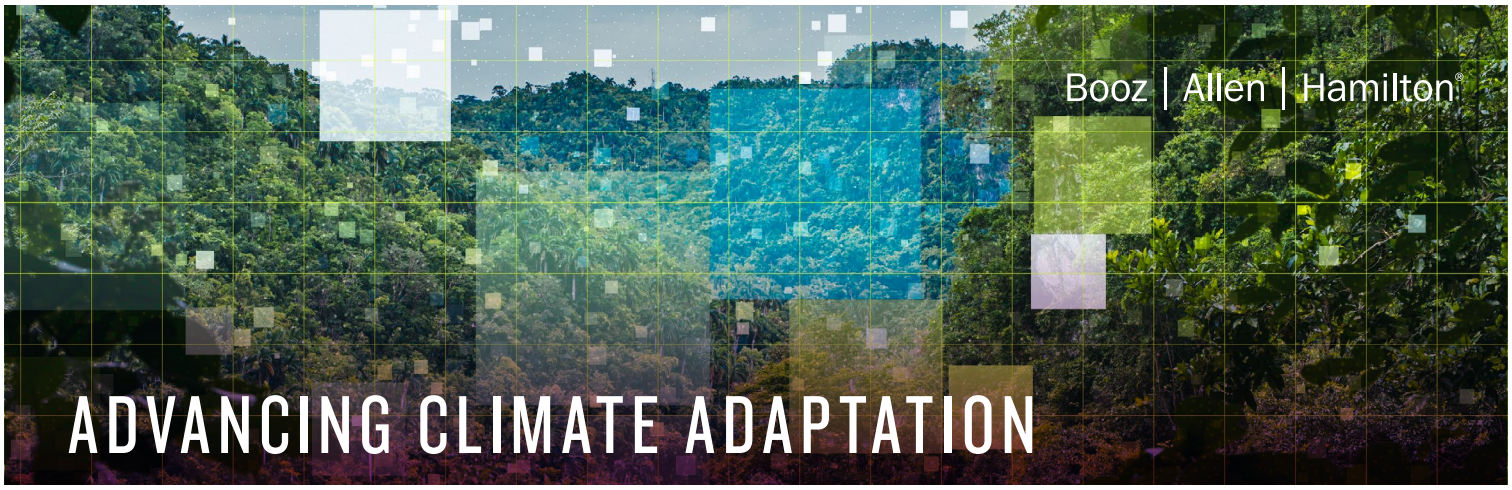

Advancing Climate Adaptation Through Data Fusion with AI/ML

INTRODUCTION

Extreme weather conditions, drought, flooding, wildfires, heatwaves, and other increasingly frequent and intense natural disasters provide dramatic proof of the escalating climate crisis. Environmental information is critical to understanding these devastating events and making decisions about how to respond to and prepare for them. Many organizations collect data streams from in situ measurements, remote sensing observations, airborne platforms, personal devices, and social media to better evaluate climate vulnerabilities, develop adaptation solutions, and respond to climate impacts. This information may be incomplete, inconsistent, or imprecise. Data fusion from different sensors can help relevant organizations more clearly define the environmental system.

But increases in the amount and variety of data may impede the integration of diverse datasets. Traditional data-merging approaches fall short of the adaptability and scalability necessary for working with big data. Yet, it is possible to use advanced information technology (IT) to catch up with complex environmental data. Relevant technologies include artificial intelligence (AI), machine learning (ML), cloud computing, high-performance computing, and quantum computing.

In addition to intelligently thinning data to control costs, storage space, and transmission speed, there are issues in preparing environmental data for analysis and maintaining data quality control and quality assurance.

DATA FUSION

Booz Allen's point of view centers on fusing geospatial data from multiple distributed sources with AI/ML approaches to achieve lower detection error probability and higher reliability. For example, many Earth observations are from polar-orbiting satellites collecting data at high spatial resolution but relatively low temporal resolution. Spatial modeling for these data is computationally challenging even at a single time point. Supplementing satellite data with ground observations becomes useful for supporting both nowcasts and predictive modeling. Data fusion can be conducted in four elements:

Signal and pixel fusion are data transformations that harmonize sources, achieved by statistical methods, like local mean matching, Principal Component Analysis (PCA), regression analysis, and statistical region merging. However, these methods require more regular measurements, collection of large bodies of data, and statistical treatment.

Feature and decision-level fusion extract descriptors, usually features or covariates that describe the data following a specific problem-dependent procedure. These features can be further processed by applying algorithms and different processing paths with fusion at the decision level.

The desire to push AI frontiers from the network edge to the data source: Munir et al. (2021) showed that combining AI with data fusion can increase speed up to 9.8 times while reducing energy consumption up to 88.5% over AI without data fusion.

Data fusion either maintains or improves the accuracy of AI in most cases. Decentralized edge AI with data fusion could be useful for both government and commercial applications.

Common data fusion in environmental observation includes fusing spatiotemporal data with different grid sizes, spaceborne and airborne data, and remote-sensing data with ground-based measurements. Widely adopted approaches include vector machines and deep learning neural networks. Bayesian procedures or the dynamic fused Gaussian process are often applied as well.

CURRENT STATUS AND FUTURE TRENDS IN GOVERNMENT AND INDUSTRY

Two big challenges will become increasingly significant as more data is collected daily: extracting information in highly unstructured data and achieving understanding through information fusion. Having scalable AI/ML algorithms enhances model accuracy and improves model consistency and interpretability in the big data era. This aligns with the President's Emergency Plan for Adaptation and Resilience (PREPARE), launched in November 2021 to adapt and manage climate change impacts. The Plan designated relevant federal agencies to increase their climate information service capacity, federal agencies to increase their climate information service capacity, and data fusion could be a key component in better understanding and responding to climate hazards.

For the industry, fast-developing IT technology, data collection, and decision-making are moving toward decentralization, using more localized, personalized, and real-time data to effect better resolutions and higher frequency prediction results. While more data from the proliferation of sensors is being used, transferring data to the cloud is often infeasible due to limited network bandwidth and real-time constraints. Thus, it is a desire to push AI frontiers from the network edge to the data source. Figure 1 provides a framework for data fusion and AI at the edge. Decentralized edge AI with data fusion is useful for both government and commercial applications.

WHY BOOZ ALLEN HAMILTON

- Booz Allen is the largest provider of AI services to the public sector:
  - Booz Allen has delivered on more than 120 AI projects.
  - Our practice consists of over 500 AI/ML practitioners and 4,000 data scientists.
  - Booz Allen has 63 AI patents.
  - Booz Allen has volunteered 83,830 hours of pro bono work to advance science and social good.
- Our integrated AI/ML data fusion solutions have resulted in 3–25 times performance improvement across processing petabytes of geospatial Earth observation data.
- Booz Allen has provided big data and scientific-focused AI solutions for numerous federal agencies with defense, civilian, and science missions. Booz Allen has produced eight academic publications and developed four public data science tools in the cloud.
- Booz Allen builds open data platforms that allow organizations to leverage the latest AI/ML modeling techniques and incorporate them immediately into the platform and technical baseline.

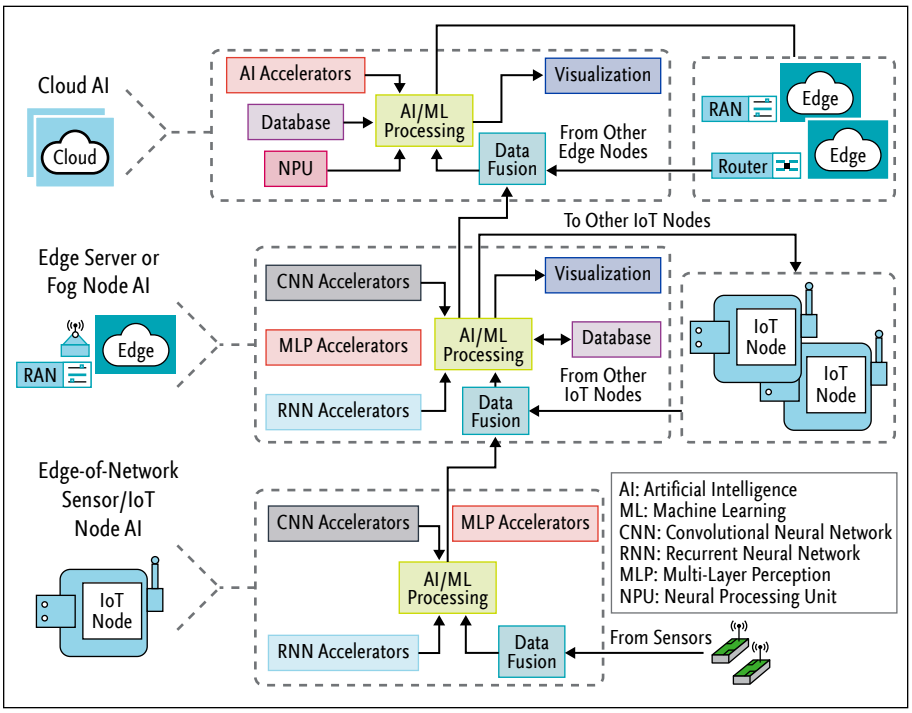

FIGURE 1:
Framework for data fusion and AI at edge.

Munir, A., Blasch, E., Kwon, J., Kong, J., and Aved, A. (2021). Artificial Intelligence and Data Fusion at the Edge. The Institute of Electrical and Electronics Engineers, *Aerospace and Electronic Systems Magazine,* 36(7), 62-78.

About Booz Allen

Booz Allen is the established leader in scientific-enabled missions for the federal government. Booz Allen serves as the prime mission systems implementor across multiple federal programs spearheading climate, health, and energy to solve our nation's most complex challenges.

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