Universal 3D (U3D)

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Abstract

Designers have been creating three-dimensional (3D) objects with computer-aided design (CAD) applications for approximately 25 years, creating a huge library of data with a vast potential for reuse. One estimate suggests for that every 3D CAD user in design, engineering, or manufacturing, there are 30 potential users of the data in marketing, product documentation, sales, support, customer service, and beyond. Through the 3D Industry Forum (3DIF), Intel is working with other companies to develop a standard file format and sample runtime libraries designed to support the efficient reuse of 3D data in such mainstream applications. The Universal 3D (U3D) specification and sample implementation will simplify the transformation of complex 3D data into a format that can be streamed, compressed and viewed on affordable, nonproprietary software/hardware platforms while providing a high quality viewing experience. By removing the voluminous detail needed by manufacturing and retaining the integrity of the original data model, U3D will enable efficient distribution of 3D data over the Internet and applications requiring lightweight 3D data. The first version of U3D, as well as the sample software, was released in December, 2004.

1. INTRODUCTION

Despite the many potential uses and value of repurposing the 3D datasets used in design, engineering and manufacturing, there has been little attempt to adapt this data to mainstream uses. Marketing, product documentation, training, sales, technical support, customer service, and others could all benefit from these assets. A major reason for the negligible use of 3D CAD data in these areas is the difficulty and expense of delivering this type of data in forms people working in these areas can use.

This is an immense waste. Companies could be using this 3D data to enhance communication of concepts and new products, reduce production costs, improve time to market, and provide better training and support of products throughout their life cycles. A tremendous opportunity for return on investment is lost by shelving these resources once the engineering, design and manufacturing processes are completed. Finding a way to reuse 3D data in mainstream applications makes good business sense, especially since today's powerful servers, desktop and notebook computers can easily handle the processing demands of 3D imagery.

What's needed is a common 3D format that enables a company to access the essential 3D data necessary for downstream uses (as opposed to the complete data used for manufacturing).

Universal 3D (U3D) is being developed to be that format. What the JPEG format has done for digital photography and the MP3 format for music, U3D is targeted to do for 3D data. In fact, it's being designed to go much further. The very nature of 3D data demands a format that will enable companies to enrich, animate, and add interactivity that enhances the potential for reuse.

Intel, Adobe, Boeing and more than 25 other companies have joined the 3D Industry Forum (3DIF) to develop a standard for U3D. The goal is an open and extensible 3D data repurposing and visualization format with enabling features like Web streaming and continuous level of detail. Additional advanced graphics capabilities will be added over time. These advanced features will make good use of Intel's future multi-core architectures. The 3DIF is working on the standard with Ecma International (www.ecma-international.org), an industry standards group, and will submit the results of their work to the International Organization for Standardization (IOS) for ratification as a formal standard during 2005.

This paper will discuss previous 3D interchange format solutions, the need for the U3D standard, the advantages of U3D, and immediate milestones. It will also provide use cases demonstrating ways U3D could be used.

2. MAKING BETTER USE OF 3D ASSETS

Pictures are the "lingua franca" for the worldwide economy. If a picture is worth a thousand words, an animated, inter-active 3D model is worth exponentially more. Interactive 3D has proven itself over and over as a powerful marketing, training and educational tool.

3D CAD systems were introduced around 25 years ago and like other hardware/software solutions have become increasingly more sophisticated, versatile and robust through the years. Today, everything from toasters to automobiles to jet aircraft are designed on 3D CAD systems. This includes over-all product design as well the development of individual parts. The data is extremely complex and expensive to create.

Unfortunately, once the product is built, the data is typically shelved. If it's used again, it's for designing product updates, changes and modifications. Think of the huge amount of money (anywhere from thousands of dollars to in some cases millions) spent producing these assets. What if there was a way to strip out the proprietary information and supply the essential 3D data in a universal format in which it could be modified and adopted in a number of ways for downstream uses and mainstream business applications? With such a solution, 3D data could be repurposed many times over. Early in the life cycle, repurposed 3D CAD data could enable suppliers, end users, support personnel, and others to visualize, evaluate and prepare for a product in tandem with value engineering or first-run manufacturing. This would simplify the presales process, component manufacturing, preparation and distribution of service manuals and routines, and many other aspects of bringing a product to market. Later in the product life

cycle, repurposed 3D CAD data could play an essential role in long-term product maintenance.

Repurposed 3D data could be used for:

- Early sales and ecosystem-building activities
- Sales/marketing tools
- Electronic documentation
- Assembly instructions
- Training materials
- Customer service
- Repair guides

3. CURRENT SOLUTIONS FOR REPURPOSING 3D DATA

CAD companies and users have struggled to find an easy and cost-effective means to share 3D data across multiple software platforms. Each CAD system has its own proprietary format, making it a challenge to take data authored in one format and view and edit it in another. Likewise, formats for putting 3D models on the Web have failed to flourish as well. They all have strengths in addressing the problem, but only provide part of the answer – various combinations of compression, streaming content, extensibility, player size, and performance. These Web formats also lack broad acceptance. What's more, due to the proprietary nature of many efforts, there's a lack of agreement within the industry on which to use or adopt.

A number of independent software vendors (ISVs) have attempted to repurpose 3D data using digital content creation (DCC) tools. However, the process of repurposing CAD data with a DCC tool is cumbersome and costly. Often, the data serves only as a guide for rebuilding an object from scratch. Sometimes, valuable meta-data such as bill of materials, part numbers, or assembly instruction animations are lost in the process. Virtually always, the data set remains or grows too large for exchange over the Internet or deployment on nonproprietary software and affordable hardware.

The intent of U3D is to remove some of these barriers by providing the industry a standard that complements the current formats that exist today. When adopted by ISVs, the U3D standard will help break down the barriers for viewing 3D data across various platforms, enabling end users in engineering, sales, and marketing to have access to data that was once very difficult to obtain and share.

What Has Held 3D Back?

1. Bandwidth and infrastructure constraints
2. Requires certain skills to repurpose 3D content/assets
3. No easy repurpose path
4. Industry is fragmented

4. ADVANTAGES OF U3D

U3D will give the industry a single international standard for exporting and importing complex 3D data to mainstream business applications and visualization over the Web. An open source sample U3D implementation will simplify the re-purposing of 3D data, foster extensions, and enable ISVs to easily implement compression, streaming, continuous level of detail (variable resolution based on bandwidth or the author's discretion), and other capabilities into their applications. U3D SDK will include a player as a simple example of how to deploy the sample software. ISVs can create players with their own value added features, just as is done for JPEG viewers and MP3 players today.

3D features include:

- Continuous level of detail
- Progressive streaming
- Compression
- Rigid-body and skeleton-based animation
- File format and run-time extensibility

Extensibility will be a key feature, allowing the addition of new modifiers that can change a 3D model. The use of the standard Common Language Runtime (CLR) with the associated Common Intermediate Language (CIL) for plug-ins – and the inclusion of their required interfaces in the standard – will facilitate cross-platform availability. Write them once and they will work with a variety of different operating systems. This encourages ecosystem development, enabling developers to differentiate their offerings by building on top of the standard. Developers can extend the file format on their own without being dependent on the 3DIF. By allowing market needs to be addressed quickly, this extensibility will help facilitate the longevity of the standard.

An important advantage of U3D is it will enable DCC ISVs to retain the integrity of the model while removing the data needed for manufacturing but not for other purposes. By re-moving such information, companies can protect proprietary product information and create files small enough to exchange over the Internet and operate on ordinary hardware without the need for special or proprietary software.

U3D will offer numerous runtime benefits, particularly over the Web. For instance, its continuous levels of detail capabilities will enable data to be progressively viewed and enable inter-action during downloading. It will also enable regulation of complexity so different levels of detail can be deployed for viewing based on the particular application needs. Down-stream tools using U3D will be able to add animations, textures, shading and text to tailor 3D data to a particular use and end user.

5. EXTENDING THE LIFE OF 3D DATA THROUGH U3D

Data starts life as a 3D CAD model created by a designer for design and manufacturing. The data is extremely complex and large. It can only be viewed and altered via proprietary software and an expensive computer system. Usually once a product is built, data like this is typically shelved, often never to be seen or used again.

By unchaining people from the need for expensive, heavy-duty hardware for viewing 3D data, these assets could be delivered and taken anywhere. People could experience them on a notebook computer, handheld or smartphone.

Using a U3D exporter, essential elements of the original 3D data are preserved and rendered as a smaller file suitable for mainstream uses on standard computer systems and online. A tool created by a DCC ISV (and conforming to the U3D standard) imports this 3D data and turns it into a much smaller file for use

in online training. The tool enables the addition of text and animation.

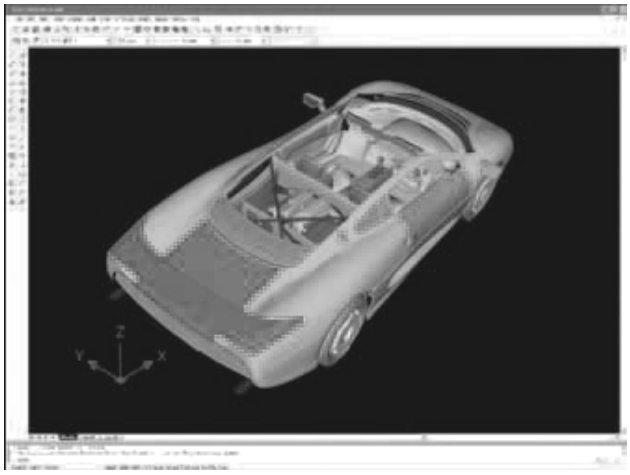

Figure 1: Data starts life as a 3D CAD model created for design and manufacturing.

Figure 2: Using a U3D exporter, essential elements of the original 3D data are preserved and rendered as a smaller file suitable for mainstream uses.

The same exported 3D data could also be used in sales, creating in this instance an online showroom providing a 3D animation of the car complete with opening doors, trunk and hood. Potential buyers can try different color choices and examine the car's features from the comfort of their living room.

6. CONTINUOUS LEVEL OF DETAIL

The Continuous Level of Detail feature of U3D enables data to be progressively viewed during a download so viewers can initiate their interactive visualization experience with the streaming of the data. Developed by Intel, this feature can also be used to regulate complexity during viewing of interactive 3D data, providing the best performance for the platform being used.

Figure 3: U3D unchains people from the need for expensive, heavy-duty hardware for viewing 3D data.

7. ELECTRONIC DOCUMENTATION

Electronic documentation is becoming increasingly common for many industrial, business and consumer products. A lot of this documentation makes poor use of digital media. It is created simply by scanning pages directly from a manual and storing the result in a PDF read-only file.

By repurposing existing 3D assets, U3D could open up a new era in electronic documentation. Instead of static, scanned diagrams, it would be easy and cost-effective to include animated and interactive 3D visualizations. These could show people how to:

- Operate features
- Install accessories
- Replace parts
- Fix common problems

What's more, by making 3D assets small enough to exchange over the Internet and run on ordinary hardware without special or proprietary software, U3D would make 3D visualizations easier to include in any electronic document. Consequently, end users will be able to get the most up-to-date information from the data with which the product was manufactured.

8. INTEL'S CONTRIBUTION TO U3D

Recognizing the potential value of 3D CAD data beyond design, engineering, and manufacturing, Intel has worked for many years on the development of a strong 3D ecosystem. This has involved alliances with not only DCC and 3D CAD ISVs, but also hardware manufacturers, graphic artists, Web authors, platform developers, end users, and others. Intel also has developed technologies such as continuous level of detail and compression algorithms designed to enable 3D CAD data to be distributed easily and effectively throughout the Internet and within enterprise applications.

Intel is a founding and leading member of the 3DIF. Intel continues to work closely with other forum members on the successful development and implementation of U3D.

The 3D Industry Forum Established in 2002, the 3DIF (www.3dif.org) is a special interest group of more than 25 companies that promote 3D technologies and standards, and provide tools, information, and education for using these technologies. The group will also define conformance testing and compliance for its offerings, while providing a point of industry-wide contact for ongoing 3D activities and development.

To create commercially viable and industry-focused results, the organization encourages open international collaboration on technologies, offerings and contributions by members. 3DIF has selected Ecma International as the sponsor for ISO certification of U3D. In December, 2004 Ecma International General Assembly approved first version of Universal 3D format as Ecma Standard (Ecma-363). Work on second version of U3D specification which will include file format extensibility is in process.

9. MOVING FORWARD

3D CAD data is a real and relevant form of informational exchange in the business-to-business world for many applications beyond design and engineering. Historically, however, the ISVs who build the tools for repurposing such data, and the companies that use them, have found the process cumbersome, inefficient, and dependent on proprietary software and costly hardware.

With the introduction of U3D – an open standard format and software implementation designed to simplify the repurposing of 3D CAD data – ISVs and industry will find it far more timely and economical to make 3D data accessible to applications beyond design, engineering, and manufacturing. This will enable faster go-to-market activities and more opportunities for presale and marketing efforts. It will provide multiple audiences, including suppliers and customers, with early views of a completed product. And it will vastly improve the quality of training materials and electronic documentation. Gold version of Universal 3D software is already available to 3DIF members as open source.

10. FOR MORE INFORMATION

Learn more about 3DIF at www.3dif.org

Find out more about the Ecma's work on an international standard for U3D at www.ecma-international.org/memento/TC43.htm

Link to Standard Ecma-363 "Universal 3D File Format": www.ecma-international.org/publications/standards/Ecma-363.htm

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