WHITE PAPER

Media and Entertainment
Artificial Intelligence

Intel and Ziva Dynamics: Transforming Computer-Generated Imagery

With the help of Intel® artificial intelligence and machine learning, Ziva Dynamics is transforming how filmmakers create visual effects.

"We made conscious decisions in architecting Ziva's software to not only take advantage of key math and ML libraries of Intel's, but to ensure that any studio could integrate Ziva regardless of how they were generating animations or dealing with simulated characters—the inputs and outputs—to meet the technical needs of creative teams around the world."

—James Jacobs, CEO and co-founder of Ziva Dynamics

Introducing the Computer-Generated Imagery (CGI) Challenge

CGI visual effects (VFX) generally require a complex orchestration of expertise, technology, and often time-consuming and exhaustive creative iterations. Traditionally, they are created by first building characters and then animating those characters for the specific needs of shots, often requiring painstaking, frame-by-frame revisions. However, there are many variables in how characters move based on physics and size, their underlying anatomical structure, and more. As a result, when a visual does not look correct, artists and their teams need to go back to the drawing board to figure out exactly which layer or which creative contribution is not correct.

Ziva Dynamics addresses this problem with artificial intelligence (AI)-based simulation software that enables VFX artists to create creatures that look and move correctly based on the laws of physics. With this technology, teams can use parallel computer simulations and automation in place of linear, manual frame-by-frame design workflows.

The flagship Ziva Dynamics* product, ZIVA VFX*, is powered by a proprietary finite element method (FEM) solver that enables the simulation of anatomy, physics, and soft tissue for virtual humans and creatures. ZIVA VFX allows users to create computational models of the natural body features of real people and creatures. These models are then simulated through an offline computation process to achieve highly realistic results. The results of those simulations—the data describing the movement of virtual characters—can even be fed into machine learning (ML) algorithms that learn the body's movements.

As a result, ZIVA VFX introduces new use cases that compress character-creation times, shorten rendering and review workflows, and enable transmedia character assets to remove redundant production efforts across entertainment franchises and media formats, including film, games, and the augmented-reality (AR)/virtual-reality (VR)/mixed-reality (MR) field. Additionally, one of the hallmarks of Ziva Dynamics' character simulation is the standardization of the data models and algorithms that power the shape of people and creatures. By simulating consistent physically-based results, the outputs of ZIVA VFX offline simulations serve as effective training data for machine learning techniques.

AI Is Pushing the Boundaries of Simulation

The Meg, a Warner Bros. Pictures and Gravity Pictures film now in theaters, is a science-fiction action thriller film starring a pre-historic 75-foot-long shark, known as the megalodon. The film is based on Steve Alten's 1997 novel. The technology to bring the

Figure 1. Image courtesy of Warner Bros.

central giant creature, the megalodon, back to life in a realistic way certainly didn't exist back in 1997—but with the application of AI, supported by powerful Intel® technology, creating the megalodon has finally become possible.

"Today, we are dealing with very intelligent audiences," says Mohsen Mousavi, VFX Supervisor at Scanline VFX, Vancouver, the visual effects company in charge of creating the megalodon. "Obviously, when they're looking at a 75-foot creature on the screen in *The Meg*, they already know it's computer-generated. So it's very important for Warner Bros. to make sure we are putting the actual realism of the shark on the biggest screen."

According to Mousavi, ZIVA VFX was really the only tool available to accurately simulate the behavior of the shark, which enabled the company to create physics-based computational models of the natural features of the prehistoric megalodon, along with present-day sharks. Ziva Dynamics' groundbreaking technology lets users rapidly simulate soft-tissue materials, such as muscles, fat, cartilage, and skin, and embed real-world physics in every creation.

It all starts with creating virtual objects in the shape of bones, muscles, fascia, fat, and skin; these are the building blocks of any anatomical character. In ZIVA VFX, all of these layers are interdependent, just as one might expect, which is enabled through the use of attachments and the associated physics. The Ziva Dynamics FEM physics solver enables users to apply "material properties" to these objects, which specify the physical performance and behavior of each simulation object. The properties describe how flexible, volume conserving, and dense an object is.

As each layer of an animation is simulated sequentially through the ZIVA VFX solver to build the scene, the physical properties of the materials automatically react and respond to the movement of the creature. By mirroring the fundamental properties of nature, users achieve CGI characters that move, flex, and jiggle just as they would in real life. This approach empowers creatives by giving them a highly performant and scalable approach to achieve character results of unparalleled quality in all forms of digital media, including films, games, VR, AR, and more.

But for *The Meg*, creating animation wasn't just about animating giant creatures. It was also about creating the water through which sharks move at the same time. In perhaps the most iconic shot of the film, Scanline needed the Megalodon to reveal itself to audiences by launching out of the water to attack the human party on the boat, while taking a huge bite out of an existing catch on the boat. This required the virtual creature to interact with volumes of water—the sea—along with water spray in the air, the ship, the other creature, and finally fall back into the ocean. For the water, Scanline VFX used its proprietary fluid-effects software, called Flowline*, a technology for which the company received a Scientific and Technical Achievement Academy Award* in 2008. The question then became how to integrate the two products.

Everything in ZIVA VFX is described geometrically, and the animation inputs and simulation outputs are industry-standard. This creates a flexible environment for any studio and creative team to be able to integrate Ziva Dynamics software into its respective pipeline and technology choices without significant change required.

"We made conscious decisions in architecting Ziva's software to not only take advantage of key math and ML libraries of Intel's, but to ensure that any studio could integrate Ziva regardless of how they were generating animations or dealing with simulated characters—the inputs and outputs—to meet the technical needs of creative teams around the world," says James Jacobs, CEO and co-founder of Ziva Dynamics.

As a result, the creative team was able to construct scenes representing best-in-class fluid simulation using Flowline with its counterpart in character simulation and enabling a complex sequence to come to life. Animation was applied to the shark rig to represent the vertical path out of the water. Then running simulation passes with a representation of external forces (water and air) generated the right motion on the body of the animal. This, in turn, allowed the final fluid simulations to run, all based on physical realism.

Additionally, Ziva Dynamics provides an open source Python* framework and library, which enables artists to deconstruct and then rebuild a simulation rig programmatically.

To this end, ZIVA VFX provides a Python module, called zBuilder*, that handles the complexity of loading, saving, mutating, and mirroring character-simulation setups. This allows users to find efficiencies in iterating on characters and repurposing their work to new characters. It also encourages sharing development insights within the creative community.

ML and statistical fitting techniques can also be applied to transfer geometry and physics information from one creature to another, which was instrumental when transferring movement from one shark to another in *The Meg*. In other words, shark models only needed to be built once, and then that model's characteristics could be applied to all sharks and tweaked according to size. Not only does ZIVA VFX apply the laws of physics, but it provides users with the ability to change properties to achieve the exact effect required.

Scanline VFX's implementation represented a best-in-class combination of ZIVA VFX, powered by Intel technology, and backed by the expertise of Academy Award winners at both Scanline VFX and at Ziva Dynamics.

The Intel and Ziva Dynamics Partnership Brings a Giant Shark to Life

Ziva Dynamics software makes heavy use of Intel technology, which the company uses in all levels of its products. "Ziva software runs really well and is written against a lot of Intel software. You pair that with an Intel® Xeon® Scalable processor–based server environment, and you can do some really amazing work really quickly," says Michael Smit, Chief Commercial Officer for Ziva Dynamics. "Intel Xeon processors and Intel Xeon Scalable processor–based server tech powers a lot of the great work that's happening, both here at Ziva as we make software and with our customers, who are making characters and creatures for films and games."

ZIVA VFX is an Autodesk Maya* plug-in that enables character authoring and simulation of anatomy, physics, and tissue. Much of the software was written using **Intel® Math Kernel Library (Intel® MKL) PARDISO*** and **Intel MKL Linear Algebra Package* (LAPACK*)**.

As a result, Warner Bros. and Scanline VFX were able to recreate an extinct creature realistically and quickly. "When we work with Ziva, we can pretty much hit a button, and that can calculate and simulate the physical relations between all of the different layers of the very complex anatomy of any creature," says Mousavi. "You can get a simulation within a few minutes, look at the results, discuss, and iterate."

To put this in perspective, consider the following: for *The Meg*, Scanline VFX ran a whopping 2,719,885 simulation tasks, 1,769,681 2D image renders, and 1,370,143 3D image renders during the length of the project—averaging out to about 5,925 simulations and renders per day.

This feat is made possible using ZIVA VFX Batch*, a distributable, virtual version of the Ziva Dynamics solver that enables studios to distribute simulation jobs to render farms for greater processing capacity and create performant virtual characters for movie creation extremely quickly. This process is enabled by an Intel Xeon processor computation that can run in highly parallelized scenarios.

For Scanline VFX, parallelization made the project possible by using a render farm that consisted of 2,500 Intel Xeon processors with almost 100,000 cores, which were used to compute all of the needs of the movie. This enabled fast iterations and the ability to present multiple options to the director, enabling the best possible visual effects. "To create the massive computations that are needed in feature films these days, we really basically take our Intel Xeon processor–based render farm and combine it into a supercomputer," says Stephan Trojansky, President and VFX Supervisor at Scanline VFX. "We're not only processing on one computer … we're combining them together as if it would be in a supercomputer. And that's what makes it possible to create these massive simulations that you need for feature films."

In fact, Scanline estimates that if it had rendered the whole project on a single machine, it would have taken 113 years, 89 days, 16 hours, and 57 seconds. By contrast, rendering the whole project on its farm at full capacity would take 20 days, 16 hours, and 57 seconds.

Finally, Ziva Real-Time* is a real-time player and asset-conversion plug-in that allows film-quality characters to be used in ground-breaking new ways. For instance, it features real-time, poseable characters that animators can work with quickly and easily, along with performant characters that can run within interactive game engines for pre-visualization, virtualization, and innovative real-time performance.

At all levels, Ziva Dynamics applies ML solutions based on Intel technologies that help resolve modeling challenges. The use of ML enables VFX companies to continually automate more and more of the steps of character production and empower real-time interactive humans and characters that are nearly indistinguishable from live-action film. In addition, it drastically shortens iteration times. Taken together, these

Figure 2. Image courtesy of Warner Bros.

Figure 3. Image courtesy of Warner Bros.

capabilities enable film companies to do more. According to Anne Kolbe, executive vice president of visual effects at Warner Bros., Ziva Dynamics software enables Warner Bros. to tell stories that wouldn't have been possible even five years ago. "New technology like Ziva is supporting our films so that we can get more iterations out and have more of a feedback loop with our audiences before we release the film, so we really can deliver a project that they really want to see," she says.

A Deeper Dive into the Intel Backbone

According to Smit, using a wide array of Intel products and solutions makes Ziva Dynamics technology particularly effective. This functionality is due to the fact that Ziva Dynamics software relies heavily on a number of Intel libraries for optimal performance. As a result, users can efficiently generate results by running a number of offline simulations that would otherwise be extremely costly and inefficient.

The heart of the Ziva Dynamics solution relies on FEM physics simulation and ML algorithms to create and animate characters, which are run on Intel processors, like **Intel Xeon Scalable processors**, and on **Intel architecture–optimized frameworks**. Making use of these technologies enables incredible productivity for a studio, helping to reduce time to market—readily apparent in the creation of *The Meg*. "We heavily leverage Intel hardware in order to run our offline simulations," says Jacobs. "And that ends up being an amazing way to generate training data for our machine learning process, which also runs on Intel hardware."

Within ZIVA VFX, the **Intel MKL PARDISO** solver solves linear system equations in the FEM simulation software. This framework features highly optimized, threaded, and vectorized math functions that improve performance. Without PARDISO, Ziva Dynamics estimates that solves would take twice the time they currently do.

Ziva Dynamics also uses **Intel MKL Basic Linear Algebra Subprograms* (BLAS*)** for matrix multiplication in Ziva Real-Time, its real-time player and asset-conversion plug-in. With this product, users can take a virtual human "offline" asset and convert it into a character that runs in real-time environments. Additionally, simulation training designed to reduce the complexity of the data model and associated computation uses **Intel MKL LAPACK**.

Intel® Threading Building Blocks (Intel® TBB) is a widely used C++ library for shared-memory parallel programming and heterogeneous computing that provides a range of features for parallel programming and enables greater parallelization in both ZIVA VFX and Ziva Real-Time.

Finally, **Intel® VTune™ Performance Analyzer** assesses and fixes suboptimal computation speed, and **Intel® Inspector** assesses code correctness.

The Future of AI in Animation

For Warner Bros. and Scanline VFX, recreating an extinct 95-foot shark that moves within its watery environment realistically was an exciting challenge. AI and ML are radically altering how studios create their CGI characters, and they are offering some real advantages. In addition to giving studios the ability to create more lifelike characters more quickly, the AI in Ziva Dynamics' software generates clean simulation data that can be used to train additional ML models for follow-on projects. "Before AI, we had to plan every move and make sure that the software that we have can tackle every scenario. And that was a tremendous amount of engineering," says Mousavi. "With AI, you can basically leave the decision-making to the computer and have the system and the software do the heavy lifting for you. AI will help you to create a framework that thousands or millions of decisions can be made within the same algorithm."

Ziva Dynamics expects its software to continue to get better and better. Simulating anatomy and biophysics elegantly was a big first step; shifting from manual, artist-driven processes

to using data and computation is an enormous leap forward in the CGI industry. As hardware becomes more advanced, for instance, ZIVA VFX will be able to create new characters and models even faster, opening the door to smaller studios. Additionally, other Intel frameworks—such as the **Intel® Data Analytics Acceleration Library (Intel® DAAL)**—could further advance ML to automatically generate virtual humans and improve their characteristics and performance.

Ultimately, the practical applications for Ziva Dynamics' software are endless, and they are not confined to the cinema. For instance, imagine scenarios in which everyone can create a virtual self automatically for richly interactive applications in commerce, gaming, fitness, travel, and more—it could even be applied to multiple scenarios in healthcare.

What Can Intel AI Technologies Do for You?

For Warner Bros. and Scanline VFX, Intel AI is transforming the overall approach to CGI creation, leading to more and more sophisticated VFX that wouldn't have been possible even a few years ago. AI is fast becoming ubiquitous in our world. By allowing machines to learn, reason, act, and adapt in the real world, AI and ML are helping businesses unlock deeper levels of knowledge and insights from massive amounts of data. From movies to medical challenges, scientific research to predicting events and human behavior—the possibilities are endless.

To learn more about Ziva Dynamics and Intel, visit https://ai.intel.com/ziva-dynamics.

To learn more about Intel AI technology, visit https://ai.intel.com.

About *The Meg*

Warner Bros. Pictures and Gravity Pictures present a di Bonaventura/Apelles Entertainment Inc.*/Maeday Productions Inc.*/Flagship Entertainment Group* production, a film by Jon Turteltaub, "The Meg." The film was released Aug. 10 in 2D and 3D in select theatres and IMAX. It will be distributed in China by Gravity Pictures, and throughout the rest of the world by Warner Bros. Pictures, a Warner Bros. Entertainment Company. "The Meg" has been rated PG-13.

Printed in USA 0918/LR/PRW/PDF Please Recycle 337976-001US