Dyndrite

Delivering on the Promise of

Additive Manufacturing

A Modern Approach for Modern Aspirations and Efficiency

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Abstract

It's been a little over 30 years since the introduction of the existing incarnation of geometry kernels. Over that time there have been significant new inventions in computer architectures, programming languages, mathematics, data formats, and manufacturing processes. More importantly, new goals and aspirations have arisen requiring capabilities that far surpass those of the geometry kernels available today.

Today's users need a modern kernel, one that leverages these many advances. It must take advantage of modern computing architectures, namely the GPU. And it must be accessible to the widest possible user base, supporting both a modern GUI interaction as well as modern programming languages such as C++ 17 and Python 3.6+.

The Dyndrite Accelerated Geometry Kernel (AGK) is the world's first native GPU-based geometry kernel with all these modern features. The Dyndrite Kernel makes emerging technologies such as Additive Manufacturing more accessible by providing the infrastructure to support additive-specific computations: generation of lattices, supports, and slices.

To that end, based on this new kernel, Dyndrite has developed an Additive Toolkit which streamlines the CAD-to-Print workflow. The Additive Toolkit provides a direct interface to CAD (spline) data, freeing users from the limitations inherent in the STL file format — which until now has been the standard for 3D printing. Using CAD spline data as the driver for toolpaths, the Dyndrite kernel supports finer user control over part characteristics, increased print speeds, and higher quality output.

The Dyndrite Accelerated Geometry Kernel is a paradigm shift, and promises to do for 3D printing what Adobe and PostScript did for 2D printing in the 1980's. Laser printing technology powered by PostScript set off a revolution that radically changed printing and publishing. In the new revolution, 3D printers powered by the Dyndrite AGK will bring about an even more sweeping change, reshaping design and manufacturing as we have known them.

Additionally, leveraging the full power of GPU processing, the Dyndrite kernel and Additive Toolkit reduces processing time for the additive user or technician. Workflow elements that once took hours of processing time—such as lattice, support, and slice generation—now occur on the fly. The toolkit further assists the technician by enabling them to script a significant part of the workflow via the Kernel's Python Interface. Python, widely noted for being easy to learn and use, is woven into the application and can be used interchangeably with the GUI. Users can script interactive workflows that augment the build setup — speeding production and eliminating repetitive tasks.

Dyndrite's goal is to dramatically improve iteration times and simplify an overly complex additive workflow. Dyndrite reduces the time and improves quality by streamlining and enhancing the additive workflow. Dyndrite offers a fast CAD-to-Print application, with fine grain control over geometry and parameters. Dyndrite allows the user, developer or OEM to differentiate and customize on top of the app without revealing any proprietary information.

Background: CAD and Early 3D Printing

Computer-aided design (CAD), when introduced in the 1980s, revolutionized the industry, moving designers and engineers from draft tables to computers that enabled 3D visualization—either as wireframes or beautiful photorealistic images that represent shapes as collections of points, lines, and surfaces. To render the models, the software tessellated the surfaces as triangular meshes.

Visionary Chuck Hull, distilling the wisdom of the time, coined the term stereolithography for a new technology that brought CAD models to the factory floor (or at least the lab). Stereolithography, the venerable predecessor of today's 3D printing, used a laser to draw a model in 3D space with a photopolymer, one horizontal layer at a time.

To help translate the CAD data into language the equipment could understand, Hull also developed the STL file format to represent complex 3D surfaces by linearly approximating them as a collection of triangles. While dozens of other file formats have since sprung up, primarily to address the limitations of STLs, STLs remain the de-facto leader as geometric representation standard. The vast majority of third-party software continues to be written to accommodate and band-aid workflows involving STLs.

Rapid Prototyping and Beyond

The first practical application of the additive process was in prototyping. In this context, generating a physical approximation of a digital object prior to production was a huge leap forward in the digital-to-physical product-development process: The rapid-prototyping industry was born.

Over time, new additive processes, new materials, and new post-processing methods have appeared. It didn't take long before the right combination of design, process, material, and ingenuity enabled users to create parts for final use. Today, there are innumerable stories of final-use parts in aerospace, automotive, medical, and other arenas. Unfortunately, while many hardware innovations have ushered in the rise of additive manufacturing, many aspects of the software have stagnated the adoption process: namely the software tools, the kernels underpinning these tools, and the all-reigning STL format.

Users must convert their models to STL files that invariably consume time and labor to process and are notoriously prone to error—necessitating significant manual time to repair misplaced triangles and holes in meshes.

Furthermore, as STLs break spline surfaces into discrete triangles to represent the entire model, the result is too often a data explosion: gigabyte-sized data files that are slow to transmit and can lead to frequent software and machine crashes. This explosion of data becomes even more pronounced as users harness additive advantages such lightweighting or "latticing" a surface, a process that reduces the amount of material and/or time it takes to print. Although lattices can be easy to represent algorithmically, they can significantly bloat files when represented as polygons (either within an application, or in an STL destined for a printer).

The complications inherent in the use of STLs means that workflows increase in complexity. Additive-manufacturing professionals are constantly required to make tradeoffs in resolution versus file size and quality versus time, and burn up precious hours in low-value tasks such as repairing the STL. Should a design have to be modified, the user must go back to the proverbial drawing board and put countless more hours into generating the design—especially if the only data files available are in STL format.

Additive Manufacturing and the CAD Legacy

The design process has changed dramatically in recent years, incorporating much more complexity than it did in the early days of CAD. Methods and tools associated with Design for Additive Manufacturing (DFAM) address core requirements such as topology optimization, design for multiscale structures (lattice or cellular structures), multi-material design, mass customization, and part consolidation. Designers must plan for and optimize iteration time, weighing industry benchmarks against the unique specifications of their own products and market demand. They must incorporate simulation and prototyping and the associated costs of these into every design. Facing such challenges, the profile of the typical designer (along with the typical engineer and technician) is expanding to include greater knowledge of and experience with programming.

Over the same time, the manufacturing process has undergone even greater transformation. For example, modern manufacturing is becoming more and more precise. How the tool precisely travels

"A geometry engine built for today's additive-manufacturing requirements"

impacts both the time required for, and the ultimate quality of, the finished product. Precision control allows for variances as small as 20 – 100 micrometers. Working at this scale requires frequent on-the-fly adjustment, control, and recognition that every machine is like a fingerprint (slightly different in its own way). How you represent this information leads to another example of data explosion.

So, on one hand, today's 3D printers and computers are state-of-the-art. On the other hand, much of the software has not progressed significantly over the past three decades. In particular, the foundational geometry kernels, such as Parasolids, ACIS, and Polygonica, which are used to run additive-manufacturing processes—from design conception through modeling, prototyping, and manufacturing — are increasingly out of date.

Between the STL workflows, the new design workflows, and the increasing demands from machine precision: Hardware has literally outpaced the software.

Dyndrite: A New Kernel for a New Era

In 2015, a group of mathematicians, computer scientists, and mechanical engineers came together with the aim of developing a brand-new geometry kernel and user application that would break away from the STL status quo and deliver on the promise of additive manufacturing. This new platform, developed from a first-principles approach, would be designed to take advantage of the very latest in computing architectures, languages, mathematics, geometry types, and manufacturing processes.

As such, this team created a completely new math and geometry architecture, the Dyndrite Accelerated Geometry Kernel (AGK) — the world's first fully GPU-native geometry engine, a modular hybrid kernel that interacts with multiple representations of geometry simultaneously — surfaces, splines, volumes, solids, voxels — and is architected to be extended. Users can import native design files while maintaining the original data of the imported file, and work on the spline data directly, or convert between formats — while still maintaining the original. This allows, for example, the conversion of an STL slice data into a spline model or voxel set. Or the ability to discretize to the resolution of output devices, drive tool paths or more accurately produce better quality parts.

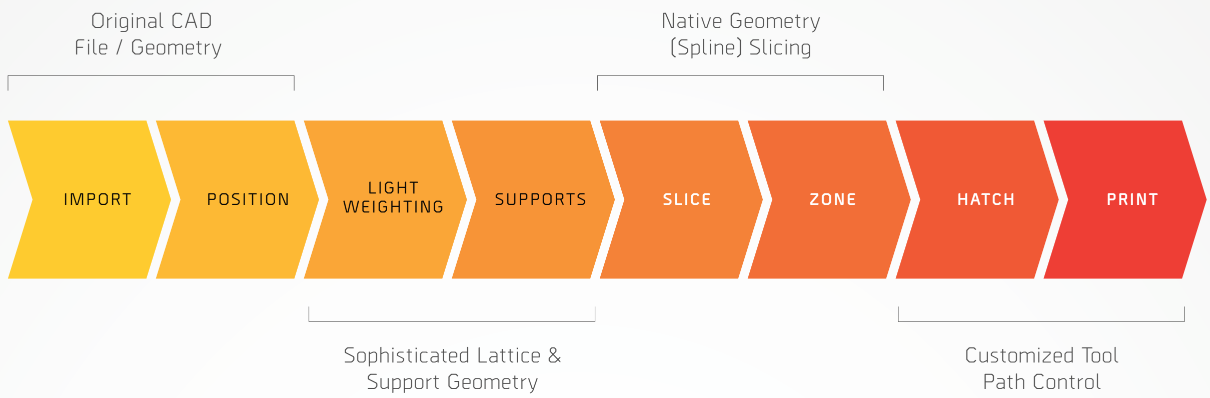
By using the Dyndrite kernel, the user can bypass the traditional requirement of an STL as an intermediary file, allowing for the full fidelity of the designs in his or her imagination, without the need to trade off file size for resolution or vice-versa. The Dyndrite AGK is the first kernel to exceed the capabilities of additive-manufacturing hardware.

The GPU-powered kernel allows users to compute model geometries in a fraction of the time required by CPU-only methods. Using the GPU, additive specific computations such as generating lattices, supports, or slices are done on the fly — often reducing hours to seconds. Furthermore, the inherent scalability of the kernel means it's no longer a matter of how fast, but how many computing nodes one has access to, whether locally or in the cloud.

In addition, addressing the shift in user demographics, Dyndrite has developed a Python Application Programming Interface (API) that allows the user to harness the kernel's capabilities directly. A modern GUI and a Python API open the AGK to a wide pool of users who will have the ability to quickly create and customize workflows for design and manufacturing problems. Users can work interchangeably between the GUI and Python. The user-friendly, intuitive interfaces serve as a way to customize the toolkit for streamlined design, prototyping, and manufacturing processes and provide an easy-to-use environment for design and engineering processes and team collaboration.

The Dyndrite Additive Toolkit – The First Application on the Dyndrite Kernel

The Dyndrite Additive Toolkit is the first application to be built on the AGK, directly inheriting the freedom, power and control afforded by the Dyndrite Kernel. Using the Dyndrite Additive Toolkit, designers, engineers, and technicians now have a high-performing, scriptable platform capable of seamlessly working with their CAD design files directly.



Using the toolkit, additive technicians can quickly explore a wide variety of options in a shorter period of time, drastically reducing time to manufacturing while minimizing the incidence of failed prints due to limited choices. Additionally, the kernel's Python interface allows users to script repetitive, menial, or time-consuming tasks, freeing up significant time they can devote to more creative, interesting, value-added design and engineering work.

Based on the real needs and work processes of additive-manufacturing users, the Dyndrite team formulated the following streamlined order of operations:

- Specify type of printer to optimize workflow
- Import CAD geometry (splines) or STL data
- Orient and position geometry, including putting multiple copies of the geometry (as needed) on the build plate; optimize position and orientation
- Lightweight the design as needed
- Generate supports as needed
- Slice the model, then zone and hatch the slices
- Print the model, then measure and validate

The Dyndrite Additive Toolkit can be controlled via a GUI or directly with the Python API. Users can even script interactive workflows that integrate the two — pausing an automated task to prompt the user for data input, such as for positioning serial numbers of parts.

And finally, the Additive Toolkit supports a wide variety of 3D printing processes, including for metal, thermoplastics, and resin processes.

A New Paradigm for Additive Manufacturing

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Conclusion

A geometry engine built for today's additive-manufacturing requirements.

Additive manufacturing professionals have many demands to satisfy, stemming from shrinking product-development cycle times to increasing consumer appetite for an ever-wider variety of innovative goods and services. The Dyndrite kernel takes advantage of the impressive capabilities and speeds of today's computing and manufacturing technology, sidesteps the unnecessary intermediary steps that are creating the lion's share of bottlenecks in the process, and provides designers, engineers and technicians with an intuitive, streamlined, versatile technology. Dyndrite allows these professionals to minimize the time spent managing files and correcting errors, and concentrate on what they do best: creating and producing their brightest ideas.

Keywords: Dyndrite, kernel, geometry, spline, CAD, STL, stereolithography, additive manufacturing, DFAM, 3D Printing

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