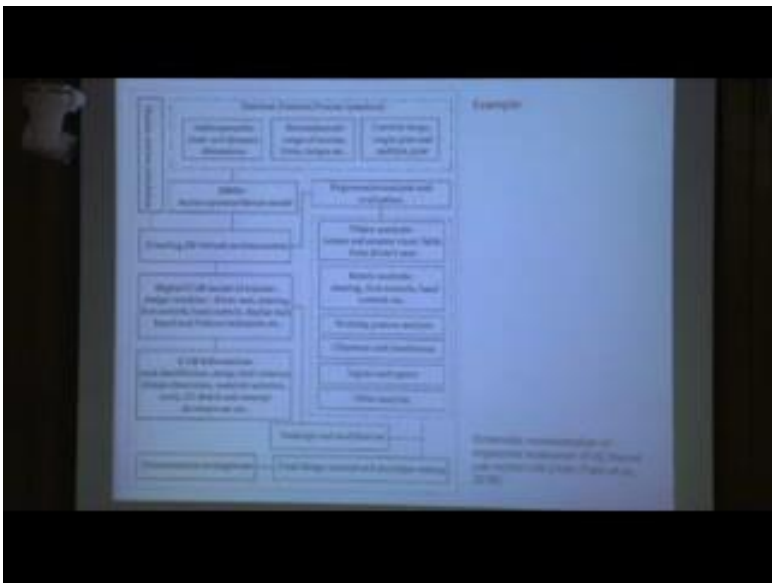

Now, here we will discuss on example. In this example for tractor cap design, so this is taken from Fertilater 2016. Schematic representation of ergonomic evolution of a 3D captor CAD model with digital human model, so how we do that. If you learn to evaluate the CAD model of a tractor, in virtual environment, how should we proceed? First database require farmers or tractor operators, later database. So anthropometric that is static and dynamic dimension is required. Then biomechanical information biomechanical related to range of motion force torque etcetera required. In comfort range single join multiple join comfort data is required, so these 3 areas. Anthropometric data, biomechanical data, and comfort range data, from this data availability into help of those data, we can create digital human model.

Detail digital human modeling of tractor operator or farmer, who will operate the tractor. When that human model is ready, then what we are doing human motion simulation, that information creating virtual 3D moment. That information also we can put, and we are creating 3D virtual environment. So from this side based on this database, we are developing digital human model of tractor operator or farmer model.

On the other hand, we require cab information the tractor cab, for that purpose need we will go for need identification, designing the selection various details, because designing the selection means various dimensions' material selection, cost all these based on those 2 d sketches and concept development. While that concept development is ready then we are using various types of CAD software, with those CAD software we are developing the 3D CAD model of the tractor cab. And also we are repairing that one, so digital cab model of the tractor, design variables like driver seats steering moving various types of foot controls hand controls display dashboard all those are made.

So, from this side, digital human modeling is ready. And from this side tractor cab model 3D cab in that cab model is ready. Then we are interfacing digital human models are given, actual working posture and cab model and which is that models are positioned in tractor cab model. So we are getting that virtual environment, in this virtual environment, both digital human model software and tractor CAD model is also present. While that virtual environment incorporative CAD model of the product and human is ready then we are moving towards ergonomic analysis.

What ergonomic analysis we can do, we can go for various types of ergonomic evaluation for this tractor cab, or we took example we can go for vision analysis interior and exterior visual fields from driver seat reach analysis, reach towards various types of foot controls, hand controls. Then working posture and driving posture driving comfort, clearance interference, in this whether the driver can easily enter, from the driver cabin and various other analyses we can do.

At this phase, people find after evaluation. With digital human model if we find that whatever concept model we develop, if that is fine, as per the ergonomic evaluation then, we will proceed for final design concept and prototype making, if we find no there is some modification or redesign is required, then again we will go for redesign and modification phase, and again we will modify the tractor cab model and again we will go for further ergonomic evaluation. While ergonomic evaluation is satisfactory if we will find that tractor cab model, has been designed as per various human factor issues, at it has properly incorporated though or it has been developed as, per various human factor issues, then we will go for prototype making and finalist documentation.

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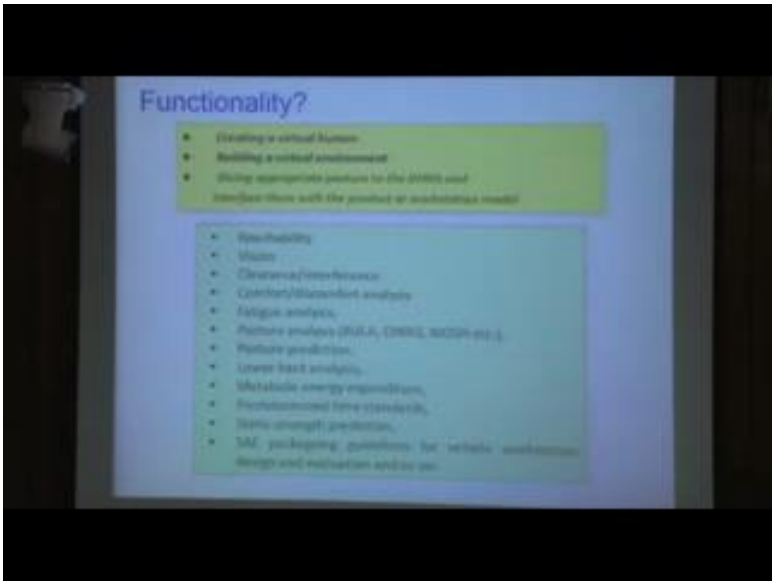

Now, what are the functionality of digital human modeling. So basic functionality of any of this digital human modeling software, whatever softwares we just discussed that may be Jack that may be Sammy Gramcies or Santosh, for all these software, basic functionalities creating digital human modeling. For digital regarding this digital human

modeling, occasion we will as we mentioned, we can create customized human means human model as per our intended user population, or intended user. At any short of graduation in terms of anthropometry type we can do that.

Then we move towards building virtual environment. Virtual environment making the CAD model of the product or importing the CAD model of the product or work station from other CAD software, other CAD software develop work station model and interfacing these 2 human model and virtual environmental virtual product model. Then we are interfacing with appropriate posture. So these 3 are the basic for any software. Then software to software other functionalities varies, but few basic functionalities are there in almost all these softwares, those include reach analysis vision, analysis clearance interference study comfort discomfort analysis fatigue analysis various types of postural analysis using various types of postural tools like RULA, REBA, OWAS, NOISH, etcetera. Then posture prediction based on pre-set criteria lower back analysis, spinal computation forces, shearing forces, we can analysed.

Not only that you can metabolic energy expenditure, predetermined time standard static strength prediction various type of packaging guidelines as per society of automotive engineers, or any other standard organization as per their requirement, we can also analyse our product or work station.

So, these are some basic functionality which is available almost in all the developed software, which are right now in the market. Now Stephen and Johns 2009, embarked and 2009, they mentioned digital human modeling or digital human models or digital human modeling software has the capability to interact with the either work station and subsequent various types of ergonomic evaluation is possible.

As ergonomic evaluation they mentioned we can study work station layout workflow simulation assembly accessibility, reach analysis clearance analysis strength capability, studies safety analysis assembly feasibility, others like process compatibility issues posture and human simulation for various body parts movements, then inverse kinematic forwards kinematics different types of kinematics for posture giving the appropriate working posture or simulating various types of tasks, then vision simulation, then comfort analysis based on single body joint or multiple body joint, then maximum force

calculation and strengthen of gravity analysis biomechanical information spinal computation.

They mention all these types of analysis actually we can perform with the help of digital human modeling software.

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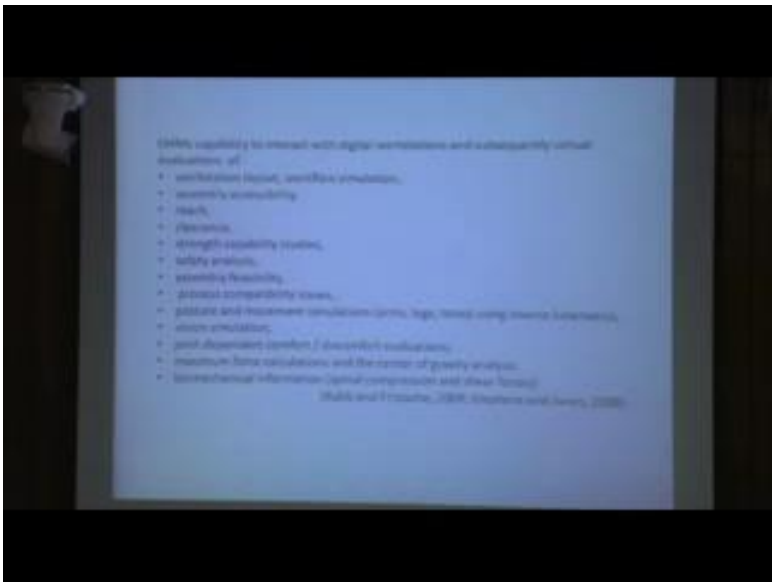

And that is why digital human modeling softwares are very much essential for proactive ergonomic evaluation of various types of product, and facility in production engineering or manufacturing sector or in production.

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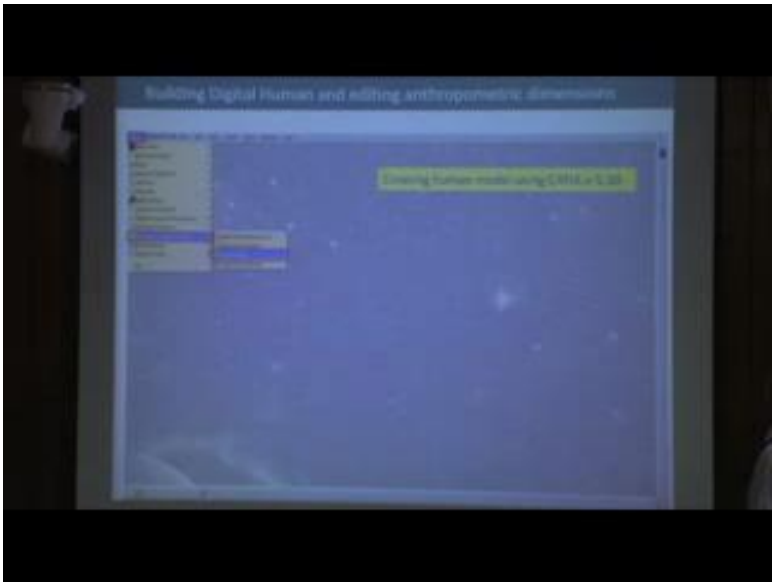

Now, we want to discuss, how these digital human models are created using digital modeling software. So software to software it varies from one software to another software interface is defined you will find in some software, we can create that user interface is very user friendly in some software it is actually difficult you have to learn. So here we have given the example from CATIA software. In CATIA software we can create digital human model. For that purpose, if we open that software we find the start menu, under start menu there is one sub menu called ergonomic design and analysis. Under this ergonomic design and analysis, we will find human hilder.

There are 4 options human measurement editor, human activity analysis, human builder and human posture analysis. While you are creating digital human model, you want to create new model then we follow the step from start, we will go to human builder.

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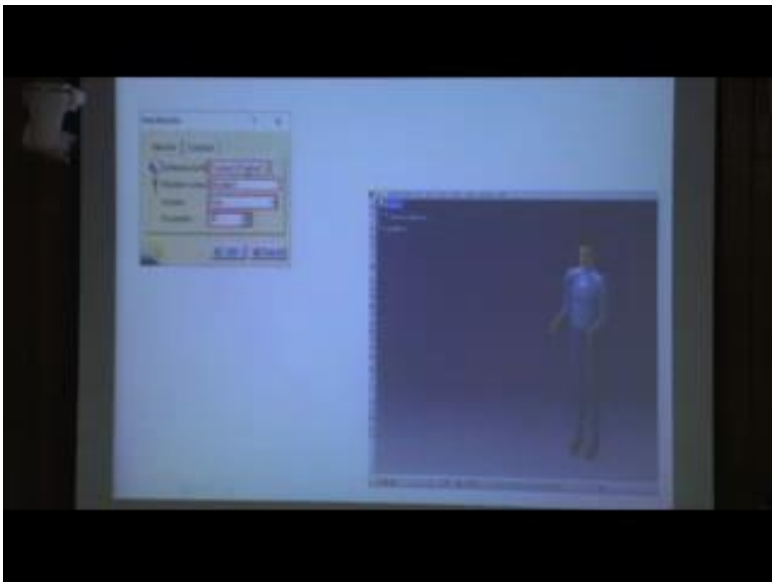

While we click on human builder, it will open this particular window while so many other tools are there.

So, first we will use this tool. This tool is insert new manikin for inserting new manikin while we click on that one it will open this type of window. In that window, which in formations you need to put first one is you have to select the product. First there should be a product tree in that first you have to identify the human model, which you are going to give that is associated if this product come.

Now, manikin name, you can put the name of the manikin one manikin 2 or any other particular name that percentage model or 5th percentile model or whatever you wish accordingly you can put the name. Then there you can specify the gender whether that is the male model or female model. Then you can go for percentile which percentile model you want to create. You can create as per your requirement various percentile. Starting from first percentile to 99 percentile or 100 percentiles, after that while you are clicking on then this type of models are created, human model is generated.

Now, while this human model is generated, now you can go for further modifying individual body parts based on anthropometric data. From that purpose you have to follow this path from start.

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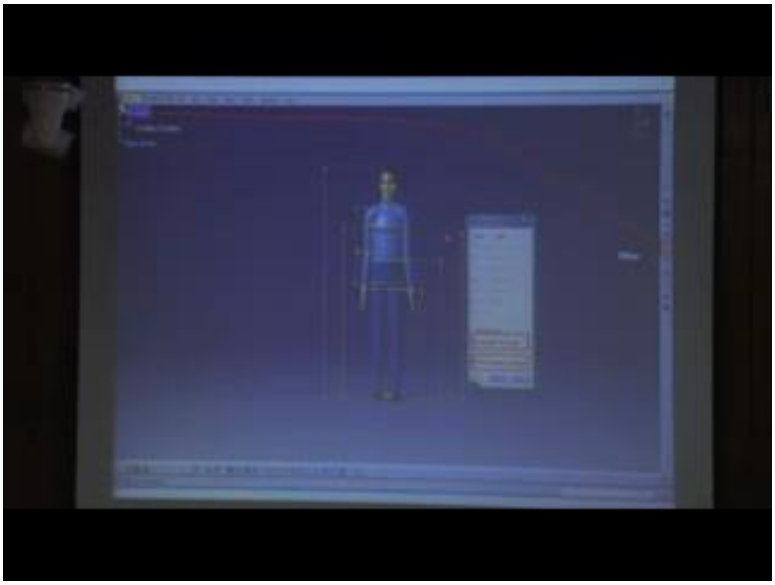

Then ergonomic design analysis, under the human measurement, human measurement editor, then under human measurement editor, when you will click on human measurement editor this window will open. In that window you are first selecting this one called filter. In that filter various parts are there. Then you can go for part body head torso arm hand and this has various body parts are there. Types what type of anthropometric valuables you want to consider, like circumference height, length breadth depth mass, so all these is possible

Now, here we can go for manual, if you want to manipulate it. We can put it manual then we can go either one after individually or we can select all at a time. So while we are

putting all then all the body parts and it is all types of varied anthropometric variables will be displayed on human body. And each of the body segment and with anthropometric dimension we can modify.

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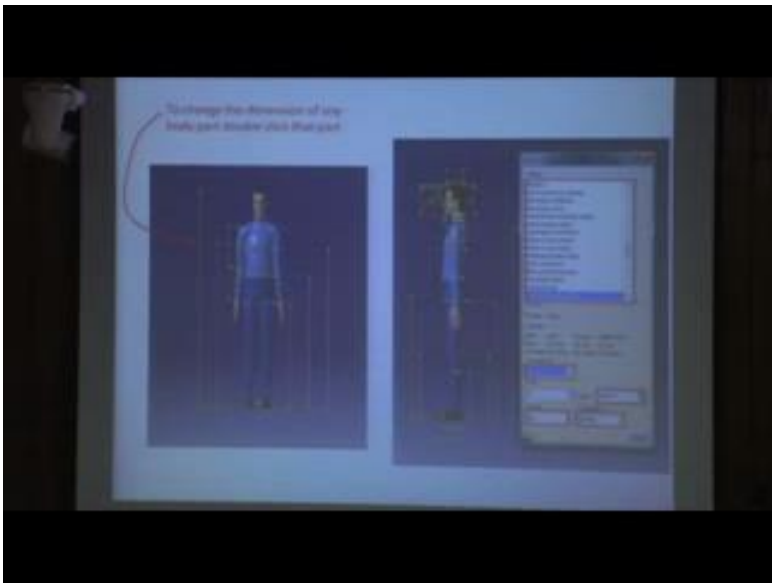

So, here it is shown, that how we can to change the dimension of any body part. Double click, on the part if we click, or double click on that one then this type of window will open. If you say for example, here; so from front to back, even if we say this is the head gate or to back of the protection to back of head, it is not clearly visible anyway see if you want to decide the head dimension then, you can select this particular dimension while we will fit from that list that will be highlighted and when that is highlighted then you will find the variables various values are shown there.

Now, as we manually manipulate the dimension for that purpose, we are selecting as manual. Now if you want to create which percentile, you can put it here otherwise if you have anthropometric data for the particular percentile, or for individual then you can put that value here. While you will put that value here automatically it will change the percentile value, as per the incorporated database. If that database is not there incorporated, for a particular population, then as per the particular population the anthropometric data, you can put the dimensional data for specific body parts. Then obviously, general health it is man and construction which is standing. This is for these dimensions are for standing posture.

Similarly, we will we can find for sitting posture also. So many other variables so, here you can find 100, 103 anthropometric variables are there for constructing this digital human model in case of this CATIA digital human modeling, which we also known as so this is one example for CATIA software.

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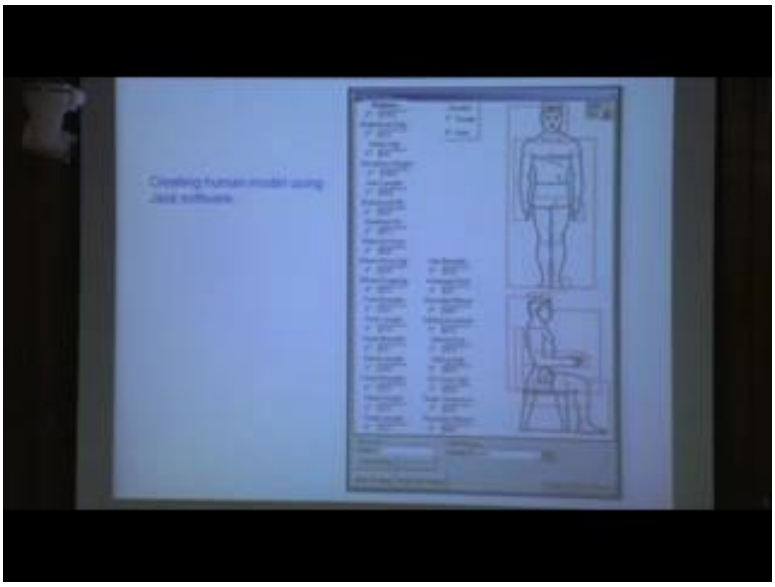

From other softwares, say now if we go for other software, if you see the interface of Jack software. In Jack software we find this type of interface, perhaps we can put very the dimension so first we are creating new human model. In that new human model, we can create, that which human model, you want to modify the body dimension, we can put the name of that we can specify whether we are creating male model, or female model, after that while the human model is ready. Then we can manipulate or we can change provide the anthropometric dimension for various body parts, based on that we can create that human model. While that human model is created, then there are 2 options one is basic scaling. So this is coming under basic scaling.

Then we can go for body parts scaling. Individual body parts, it is possible for further scaling of individual body parts. So this is for overall body, then we can go for only we can further when that human modeling is ready. Then we can go for further modification or further refinement of individual body parts. Say for example, for lower arm lower arm length, we can modify, we can modify the lower arm circumference for that purpose you have to work for body parts scaling. So in this way software to software, there is

variation in terms of number of anthropometric variables, considered for creating the digital human model, at the same time various types of anthropometric database, incorporated in that software that is also difficult for different softwares.

So in this way using different types of digital human modeling software, here only we discussed about the example of CATIA and Jack, but we can use any other software like Ramcis, Sammie, and Santosh for with this type of softwares. We can create digital human modeling based on our anthropometric data. Further again we can manipulate biomechanical data also, there is in those all these digital human models there is options for modifying the joint limit with the range of movement modification there is provision for defining the comfort joiner joint angle for different body joints, based on that again we can also modify biomechanical data for that particular human model.

So, after discussing about how to create digital human modeling using anthropometric data using different types of softwares, now, we are going to discuss about how we can provide appropriate working posture.

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While we are interfacing the human with the product or work station model so here is an example so where we have digital human model as per our anthropometric data after that we need to give proper posture particular working posture while that your time to simulate that digital human model is doing some activities in his or her respective work

station then first step is giving appropriate posture the posture may be sitting posture standing posture touch to touch it will vary.

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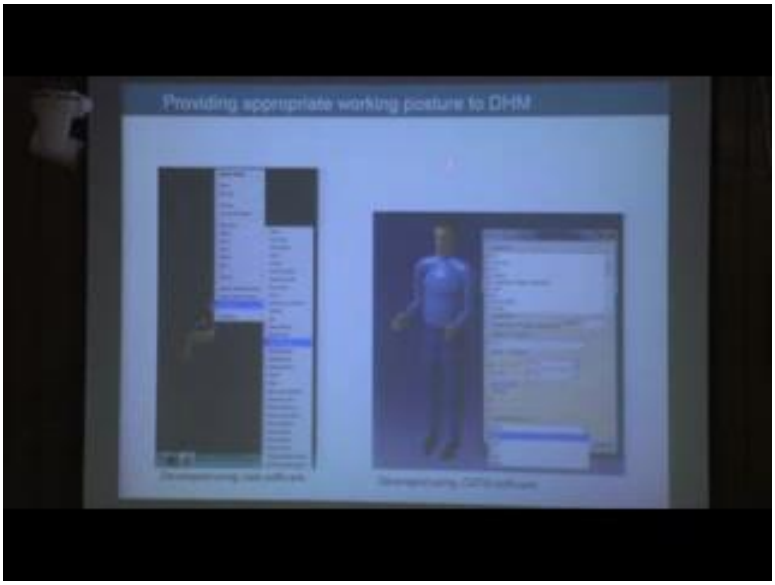

Now, work for working posture. If we look at Jack software, in Jack software interface there are predefined postures, there is a lengthy list of postures. So that is already incorporated in that software. So while we are whenever we are clicking on that right click on human model it is showing postures. And there are so many types of postures. Then you can select whatever you require. Then it is easier for that user which particular posture you want to give to digital human model, so that you can interface digital human with your product or work station model. So this is from Jack software from other softwares, say for CATIA software.

In CATIA software there is also after creating digital human model you can manipulate individual body segments, when you can change the motion of individual body segment based on this one. These are the segments list and then you can change the degree of freedom here that is what that it is based on extension induction erection or rotation and accordingly you can change the angle also. This is for different body segments

But there is also like Jack software, here is the standard posture. Similarly, there are also few standard postures are different. Stand sit bend kneel so this type of standard posture we can directly put on human body. So this types from software to software, how to create posture different posture that is different. In some software there is already

predefined postures you can directly use those predefined posture, but it for other software, what you can do you can give some initial posture, after that using body segments and joints, you can manipulate those body segment and joint and accordingly you are providing a working posture to that digital human model. Now same thing is also available in Jack software.

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So, here is the example of if we are using CATIA software, or Delmia human in that case how we are giving posture. So first we are selecting that posture, then from the posture we want to this is this tool is called posture editor. So posture we are selecting that manikin is particular manikin, for that manikin we are going for editing the posture.

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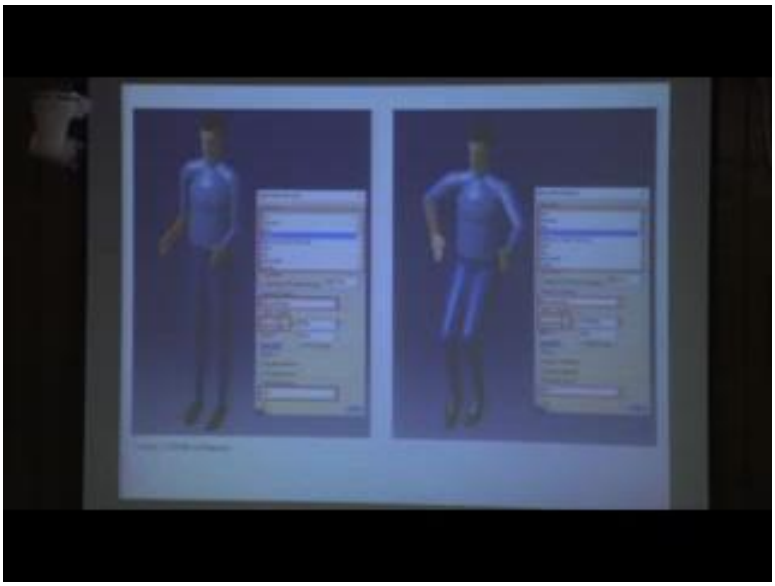

So, this is the particular tool, which we need to use in case of CATIA software. Then while we are clicking on the tool, then this type of window is opening or you can find different body segments, you can see here it is selected forearm for forearm there are different degree of freedom. Flexion extension so that type of from this drop down menu you can consider. It then you can change the angle. Accordingly, it can remove then.

The posture predefined posture is initial, in initial standing posture is there here you can directly change it to sitting sit stand or name these type of other posture also you can go. Then here is that example, so if we are modifying that particular body joint angle then, this type of different posture, we can create using manipulation of position of different body segments by changing the angle of body joints.

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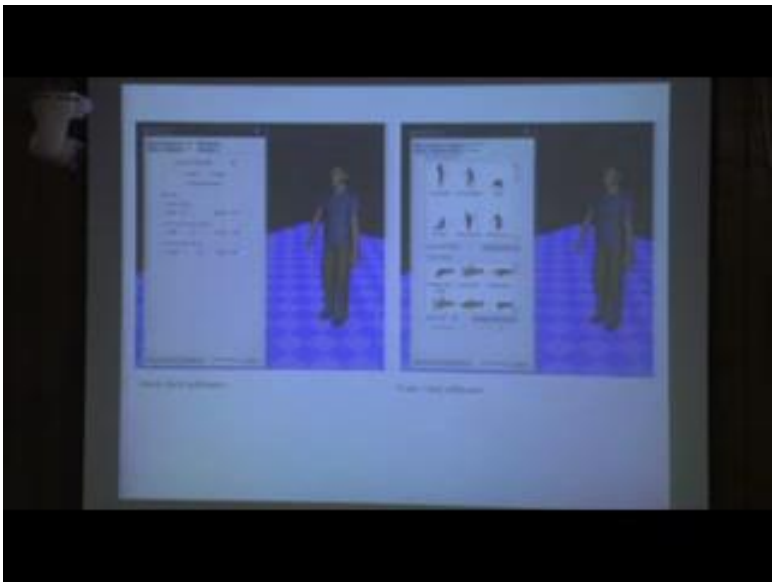

Similarly, in Jack software, how we can manipulate the posture. After giving the standard postures then for fine adjustment as per the requirement of the task, or for your simulation purpose, then you can go for this type of adjust joint. Then you can select that particular joint from, here body part you can select that here it is shoulder is selected, and under shoulder then, they will find 3 degree of freedom. And each degree of freedom you can change the angle and accordingly you can manipulate that posture of that particular body segment.

More over in Jack software, there is apart from this type of standard posture, which you can directly go for even for individual segments like hand, you can give specific type of posture like grasp, wee pointing this type of posture hand posture, also you can directly you can provide to the digital human model otherwise, most of the software what you have to do individual body segments, and it is associated joint we have to manipulate as per your requirement to meet your simulated working task.

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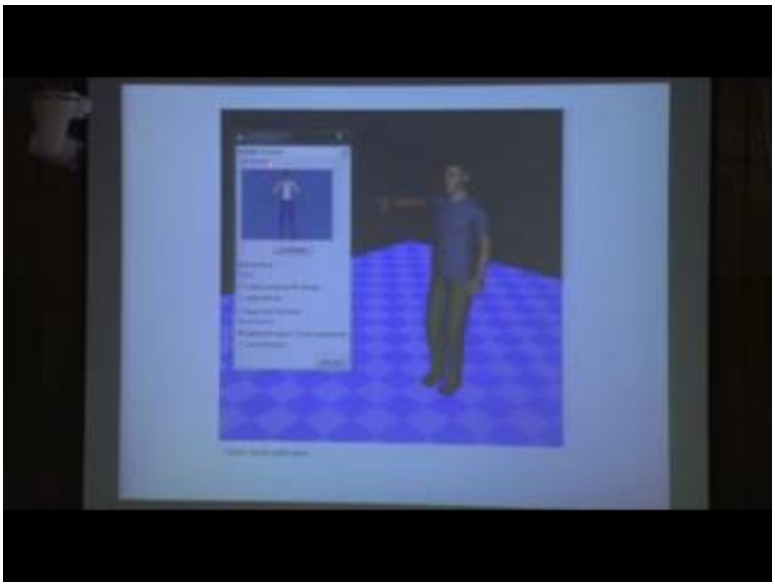

In Jack software, there are other options also, like you can select these tools called human behaviour. From human behaviour you can select the particular human, you can select various body parts like this is the trunk portion, after selecting the trunk portion there are different types of hold orientation release, keep vertical this type of manipulation after selecting, this one then you can there are so many vertebral segments, but all the vertebral segments, you can manipulate together with this type of human behaviour, tools so it makes much easier to provide a particular posture.

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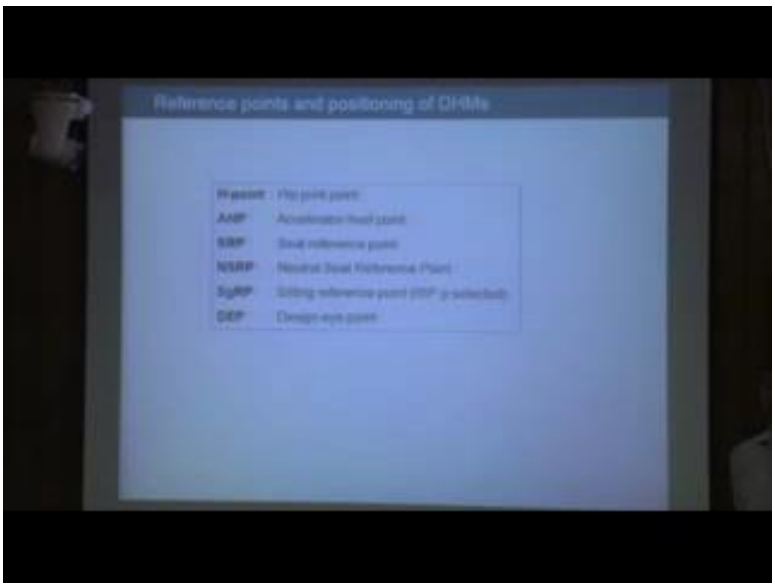

Now, so after giving the initial posture to digital human so first what we did we created the digital human models as per our requirement, that may be as per the anthropometric data say, we have few examples we created 5th percentile digital human model 50th and 90th percentile human model. Now as per our need we are giving them sitting posture or standing posture. As we have already explained how we can give a particular posture. We can provide working posture before interfacing the human model with the product or workstation model.

So, while we are positioning that human model, with the appropriate posture we need different types of reference points in, how we are positioning that digital human model or how we are interfacing the digital human model, with respective workstation or products

For that purpose, we will discuss different types of reference point. So first reference point, so this reference points are important for positioning the digital human model in workstation. So first one is h point or hip joint point; second, accelerator heel point; third seat reference point, fourth neutral seat reference point. Then there is sitting reference point design eye point we will discuss one by one.

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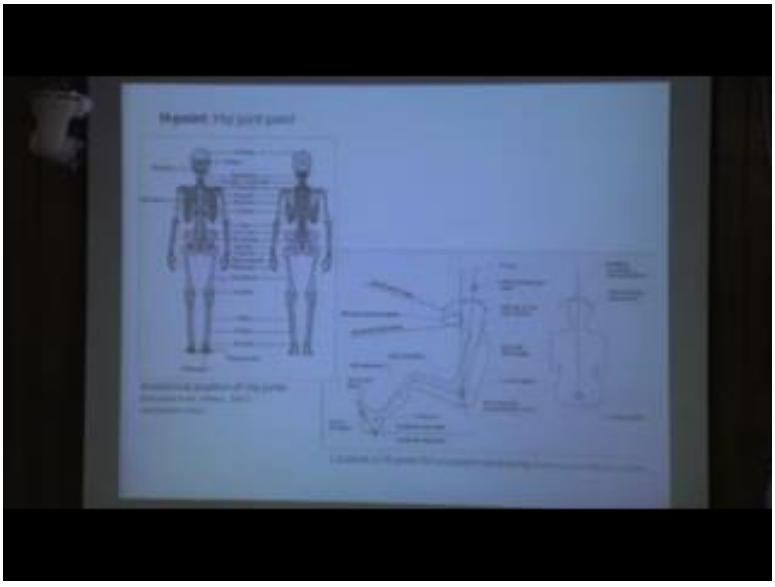

So, first h point if we discussed. So what is h point? H point means hip joint point. If you look at this anatomy of human body, then you will find there are 2 hip joints left side and right side hip joints. These 2 from this hip joint of human bone actually moves around this joint. So this is a balance of hip joint and around this there is 3 degree of freedom.

So these 2 points are known as this point and this is a second point. These 2 points are known as hip joint point. This hip joint if we connect with an imaginary line, this line does not exist this, is a this is an imaginary line, the middle point of that imaginary line is known as hip joints point or h point. So, based on that h point that h point is very important for us, because while that is a sitting workstation, then how the digital human model is positioned on the seat that positioning is depending on h point location.

Now, if you look at this one. So it is position at the hip joint point these are the hip joint, but hip joint at that particular reference point at the middle of this line, so we can define what is if we defined the hip joint point we can mention as, h point or hip joint point, is the midpoint of the imaginary centre line, which is connecting 2 hip joints

Now, if you look at this particular image, while this is from for automobile driver, when the driver is in seated posture, and then from side view we can find out that hip joint point is there. So this is the actually here is the location of humour bone, and this is that hip joint with the pelvic girdle. So this particular joint this particular point is called hip joint. Now this is from side view, but from front view or back views the position of actually, as we mentioned this is the midpoint of the body. So h point from side back view or front view it will come at the middle.

So, in sitting posture, called workstation where, the task requirement is the line the task requirement requiring seated posture, in this situation first you have to give the appropriate sitting posture to the digital human model.

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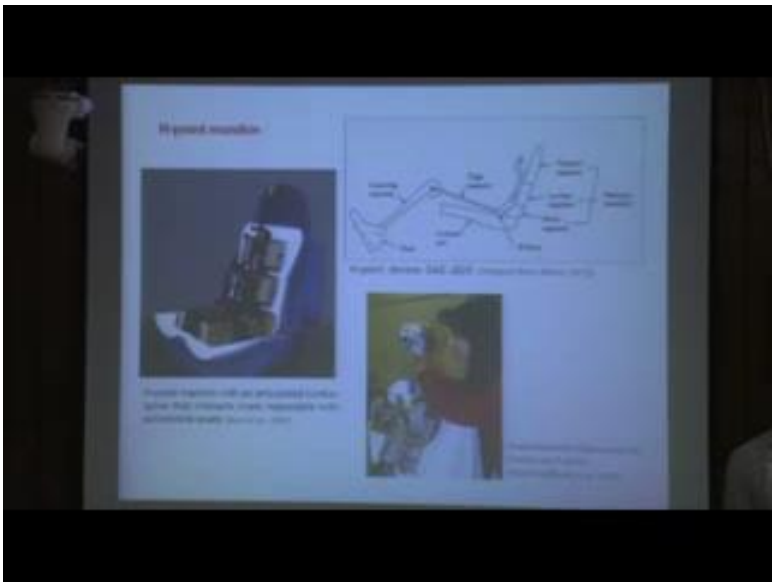

After that based on you have to position human model on the seat in relation to it is h point. For automotive industry while we are positioning or we are defining this h point for that purpose h point machine or h point manikin is available. So this is a 2 d template or I will consider h point device as per SEJ 8 206, standard according to the standard. So this is actually representation of body form of 95th percentile driver. So this is that upper body means trunk portion and this is you can mention as the thigh portion, and this is the lower limb. So this is that location of h point. This is a pelvic segment lumbar segment and thoracic segment.

Now, while we are defining in automotive industry, there is requirement of defining the h point of the manufacture seat. While on seated the manufacture then you need to define the h point location, based on this h point. Manikin while we are positioning this h point manikin or h point device on that seat, then seat has been compressed and while seat is being compressed, then from the compressive seat this h point is designed in such a way that it represents the actual movement body defined body segments and as per it is mass.

So, this is actually this h point machine or manikin representing, one 95th percentile driver seated on the driving seat. And this is that as per the instrument or device this is the location of h point. So actual h point location is this the one hip joint point and that is another hip joint point. So finally, the h point is locating here. So that h point location is important for automotive industry while they are manufacturing the seat. Not only h

point machine for position for defining the h point. There are other tools also for example, if head rested measurement device on h point. So of h point manikin or h point machine we can also put head rested measurement. While when the driver is seated on the driving seat while he is using head rest. Then where should be the optimal position of the head rest. That also we can study with this type of additional features.

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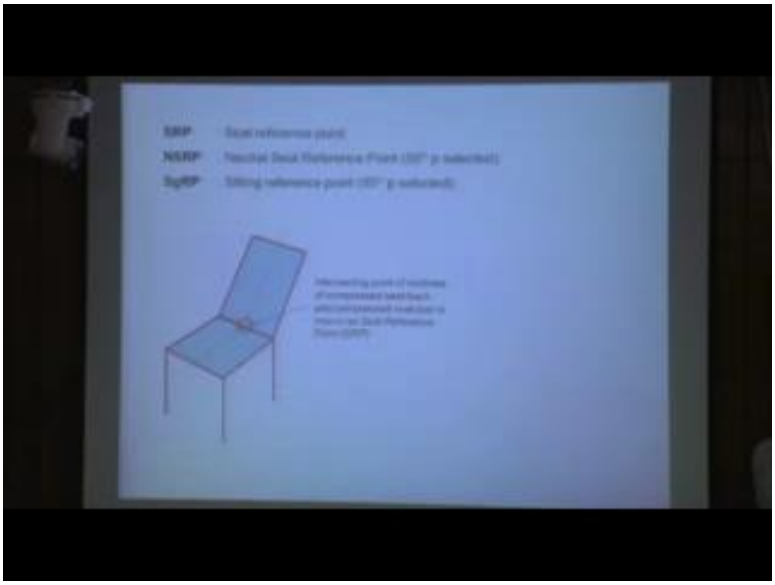

Now, next we are discussing about seat reference point SRP neutral seat reference point and SGRP, sitting reference point. So first we are discussing about SRP. SRP or seat reference point, how we can define SRP. SRP for any seat this is a point on the seat where the mid lining of the compressed seat belt and mid line of the compressed seat belt intersecting this particular point. So intersecting point of mid lines of compressed seat belt and compressed seat belt is intersecting at a particular point. That point is known as seat reference point. So although it is positioned at the middle, but from the side view it will be visible at this side from side view.

Now, next neutral seat reference point. If you take the example of automotive industry automobile design automobile interior, so vehicle car seat moves forward and backward so that we can accommodate short driver and shorter body dimension as well driver with larger body dimension. So while driver is seated on the driving seat, and he or she is adjusting the seat forward and backward, then neutral seat reference point is a location of the seat reference from seat reference point which actually is preferred by 95th percentile

driver. So 95th percentile driver, while he or she is seated on the. So in general while we are talking about in analysis 5th percentile driver, then generally you consider pooled data means not male data or not particularly female data.

So, combined data that is called pooled data, so 50th percentile pooled driver, while seated on the driving seat and adjusting the because he has he or she has to hold the steering wheel, as to operate the different types of peddles, accelerator break clutch when they are operating these types of controls, then they will adjust their seat forward and backward, so 50th percentile driver selected seat position while 50th percentile driver in adjusting the seat as per his or her requirement, then the location of SRP on the seat that is called neutral seat reference point. Similarly, this seat reference point again while 95th percentile driver is adjusting the seat forward and backward then 95th percentile driver select a seat reference point is called SGRP. So it will be more clear if we explain with drive with sketch.

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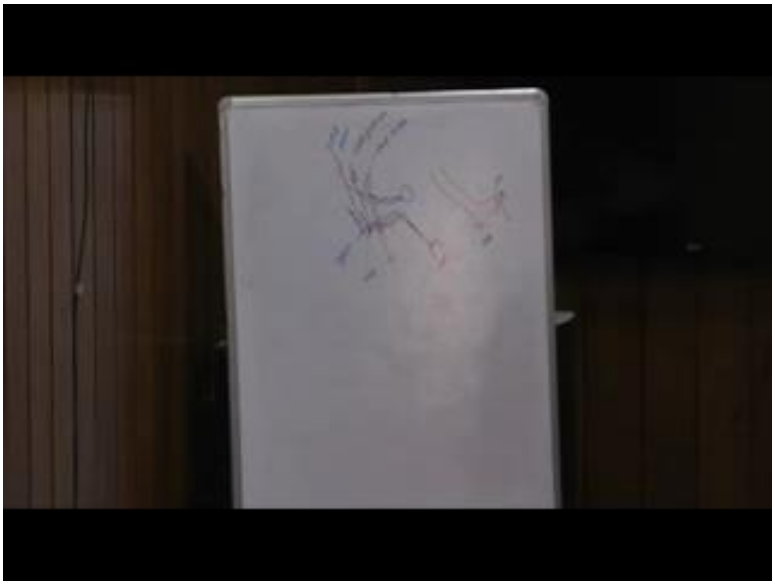

Now, say if you imagine this is a driver. This is a steering wheel, drivers' leg is on the accelerator, it is on the accelerator and this is a steering wheel. If we consider this is 5th percentile driver, then this is the 5th or 6th percentile driver and this is the SRP. Similarly, on the same seat while 50th percentile driver is sitting, automatically their leg position should be the same, but they will move the seat a little bit backward and if there is provision they can move it little bit upward also. So this location is this is 50th

percentile driver then this particular location will be n SRP neutral seat reference point. Then if seat is moved further for accommodating 95th percentile driver this is the seat position.

In this case, if we imagine this is 95th percentile driver, and so this point will be SGRP. So while driver is adjusting the seat forward and backward as per the requirement. Then all these are actually SRP. SRP means as we discussed that mid-point on the seat, which is representing the mid line of the compressed seat belt and mid line of the compressed seat belt, so that is the location of SRP as the seat is moving it is also moving so while 50th percentile driver is still adjusting the seat at that time the position of SRP is actually known as n SRP, neutral seat reference point, while it is adjusted by 95th percentile driver while driver is adjusting the seat as per his or her requirement, then 95th percentile driver selected seat reference point is known as SGRP. So these 3 reference points are important while we are positioning or manikin on the automotive seat or any other seat where there is task requirement sitting task requirement is there

So, after discussing about h point the SRP, SRP and SGRP then we want to discuss another point that is here. It is mentioned as a HP accelerator heel point, what is accelerator heel point; accelerator heel point is another reference point. Here we can show this one. If this is the accelerator while drivers are keeping their leg on the accelerator then their heel touching on the ground at a particular point, that point is known as a HP accelerator heel point.

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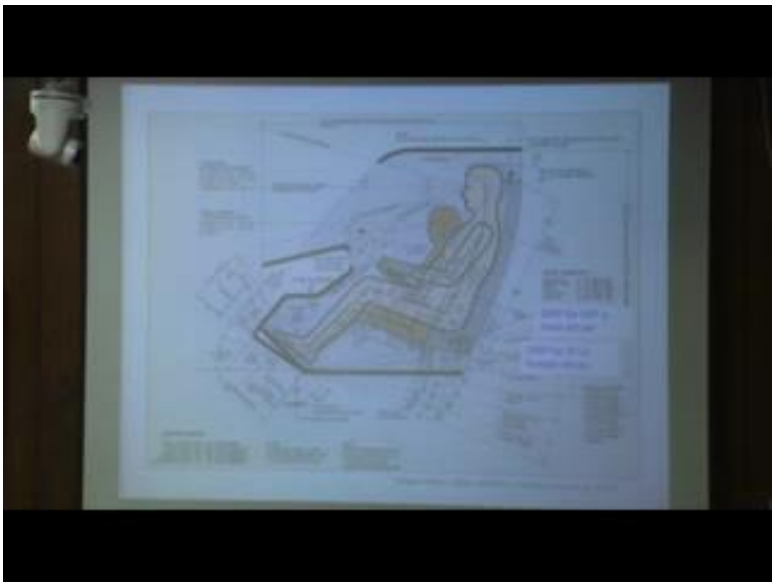

So, accelerator heel point can be defined as a point on the waiting floor, while driver keeping their feet on the accelerator then that particular point where the heel is touching. That contact point is known as accelerator heel point. This accelerator heel point is also important for positioning driver on the occupant seat. And this while drivers are keeping their then if this is the leg. And if this is the accelerator, then in this point as we mentioned the point where it is touching on the ground. So this is a HP accelerator heel point and the portion of the leg, which is with this portion which press the accelerator this portion is known as so this portion is actually, below that single or bones this portion is called ball of foot, so while drivers are keeping their leg on the accelerator

So here, we need to mention that this accelerator is in unrepressed condition, while drivers are keeping their feet on unrequested accelerator then the point on the ground where the heel is touching that point is known as accelerator heel point. Now, if we come to this image, then here you can see 2 driver points 95th percentile, male that is the representation of larger body dimension and another is 5th percentile female that is the representation of shorter or smaller body dimension, these 2 manikin is positioned on this vehicle seat, so as per their requirement they will move the seat forward and backward and if there is provision of the again up and down.

So here you can see 95th percentile driver, or 5th percentile driver they are keeping their feet on the accelerator. And this location is accelerator heel point where heel is touching

accelerator heel point. And now you look at the posture this is the typical driving posture and this is the position of the seat. On that seat this is this point is SRP. Because this is a mid-line of compressed seat belt and compressed seat belt. So from side view this is the position of SRP. SRP for 95th percentile driver because as per 95th percentile driver. This seat has been adjusted so this is 95th percentile SRP, SRP for 95th percentile male driver. Similarly, female driver or 5th percentile female driver, when she is adjusting the seat as per her requirement, so seat will be moved little bit forward and little bit downward.

So that is why SRP location has also being changed from this point little bit forward and then downward. So this point the seat reference point, it is 5th percentile driver selected SRP and both the manikin, this is the location of h point for 95th percentile driver and this is the h point to me hip joint point for 5th percentile driver.

Now, you can understand, so what is the relation between SRP seat reference point seat reference point is located on the seat defined, but it is position may change as per the shifting position of the seat as the seat is being moved forward or backward, so accordingly position of SRP is changing in 3D space, but in relation to seat position of SRP is fixed in relation to seat, but in relation to space SRP location is changing on the other hand if you look at h point. So h point for this particular individual it is fixed, but individual to individual as per percentile variation or individual variation h point location is also different, if you see from this seat surface h point location is this much height, but here it is more in many in SEG.

If we look at SE standard although you mentioned that 95th percentile driver selected seat reference point is known as SGRP or sitting reference point, but in SE standard this h point is actually mentioned as SGRP. So in SE standard of 90 this is also used for positioning the human digital human model or human model or defining the position of manikin on the seat this, h point location h point of 95th percentile driver is referred as SGRP sitting reference point in SE standards.

But in general purpose we can mention 95th percent. This SRP is also mentioned as sitting reference point SGRP for normal purpose, where we are discussing about SRP location as per different percentile, so for 5th percentile there is no specific name, but for 50th percentile driver selected seat reference point is called neutral seat reference point

and 95th percentile driver selected seat reference point is known as SGRP, in SE standard apart from that SRP, this h point of 95th percentile driver is mentioned as SGRP so in SE standard SGRP means h point location of 95th percentile driver male driver.

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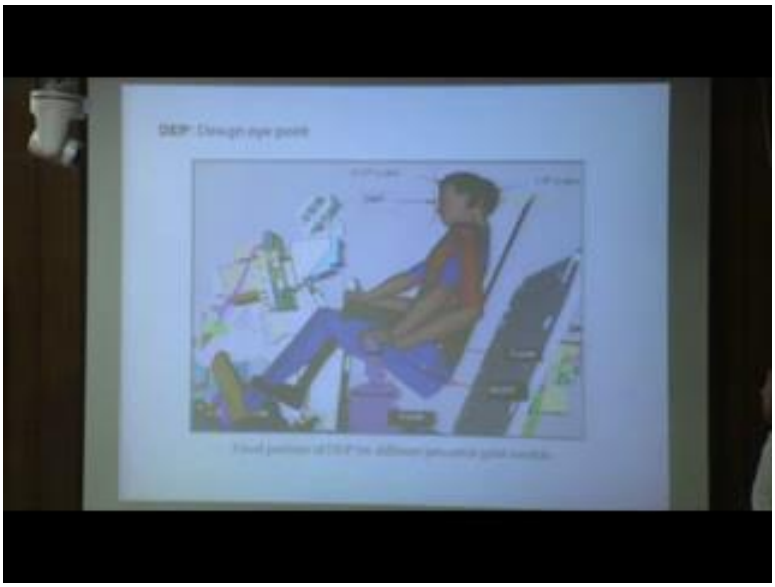

Now, we are moving to the next important point reference point, that is known as design eye point. This design eye point is used, in aerospace or aviation industry in aerospace and aviation industry. In this place if you look at automotive driving in that case location of eye position is different eye sight is different. So they are viewing visibility outside the vehicle is also different. As the eye position is eye as per the seat position seat position is almost fixed only moving forward backward, but if you look at the eye position, then the eye position is different.

So their visibility outside the vehicle is also different in case of automotive vehicle, but in case of aviation and aerospace industry looking at displace at the same time looking outside is very important. So for that purpose all the pilots' eye position should be same. In this case we need to adjust the seat can be moved up and down, to accommodate smaller pilot and largest pilot. Means pilot with pilot with smaller body dimension, or pilot with larger dimension all of their eye position or eye location should be at a particular point. Particular location this point is known as design eye point.

So, during manufacturing of that aircraft, this manufacturer has to define this design eye point. In this position is fixed so that all the drivers' eye location will be nearby this

value. So that all of them can see the important display here it is head up display, so they can see the head up display, at the same time they can see the outside. And they can also look at other displays so for that purpose all of their eye point is fixed, but their sitting location is different. So then this is an if we think this is the seat back and this is the seat front so seat will move upward and downward along the seat trap travel along the seat trap seat will travel up and down so that it can accommodate pilot with smaller body dimension as well as pilot with larger body dimension.

So, what will happen here? This is the neutral seat reference point and here is the h point. So this is h point of 5th percentile or smaller 2 point 5th percentile pilot so for smaller pilot this is the h point location, hip joint point for pilot with larger body dimension, their h point location is this one, but if you look at the n SRP neutral seat reference point; obviously, this is neutral seat reference point midpoint of the seat trap travel.

Next this seat can move upward. If it is adjusted as per the 5th percentile driver, then this will be SRP and if it is it moves down as per the requirement of 95th percentile or 97 larger pilots. Then that will be if it is adjusted as per 95th percentile, then we can mention that is another SRP. So SRP is moving from this point. This seat is moving up and down to position different percentile pilot and accordingly we can identify the location of h point and location of the seat reference point.

So, main difference, between the earlier discussed points that is accelerator heel point and h points. Here in automotive industry the main concern was sitting position is almost same. Because there we will only seat will move forward backward so that they will they can operate different types of foot peddle controls, and they can hold the steering wheel, at the same time they can see outside obviously, but their eye position is different. But in additional space industry, this design eye point is fixed so that all of them have to see the display at the same time; they are sufficient to external view for that purpose seat will be move up and down, so that it can accommodate pilots of different percentile.

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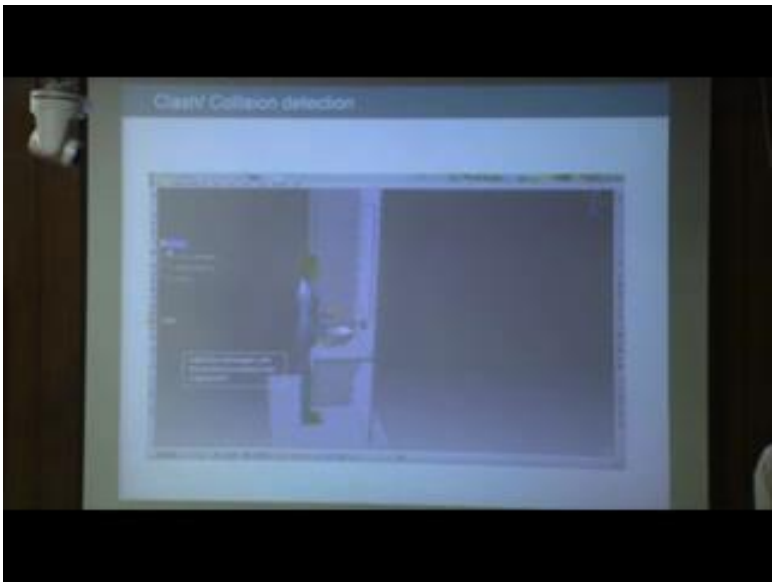

So, after discussing about the, so first we discussed creating digital human modeling after creating digital human model, we give appropriate posture after providing appropriate posture. Then we will position the digital human model on the respective workstation based on different reference points. So while we are positioning this reference digital human model or manikin on that seat or any other workstation. Then we have to think that as per the h point, as per the seat reference point whether that model has been positioned correctly or not.

So we can go for visual inspection as well as visual inspection for what visual inspection for whether that model has been oriented properly. If this is if this is the seat whether that position that pilot has been positioned at the middle of the seat for evaluation purpose. And this back they are whether their spinal curvature or vertebral curvature is matching with the profile of the seat.

You can see so accordingly, we have to position the human model based on the different types of reference, but here accelerator heel point h point SRP. So based on all these reference points we need to position correctly you need to position the human model correctly on the seat. Similarly, other workstation if this that is the industrial workstation where there is standing working posture in standing working posture that time also the orientation of human figure in respect with respect to the product or workstation model,

it should be appropriate then only we can go for epic evaluation, various ergonomic or human factor evaluation.

So, now while positioning that human model in that workstation. We can, we can check that whether the position has been positioning has been done properly or not, for that purpose. We can go for clash or collision detection, while we are positioning human model in front of this facility wash basin, so if any of this manikin's body parts touching with the workstation model or workstation components, then we can identify them say for here it is touching with this portion. So automatically how will we position. So we can keep it little bit away, then gradually moving towards that product, if it touches with that product then that touch can be identified with this clash and collision detection for that purpose in different software, Jack, Sammie, Gramcies Santosh, in different types of software, they have different this type of clash and collision with different tools

Here we are taking the example of CATIA software. In CATIA software there is one tool called clash tool.

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So if we define that clash tool in this, if we click on that clash tool then, we can find this type of clash chip so where you can put the name then type, what which type of clash we want to detect, then for which body part you can mention. For only for you can select like this way, you want to select; you want to check the collision with any of the body segments of this human model with the product.

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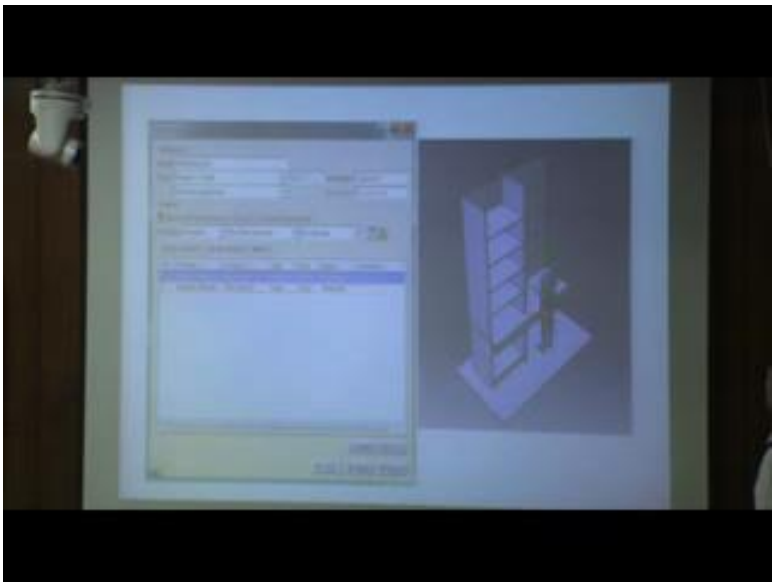

Or work station then it will show this type of clash at which portion it is touching.

So, this is highlighted with red colour in 2 places. So interference happen in 2 places that 2 you can select one after another, then you can identify that where the clash is going on. And number here the number has been provided number of position two. So in 2 places that human model is colliding with the product or workstation. If you, if you can find out where that collision is there then accordingly you can shift the position of human model, and at human model to simulate correctly. Otherwise you will visually you have to inspect or you have to rotate that human model or product model to visually inspect whether any human body segments is colliding or interfering with product or work place component.

Now, contact clash. There are different types of clash selection against all. So selection against all there are also selection type is also defined whether we want to detect the clash between this human model and another human model, between 2 human models body parts, or human model versus products model products part, or any particular body segment of human model, with any particular segment of the product. So in different types of clash we can identify. And accordingly we can modify the position of that manikin and then further go for evaluation.

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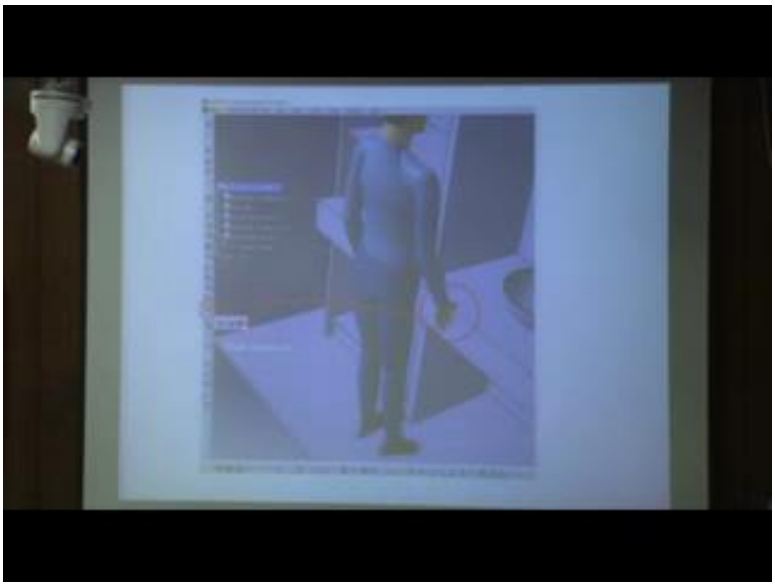

There is another tool for clash detection. There is also 3-4 options clash on clash off and restrict movement. So in that case say in that this is an example. In this example while this hand is touching, with this portion of this, wash basin. Then what is happening? It is highlighted with red colour circles. Then you can easily identify that part this particular body segment is actually interfering with this particular segment of the product. And there is this type of option. That while you are moving that human model, from this side to this side for positioning it properly; if it collides with that product, then it will restrict the movements.

So this type of pull is also there, so further you cannot move forward. Because when if you keep it on, then while you are moving that human model, towards the product or facility. Then whenever there is collision it will stop the movement. It means that is the final position it cannot go beyond that. Then there will be some interference. So in this way in different software they are defined. So this is the example of CATIA software. But there are other softwares. All of the softwares this type of facilities are available, with this facility this type of pulls or menus, which we can easily identify that what type of clash is happening and accordingly, we can simulate our work environment.

So, so far what we discussed creation of digital human model, then providing different types of posture; understanding different types of reference point and positioning the human models or manikin or interfacing digital human model, or manikin with

appropriate posture, following the different types of reference points on their respective workstations.

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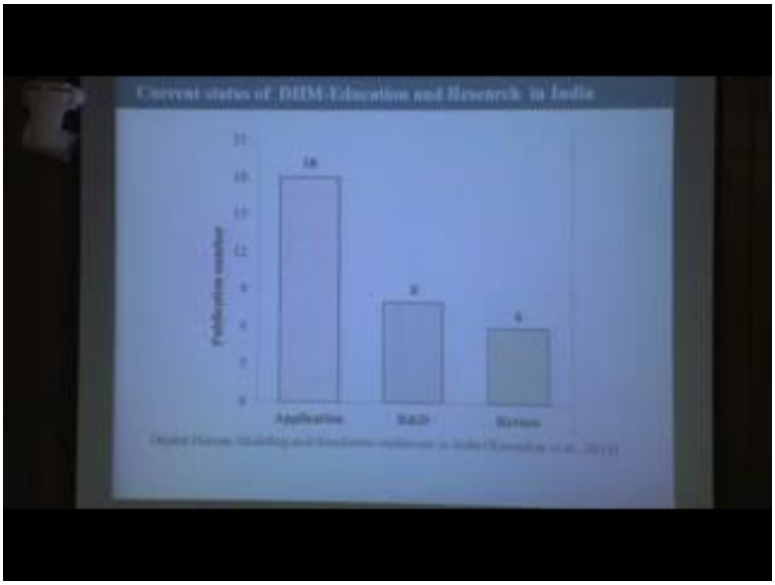

Now, as this course many of the students are from India. Who enrolled for this course digital human modeling and simulation for virtual ergonomic evaluation, so I think many students will be interested to know what is the present status of digital human modeling teaching research in related to educational research, how in India this research and teaching is going on. So for that purpose, I am referring one paper published by me in 2014. So after 2014, if we see there are 18 publications related to application of various types of digital human modeling software, for various types of product or workstation design and evaluation reported from India.

Similarly, related to research and development in either creating digital human model or modifying it is body parts, that type of research reported research is 8 in number, from India. Similarly, reviewers' literature, reviewers' paper or review article published from India till 2014. Numbers is 6. So mainly in India if we see the publication, so main publication is needed to application of digital human modeling software for various product and workstation design, but r and d activities are very limited and also few reviewers articles are also available.

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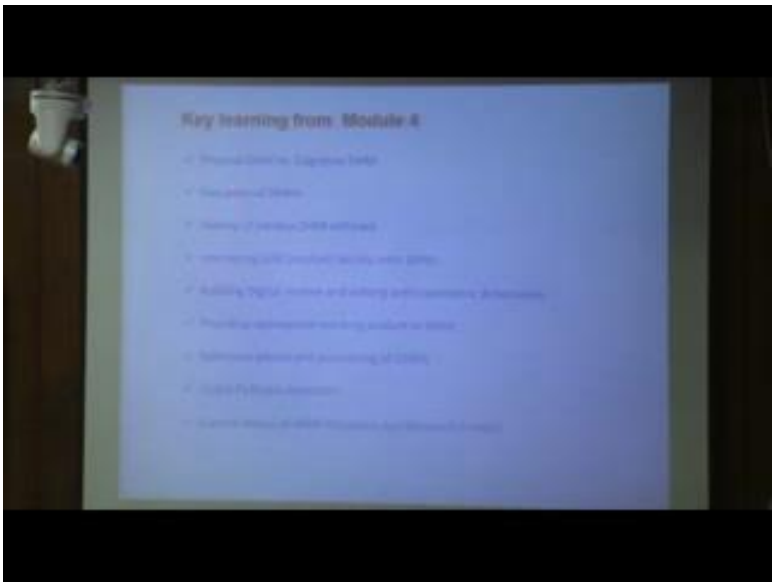

So, from this module 4 what we learnt if you recapitulate from very beginning then we will find in module 4 we have learnt about physical digital human model versus cognitive digital human model their definition and what are the difference between these 2 then evaluation of digital human model how the digital human model evolved years after years starting from 1960s to till date then history of various digital human modeling software.

We discussed about and gradually moved to Sammie, Gramcies and latest software like Santosh then we also discussed about interfacing CAD product of facility to digital human model we discussed about how to create digital human model as per anthropometric data how we can edit anthropometric data for that digital human models then providing appropriate working posture to digital human model various types of reference points clash or collision detection and learning status of digital human modeling teaching and research in Indian scenario.

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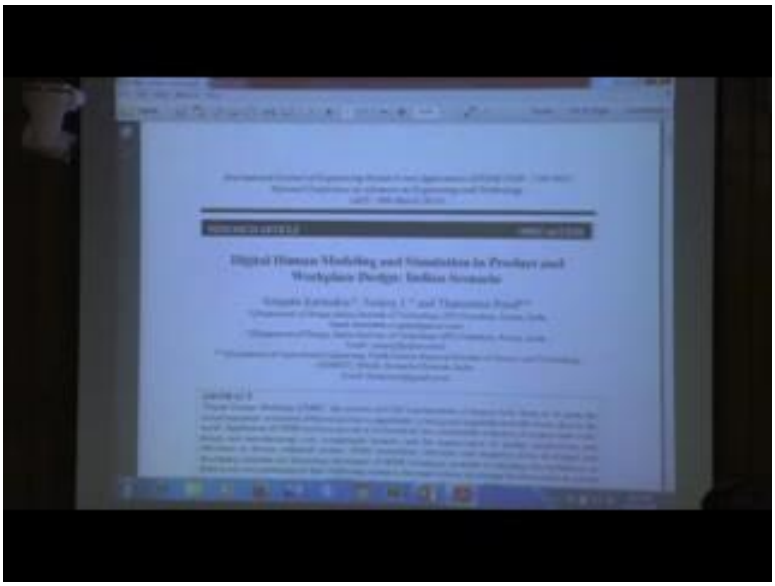

Now, I will suggest all of you to download this paper and go through then you will get clear picture of Indian scenario digital human modeling, and simulation in product and workstation design, Indian scenario. So in India what research is going on which of the institutes or organizations doing research and teaching related to digital human modeling. So here all that information are there, you can go through I just want to highlight a few areas like, so if you look at this particular section research and development initiative.

So, all the references are there. You can go through you can explore these references. Then we will get more information related to research and development in development initiative related to digital human modeling which are going on in India. So these are some picture from those published papers. And movement of eyeball then viewing new field related research is going on. Then application oriented, so if we go through all these references then we will find, there is digital human model has been used for posture analysis design and spatial layout of playing equipment analysis anthropometric size measurement of Indian driving population, modeling for anthropometry vision analysis of jet aircraft pilot, so various types of application of digital human model various different digital human modeling software has been done in Indian scenario.

Similarly, reviewers' publication, if you look at so these are some information related to reviewers paper. So I suggest all of you to go through this these differences then you will

find more information related to use of digital human model in India then if you look at this side there is a list these are the academic or research institutions in India which are using digital human modeling software for the research of product or any other facility design purpose.

So, centre for design and management CPTM, IISC Bangalore, design department IIT Guwahati department, of human engineering and human factor Indian air force. So many other institutions are there, who are using digital human modeling software for the research and development purposes. These are mainly academic institutions or research institution other research and development organization like defence institute of physiology and allied sciences, Delhi automotive research institution of India, Pune, Hindustan aeronautics limited Bangalore, aeronautical development agency, Bangalore, so these are various r and d organizations, which are used in digital human modeling software for their product and facility evaluation.

Then various industries here are few industries, names are also mentioned so from the literature it is found that in these industries also digital human modeling software has been used for their either the manufacturing software, or various types of product evaluation these industries are used using digital modeling software.

So from this paper we are getting detailed information related to digital use of digital human modeling software, for research purpose or teaching purpose in India and number of paper published in various fields, like this one review paper r and d related research and development related papers and application related papers.

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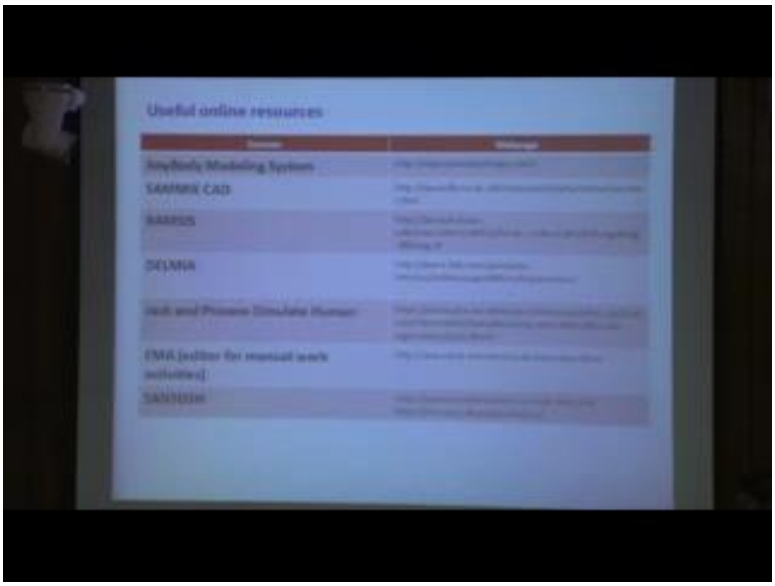

Now, various online useful resources, these are mainly these are the softwares available in the market. And these are the links of those softwares web page. If you explore these websites then you will find more information related to individual software, their capabilities their limitations as well as when they developed how they are moving forward or making the model more refined. So all those information you will here to see.

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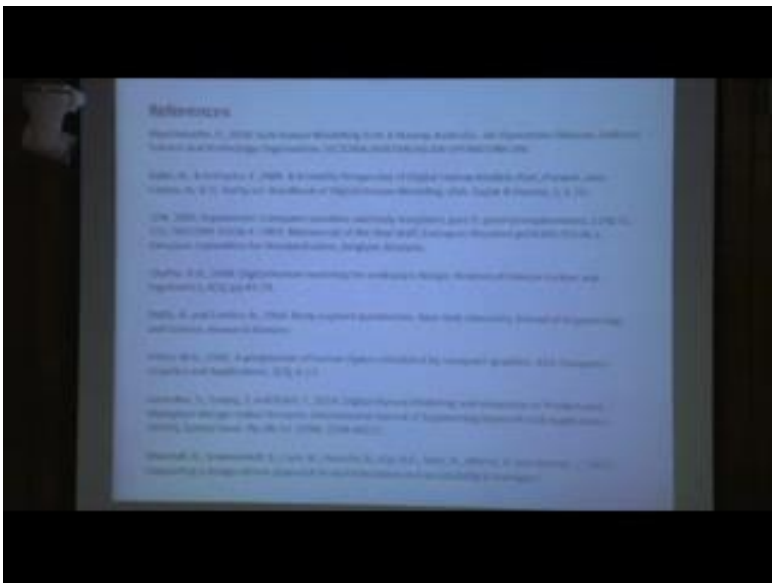

So, these are the list of references, which I have been used for in various slides. And also I would like to suggest you to download these papers and go through then you will get

more clear idea about application of digital human model, creation of digital human model this is the list.

Thank you.