WHITE PAPER

AI for Embedded Defense is Here

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Introduction

An armed Humvee is moving at night thru a smoke-filled, urban battlefield. Using multiple displays, the crew has a 360˚ view that is daylight clear, delivered by an imaging system fusing data from optical, infrared, lidar, and radar sensors.

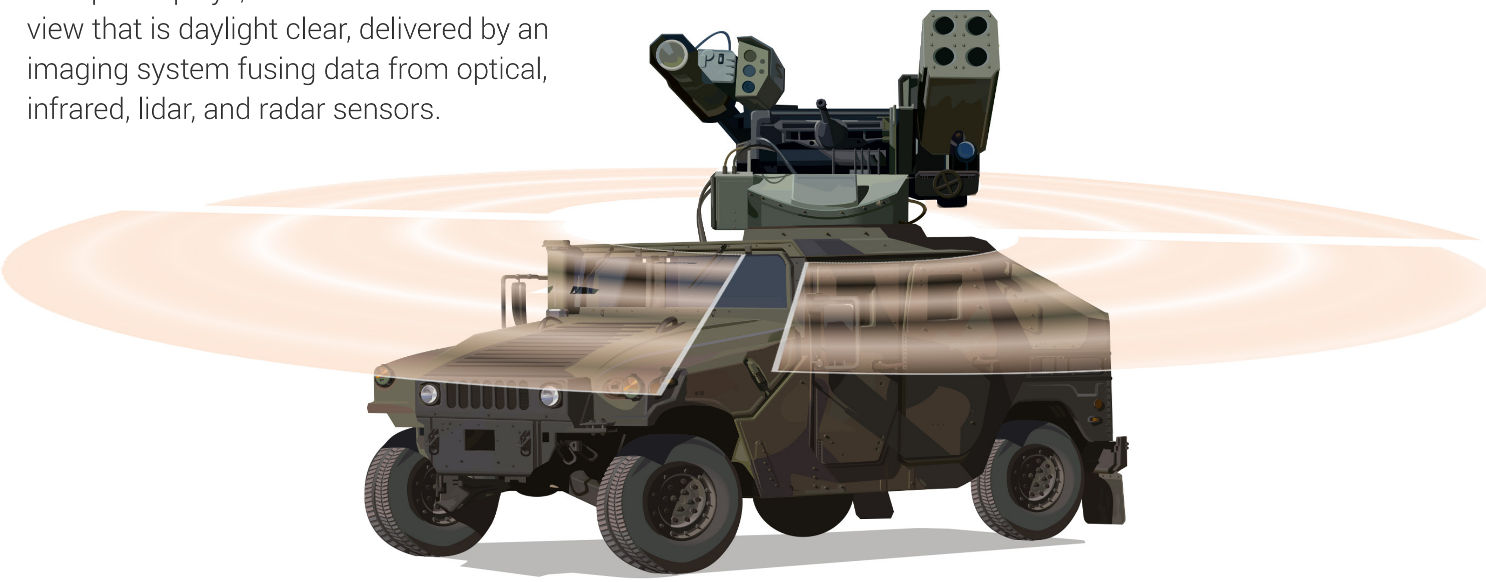

Figure 1: A Humvee with multiple sensors feeding image integration and AI-based applications

The imaging data, combined with RF input, is also feeding into an onboard AI capability that identifies objects and categorizes them into threat levels. A moving object is instantly focused on by sensors and a window on the crew's display zooms in; both the crew and the AI deep learning algorithms identify the moving object as a stray dog – no threat. The Humvee never pauses.

The AI capability is also continuously comparing the real-time data with recent aerial images, searching for anomalies. Moving into a street lined with still-standing buildings, an anomaly is identified, a van, up on cinder blocks, that was not there yesterday. Sensors focus in and the threat level moves to Extreme, as the van has not been burned, unlike every other vehicle in this area. Instantly, the Humvee stops, the crew is alerted and a high-energy, anti-IED microwave impulse is beam-formed toward the van, while RF sensors search the spectrum for potential emitters and communications.

The crew commander decides to reverse to a safe distance, then directs machine gun fire into the van. She is rewarded with a satisfying explosion.

The future is now

While this scenario may seem futuristic, the technology foundation is already here. A mammoth leap in embedded processing power is being harnessed to enable real-time AI applications based on deep learning techniques and sophisticated inference engines. In fact, advanced R&D efforts are already underway to build the first applications based on these linked technologies.

Abaco is at the forefront of this effort with the GVC1001, a rugged, evaluation-ready computing platform featuring the computing engines, I/O and software support that make deployable AI a reality for embedded defense. Based on the NVIDIA Jetson AGX Xavier System-on-Module, the GVC1001 delivers up to 10 TeraFLOPS (HP16) or up to 32 TOPs (int8) peak performance; it is, essentially, an embedded supercomputer.

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Figure 3: Unmanned convoys are moving closer to deployment

This enormous processing power is supported by broad array of high bandwidth I/O options, from dual 10GigE data plane pipes to dual CANbus ports, and packaged in a compact, rugged enclosure, designed for SwaP-constrained deployments. New program development is accelerated by a choice of mature, standards-based software development environments.

Powerful new capabilities
The GVC1001 will move large system embedded applications into small vehicles, vessels, and aircraft . For example:

- **360° situational awareness:** Providing warfighters with a 360-degree, real-time view of their physical surrounding. The focus is on allowing warfighters to understand the battlefield environment, rapidly recognize threats, and react quickly to a changing situation.
- **Multi-sensor EO/IR processing:** Generating images from sensor input collected across the visible and infrared segments of the electromagnetic spectrum. A critical function is motion imagery, delivered in all conditions, day or night.
- **Wide-area persistent surveillance:** Support for unique airborne cameras that can collect imagery across an area kilometers in diameter and then focus in on specific areas of interest within that area.
- **Hyperspectral sensor fusion:** Hyperspectral imagery collects the light intensity across a contiguous set of frequency bands, so that every pixel in the image contains a spectrum of values. When this data is combined with data from other sensors, for example LIDAR (Light Detection and Ranging), images with great precision are created.

Figure 2: GVC1001

- **Synthetic aperture radar (SAR):** A SAR sensor uses antennae movement to mathematically simulate a large fixed antennae aperture, creating high-resolution 2- or 3-D images. The computer power needed for the fixed antennae simulation used to limit SAR to large platforms.

The GVC1001's AI capabilities will also push still-emerging applications to new levels of effectiveness, including:

- **Autonomous ground vehicle operations:** Supply convoys without human drivers will help limit casualties in future conflicts. The technology is not yet operationally mature, but GVC1001 processing power remove will multiple bottlenecks, bringing it closer to deployment.
- **Counter-IED:** Detecting and neutralizing IEDs is a daunting challenge as insurgent tactics continue to evolve. Directed energy, hyper-spectral scanners, and ground-penetrating radar all offer potential as part of future solutions; implementing these technologies will demand computing capability at the GVC1001 level.

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Enabling technology
Packed into the GVC10001 are a wealth of features focused on supporting a new generation of ground-breaking embedded defense applications.

Processing
A 512 Tensor core, CUDA-capable Volta GPU and an 8-core ARM CPU provide the immense compute power needed to implement AI capability for advanced digital maps, image recognition, image segmentation, object localization, image fusion, image stabilization, object tracking and image correction. No other embedded platform has the processing horsepower that can apply AI to imagery in real time.

Memory
An advanced memory subsystem ensures that the GPUs and CPUs are never waiting for information to process. 16GB of LPDDR4 synchronous RAM is capable of a 137GB/s transfer rate, for very high bandwidth movement of data in and out of the compute engines. Tiered memory operations are further supported by 32GB of eMMC 5.1 flash memory.

I/O
Dual 10GigE data plane pipes support multiple GigE camera aggregation, delivering high-resolution, cross-spectrum image data to the compute engines. Two CANBus ports make the GVC1001 ideal for ground vehicles, while GigE, USB, and DisplayPort interfaces enable connection to all forms of sensors, specialized devices, and sub-systems.

Storage
256 GBytes of NVMe SSD bulk storage is provided as a standard feature for storing moving maps, imagery, or any other mission critical data.

Rugged Enclosure
Even as a first generation product, the GVC1001 is packaged in a rugged, small form factor enclosure. With base-plate, conduction cooling, it is ready for evaluation in mobile platform programs, including autonomous vehicles.

Application Development
The GVC1001 is supported by two mature software development environments, NVIDIA's JetPack SDK and Abaco's AXIS ImageFlex image processing and visualization toolkit

The JetPack SDK is a comprehensive solution for building AI applications. It includes OS images, libraries, APIs, samples, and documentation to jumpstart new development. AI tools include (1) TensorRT, a high performance deep learning inference runtime for image classification, segmentation, and object detection neural networks, and (2) CUDA Deep Neural Network (cuDNN) a library with high-performance primitives for deep learning frameworks, including support for convolutions, activation functions and tensor transformations.

ImageFlex gives developers a powerful set of high-level application programming interfaces (APIs) that exploit the full capabilities of the NVIDIA GPUs while abstracting the complex details. It provides an innovative, high performance image fusion function that can fuse image data from multiple sources of different resolutions. The algorithm adaptively adjusts to pull through the regions of highest contrast in each source to produce a fused result, enabling an observer or processing layer to act on the combined information of the sources. With ImageFlex, AI applications for image processing and manipulation are easier to develop, test, debug and maintain, while time to deployment is reduced by a factor of 5.

Engage with Abaco to evaluate this platform
Abaco is committed to supporting powerful, new, cutting-edge embedded applications with the GVC1001. As an NVIDIA Jetson Preferred Partner in the military/aerospace segment, we have early access to NVIDIA's design and support resources, so we can innovate earlier, and be on the leading edge of NVIDIA's product roadmap.

That technology provider partnership is complemented by customer partnerships. We understand that close cooperation with customer visionaries and engineering teams is key to success and we welcome input and ideas that will help build on this powerful platform.

Engage with Abaco's embedded defense experts to explore how the GVC1001 can move your projects and programs to new levels of effectiveness. Evaluation units are available, so your team can implement prototype application software and explore new system configurations.

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Conclusion

Embedded, many-core supercomputing is now ready for defense applications, in a rugged, deployable form factor. The GVC1001 is configured so this tremendous computing power can support a new generation of AI applications, from hyperspectral image fusion to autonomous vehicle operations.

Abaco embraces the challenge of making this capability work for a next generation of defense programs. We are engaging with like-minded Defense contractors to move past simple technology upgrades to radically new solutions that will give our warfighters every possible advantage in future conflicts. With more than 30 years' experience in embedded defense and an active presence in hundreds of national asset platforms on land, sea and in the air, Abaco Systems is trusted where it matters most.

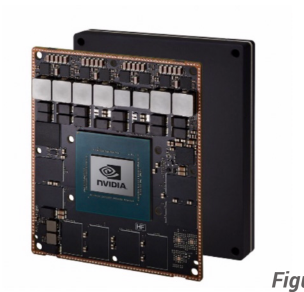

Figure 4: The Jetson AGX Xavier

The NVIDIA Jetson AGX Xavier System-on-Module

The new Jetson AGX Xavier module makes advanced AI-powered application possible, running on as little as 10W and delivering up to 32 TOPs. It benefits from a rich set of AI tools and workflows, so developers can train and deploy neural networks quickly.

AI Performance	32 TOPs
GPU	512-core Volta GPU with Tensor Cores
CPU	8-core ARM v8.2 64-bit CPU, 8MB L2 + 4MB L3
Memory	16GB 256-Bit LPDDR4x | 137GB/s
Storage	32GB eMMC 5.1
DL Accelerator	(2x) NVDLA Engines*
Vision Accelerator	7-way VLIW Vision Processor*
Encoder/Decoder	(4x) 4Kp60 | (6x) 4Kp60 (HEVC)
Size	105 mm x 105 m

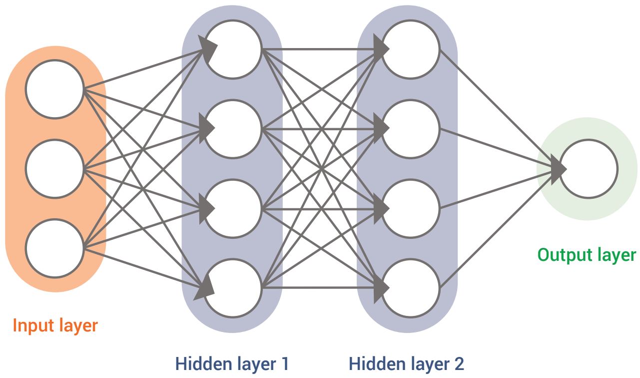

Figure 5: In deep learning, data moves thru multiple layers of manipulatio and arrangement

Implementing AI

Deep learning (also known as deep structured learning, hierarchical learning or deep machine learning) is a form of machine learning that uses multiple layers of logic to extract increasingly detailed information from input data. It is frequency applied to image recognition problems, where input data comes in pixel form and layers of logic will first define edges, then arrange those edges, then recognize certain characteristics of those arrangements and, ultimately, identify a vehicle, building, animal or human. The 'deep' in 'deep learning' refers to all the layers that the input data passes through as it is manipulated and arranged into meaningful information.

In an AI system, **inference engines** are used to apply logical rules to a knowledge base to deduce new information. The logic commonly used can be represented by IF-THEN statements, which are applied with either forward chaining or backward chaining. Forward chaining starts with existing data, which may be brand new data, and uses inference rules to build more data. For example, vehicle X is new to this area, vehicle X is abandoned, and the enemy has easy access to this area. Newly abandoned vehicles in an area of enemy access often contain IEDs. Thus, vehicle X may contain an IED. This type of logic is often referred to a data-driven. Backward chaining works backward from a consequent, or an assumption, to see if any available data supports that assumption. To use a naval scenario, suppose multi-sensor data is gathered about an approaching fishing boat. If the fishing boat is assumed to be a threat, then one of several sets of facts (for example, speed and direction or crew size and weapons) will also be true. If the imaging verifies one of these sets of facts, then the threat assumption is proven true.

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