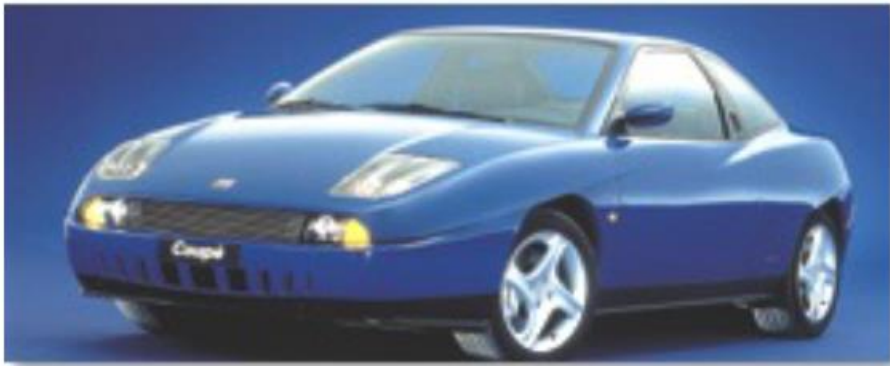# Computer Aided Building Modeling and Design (CT-314)

Constructing the Geometry

Wireframe vs Solid Modeling

Why Model?

Physical Prototype

Pros :
complete and reliable
easily understood
it can be used for tests
it provides a quick feedback

Cons :
long production time
high costs
difficult changes & alternatives
difficult to get quantitative information

Geometric Modeling

- **There are number of applications of the CAD software, one of the most popular applications being geometric modeling**.

- In engineering, modeling refers to the way data are represented in the computer memory and the way in which it is visualized. The data is stored in a suitable data structure that is easy to access for the visualization algorithm. **Geometric modeling is the process of capturing the properties of an object or a system using mathematical formulae. Or The computer/software generated mathematical representation of an object's geometry is called Geometric Modeling.**

- During the process of geometric modeling, the computer converts various commands given from within the CAD software into mathematical models, stores them as files and finally displays them as an image. The geometric models created by the designer can open at any time for reviewing, editing or analysis.

- Computer geometric modelling is the field that discusses the mathematical methods behind the modelling of realistic objects for computer graphics and computer aided design. It uses computers to store the data and the geometric properties of a system / part. It is a relatively new technology that has expanded rapidly thanks to advances in computer technology.

Geometric Modeling using Computer

Computer geometric modeling is the mathematical representation of an object's geometry using software. A geometric model contains description of the modeled object's shape. Since geometric shapes are described by surfaces, curves are used to construct them. Computer geometric modeling uses curves to control the object's surfaces as they are easy to manipulate. The curves may be constructed using analytic functions, a set of points, or other curves and surfaces. There are number of software programs that then allow the mathematical description of the object to be displayed as an image on the monitor.

A geometric model of an object can be created using these 3 steps:

- Create basic geometric object using the commands like points, line and circles in CAD software

- Use commands like achieve scaling, rotation, etc. to transform these geometric elements

- Integrate the various elements of the object to form the final geometric model

Brief History of Geometric Modeling

- The 1st generation CAD programs of the 50's were mostly non interactive. CAD users were required to create program codes to generate the desired 2D geometric shapes. Interactive CAD programs began to take shape in the 60's and were mostly used in the automotive and the aerospace industry. The 60's also marked the beginning of the development of finite element analysis methods for computer stress analysis and CAM for generating machine tool paths.The advent of microprocessors in the late 70's boosted computing power of the computers. It also triggered the development of 3D CAD programs that were user friendly and most importantly, interactive.

- The 80's saw the expansion of computer application software technology from very simple computer aided drafting to very complex computer aided design. It was at this time that 2D and 3D wire frames were introduced in the industry for geometric modeling as a tool to increase productivity.

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Brief History of Geometric Modeling

- CAD really came on its own with the introduction of 3D solid modelling technology, which boosted the usage of CAE technology in industry. The development of 3D modelling schemes started with 3D wireframes. It was a major leap in computer geometric modeling as it allowed designers to use a single object and view it from multiple angles. However, wire frames are susceptible to ambiguity because surface definition is not part of a 3D wireframe model. To overcome this lacuna, computer geometric modelling with surface definitions was the next logical step forward. With enhanced computer CPU power, the next enhancement in geometric modelling was solid modelling. Surface modelling organizes and groups edges that define polygonal surfaces, making it easier for designers to visualize an object

Steps of Creating a Model using CAD Software

There are three steps in which the designer can create geometric models by using CAD software:

1) **Creation of basic geometric objects:** In the first step the designer creates basic geometric elements by using commands like points, lines, and circles.

2) **Transformations of the elements:** In the second step the designer uses commands like achieve scaling, rotation and other related transformations of the geometric elements.

3) **Creation of the geometric model:** During the final step the designer uses various commands to that cause integration of the objects or elements of the geometric model to form the desired shape.

During the process of geometric modeling the computer converts various commands given from within the CAD software into mathematical models, stores them as the files and finally displays them as the image. The geometric models created by the designer can open at any time for reviewing, editing or analysis.
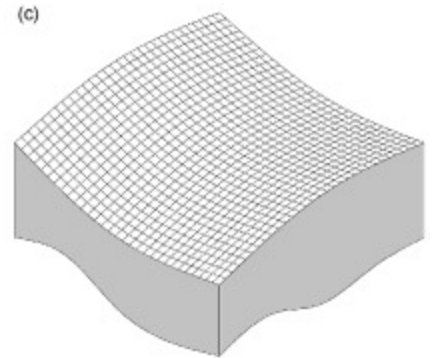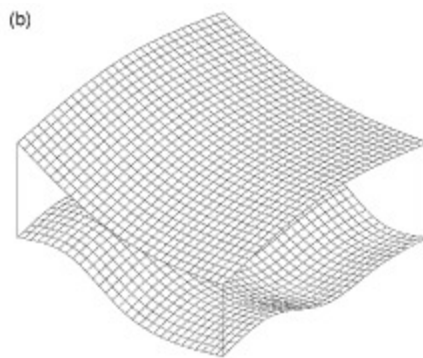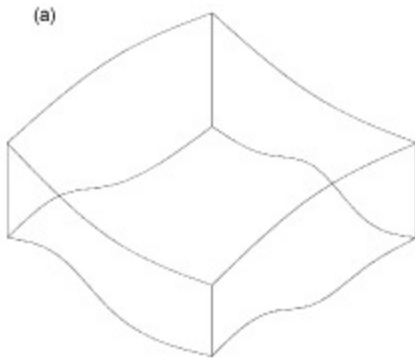
Representation of Geometric Model

Separate file

[2d 3d.pdf](2d 3d.pdf)

Types of Geometric Models

1. Wire frame Geometry/Model

2. Surface Geometry/Model

3. Solid Geometry/Model

(a) Wireframe   (b) Surface   (c) Solid

Wire Frame Modeling

1. Wire frame Geometry/Model. The wireframe model is perhaps one of the earliest ways of representing a solid model. It consists of vertices and lines and is a skeletal representation of a real-world 3D object. It was developed back in the 1960s; it is also referred to as "Stick figure" or "edge representation."

- In this type, User enters 3D vertices and joins the vertices to create a 3D object called a wire frame.

- The wire frame models lack the surface definition.
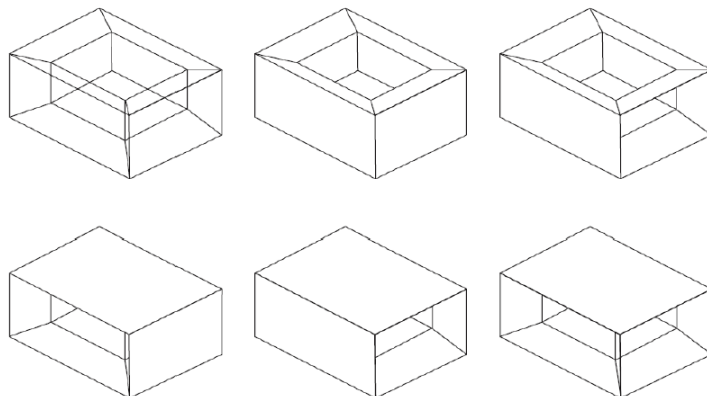
Wire Frame Modeling

- The lines within a wireframe connect to create polygons, such as triangles and rectangles, that represent three-dimensional shapes when bound together. The outcome may range from a cube to a complex three-dimensional scene with people and objects. The number of polygons within a model is a good indicator of how detailed the wireframe 3D model is.

- Wireframe modeling helps in matching a 3D drawing model to its reference. It allows the creator to match the vertex points, so they are in alignment with the desired reference and see the reference through the model as well. Although Wireframe modeling is a quick and easy way to demonstrate concepts, creating a fully detailed, precisely constructed model for an idea can be extremely time-consuming, and if it does not match what was visualized for the project, all that time and effort was wasted. In wireframe modeling, one can skip the detailed work and present a very skeletal framework that is simple to create and is apprehensible to others.

Surface Modelling

2. **Surface model:** Surface modeling represents the solid appearing object. Although it is a complicated method of representation than wireframe modeling, it is not as refined as solid modeling. Although surface models and solid models look identical, the surface models cannot be sliced open the way solid models can be.

- In this method of modeling, user enters the vertices and edges in an ordered manner. outlining or bounding one face at a time so that surfaces are defined.
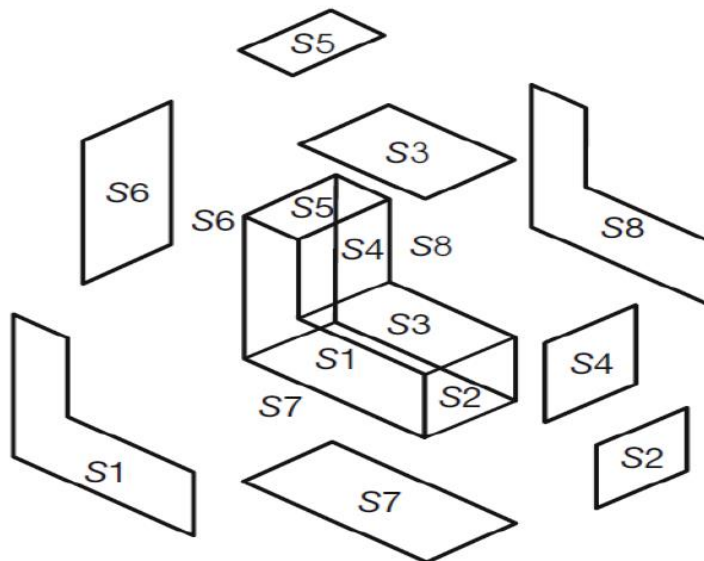
Surface Modeling

A typical surface modeling process involves the following steps:

- – Generation of a model combining the three-dimensional surfaces and solids
- – Conversion of the model to surfaces, taking advantage of associative modeling
- – Validation of imperfections with surface analysis tools
- – Reconstructing surfaces of objects to apply smoothness to the object

Surface modeling is used to:

- To shape design and representation of complicated objects such as a car, ship, and airplane bodies as well as castings

- There are situations where models imported from another CAD system usually lack details of the features it is comprised of. If the surfaces are complex, applying changes to this type of geometry can be quite the task. In such cases, surface modeling techniques can be used to one or more faces of the model to make the desired changes.

- Surface modeling enables building one face at a time so that one can control the exact contour and direction of any face. This feature comes in handy at a time when solid modeling technique fails to create the complex shape of a feature as it builds up several sides of shape at once.

- As it is not limited to the direct construction of a model face, surfaces can also be used as a reference geometry in a transitional step towards the creation of the required model face.

- Now, there is another modeling technique which requires a combination of solid and surface modeling techniques to create a solid model. This technique generally involves starting the model as a solid and using surfaces to modify it. Or, changing the solid to surfaces to shape and contour it, then turning it back to a solid when done.
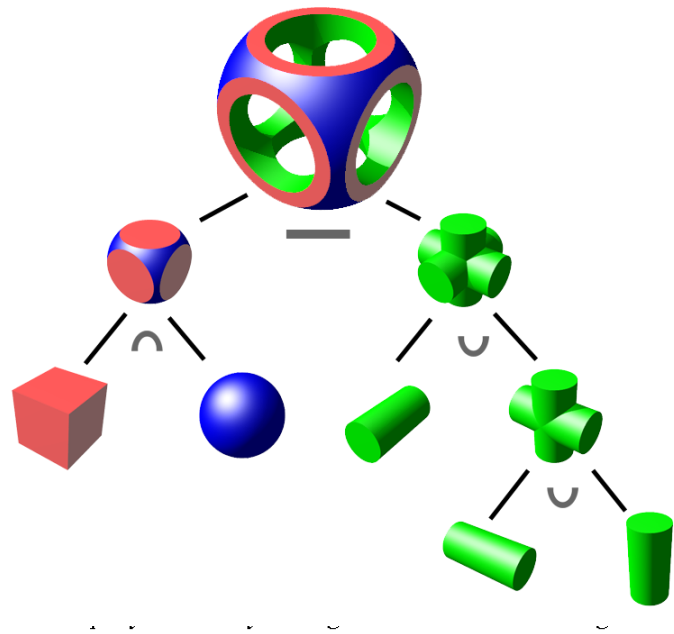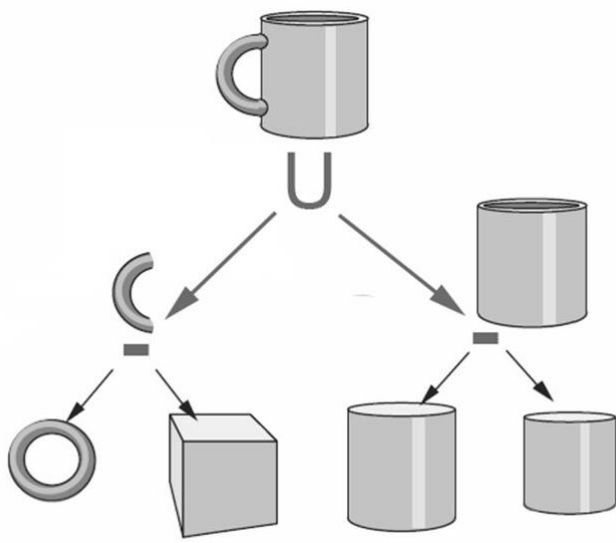
Solid Modeling

3. **Solid Modeling:** Also known as volume modeling, this is the most widely used method as it provides a complete description of solid modeling. Solid modeling defines an object by its nodes, edges, and surfaces;   therefore, it gives a perfect and explicit mathematical representation of a precisely enclosed and filled volume. Solid modeling requires the use of topology rules to guarantee that all surfaces are stitched together correctly.

There are several techniques used for solid modeling, however, two prevalent ways for representing solid models are:

- **Constructive solid geometry:** Constructive solid geometry is a combination of primary solid objects (prism, cylinder, cone, sphere, etc.). These shapes are either added or deleted to form the final solid shape (use of Boolean operators)

- **Boundary representation:** In boundary representation, an object's definition is determined by their spatial boundaries. It describes the points, edges, surfaces of a volume, and issues command to rotate, sweep facets into a third dimensional solid. The union of these surfaces enables the formation of a surface that explicitly encloses a volume.

Solid Modeling

- Solid Modeling is the most widely used geometric modeling in three dimensions, and it serves the following purposes:

    - Solid modeling supports weight or volume calculation, centroids, moments of inertia calculation, stress analysis, heat conduction calculations, dynamic analysis, system dynamics analysis.

    - Solid modeling supports the generation of codes, robotic and assembly simulation

    - Solid modeling stores both geometric and topological information; can verify if the two objects occupy same space

    - Solid modeling improves the quality of design, enhances visualization, and has the potential for functional automation and integration.

Constructive solid geometry
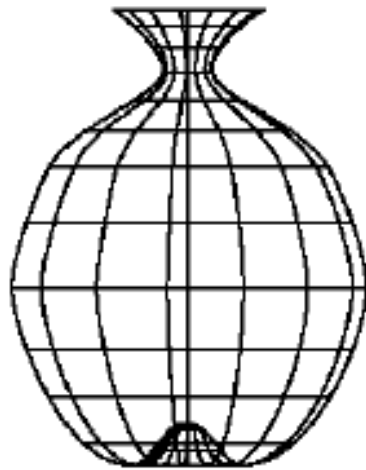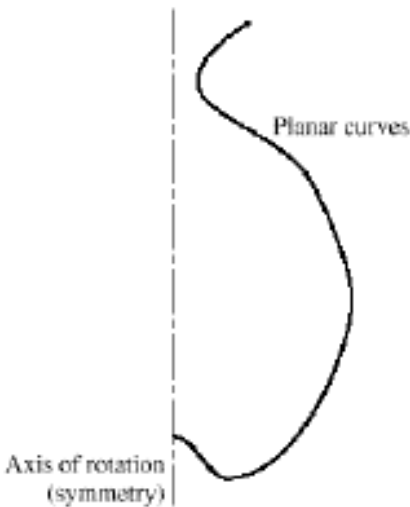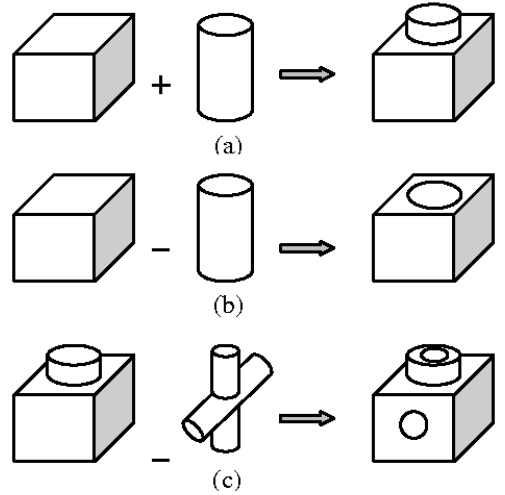
Boundary representation:
Rotational sweep
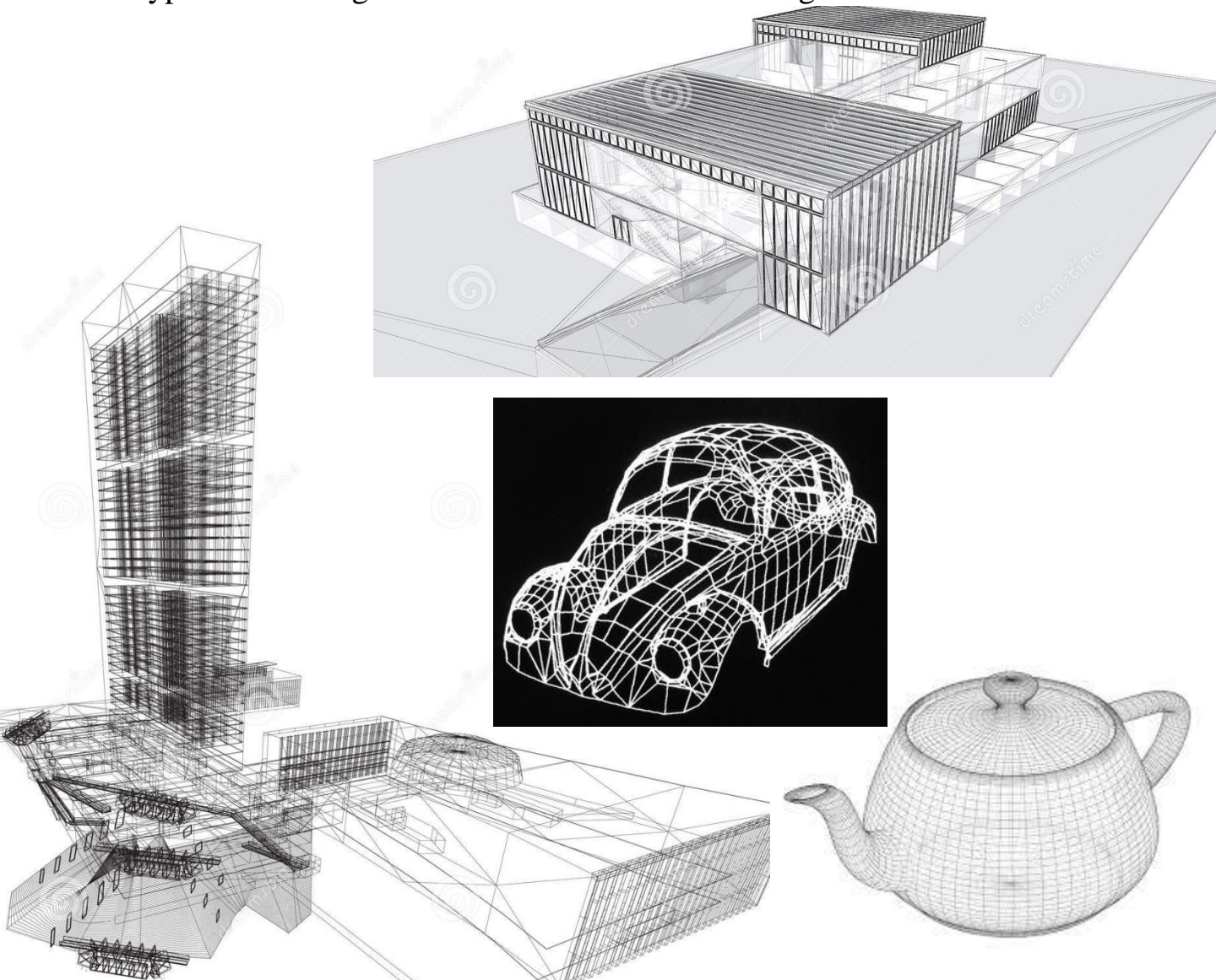
Computer Graphics Software and Data Base

Wireframe vs Solid Modelling

A **Wireframe Model** is a skeletal description of a 3D object.

There are no surfaces in a wireframe model; it consists only of points, lines, and curves that describe the edges of the object.

You can create wireframe models by positioning 2D (planar) objects anywhere in 3D space. Some 3D wireframe objects may also be constructed.

This type of modeling can be the most time-consuming.

Computer Graphics Software and Data Base

<u>Wireframe vs Solid Modelling</u>

Solid Modeling is the easiest type of 3D modeling to use.

With the solid modeler, you can make 3D objects by creating basic 3D shapes: boxes, cones, cylinders, spheres, wedges, and tori (donuts). You can then combine these shapes to create more complex solids by joining or subtracting them or finding their intersecting (overlapping) volume.

You can also create solids by sweeping a 2D object along a path or revolving it about an axis. With Autodesk Mechanical Desktop, you can also define solids parametrically and maintain associativity between 3D models and the 2D views that you generate from them.