Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

Dr. Sougata Karmakar
Department of Design
Indian Institute of Technology, Guwahati

Lecture – 21
Future research avenues and steps to be taken towards widespread Part I

In continuation to our earlier discussion related to Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation.

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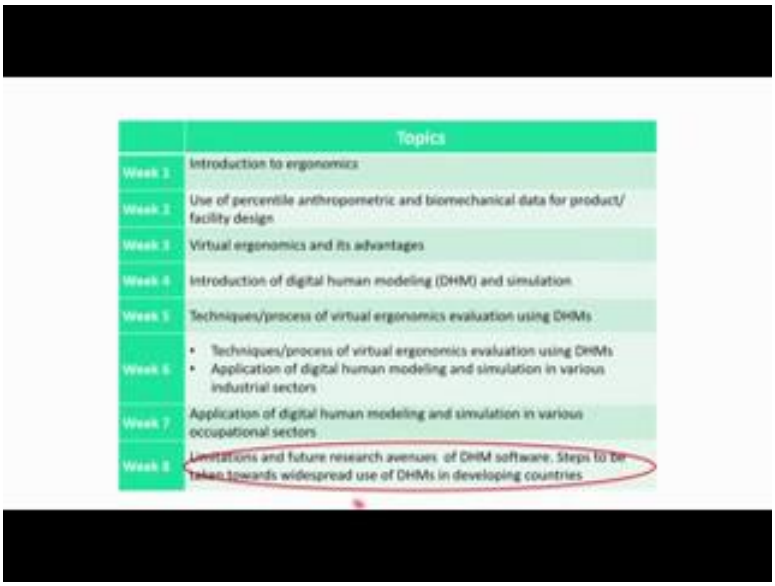

Today we are proceeding for week 8 module. And in this module we will discuss some application of the digital human modeling software, in various types of products and constitution design. And after that we will move towards discussion of limitation and future research scope of the digital human modeling software. And then also various steps which are needed to be taken towards widespread use of digital human modeling software particularly developing countries.

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So, now we going to discuss about application of DHM in different types of products as well as workstation design and it is evaluation so first we will discuss about a paper published by Sanjog et al 2012. In this paper the title of the paper is design and ergonomics evaluation of a shoe rack in CAD environment. Researchers demonstrated virtual ergonomic evaluation process using digital human models to confirm whether the CAD model of the shoe rack would really be acceptable to the targeted users and satisfy their real need in real scenario.

So, while people are or researcher or designer are planning to design a shoe rack, in various criteria which are needed to be taken in to consideration so that the design should be such that, it should be preferred by the user and it will be very easy to use so for that purpose following a small user survey and brain storming researcher decided that few basic feature should be incorporated in the design.

So, what are those basic features? So first they thought it should be usable for all family members of a small family. All shoes in each rack to be visible for someone standing in front so if this is the shoe rack so while someone is standing in front of the shoe rack he or she should be able to visualize all the shoes kept in different racks in that shoe rack.

Third easy to move; simplicity in use, so first easy to move, mean each there should be wheel or other arrangement so that it can be drag from one corner of the room to another

corner as per the requirement. And it should be simplicity; there should be simplicity in use.

So, it is operational mode will be very easy. Or easy to handle for taking the shoe keeping the shoe racks so all this activity should be very easy, at the same time tying a shoe lace. Compact and aesthetically appealing; the product must be competitive compact and aesthetically appealing for also the people will like that product and they will, there should be definite purchase intention. Then protection from dust availability of proper clearance dimension, and inclusion of safety aspects were also considered as the design features in the particular product design.

So, here is that concept model. So researchers get various provisions so from this image you can see the shoe rack is comprised of 8 inclined racks so this side 4 and left side also there are 4 racks. And to the racks are designing and kept in inclined angle so that if there is a lock if you put press that lock automatically the rack will slide down and you can keep take your shoes and you can again push it back.

Similarly, there is space 2 different heights are there and there is some platform so people of different age group can keep their feet on this space, and can tie their shoe lace. Then as I mentioned wheels are there, so that this can be move from one corner to another corner of the room as per the requirement.

Similarly, at the backside also there is some rubber padding. And it can be kept against a wall so that during tying the shoe lace it should not rotate or it should not tuple down. And there should be also lock on the wheels so that it can be fixed and the whole structure will be covered with the polythene or some other sheet, so that it can be the all the shoes all the things which are kept there can be protected from dust.

So, in this various aspects design aspects are considered or during the designing of this shoe rack. So user, how the design processed and how the design and development took place. Users survey and followed by a brain storming for the concept generation that was happened.

Next video recording of the subject's postural behavior while they are putting or removing the shoes in various scenarios, so first user survey for getting various types of insight about the requirement then the design limits selection and followed by brain

storming then what should be the concept module of the shoe rack. At the same time during user survey also video recording are carried out to understand the user's behavior mean how to keep the shoes or how they take it out so all those aspects in different user's scenario are also recorded.

Then brain storm that, brain storming wants a various CAD module 3D, 3D CAD model was developed and out of this CAD model, one CAD model was finalized based on the various analyze analyzing the various features.

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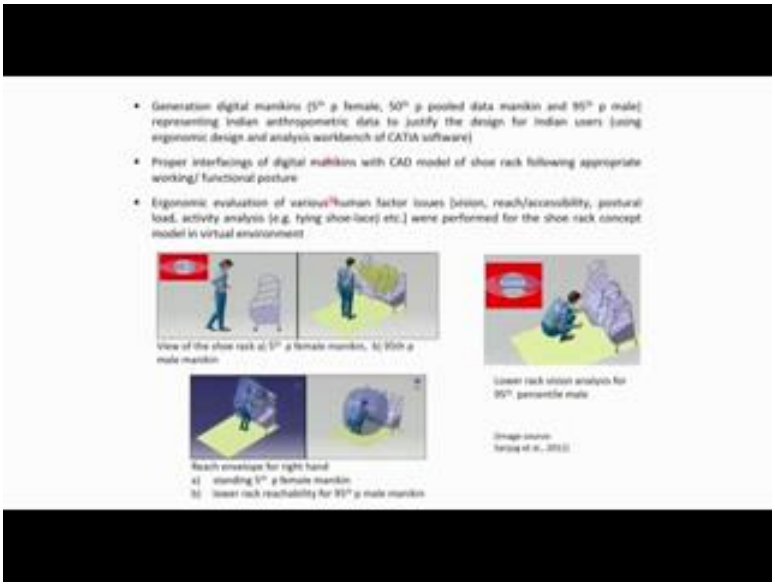

Next for evaluating that CAD model of that shoe rack, with digital human model 5th percentile female, 50th percentile pooled manikin mean this is the combination combine data of male female. So 5th percentile female 50th percentile pooled data manikin and 95th percentile male manikins are generated.

And this manikin represents Indian anthropometric data of civilian population to justify the design for Indian users. And for this purpose ergonomic design and analysis workbench of CATIA software was used. Following that videography researcher have understood, how to the user scenario and accordingly proper interfacing of the digital manikins with the CAD model of the shoe rack, following appropriate working or functional posture, that interface was done. In first that digital manikins are given appropriate working posture or functional posture. And then it was interfaced with CAD model of the shoe rack. Then various types of ergonomic evaluation are carried out. This

ergonomic evaluation includes vision analysis reach or accessibility analysis postural load activity analysis like tying shoe lace etcetera.

Now, here are few images. From this images which is visible that while that 5th percentile female standing in front of the shoe rack, she can visualize the rack clearly. So from vision analysis it is very much visible.

Similarly, while the person from 95th percentile male standing in front of the shoe rack, within 30-degree view point. He can see most of the shoes and little bit neck movement he will be able to visualize all the shoes. Here it is shown that while some person is sitting on the ground, and opening the bottom cupboard, then how is the vision. So he or she is able to visualize what are kept inside.

Similarly, reach was also evaluated for 5th percentile female, as well as 95th percentile male, in different postural condition in either sited on in spotting posture or up bend or standing so various types of reach analysis are performed.

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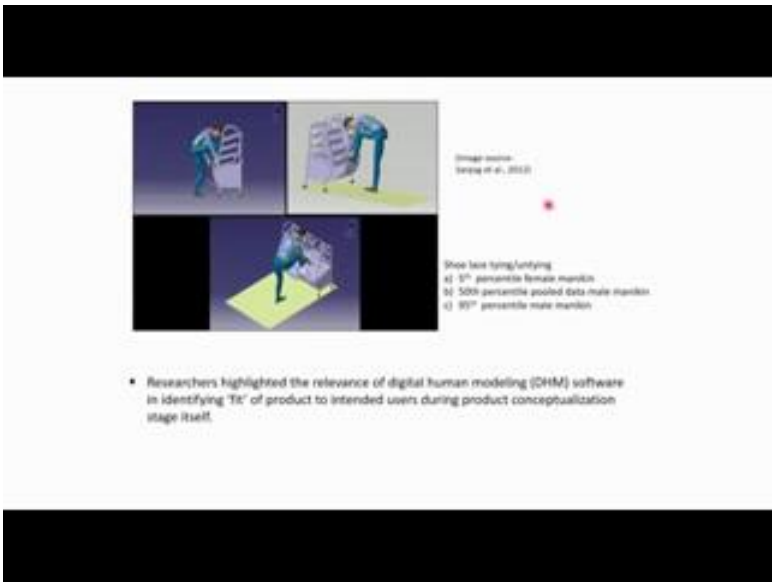

Then, as I mentioned earlier different user scenario particularly while there were persons are tying shoe lace, different percentile 5th percentile female and 95th percentile male while they are tying shoe lace keeping their foot on the shoe rack. Then how is the scenario, how is the body joint angle that was also measured.

So, following this analysis of the shoe rack, from various ergonomics aspect, researchers highlighted the relevance of digital human modeling software in identifying fit to the product to intended user during product conceptualization itself. So instead of making the actual product or actual physical mockup, it was perceivable by the researchers to validate the design concept in terms of ergonomics aspects in virtual environment.

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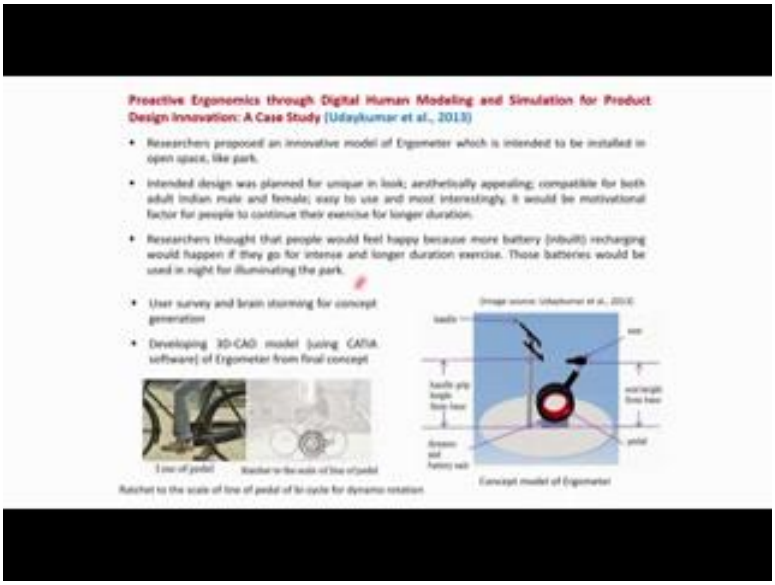

Now, moving to the next paper, by Uday kumar et al 2013, the title of the paper is Proactive Ergonomics through Digital Human Modeling and Simulation for Product Design Innovation. This is a case study.

So, in this case study researchers proposed an innovative model of ergometer. So what is ergometer, which is intended to be installed in open space like park? So ergometer as the exercise equipment which generally people use in the different types of for gymnasium or in different types of exercise places. So they keep this type of instrument for regular physical exercise.

So, in this paper, researchers reported the concept model of an ergometer, and also how that ergometer design, was conceptualized and evaluated to it digital human software for various ergonomics aspects. Intended design was planned to be unique in look aesthetically appealing, compatible for both adult Indian male and female easy to use, and most interestingly it would be motivational factor for people to continue their exercise for longer duration.

Now, why they will be motivated? Because researchers thought that the people would feel happy; because more battery which is inbuilt battery recharging would happen if they go for intense and longer duration exercise. So while the user is doing exercise on the ergometer, then the battery kept inside this bottom portion. So that battery will be recharged and that energy, or that stored from that battery will be that recharge battery will be used for illuminating the park in night.

User survey in and brain storming was also carried out for like earlier case, for developing the concept. Developing a 3D CAD model using CATIA software of the ergometer from the final concept among various concept one concept was finalized and 3D CAD model on that the concept was made.

So, now how was the concept? So like normal bicycle, so while bicycle pedaling is going on, then, this, if you look at this circle. Then the pedal actually moves likes this. The same dimension or the same circumference was also used in this case for the pedal movement. So ratchet to the scale of line of the pedal. So in case of cycle pedal that is the path for movement the same circumferential dimension has been used for this motion of the pedal of the ergometer.

So, in this image we can see various components of the ergo proposed ergometer. So this is the seat, this is pedal, and at this place dynamo and battery unit. Then this is the height of the hand width from the ground. Then this is the handle and this seat height. And seat height is also adjustable so that we can various percentile or people with different dimension shorter or larger they can seat and they can adjust as per the requirement.

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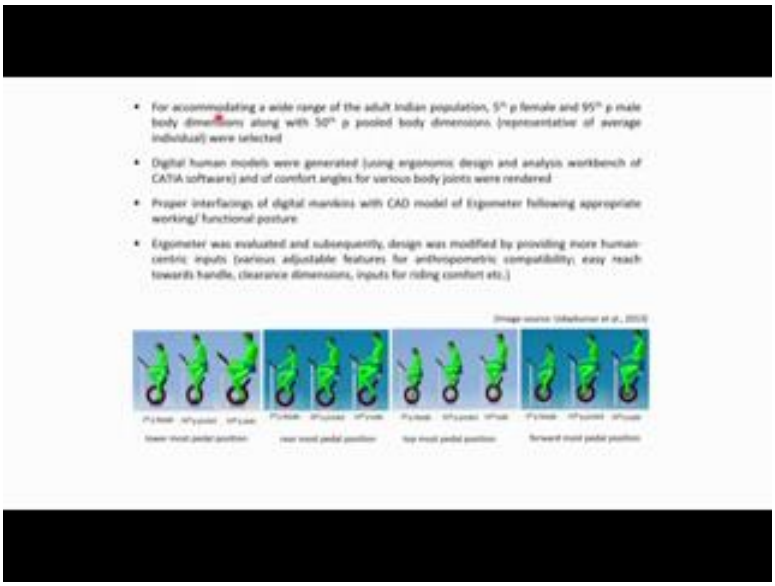

For accommodating a wide range of the adult Indian population, 5th percentile female and 95th percentile male body dimension, along with 50 50th percentile pooled body dimension, which is the representative of average individual were selected for this purpose, and digital human model for all those 5th, 50th and 95th percentile manikin is generated using CATIA software.

After developing that CAD model of the manikins, then for different joints comfort angels are rendered. So that when the body joint will move beyond the comfort range, it will show with highlighted colors. Proper interfacings of digital manikins with CAD model of the ergometer following appropriate working or functional posture are given. Ergometer was evaluated and subsequently design was modified by providing more human centric inputs various adjustable features of the anthropometric compatibility easy reach towards handle. Clearance dimensions' inputs for riding comfort etcetera. So this various ergonomic aspect I considered during the design and modification of the ergometer.

So, if you look at these 4 images, in every case there are 5th percentile female, 50th percentile pooled human manikin, and 95th percentile male. So these are the 3 human models, you know all this 4 images this are there.

So, first it is seen that all the human models are in green color means their body joints are in comfortable in the movement. So while there, left leg at the bottom most position of the pedal, then this is the scenario.

Similarly, while the left leg or left foot at the rear most position of the pedal. Then this is the scenario. Similarly, for top most position and the forward most position see in all this cases, how the scenario that was studied and accordingly body joints angle is measured and it was found that this is within the comfort zone which was defined.

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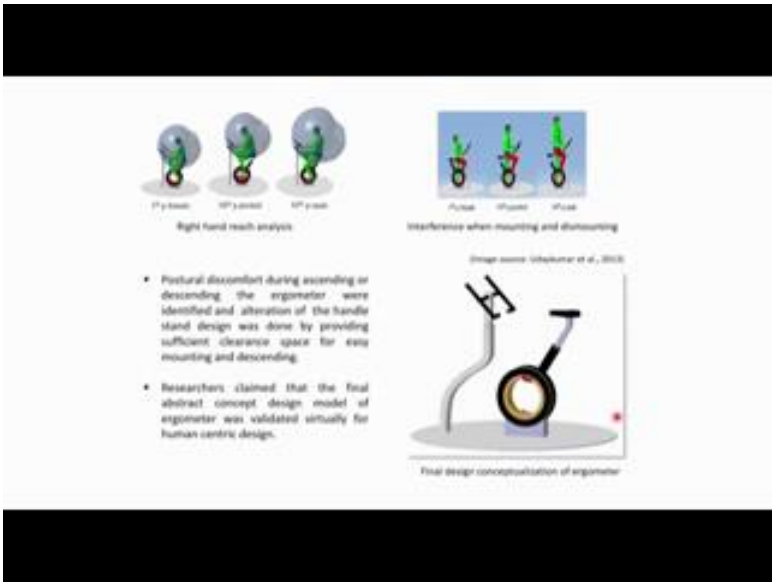

And indicated by green color, researchers also analyzed reach for all the percentile human models and found that the handle can easily be reached by all percentile people, particularly the shorter 5th percentile female. They can easily access the handle.

One problem was noticed during the evaluation that, due to as the space in between the handle stand and this ergometer, the space was very less, for that purpose there is chance of interference and at the same time the who is doing the exercise he or she has to move their leg from, they have to lift their leg and move from one side to another. During the ascending or descending process and this is highlighted with red color. So while they are lifting their leg to move it from one side to another side for either for ascending or descending so that time their body joints is this leg is highlighted with red color mean there is discomfort.

Postural discomforts during ascending or descending the ergometer were identified and alteration of the handle stand design was done by providing sufficient clearance space for easy mounting and descending. So earlier it was straight now following this analysis while it was found that this space is insufficient and person has to lift their leg from one side, to another side then this space was empty.

Now, after modification of the handle stand. It is easy for the people to take their leg from one side to another side and climbing or ascending or descending down from the seat. Researchers claim that the final abstract concept design of that model of ergometer was validated virtually for human centric design. So this is the final concept.

So, in these last 2 papers, one is related to shoe rack design and in this case it is the design of ergometer. In both the cases we found that digital human modeling software can be effectively used for design and ergonomic evaluation of various products.

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And also we can ensure that wide range of people with wearing anthropometric dimension they can be accommodated.

Next research paper is ergonomic evaluation of Knapsack sprayer used in agricultural application by Bhuse and Vyavahare, 2014. Researchers carried out ergonomic assessment of Knapsack sprayer which is commonly, used by farmers for spraying

insecticides and pesticides. Following analysis in CAD software physical prototype of the Knapsack sprayer was made and tested.

So, they not only evaluated in virtual environment they also made the actual prototype and that was tested. Digital manikin of 5th and 95th percentile was developed from 33 anthropometric parameters of male agricultural workers from 4 districts of western Maharashtra India using CATIA V5 software. So using CATIA V5 software and this anthropometric database they develop 5th and 95th percentile male model of agricultural workers. CAD model of the most popularly used Knapsack sprayer was developed using CATIA so this is that model in various components existing sprayer model with tank stand handle straps etcetera and this is the lance model of the existing sprayer.

Various postures of farm workers during the operation of knapsack sprayer were studied using human activity analysis, and rapid upper limb assessment tool with the CATIA software.

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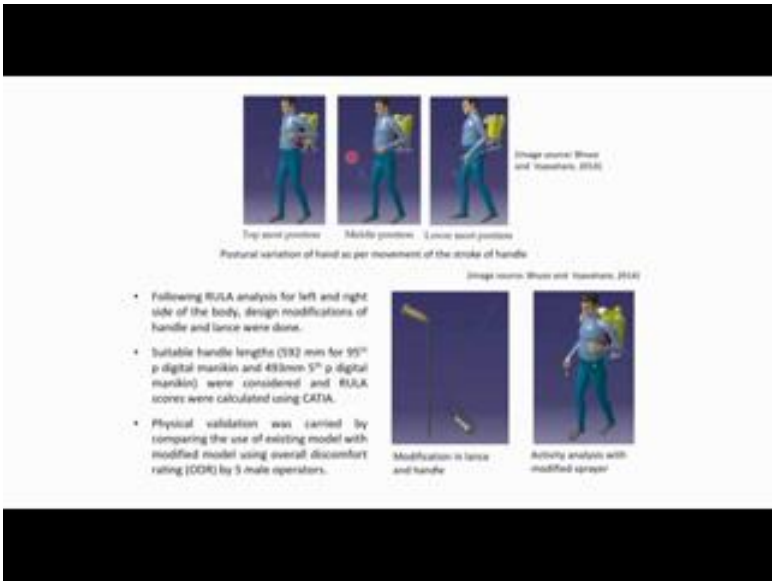

So, from this image we can see that, while the operators are using that sprayer, they are they actually need to operate this handle, stroke handle. And it has seen different positions the top most position and this is a body joint angle for the joint angle for hand.

Similarly, middle position and this is the lower most position of the handle. So in different position for the different activities they simulation researchers simulated all

those conditions, so postural variation of hand as per the movement of the stroke handle. Following RULA analysis for left and right side of the body, design modifications of the handle and lance were done. So this is the modified design. This is for the modified design of the handle and this is for lance model. So lance handles and this is the stroke handle. So both designs of both the things are modified. Suitable handle lengths 952 millimeter for 95th percentile digital manikin and 493 millimeters for 5th percentile manikin are considered and a RULA score were calculated using CATIA.

Physical validation was carried out by comparing the use of existing model and the modified model using overall discomfort rating by 5 operators. So they after modification of the component they tested the design with the compared the design with the existing one in terms of comfort and for that purpose they collected ratings on overall discomfort rating scale from 5 operators. So this is after modification of the design.

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Now, how are the posture and how the activity is being carried out? And this is so, and this is the original prototype after modification. Higher ratings were found for improved design, consisting of adjustable handle length adjustable angle of grip modified lance and nozzle.

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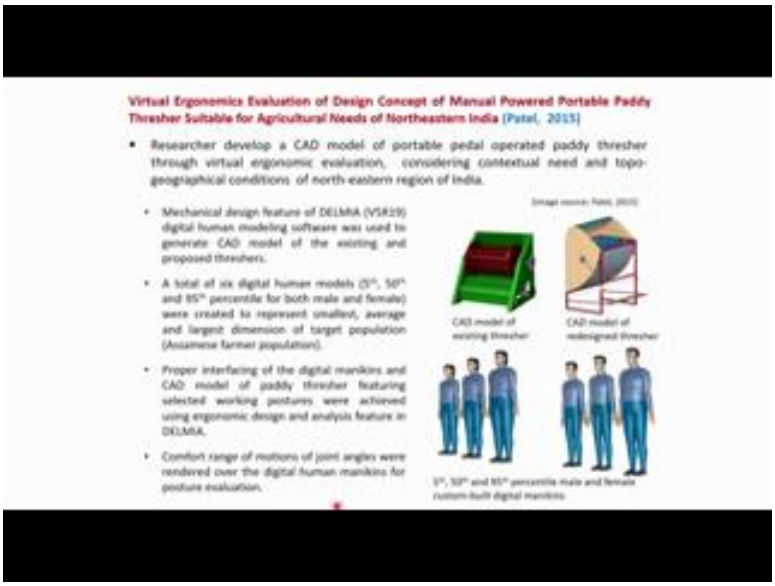

So after collection of the rating from this overall discomfort rating it was found that operators give higher rating for the modified design or new design. Researchers concluded that an ergonomic as well ergonomic well designed hand tool improves the user posture and it is possible to make ergonomically sound hand tools using digital human modeling software and analyzing RULA. So this is showing that with that modified design the real prototype is been used by the worker.

Next is actually this is from this is a part of a thesis, by Patel et al 2015. In this thesis entitle virtual ergonomics evaluation of design concept of manual portable paddy thresher suitable for agricultural need of the northeast India.

So, in his thesis Patel et al 2015, they describe these issues. That virtual ergonomic evaluation in that thesis so many am collecting from anthropometric data so many other areas are being covered, but particularly in this slide we want to discuss this virtual ergonomic evaluation of design concept of manual powered operated paddy thresher. And this was design for agricultural needs of the northeast India.

So, reach so in this thesis one or this particular part of the thesis, researcher develop a CAD model of portable pedal operated paddy thresher through virtual ergonomic evaluation considering contextual need and top geographical condition of the north eastern region of India.

So, this is the existing CAD model, existing CAD model of the existing thresher, and this is the modified design. Mechanical design feature of DELMIA digital human molding software was used to generate CAD model of the existing and proposed thresher and as it is shown here total 6 digital human models 5th percentile 50th percentile 95th percentile both male and female.

So, this 6 digital human models are generated which are represent smallest average and largest dimension of the targeted population and this targeted population was Assamese farmer population in farmer population from the state of Assam.

Proper interfacing of the digital manikins and CAD model of the paddy thresher, featuring selected working postures were achieved using ergonomic design and analysis feature of DELMIA software. So this are the 3 female models and this are the 3 male the digital models of farmers. And those were based on their working posture those are interface with the CAD model of the existing thresher as well as newly developed thresher. Comfort ranges of motion of joint angles are also rendered over the digital manikins for posture evaluation.

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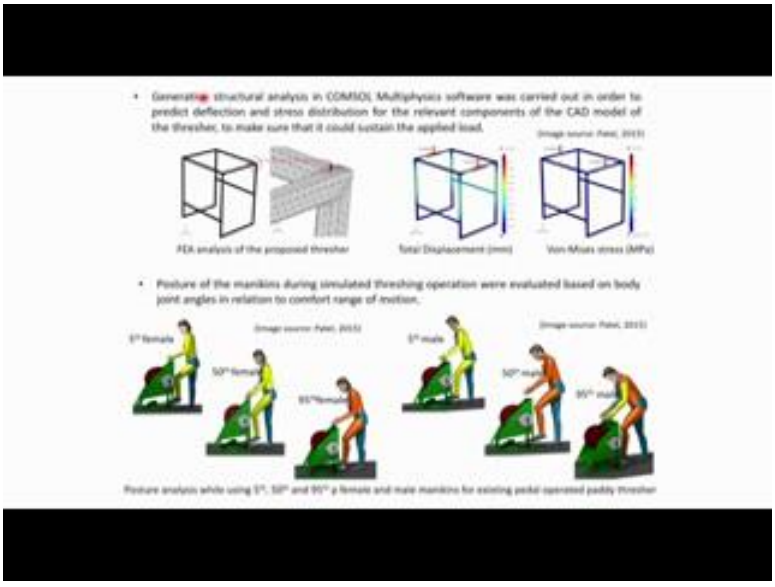

Generative structural analysis in cosmos multi physics software was carried out in order to predict deflection and stress distribution for the relevant components of the CAD model, of the thresher to make sure that it could sustain the applied load.

So, this is the structure the main structure of the newly developed paddy thresher and that finite element analysis of the proposed thresher are carried out. And here load was applied and based on that it was checked the total displacement as well as the strength.

Postures of the manikin during simulated threshing operations are evaluated based on body joint angles in relation to the comfort range of motion. So while the users are using existing paddy thresher, that is the old design 5th percentile female 50th percentile female and 95th percentile female from the color coating, it appears the 95th percentile female is not comfortable in operating because the height is relatively low for them and they need to adopt bending posture.

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On the other hand, the existing model is suitable only for 5th percentile female, but not for 50th percentile male and 95th percentile male. But while the design was modified and various other issues regarding less force exertion and all and compact design then prop proper cover.

Then it was found that new dimension of the thresher, was anthropometrically comfortable with the user population. So starting from 5th percentile female to 95th percentile male for everybody it is comfortable they can use comfortably, and they need not to adopt bending posture. So as it is indicated by yellow color, but in earlier cases it was for 95th percentile female as well as 50th percentile male and 95th percentile male it was in orange color.

The model of the existing pedal thresher was found anthropometrically compatible for 5th percentile, 50th percentile female and 5th percentile male manikin only. Whereas, newly developed thresher was found compatible for all manikins used for the evaluation. The absolute values of L4-L5 intervertebral, this compression are found to be lesser for the developed newly developed thresher compared to the existing one.

So, all the cases for the old design as well as the new design intervertebral dis pressure at L4-L5 level are measured and it was found the amount of intervertebral dis pressure is less in case of new design in compared to the earlier one following virtual ergonomic evaluation, researchers conclude, researcher concluded that the proposed design of pedal operated paddy thresher would be acceptable, to the prospective users and satisfy their need in real scenario without compromising comfort and efficiency.

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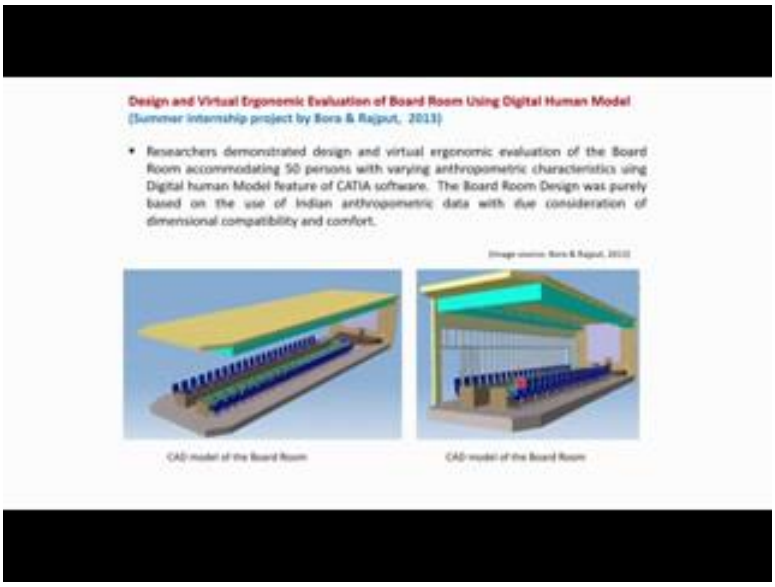

So, after discussing this 3 products model, 4 product model related to one was shoe rack design another was ergometer then we discussed about the knapsack sprayer then paddy thresher now we are moving to few case example of some work stations.

So, first, all these are, now whatever you are going to discuss this are actually not reported. These are summer internship project by different students, so first project is related to design and virtual ergonomic evaluation of a board room using digital human model. This was done by Bora and Rajput in 2013.

So, researchers demonstrated design and virtual ergonomic evaluation of board room accommodating 50 persons with varying anthropometric characteristics using digital human modeling feature of CATIA software. The board room design was purely based on the use of Indian anthropometric data, with due consideration of dimensional compatibility and comfort. So this are the view different view of the board room or at the 50 sitting are seats are chairs are there, and this is the main table and this is the projection board then this side 2 door are there 2 doors are there on this side.

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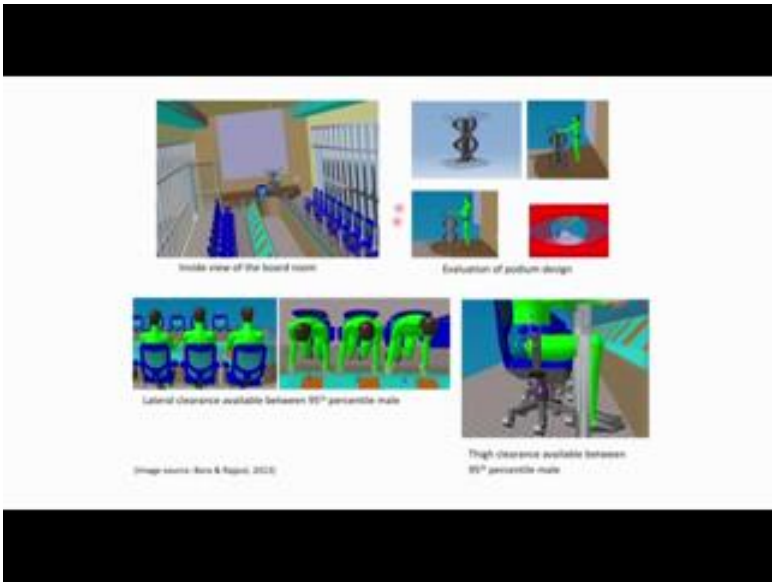

And another is this side and this is the inside view, and there is podium and this is the chairs arrangement.

Now, individual components of the board room are designed as it is appearing from this one. The main table then all the speakers then chairs podium stand then dais so all these are CAD model of all this component are developed and evaluated with human model. So while 5th percentile human model is using this podium this is the posture similarly this is for 95th percentile male and this is the visibility.

While person is standing on the dais, so how much area of the room you can see that is visible here. Similarly, while the people are seated side by side how much is the gap in between 2 people. So it was found that sufficient or the chairs were arranged in such a way in such a manner that the space in between 2 person is sufficient from this image it is also visible.

See if we look at the table, the table was designed in such a way this are the displays at kept at an angle below the table surface. Table surface is transparent below the transparent table surface this are the displays kept at an angle. So from here it is very visible clearly visible. So person is seated on the chair and this are the displays and this is the table surface, transparent table surface.

So, they are keeping their hand on the transparent table surface and below the transparent table surfaces, this are the displays arranged. So they can see they instead of looking or bending the neck to the main display board they can also see the same information on the displays kept below the table surface.

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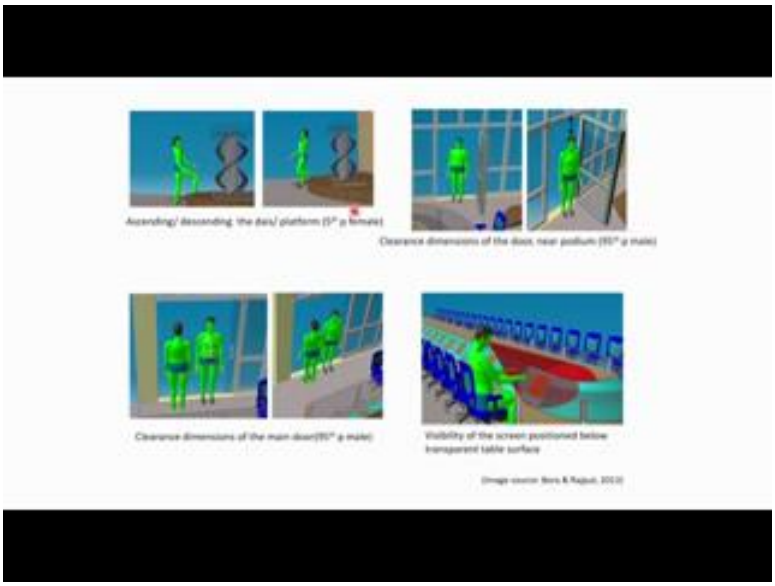

And here from this image it is also visible that there is sufficient clearance then the height of the dais that was also evaluated. For ascending or descending by smaller person is also possible. Then the door dimension of the door near by the podium as well as another door it was studied and it was found that the door dimension is sufficient for the main door 2 people's side by side 2 person of larger body dimension with 95th percentile with their, they can easily pass side by side without any collision.

Then visibility is also evaluated. While the person is seated on the chair they can with 30-degree view point or even 15-degree view point. They can visualize the display kept below the table surface.

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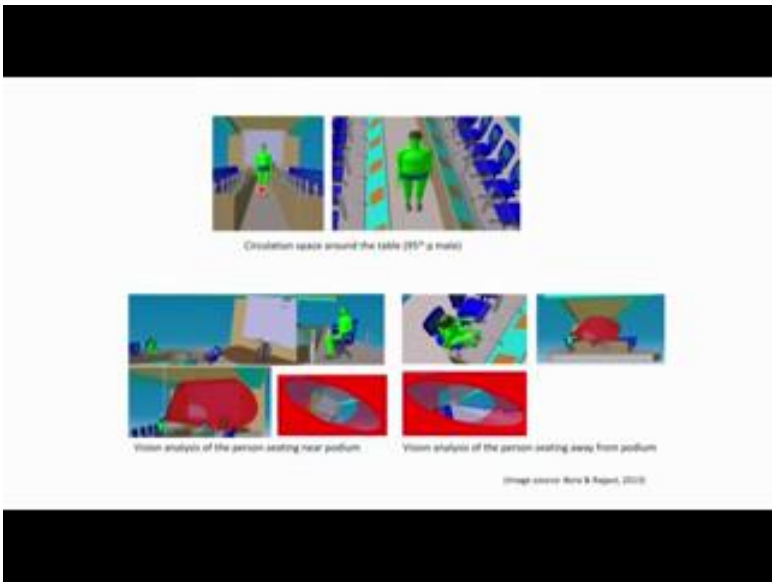

Then regarding the circulation space at the middle of the table so in between 2 rows the space is sufficient for one person to go and performing his required activities so circulation space around the table was found sufficient.

Now, from this image, it is visible that while the person, who is seated nearby the podium that person while he is looking at the main screen or main display, so that person this is that person and this is the binocular filled up view. So it is completely covered. So within this binocular filled up view the board is or screen is coming. And this is shown in a through eye view windows that how much is the visibility.

Similarly, the person who is seating away from the podium at the end of the room, he can also visualize. With binocular filled up view and this is the eye view window within 30-degree view point it can easily visualize the board, but for this purpose neck movement and also postural you can see he has to rotate little bit.

So, for that purpose this type of displays below the table surface has been provided. So this is as I mentioned earlier also. This are the student project so they tried to develop the CAD model of the conferential and various human factor issues they tried to evaluate using digital human software.

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The next project it was by Patra and Padhi in 2016, in this summer project they carried out research on ergonomic design intervention for easy unloading and delivery of gas cylinder from gas carrier vehicle. So researchers demonstrated using CAD and digital human model simulation. The design concept and processes of how gas cylinder unloading and delivery can be done in a more comfortable manner.

So, this is the gas carrier vehicle, all the gas cylinder is stacked. So this is the CAD model of that and it is showing that how they will bring the gas cylinder on this particular the trolley which attached with the tail gate and it will be lowered down.

So, mechanical design feature of DELMIA, digital human modeling software was used to generate CAD model of the gas carrier vehicle and accessories, 3 digital human model that is 5th percentile 50th percentile and 95th percentile male is created to represent smallest average and largest dimension of the Indian civilian population, so 3 digital human models all are male created. Manikins were interfaced with the product using human activity analysis sub menu of the ergonomic design and analysis workbench in CATIA software.

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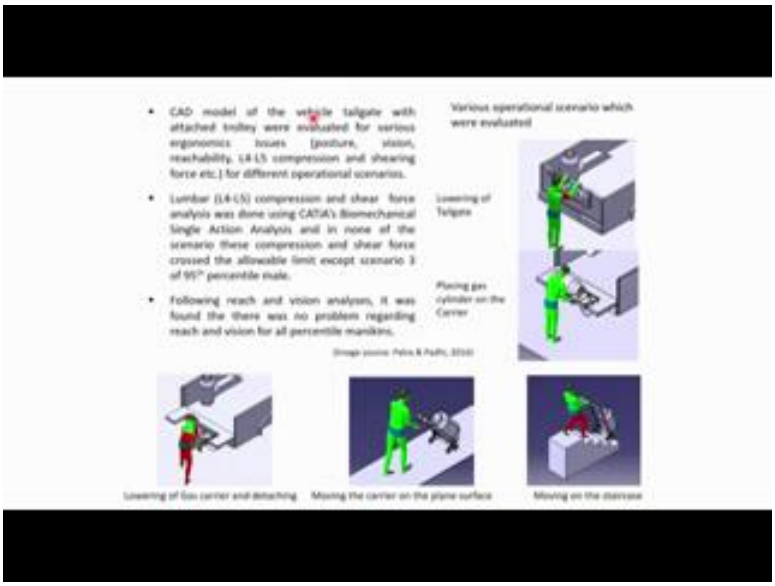

Next selected body joints of the manikin were given preferred angels or comfort range of motion for posture evaluation. CAD model of the vehicle tailgate with attached trolley are evaluated for various ergonomic issues like posture vision reachability L4-L5 intervertebral dis compression and shearing force etcetera for different operational scenarios.

So, they demonstrated the whole evaluation in 5 scenarios; so first lowering of the tailgate, next putting the cylinder on the tailgate by rolling it. Then lowering the gas carrier or the gas carrier trolley and detaching it. After that moving the carrier on the plain surface it may be moving the carrier on the stairs.

So, accordingly they design the trolley or carrier in such a way it can be, it is moveable on plain surface as well as the same it can be used for ascending or descending on the stairs.

So, these 5 scenarios they evaluated and each scenario is various ergonomic aspects like posture vision reachability as spinal compression all these are analyzed. Lumbar L4-L5 compression and shear force analysis was done using CATIA biomechanical single action analysis and in none of the scenario these compression and shear force crossed the allowable limit except in scenario 3 mean particularly in this case during the lowering of the gas cylinder carrier and detaching it. So only in this case it went the spinal

compression and shearing force when be beyond the acceptable limit. Or beyond maximum permissible limit in other cases it was within the permissible limit.

Following reach and vision analysis, it was found that there was no problem regarding reach and vision for various percentile manikins.

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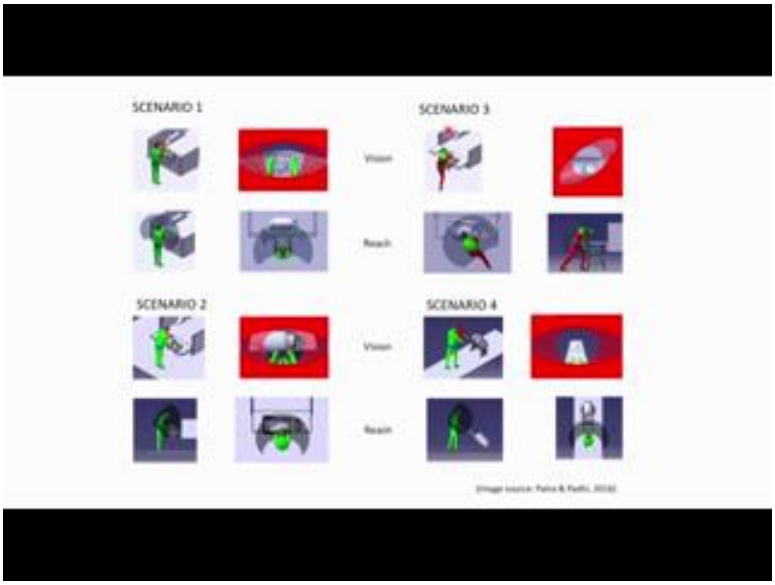

So, here are the scenarios, for each scenario, vision analysis scenario one, as we have discussed in earlier lowering the tailgate at that scenario reach and vision. Although it is not shown here so then spinal compression the posture as from the posture, you can see all the body parts except the hand is in green color when this is all the body joint angle except this shoulder on is within the comfort range.

But in case of scenario two, it is also comfortably done vision is also sufficient and reach is also mean the cylinder and the carrier can be reach easily.

In scenario three, many of the body parts are with red color it means beyond the comfort range of motion. So although this is a momentary activity so it will not create that much problem, but if some design modification can be done, then this will be good to avoid any muscular skeletal disorder or any problem related to this pressure also.

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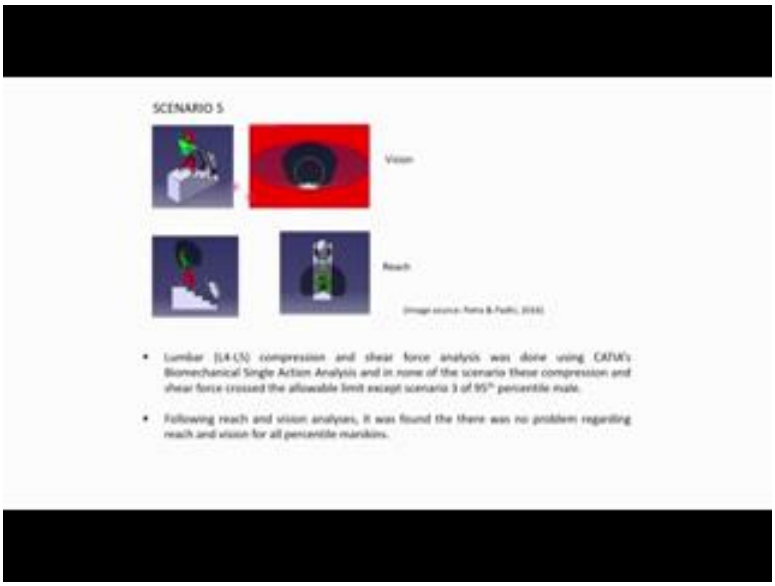

In scenario 4; carrying on the plain surface it was comfortable in terms of vision in terms of the reach. Similarly, in scenario 5 during ascending or descending on the stairs so in terms of vision reach and other ergonomic aspect, it was found no problem was found.

Lumber L4-L5 compression and shear force analysis was done using CATIAs biomechanical single analysis and, none of this scenario this compression and shear force crossed the allowable limit except in scenario 3 as we discussed in earlier slide.

Following reach and vision analyses, it was found that there was no problem related to reach and vision for all percentile manikins. So in this way this researchers during their summer project this are very small project, and with that project those students tried to understand that how digital human modeling software can be used for designing the product or the process and how it can be evaluated for various types of operational scenarios.

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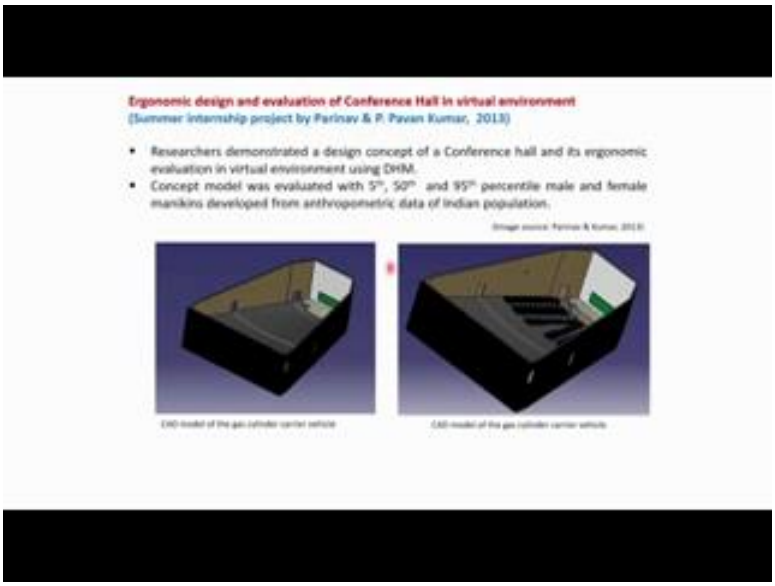

Next we are discussing another small project by the students. It is on ergonomic design and evaluation of conference hall in virtual environment, so all these summer projects are actually unpublished. So references are given at the end, but this are not published so it will not be mean students or other people will not be able to access this one. Researchers demonstrated this is being discussed to keep the students who are going through this course on digital human modeling. Then you will get a fair idea about how for your own purpose you can use CAD and digital human modeling software for virtual ergonomic evaluation.

So, next we are discussing ergonomic design of a conference hall. So for that purpose various human factor issues are considered, and each and every component starting from chairs podium stairs board dais everything all the components are designed individually as per the human comfort-ability and those are arranged inside the room.

So, researchers demonstrated a design concept of a conference hall and it is ergonomic evaluation in virtual environment using DHM. Concept model was evaluated with 5th 50th and 95th percentile male and female manikins developed from anthropometric data of Indian population.

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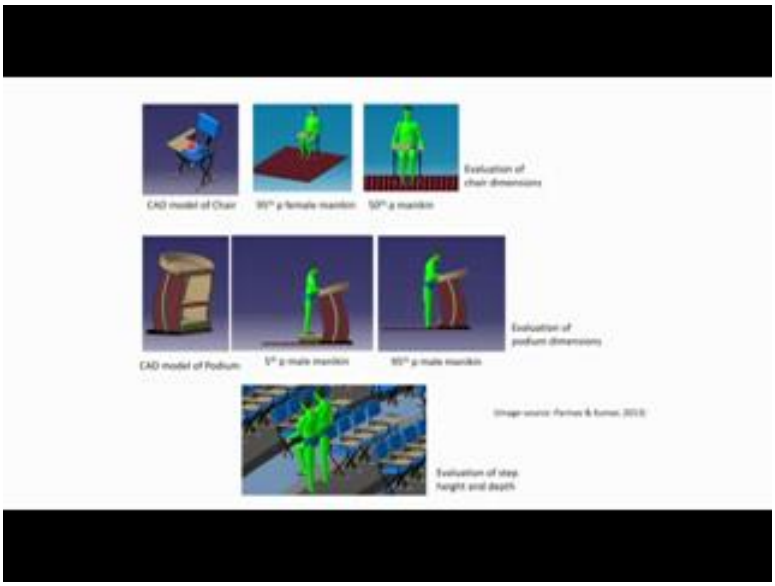

So, this project small project was carried out by Parinav and Pavan Kumar. So individual components like chair was designed and various dimensional requirements are evaluated using various percentile human models, like 95th percentile female model for seat width then 50th percentile manikin for seat height, so in this way using various percentile digital human models as per the required dimensional evaluation the chair, CAD model of the chair was evaluated and model was finalized.

Similarly, model of the podium was designed, and in that podium model interestingly you can see, this types of steps are given there which can be kept out and brought out from this bottom portion and on that the people with shorter height can stand.

The people with larger body dimension or larger stretcher, they can stand on the ground, but whose body dimension is shorter. They can use this type of supporting steps, which are kept there, or stack at the bottom of the podium. So for 5th percentile it is shown here for 5th percentile model 5th percentile model manikin or 5th percentile people can use this type of step, or this type of platform to achieve optimum height with the podium. But larger people they can directly stand on the dais surface.

Then inside that conference hall for various steps, how is the height and whether the space is sufficient for movement of the people those aspects are also evaluated.

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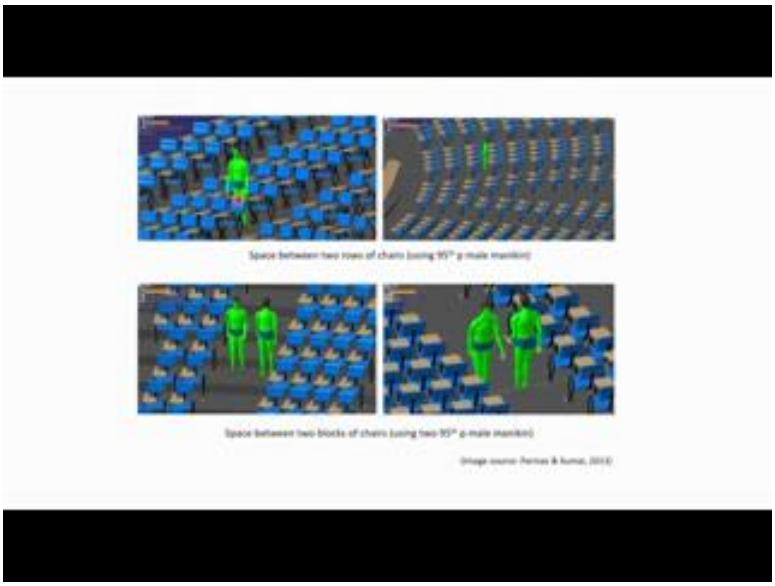

From this image it is visible that while the chairs are arranged in block form. So in between 2 doors of chair the space is sufficient so that one 95th percentile or people with larger body dimension can easily go inside and come out. So here you can see the chair arrangement. And in between 2 blocks of seats or chairs the space is sufficient for movement of at least 2 people side by side with larger body dimension. So that is also shown here.

So, in this way various aspects of the conference hall design are evaluated by these researchers and based on that they finalize their design concept.

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And these are the references as I mentioned earlier this last few summer internship project those are actually not published. And these are very small project, and we discussed here to give some idea about how students in their small project they can consider, and they can use the digital human modeling software for product or cost evaluation.