Computer Aided Decision Systems - Industrial practices using Big Analytics
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Lecture 32
DSS in CAD/CAM

Welcome all. We are in the course on Computer Aided Decision Support Systems. We are discussing Big Data Analytics and the Decision Support Systems. How the big data or humongous amount of data that is still in different fields is handled or is contracted to have a specific or useful output out of it.

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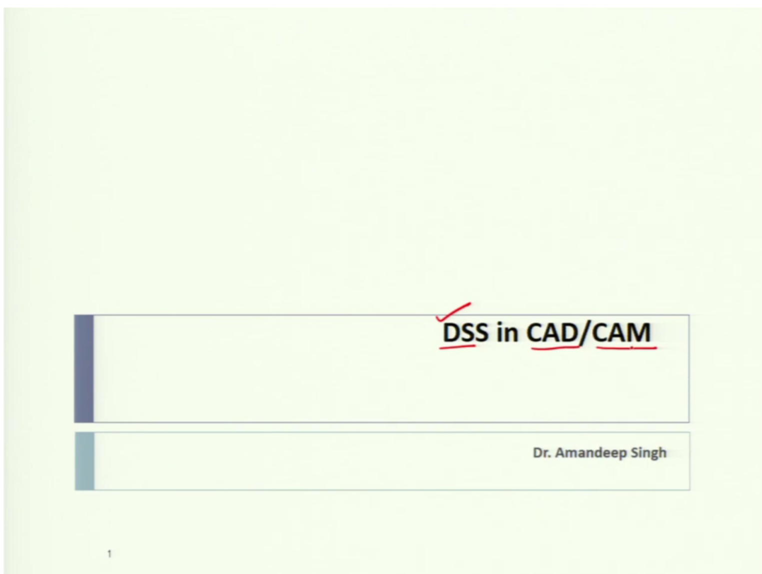

In this lecture, and in this video, I will discuss the Decision Support System in Computer Aided Design and Computer Aided Manufacturing, Big Data Analytics, and how it helps in the contemporary computer aided manufacturing systems.

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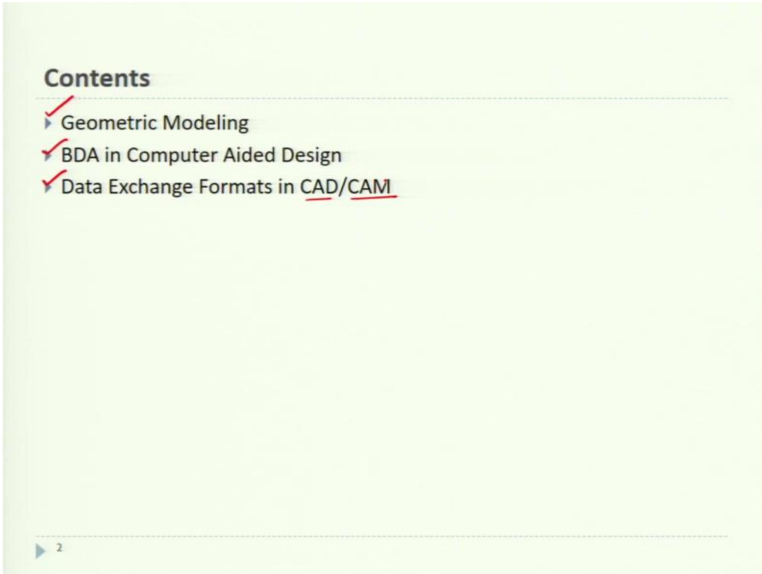

- We will start from the 'Geometric Modeling', introduction to what is geometric modeling and how it is a core in the product design process.
- Then, 'Big Data Analytics in Computer Aided Design. Computer Aided Design in general, we use AutoCAD starting from point, line, surface, volume or so. We now use new algorithms, new methods such as, convolutional neural networks, artificial bee colonies such heuristics could be used with the advent of Big Data Analytics could be handled using modern technology.
- And, Data Exchange Format in Computer Aided Design and Computer Aided Manufacturing. When Computer Aided Design communicates with the manufacturing, that is the machine, that is a CNC machine, then comes the part programming. The part programming, how is that supported by the CAD (Computer Aided Design) that we have made.

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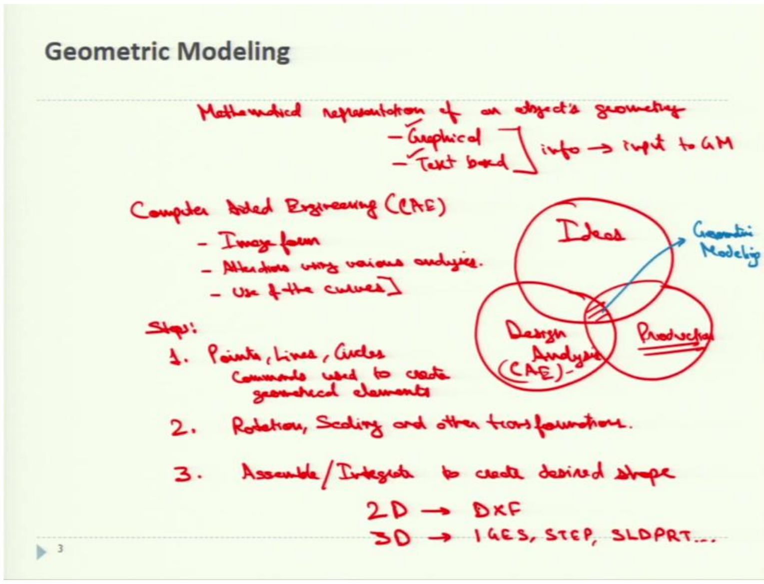

Geometric modeling. Geometric is a mathematical term. When we say geometry, it is the collection of points, lines, circles or so. Modeling, when we try to collect them to get into a specific shape that is Geometric Modeling.

- So, Geometric Modeling is a mathematical representation of an object's geometry. This is created by a computer or a piece of software then we call it Geometric Modeling. We also call it Computer Aided Design, when specific geometric models are collected together to get some information that is useful. So, it helps us to collect information that is both graphical and text-based. We get
- Graphical and
- Text-based information

This goes as input to geometric modeling. So, in the product design process or when we suppose some ideas are there. For instance, if you need to design a new mobile phone, or need to design a new car, or maybe need to design a new chair, the ideas for that would be there. Those ideas go through design analysis. Design analysis means the curve that you are putting for your mobile phone, are those actually able to be manufactured or not, do they fall in specific mathematical models or not? If not mathematical support and that could be infection through maybe additive manufacturing. The CNC programs generally go to the five-axis level of the machining. So, there also the complex shape could be shaped.

But, sometimes some of the shapes which are very organic or so, could not be manufactured. So, the design that you are presenting, is it mathematically presentable or not? If it is there, that could be directly converted to a CNC program and we can have a code, part programming code out of that, that could be manufactured in a production. The core or the heart of all these three ideas production and design analysis here we have at the center is Geometric Modeling.

So, geometric modeling tries to work for the entire manufacturing process, it depends heavily on Computer Aided Engineering. The purpose of Computer Aided Engineering or CAE has changed so much over time that various applications have been now created based upon the usage and the execution. So, one of the most used CAE applications is actually geometric modeling. Computer Aided Engineering, if I may say, if I have designed anything, I have only come up with a shape that I think could be manufactured, but Computer Aided Engineering is one that we put here in the design analysis. That helps us to have the understanding or analysis on the model that we have developed to see whether the model would be manufactured rightly or not, or if it is manufactured, what would be strength at various points. For instance, this is a pen model of pen only. In the pen, this is the fit, if I click it, there is a sound fit. This is known as push fit. It has to be a push fit, that means a tolerance dimension that is given to this projection and deceleration that is given here it has to be overlapping, that means interference has to be there. So, this kind of thing uses Computer Aided Engineering itself, what is the force that is required to push the pen end, what is the size of the screws that we have put here is required, what should be the dimension of the pen, what should be the length of the pen, how do we put the colors and everything, that could be seen in the Computer Aided Engineering only.

So, Geometric modeling helps to have the exact dimensions. This is a pen, maybe 12 mm in diameter, maybe 120 centimeters of the length and the cap of the pen. How do we put it, how do we click it, how do we put it in the pocket, the penholder everything, how do we design? When we have the complete dimensions, geometric modeling has helped us to bring this into existence, bring this into reality and later Computer Aided Design, that design analysis helps us to develop programs to manufacture them in the production.

So, information is ingested in the graphical and in the text-based form as both. So, this data is presented as a picture and kept in a database. So, a geometric model is a picture or I would say image. There are certain projects that exchange data forms or the formats IGES, DXF. I will talk about them in the coming lectures. So, those formats go into the computer aided manufacturing system that is My CNC machine to manufacture the component.

- So, that is in the image formally.
- Alterations using various analyses, I would say analyses as a plural.
- Geometric modeling frequently employs curves to build services because they are simple to manipulate and they can be bent to suit the application. A set of points or analytic functions or other functions can be all used to create curves.

The object's mathematical representation can be seen on any computer and then it can be used to generate drawings that can then be analyzed and ultimately it can be manufactured in our production system. So, to create a geometric model, there are generally three typical steps:

1) We use commands such as points, lines, circles these are the commands used to create the geometrical elements.
2) These points or the elements that we have created now, have to be put into a specific shape. For instance, we have created cones or prisms or we have created the shape of the pan that I have the cap on. Now, this has to be rotated and transformed to the various requirements. Then we use rotation, scaling, (upscale or downscale) and other transformations.
3) We use a variety of commands to build a geometric model in which we integrate the model components to create a desired shape. Then, we try to assemble or integrate. The word assembly is only used in Computer Aided Design, if the components have different elements in it. For instance, this cap and the body put together is an assembly, this cap having its main body and its holder is not called an assembly because this is a single component. This I could just call as integration of a cylindrical or a cylindrical shape with a straight flat shape here, integration with a small gap in between them, so this is integration.

So, these commands are used to create the desired shape. These can be helpful to generate the models which are in two specific kinds that are 2D or Two dimensional or 3D what we call it Three dimensional. 2D is used for flat objects and project’s two-dimensional view, the file formats generally are DXF and 3D is a model in which, intricate geometry can be also seen and it is completely viewable in three dimensions using an image form itself.

Solid modeling is the primary method for 3D geometric modeling. So, a 3D computer program is used to describe geometric relationships and the physical scope of a component, when building a geometric model in CAD, and there are various formats such as IGES, STEP, in solid works SLDPRT solid part and so on. A component's properties such as its mass properties, other physical properties can often be calculated using the CAD software in which the Computer Aided Engineering module is integrated.

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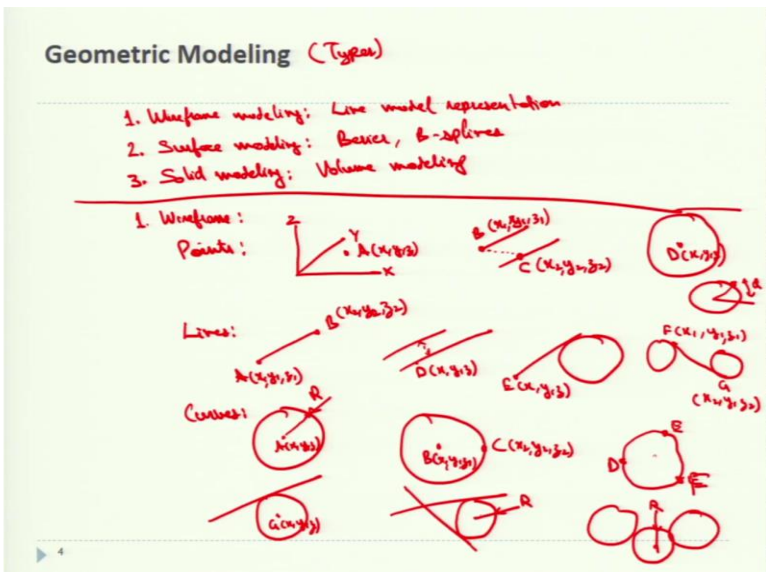

Geometric modeling types I would say are of majorly 3 kinds.

1) Wireframe modeling: It is a straightforward modeling system that uses only lines to represent the object, so straightforward it is also known as line model representation. The wireframe modeling is only used to describe a wiring system because it cannot adequately express complex solids, so small businesses that need to design products with intricate surface details, generally, consider wireframe modeling as a part of it.
2) Surface modeling: This is a kind of modeling which represents the object as it appears on its surface as is implied to describe the object with clear understanding of its manufacturing. Surface modeling is used to produce the objects with intricate forms. For

instance, the big objects, such as the car bodies, ship bodies or airplane bodies, the outer surface how would that look like that is represented using surface modeling. Inside of the body, what are those that should be presented by solid modeling? In surface modeling, we have curves such as Bezier which are mathematical curves or B-splines. So, the engineer organizes the edges so that it categories the polygonal surfaces in the surface modeling.

3) Solid modeling: Which is also known as volume modeling, the complete model could be described. Multiple sides of an object can be built simultaneously using solid modeling tools. Surface modeling is less ambiguous when using Solid models with them, which can create multiple sides at once. In solid modeling, there are certain topology rules that tell us. For example, a cube has six faces, or the specific radius, the numerous radii of the cube, if this is the pen the example that I am taking, so this is the radii of the pen, the radii of the back of the pen, this outer area has to match with this inner area because it does not know much field that the component is different. Then, there is a step in it, what is this radius that all comes in the outer surface only in a way. So, this could be put in a surface modeling, but inside do we have threads and what is the shape, what is the thickness of this. So, this is a plastic component, it is manufactured through the molding process through the pen molding. So, generally in the injection molding these are my fracture the plastic pens or so. So, for those what is the thickness that is required, allowances for the thicknesses, those tolerances also come into play in the solid modeling.

1) So, let me start with a Wireframe modeling a little introduction to that. In the wireframe modeling, the user enters 3d vertices and joins the vertices to create a 3d object that is known as wireframe. The wireframe models lack the surface definition, because it is only the outer frame of the model. So, how does it start? It starts to connect points, lines and curves. When I say points, it could be anything. If I need to define a point, let me say I have x, y and z axes, x, y, z, there is a point A here in the space, which is of the coordinate x, y and z.

Or, I can have a point B and another point in space C, this B has coordinates x1, y1, z1, there is another point C which is this distant from B coordinates could be x2, y2, and z2. Or I can say there is a point which is the center of a shape, this in another point I would name it D (x, y, z). Point could be maybe on the circumference of the circle as well. This is a circle here D we have a point and the distance from the center we can say this a point from a distance from the circle, there is an angle to it, I would say angle Θ.

Or, it could be a point that is at an angle to the origin, so, it could be any space mathematically if you tried to present. Line or a line segment is that connection between two points. In general, this is a definition. So, we have point A and point B when we try to connect them A is x1, y1, z1, B is x2, y2, z2. Or it could be a line parallel to another line. There is a line the distance between two lines and this is a line that is parallel to it starting from a point D (x, y, z).

Or, it could be a line that is tangent to a circle and starting from a point at a distance from the circle, let me say E (x, y, z). Maybe it could be tangent to two circles F, G (x1, y1 z1). Then G is x2, y2, z2. Similarly, the curves could be there, very simple curves, if I tried to start with. Circle is a very simple form of the curve, which is concentric, which is having one common center and a distance from the center is all equal, which is known as radius of a circle.

So, this curve, let me start the, it could be a circle with center A x, y, z and radius R. Or it could be a circle with center and the point at the diameter, I will call it point B (x1, y1, z1) or C (x2, y2, z2), or a circle could be drawn through three points, this is general mathematics. If we have three points with a center of this, that is the point centered at center here, so we can draw a circle. These three points give me a circle, let me call the points D, E, F with dimensions x1, y1, z1; x2 y2, z2 and x3, y3, z3.

Or, a circle could be joined with the tangent, with the center G (x, y, z). Or, if two lines are there, we know the diameter of the circle, a circle could be put here with a specific radius. So, anyways we can represent the circles. These are two lines which are encircled here. So, these two circles might also have an encircle between them of which radius is fixed.

I am trying to represent this because these only coordinates A, B are connecting the coordinates E, D, F to make a circle which would lead us to have geometric shapes which we try to connect together, which we try to interlink together. To have the final shape of the object that brings us the wireframe model. Wireframe model can be connected to a surface model, then it could be converted to a solid model to have a final program that is used as a support system for the production. The Decision Support Systems where to alter, which circle is cut or so is starting from here itself. This is very fundamental. The 3D drawing model can be matched to its reference using the wireframe modeling. Once created a wireframe model the planner objects in the single plane can be transferred to a 3D location. This enables the creator to see whether the reference to the model or match the vertex wants to align with that desired shape or desired references.

So, this helps us to have a quick and simple way to illustrate the concepts, how the model would look like, in place of having a long detailed solid model and then to precisely construct the model or so. So, while skipping the detailed work in wireframe modeling, one can present a very basic framework that is easy to make and understandable by others. So, we can make a solid or surface model that has a specific shape using a wireframe model as our geometry.

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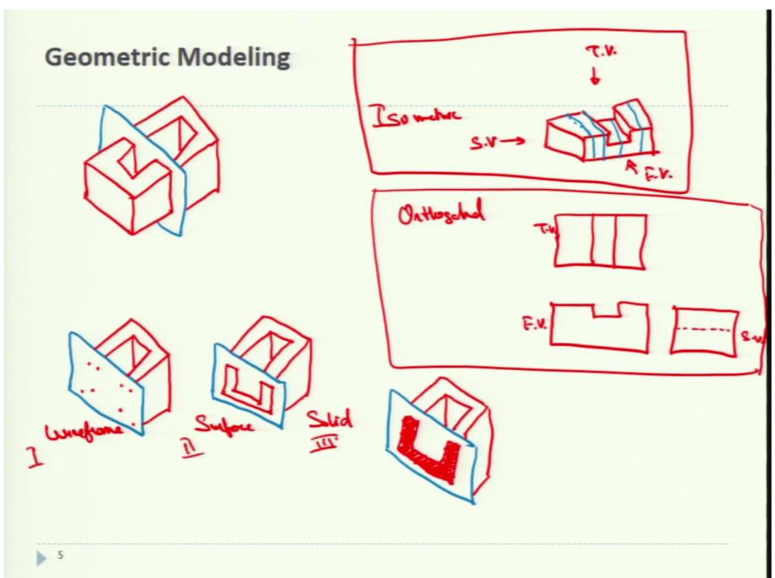

So, we can, let me say I will put a model here. So, this is like, suppose if this is a model, this is a mobile phone. And, this is a full solid model in which a full mobile phone is there, body is there. If I just tried to connect his vertices and try to have a wire, the surface wire here, then another wireframe here, another wireframe here. And, it is only one wire, so it will look like a rectangle wire. Then here also it will look as a rectangle. From each side different views would be there. So, we can have different views. For instance, let me draw a body of which different views can be seen. Let me say the different views that could be seen could be orthogonal, isometric. Let me say this is an isometric view of a model. Isometric means, we have view from the top, view from the side and view from the front. All of them are in one view and equally distributed.

We can have an orthogonal view of them as well. This is isometric. Let me say orthogonal, orthogonal would have its top view from the top, it would look something like this. From the front it would look like this. I would say this is the front view, this is the top view, this is a side view. Now, this is my top view, this is the front view and from the side, it would look like this, a hidden line inside, this is the side view. This is orthogonal. And, up we have the isometric.

If we have just these lines only, that is a wireframe model or we can have maybe more frames here, we can have one more frame here, second frame, a third frame, a fourth frame, so this is my wireframe model. If this is completely filled, it is a solid model. If it is a complete surface only, then it is the surface model. Now, if I try to cut my solid model. For instance, this is my solid model. If I try to cut it, I would see in the wireframe model only the points of the wire.

And, if it is a surface model, I will see this surface only. In the solid model, I will see the complete solid. For instance, if I am cutting a brick with paper or maybe a saw, let me say I have a brick model here, that plane is, let me say a plane or a paper. And, the other side of the brick would look like this. So, this is a brick being cut with a plane of paper. If I try to see only a half-cut view of it, what would that look like in the case of a wireframe, surface and solid model? In the case of a wireframe, let me make the other side of the brick behind the plane. This is the cutting plane and other side of the brick in red color. So, here what would I see? I would only see wires here. Two points of the wire at the top on both left and right side, then this wire here and the inner part of the brick. In the case of the surface model, it would show me the complete surface when I joined these points.

So, if I join these, I will see this surface. In the case of the solid model, what would I have, a complete solid? Here, the points are connected, the points are there just like the wireframe before. If I connect them, this makes the wireframe to a surface. If I try to have a solid model, I will see a complete filled solid here. So, this is a solid modeling, wireframe, surface and solid modeling.

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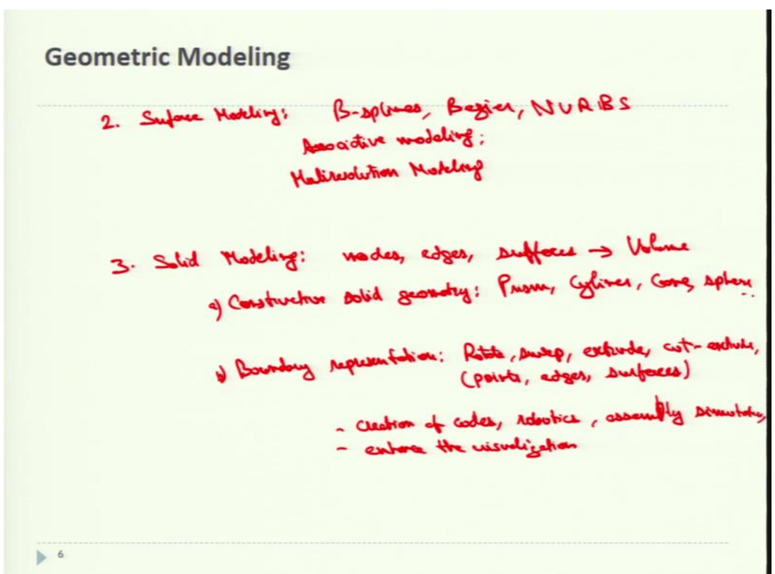

2) Next is, in the surface modeling, the object appears to be a solid but it is less sophisticated than the complete solid modeling. So, despite being more complex, because of the fact that surface and solid models have the same appearance, the surface cannot be cut into open just like solid models. So, the curves which I mentioned before are B-splines or Bezier or

NURBS which are also B-splines. These allow a computer to translate commands into the mathematical models. I showed you the mathematical coordinates because the arcs are converted into the mathematical models, which are taken as codes, which are known as G or M codes in the part programming. So, these are taken by the computer and mathematical models are made out of them. These models are stored in files and always available for editing or analysis at any point when we require them. The surface modeling enables precise adjustments to challenging surfaces.

So, the typical procedure is we create the model by combining the solid surfaces in three-dimension. The model is converted into surfaces by utilizing associative modeling. And then we confirm the flaws and surface tools. So, these are generally used to mold the castings, the complex objects like cars, ships, aero plane bodies or so. So, the basic castings in which the surface of the casting was required, those are made by the surface modeling. Then, users can view all the surface points at once with surface modeling. The models are imported from another CAD system as well occasionally, where the features are lacking in these situations; desired changes can be made on one or more model faces by applying surface modeling techniques. So, building one face at a time using surface modeling allows for precise control over the contour and direction of any face. So, multi resolution modeling could also be developed through it.

3) So, not going into much detail, I will move to solid modeling and we will see in the assembly support systems how different models help us to have a geometry that is useful in manufacturing. In the solid modeling, the nodes, edges, surfaces are combined to get the volume of the object that is being designed. So, topology rules are a necessity for solid modeling to ensure that all covers are properly seen together. This method of modeling geometry is based upon the idea of half space, that is starting with a solid. The solid model is pieced together using topology rules. This is a complex method known as a topological design or so. So, complex geometric shapes can be quickly calculated. For instance, a cube has six faces or not or we can have a connection between various faces.

So, it is represented generally in two ways:

a) Constructive solid geometry
b) Boundary representation

a) When I say constructive solid geometry the primary solid objects such as prism, cylinder, cone, sphere etcetera, so they combine together to have a constructive or construction on each other to create a final solid shape, these shapes are either included or removed to have a constructive solid geometry.
b) Next is the boundary representation. The boundary representation means the object's spatial boundaries serve its definition in building up the model; it gives an order to rotate, sweep. Generally, the CAD models use this kind of method: the boundary presentation where you rotate, sweep, blind face sets you, extrude, cut, extrude. Various face sets into the three-dimension solid which describes at various, again, points, edges or surfaces as a volume.

These surfaces can be combined to create a surface that expressly encloses a complete volume which I showed you in the previous slide. The most popular form of the metric modeling in three dimensions is solid modeling only where the calculations for the various engineering inputs such as for the moment of inertia, for the mass of the object, for the weight of the object, for the density of the object, for the putting into the software, what is the material calculating a temperature, it could conduct temperature, it could resist. So, the connectivity of the insulation, not resistant, insulation to that specific temperature that could also be put. These solid models help us to do the Computer Aided Engineering part like system dynamic analysis.

- So, creation of codes, when I say code, these codes could be the G codes or maybe for the robotics etcetera if the robotics moments have to be given those codes are generated. Then assembly simulation, these are all supported by solid modeling types. Solid modeling can confirm whether two objects occupy the same space by storing both topological and geometric information.
- It can also enhance the visualization. So, it enhances the design quality and that has a potential to automate or integrate the different functions.

So, different kinds of techniques are there for solid modeling. Different kinds of software are available. I would like to take a break here and would discuss the assembly support systems, how are those developed, and how Big Data Analytics with small cases or studies or examples, I will say helps in having a new era of Computer Aided design. Let us talk about that in the next lecture. Thank you.