CJADC2 interoperability: AI-/ML-based sensor fusion at the edge

By Dominic Perez

The U.S. Department of Defense (DoD) Coalition Joint All-Domain Command and Control (CJADC2) system is revolutionizing modern military operations by integrating data across all military domains: land, air, sea, space, and cyberspace. For effective multidomain operations, sensor data needs to be processed rapidly and shared across different military branches. Achieving this level of interoperability requires sophisticated technologies to handle vast and complex data streams in real time, particularly artificial intelligence (AI) and parallel sensor fusion processing at the edge.

AI and machine learning (ML) algorithms, vital enablers in CJADC2, help to automate decision-making by rapidly analyzing diverse data sets from various sensors and sources. These algorithms excel at processing complex sensor data, identifying patterns, generating actionable intelligence, and perhaps most importantly, they do not get tired or distracted as a human operator might. In the CJADC2 environment, information from different systems – whether airborne, space-based, or ground-based sensors – must be harmonized into a common operational picture (COP).

For interoperability, AI serves as a bridge between disparate data systems and protocols. Military platforms and sensors were often developed independently and are not inherently designed to communicate with each other. AI-driven systems can standardize data formats and protocols, transforming raw sensor data into actionable intelligence that can be accessed and used by all branches of the military, our allies, and coalition partners. Generating a COP requires data from multiple sensors to be combined and correlated to create a unified understanding of the environment. For example, radar, video, and infrared sensors may all capture data at the same time, but each sensor offers a different perspective of the same battlefield.

Appropriately configured CJADC2 systems can analyze all sensor inputs concurrently, fusing them into a more detailed operational picture. This ability to analyze real-time sensor data is critical in rapidly changing combat environments, where delays could cost lives. AI algorithms drive sensor fusion by analyzing relationships between data streams and identifying threats or opportunities that individual sensors might miss.

Edge computing is integral to CJADC2 because it enables the processing of sensor data close to where it is collected, rather than relying on a centralized data center. When data travels back to a central command, delays can undermine military operations. While a data center can handle orders of magnitude more processing, edge systems can operate independently in communications-denied environments. This factor is crucial for ensuring real-time actionable information is available to commanders regardless of battlefield dynamics. Processing data at the tactical edge ensures that operators can act immediately based on real-time data.

Edge systems, such as Curtiss-Wright's PacStar 454 GPU enhanced server, provide the computing power necessary for processing large-scale AI inference and sensor fusion at the tactical edge. These systems can be used in mobile, vehicle-mounted, or remote environments.

AI- and ML-powered sensor fusion at the edge represents the future of CJADC2 interoperability. The military can leverage these technologies to create a seamless, real-time understanding of the battlefield in order to make faster, better-informed decisions. Edge computing platforms are key to this future, enabling real-time processing of vast amounts of sensor data in austere environments. However, implementing AI and sensor fusion in CJADC2 faces several challenges:

1. Data collection: The old adage "garbage in, garbage out" applies both to AI-based systems and legacy system designs. Data from the battlefield must be collected and added back into datasets used for training/retraining AI models. Ideally, data is stored at the edge and forwarded to a data warehouse when connectivity allows.
2. Data standardization: AI systems must handle different data formats and protocols from various sensors, making it critical to establish standardized formats and labeling systems for sensor data.
3. Security: As AI systems become integral to processing military data, they also become prime targets for cyberattacks. Secure and encrypted communication between sensors and AI systems must be ensured. National Security Agency (NSA) Commercial Solutions for Classified (CSfC)-certified data-at-rest (DAR) solutions provide dual-encrypted data storage solutions.
4. Scalability: As the number of sensors and data streams increase, AI systems must scale effectively, maintaining performance while ensuring interoperability across different military platforms.

These challenges related to data standardization, security, and scalability, must be addressed to fully realize the great potential of CJADC2.

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