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Ingenuity for life

Designing complex shapes for consumer products

Using subdivision modeling to remove design barriers and rapidly conceptualize ideas

Siemens Digital Industries Software

Manufacturers of consumer goods are facing increasing pressure to bring unique products to market. An aesthetically pleasing product can spark an emotional response with customers, allowing manufacturers to command premium prices and drive customer loyalty. Good consumer design is as much about creating a positive user experience as it is about creating a product that works.

Designing shapes that are visually appealing can challenge even a seasoned designer's capabilities because developing unique shapes often requires designing complex surfaces. However, just because a shape is complex doesn't mean designing it has to be.

New approaches to creating unique shapes promise to simplify the design work behind developing complex surfaces. Improvements in computer-aided design (CAD) tools cannot only simplify the design of consumer products; they can even make it fun! Manufacturers need to be aware of the impact of new design technologies and move quickly to adopt them where they can be most effective.

Design begins in the mind

Conceptual design is the first stage of any new design. It requires practical communication skills – visualization, modeling, requirements, aesthetics, ergonomics and regulations. CAD provides the ultimate medium for communicating concepts – CAD data accelerates engineering and manufacturing efforts and can improve efficiency throughout the product lifecycle.

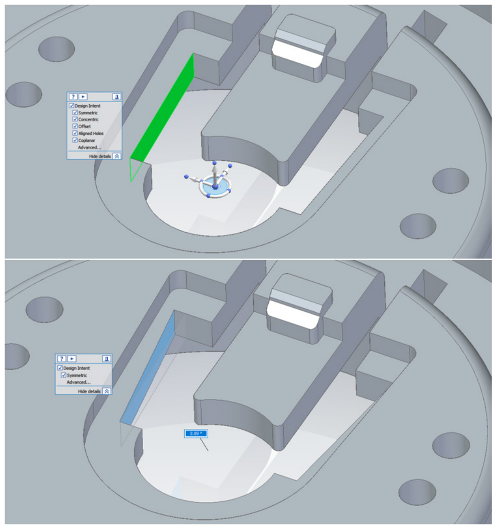
CAD details the specific shape and properties of each part and specifies how they go together. The data is used in downstream applications that range from creating photorealistic rendered images for marketing to creating the machining toolpaths that will be required to manufacture the part.

In fact, data may be used as the basis for all areas of product development, including managing customer requirements, concept and detailed design, prototyping, simulation, manufacturing, installation and service. By using an integrated solution for product development that creates a comprehensive digital twin, you can create a detailed 3D digital model of the proposed product. Data and intelligence can be added as the design progresses, enabling its use in downstream processes such as developing instruction manuals.

Design intent

In CAD, design intent helps with planning for changes that will inevitably occur during the design process. When dimensions in a model are modified, changes in one object need to propagate automatically to others. Yet, change can be the most difficult thing for which to plan.

Design intent is most often associated with parametric modeling, the process of changing the shape of model geometry as soon as the dimension value is modified. It helps with planning for change, and while much has been written about design intent, it is still an elusive beast for many users.



Conceptual design builds on design intent. A typical modeling process begins with a base feature controlled by a 2D sketch, which is either a linear, revolved, lofted or swept extrusion. Each subsequent feature is built on the previous feature. In a history-based approach, when editing a model it is rolled back to the point where the feature was created so the user cannot try to apply constraints to geometry that does not yet exist.

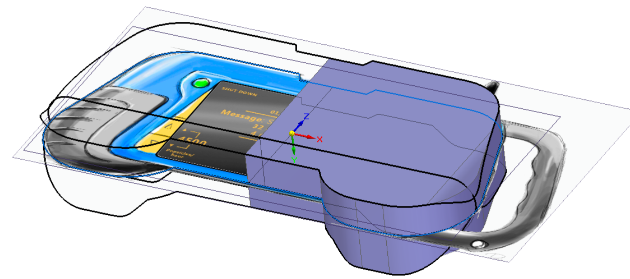
However, this history-based process has drawbacks. The user cannot see how the edit will interact with the subsequent features. Next-generation CAD systems provide direct modeling features that allow the user to change model geometry or topology without being hindered by a native model's, or an imported model's, lack of existing parametric and/or history data. Direct modeling can be useful in designing complex shapes.

CAD systems have always been good at representing geometrically defined shapes, and they are good at developing smooth aesthetic surfaces as well. However, developing complex, organic or freeform shapes is tough and always has been.

Implementing a design's intent can run the gamut of being pretty easy to seriously complicated. So, let's look at a few ways of using design intent in building complex shapes.

How CAD systems represent shapes

One popular method for conceptual design is to use a layout: a sketch or collection of sketches and planes that help to arrange, locate and relate primary design features. For the sketch-and-plane layout approach, the wireless machinery control panel shown here demonstrates the concept. The concept design process starts by sketching 2D profiles and outlines in 3D space, and from there curves are created to be used for making 3D surfaces. At this point it's not necessary to decide what kind of features to use, as the goal is to sketch a wireframe for visualization and modeling.



The layout sketches and planes are functional 2D geometry that drive the creation and editing of 3D surfaces and solids. The layout geometry can serve as spatial references or in feature modeling.

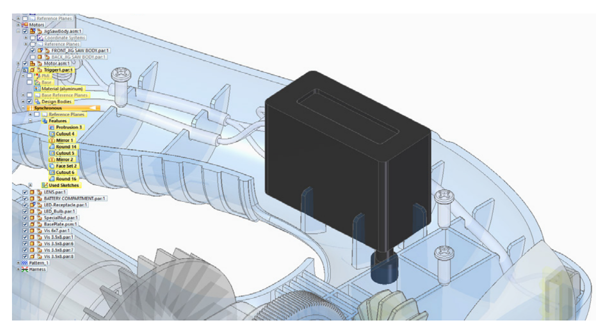
The idea is to have items at the top or near the top of the feature tree that drive the shape of the product. This type of hierarchy can be tricky to get right more often than not when making changes, but that is what design intent is all about.

Solids modeling or surface modeling?

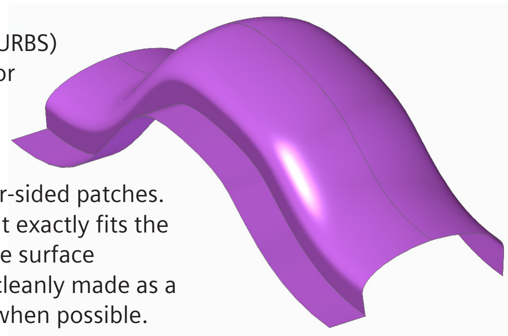
Solid modeling is more commonly used in mechanical design than surface modeling. With solids, a single feature can create faces on all sides of a model. However, surfaces are more typically used to create complex shapes, one face or one side at a time, or in situations where more control is needed over the finished shape than solid features may allow for (for example, a propeller blade or wing tip). Surfacing generally takes a lot more time than solid modeling because the designer does manually what the solid modeling functions do automatically.

Solids

Feature-based solid modeling often helps with specific detail tasks for engineering the fit and interface between parts. These are features like bosses, ribs, reveals, drafts and rounds. Before using such features, surface geometry should be solidified and shelled. Hopefully, most of the major design changes are done by the time this level of detailed work is underway.

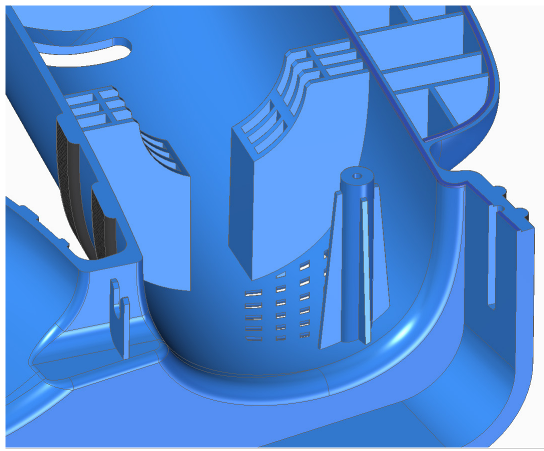


Surfaces



The nonuniform rational basis spline (NURBS) is the underlying mathematical model for curve and surface design in most CAD programs. Because NURBS describes curves in two directions, surfaces developed from curves work best as four-sided patches. If it's not possible to create a surface that exactly fits the desired location, it's best to overbuild the surface (make the smallest surface that can be cleanly made as a four-sided patch) and then trim it back when possible.

Super features



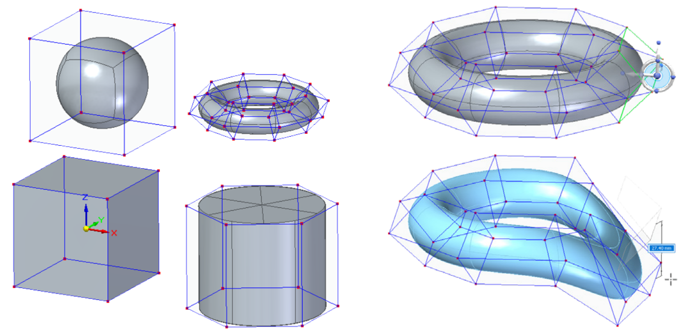
Many CAD programs have been used to create so-called super features that combine multiple simple geometrical operations that are commonly found together into a single command that makes more complex geometry.

These can be huge time savers if the creation of these types of geometry are needed. These features may include webs, lip/groove features, vents and mounting bosses. Typically, a mounting boss would include a cylindrical boss for a screw or a pin connection between parts, and then supporting ribs with fillets and draft and the rotation of the ribs. Advanced users may want to create their own library features, but it is convenient to have something built right into the software that fulfills the design requirements. These tools can be flexible, and if one takes advantage of super features, it is one way of re-using design information to help save time, both in the design process and manufacturing.

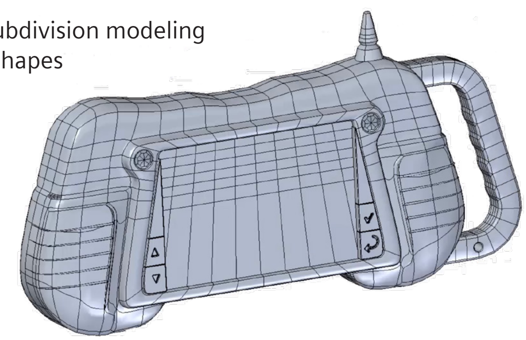
Most CAD programs allow hybrid design, with solid and surface geometry in the model at the same time.

A revolutionary approach to shape development: subdivision modeling

Aesthetic organic shapes have traditionally been developed by industrial designers using advanced surfacing applications because in the past creating uniquely shaped designs required a specialized skill set. Experts would manually create NURB surfaces that had to remain tangent to each other, which could take a significant amount of time and expertise. These designs would then be moved into a CAD application to build the internal aspects of the product. The transition from one to another has historically been time-consuming, painstaking and prone to errors. However, new subdivision modeling techniques, which aid in the design of complex, aesthetic surfaces, are now available in CAD applications. Having one software application that includes all aspects of modeling allows engineers to avoid import/export issues that can result in broken or missing geometry that must be painstakingly fixed.



A subset of regular surface modeling, subdivision modeling uses stylized design to model complex shapes quickly and accurately. The intuitive freeform modeling technique helps you develop unique products based on organic shapes. A subdivision modeling environment enables the creation of freeform shapes based on an initial primitive. It's an easy way to create complex geometry, which can be subdivided to give a shape flexibility. The modeling technique starts with a polygonal cage to control its shape. By continuously manipulating and subdividing the cage, you can add greater levels of detail and control until you have the shape you desire.



"Subdivision modeling will be very valuable for creating more stylized designs."

Jason Inglis
Senior CAD system administrator
Ditch Witch

Enter Solid Edge

Solid Edge® software, which is part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, has a complete set of history-based tools in which most of the best-practice techniques have been developed. Solid Edge can be used to drive surface and solid features with sketches, create multiple bodies, split those bodies out to individual parts and do the detail engineering work to add mounting bosses, ventilation holes, draft, fillets and bring the finished parts back together in a completed assembly of parts. Solid Edge also offers well-recognized capabilities in the areas of sheet metal and 2D drawings.

In addition to these traditional history-based tools and techniques, Solid Edge has built-in synchronous technology, which is a set of order-independent enhancements on top of direct editing. Parts can be entirely or partially built using either synchronous or history-based methods, and these features can be edited in the context of an assembly.

Solid Edge also enables you to remove limits on creativity by allowing you to create stylized shapes with subdivision modeling efforts. Subdivision modeling allows you to develop product forms in a fraction of the time required with traditional products and isn't susceptible to rebuild errors or rebuild time delays. Subdivision modeling doesn't require the user to maintain history or use a feature tree. You just push a shape around until it resembles what you want to develop. Resulting shapes are high quality, associative, editable and suited for use by downstream users of CAD data. No data conversion is required, and there's no need to leave the Solid Edge environment.

Removing design barriers

Complex shape design can challenge the current capabilities of designers. But, next-generation technologies, such as those provided in Solid Edge 3D CAD, may help. Solid Edge offers flexible, advanced capabilities for shape creation, manipulation and analysis, with intuitive freeform modeling tools that create stylized shapes.

All modeling techniques can coexist in design development, with users able to use subdivision modeling to create complex models with a lot of curves, yet still use surface modeling techniques to design other aspects of the design, such as using NURBS for engineered features.

Subdivision modeling can remove design barriers with automation, allowing those without expert knowledge to create unique shapes. Based on technology that originated in the entertainment industry but has been adapted to suit the manufacturing industry, subdivision modeling opens up a new way to rapidly conceptualize ideas. Using subdivision modeling, you can achieve automated results in just a matter of minutes.

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Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

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