2015

Big Data Architecture and Analytics (BDAA) for Improving Combat Identification (CID) and the Common Tactical Air Picture (CTAP)

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NAVAL POSTGRADUATE SCHOOL

NAVAL RESEARCH PROGRAM

MONTEREY, CALIFORNIA

Project Title: Big Data Architecture and Analytics (BDAA) for Improving Combat Identification (CID) and the Common Tactical Air Picture (CTAP)

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Performance Period: 10/1/2014-9/30/2015

Prepared for the Topic Sponsor: OPNAV N2/N6 F33 Integrated Fires

Topic Sponsor POC: Mr. William Treadway
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EXECUTIVE SUMMARY

Project Summary

In summary, in the past year, the research team found that the AEGIS combat system, CEC, and Link 16 are critical systems supporting combat identification (CID) for sharing data among distributed platforms, correlating and fusing data, and displaying tracks. The CID process was found to rely on the application of doctrine and the collaboration of multiple decision makers. The process was found to be significantly manual and very reliant on the experience level of analysts and decision makers. The team found that Big Data Architecture and Analytics (BDAA) shows significant potential to improving Common Tactical Air Picture (CTAP) and CID. The team also found that BDAA could be leveraged to develop advanced data models as part of data integration, data storage and retrieval; and it could support advanced automated decision aids and resource management capabilities for battle management.

Background

Accurate, relevant and timely CID enables the warfighter to locate and identify critical airborne targets with high precision. An effective CID capability optimizes the use of long-range weapons, aids in fratricide reduction, enhances battlefield situational awareness, and reduces exposure of U.S. forces to enemy fire. CID plays an important role in generating the CTAP which provides situational awareness to the air warfare decision-makers.

The amount of exponentially expanding and diverse data generated by intelligence, surveillance, and reconnaissance (ISR) sensors has created a Big Data environment that poses a CID challenge. Traditional information systems cannot meet the timelines required for air picture CID when presented with extremely large amounts of data. Nor can they process and analyze additional types of data such as information from the Internet, social media, and commercial airline information. New information system technology and methods, such as BDAA, show promise for handling and analyzing the rising tide of sensor and non-sensor data, and fusing it in a timely manner to enhance CID dramatically.

Findings and Conclusions (to include Process)

In the past year, the research team participated in the exercise Northern Edge at Alaska, worked with domain experts on the USS Howard, the Pacific fleet Naval Air Weapons Station (NAWS) at China Lake, the MIT Lincoln Lab and the Navy Tactical Cloud at Dahlgren. The team has studied current CID methods used in existing Joint and Naval systems including platforms, sensors, networks, and data/databases. The team's primary questions for Phase I of the project were:

1) What information is used for the current CID process?
2) What data sources, displays and fusion processes are currently used for CID decision makers and end-users?
3) What are the challenges for the current CID process?
4) How can BDAA assist in CID?

The team found that current CID processes included the use of Naval and Joint combinations of:
- Platforms: destroyers, cruisers, carriers, F/A-18s, E-2Ds
- Sensors & data sources: radar, Forward Looking Infrared (FLIR), Identification Friend or Foe (IFF), Precision Participation Location Identifier (PPLI), and National Technical Means (NTM)
- Networks: Link-16, Cooperative Engagement Capability (CEC), Global Command and Control System (GCCS), and Global Information Grid (GIG)
- Decision makers: Air and Missile Defense Commander (AMDC), Air Warfare (AW) Officer, and Tactical Action Officer (TAO).

The team identified the following CID air picture challenges for the Navy:
1) An extremely short dwell time for fusion, decision making, and targeting.
2) Uncertain and/or missing data outside sensor (e.g., radar, radio) ranges
3) Track picture uncertainty (track conflicts, multiple objects per track or multiple tracks per object).
4) Manual decision-making, group decision-making and overwhelmed decision-makers (i.e., complex threat environments can create situations in which decision-makers can be overwhelmed by large amounts of data, uncertain track pictures, and complicated if-then doctrine statements)
4) Hard-to-detect anomalies and a lack of predictive analytic capabilities.
5)Manual methods for incorporating electronic warfare (EW) and non-cooperative sensor measurements and signature databases, into the CID process.

The team explored how BDAA could address these challenges. BDAA technologies have been developed in the commercial world to provide: 1) data collection, ingestion, integration and safe storage, 2) parallel/distributed processing, and 3) deep analytics. The team developed a Big Data Architecture concept for CTAP and CID called the CTAP Cloud Concept. The CTAP Cloud Concept, which could be physically associated with a Big Data cloud implementation such as the Naval Tactical Cloud (NTC), is used to store the additional data sources that are not traditional CTAP and CID data sources, such as temporal, spatial and organic sensor data that are collected but not currently used (e.g. AEGIS residual data), open sources flight schedules, advanced (EW) signature data sources and Intel. These new data sources could be fused and analyzed in parallel using deep analytics in the CTAP cloud. The resulting knowledge repository, i.e., Smart Data, could be searched, matched and cross-validated with real-time data streams of traditional sensor and track level data in the current CTAP and CID platforms, used by the warfighters to provide new and enhanced situational awareness. For example, the cloud could send or push Smart Data (e.g. early warnings or alerts generated based on BDAA) to various platforms within a battlespace. A platform with partial or uncertain sensor/track data could send a real-time query to the cloud to find a higher certainty match with a higher probability or confidence. The Smart Data push and pull would have a relatively small data size and therefore not strain current networks for transmission between platforms.

The team also studied Big Data Analytics to address CTAP and CID challenges that included unsupervised learning, self-taught learning, deep learning, pattern recognition, anomaly detection, and data fusion. The team developed and selected machine vision and deep learning algorithms for improving object recognition, classification accuracy and certainty of air objects by associating, correlating, and fusing heterogeneous data sources that do not share data models. The team developed pattern recognition and anomaly detection that could be used for identifying intent, air picture event anomalies or launch predictions. The team provided evidence for the selected tools and methods on how to fuse tactical data such as infrared, Electro-optical (EO), and radar with alternative data such as text-based data from open Internet and social media sources to improve object recognition and predict interesting events.

Recommendations for Further Research

In the follow-on research program, the team will provide additional evidence through further collaboration and experimentation. The team plans to further develop the CTAP Cloud Concept and associated analytics, as well as pursue data models and battle management tools.