Eye in the Sky With AI: UCSB Initiative Aims to Pulverize Space Threats Using NVIDIA RTX

UC Santa Barbara Professor Philip Lubin and his students are using AI and NVIDIA RTX A6000 GPUs to accelerate detection of hazardous asteroids on a collision course with Earth.

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When meteor showers occur every few months, viewers get to watch a dazzling scene of shooting stars and light streaks scattering across the night sky.

Normally, meteors are just small pieces of rock and dust from space that quickly burn up upon entering Earth's atmosphere. But the story would take a darker turn if a comet or asteroid is a little too large and heading directly toward Earth's surface with minimal warning time.

Such a scenario is what physics professor Philip Lubin and some of his undergraduates at the University of California, Santa Barbara, are striving to counteract.

The team recently received phase II funding from NASA to explore a new, more practical approach to planetary defense — one that would allow them to detect and mitigate any threats much faster and more efficiently. Their initiative is called PI-Terminal Planetary Defense , with the PI standing for "Pulverize It."

To help the team train and speed up the AI and machine learning algorithms they're developing to detect threats that are on a collision course with Earth, NVIDIA, as part of its Applied Research Accelerator Program , has given the group an NVIDIA RTX A6000 graphics card.

Every day, approximately 100 tons of small debris rain down on Earth, but they quickly disintegrate in the atmosphere with very few surviving to reach the surface. Larger asteroids, however, like those responsible for the craters visible on the moon's surface, pose a real danger to life on Earth.

On average, about every 60 years, an asteroid that's larger than 65 feet in diameter will appear, similar to the one that exploded over Chelyabinsk, Russia, in 2013 , with the energy equivalent of about 440,000 tons of TNT, according to NASA.

The PI-Terminal Planetary Defense initiative aims to detect relevant threats sooner, and then use an array of hypervelocity kinetic penetrators to pulverize and disassemble an asteroid or small comet to greatly minimize the threat.

The traditional approach for planetary defense has involved deflecting threats, but Pulverize-It turns to effectively breaking up the asteroid or comet into much smaller fragments, which then burn up in the Earth's atmosphere at high altitudes, causing little ground damage. This allows much more rapid mitigation.

Recognizing threats is the first critical step — this is where Lubin and his students tapped into the power of AI.

Many modern surveys collect massive amounts of astrophysical data, but the speed of data collection is faster than the ability to process and analyze the collected images. Lubin's group is designing a much larger survey specifically for planetary defense that would generate even larger amounts of data that need to be rapidly processed.

Through machine learning, the group trained a neural network called You Only Look Once Darknet. It's a near real-time object detection system that operates in less than 25 milliseconds per image. The group used a large dataset of labeled images to pretrain the neural network, allowing the model to extract low-level, geometric features like lines, edges and circles, and in and in particular threats such as asteroids and comets.

Early results showed that the source extraction through machine learning was up to 10x faster and nearly 3x more accurate than traditional methods.

Lubin and his group accelerated their image analysis process by approximately 100x, with the help of the NVIDIA RTX A6000 GPU, as well as the CUDA parallel computing platform and programming model.

“Initially, our pipeline — which aims for real-time image processing — took 10 seconds for our subtraction step,” said Lubin. “By implementing the NVIDIA RTX A6000, we immediately cut this processing time to 0.15 seconds.”

Combining this new computational power with the expanded 48GB of VRAM enabled the team to implement new CuPy-based algorithms, which greatly reduced their subtraction and identification time, allowing the entire pipeline to run in just six seconds.

One of the group’s biggest technical challenges has been meeting the GPU memory requirement, as well as decreasing the run-time of the training processes. As the project grows, Lubin and his students accumulate increasingly large amounts of data for training. But as the datasets expanded, they needed a GPU that could handle the massive file sizes.

The RTX A6000’s 48GB of memory allows teams to handle the most complex graphics and datasets without worrying about hindering performance.

“Each image will be about 100 megapixels, and we’re putting many images inside the memory of the RTX GPU,” said Lubin. “It helps mitigate the bottleneck of getting data in and out.”

The group works on simulations that demonstrate various phases from the project, including the ground effects from shock waves, as well as the optical light pulses from each fragment that burns in the Earth’s atmosphere. These simulations are done locally, running on custom-developed codes written in multithreaded, multiprocessor C++ and Python.

The image processing pipeline for rapid threat detection runs on custom C++, Python and CUDA codes using multiple Intel Xeon processors and the NVIDIA RTX A6000 GPU.

Other simulations, like one that features the hypervelocity intercept of the threat fragments, are accomplished using the NASA Advanced Supercomputing (NAS) facility at the NASA Ames Research Center. The facility is constantly upgraded and offers over 13 petaflops of computing performance. These visualizations run on the NAS supercomputers equipped with Intel Xeon CPUs and NVIDIA RTX A6000 GPUs.

Check out some of these simulations on the UCSB Group’s Deepspace YouTube channel .

Learn more about the PI-Terminal Planetary Defense project and NVIDIA RTX .

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