Machines

can see, hear and learn — from humans

Human-centric machine learning in India

BY BHAGYASHREE CHAUDHARI AND DR. SEEMA CHOPRA, BOEING INDIA

Connection is critical. To the untrained eye, the thousands of wires tucked into the walls of every aircraft look like a perplexing puzzle, a snarl of complication. But followed from source to object, each wire leads to a purpose. Each connects to a job the aircraft must execute. If overall aircraft performance can be achieved, even improved, by fewer connections, all the better.

Fewer wires can foster more efficient production and maintenance and, as a result, improve safety and quality.

Digitization is helping in that quest for ideal connectivity using fewer wires. Automation and digital tools make processes more consistent, repeatable and safe. Machine learning (ML) technology and enhanced software tools can strengthen quality and save thousands of labor hours. But to maximize possible gains from these tools, it takes teamwork, creativity and innovation.

WIRED UP
Nikki Then inspects a wire bundle on a tanker in Everett, Washington.

Photo taken before Boeing implemented COVID-19 pandemic safeguards.
PHOTO: MARIAN LOCKHART/BOEING

MACHINE TEAM

Boeing India team members (top, from left) Bhagyashree Chaudhari, Adarsh Vittal Shetty, (bottom, from left) Dr. Seema Chopra, Neha Wani, Anand Kumar, Rohit Kumar and Baby Rachel collaborate virtually to devise a novel approach to machine learning for aerospace application.

PHOTOS: BOEING INDIA

The team at Boeing India Engineering & Technology Center (BIETC) in Bengaluru, in collaboration with colleagues in the United States, has been applying ML technology and automation tools to improve and accelerate the transition of wiring designs from legacy formats to digital enterprise data standards.

BENGALURU BEAUTY

The Boeing engineering and technology campus in Bengaluru, Karnataka, will conduct core engineering and research for Boeing's iconic products as well as future platforms. The campus will be one of the largest for Boeing outside of the United States.

IMAGE: BOEING

Upgrade to digital:
Wiring design takes time

Wiring designs are the assembly of electrical wires that transmit electrical power within an aircraft. Each design comprises anywhere from 20 to 1,500 components, and each wiring design is associated with several data points.

The upgrade from legacy formats to digital enterprise data standards required extensive manual data formatting. In fact, it took the team, on average, 18 hours to transfer a single design while synchronizing wiring data, capturing cable length and adding individual component part numbers. This also increased the chances of human error. And to update any such incorrectly translated data, an engineer had to redo the entire wire design, which could take more than 120 manual hours.

PROOF OF CONCEPT
A CH-47F(I) Chinook for the Indian Air Force participates in a flight training exercise in Middletown, Delaware. Machine learning increases safety and lowers costs when building H-47 helicopters.

PHOTO: FRED TROILO/BOEING

Critical thinking and creativity:
Core tenets for automation

Engineers in the Electrical Design Integration (EDI) group knew manual translation of the designs is a tedious job with repetitive tasks. It is also highly inefficient, as almost 50% of the data may be rejected by the new system due to unacceptable quality. The team brainstormed and defined four core tenets for automation to resolve these issues:

- First-time quality — imperative in all aspects of electrical design.
- Engineering productivity — constantly drives speed and efficacy.
- Digital thread — must exist through all design phases.
- Automation — drives quality and engineering efficiency.

With industry advances in artificial intelligence (AI) and ML, it won't be long before design tools incorporate ML as design aids for the user. Therefore, the EDI team decided to collaborate with the AI/ML team to explore the integration of ML-based automation for translating wire designs.

ML automatically corrected the wiring design with minimal human intervention and validated the design without extensive rework.

The algorithm was implemented for hundreds of Boeing H-47 Chinook heavy-lift helicopter designs for proof of concept. The ML model resulted in harness deliveries with expected project design quality and a 30% reduction in design cycle time.

The team automated the process by using image processing for reading and extracting details from the wiring design and used natural language processing to visualize the relationship between various components in the form of knowledge graphs. The AI/ML-based executable automation tool is capable of designing hundreds of wiring diagrams with required design properties automatically — and in a short span of time.

There's immense potential to reuse and replicate the technique. The model was successfully implemented on some key defense aircraft as well. The team is now leveraging its early success to develop a proof of concept to automate migration of wiring designs in commercial aircraft. This model will provide a significant opportunity for data migration savings in terms of labor hours and cost.

CHINOOK INSIDE LOOK
Technician Keith Repko performs a wiring installation in a Chinook helicopter at the Boeing site in Ridley Park, Pennsylvania.

Photo taken before Boeing implemented COVID-19 pandemic safeguards.
PHOTO: BOB FERGUSON/BOEING

Machine learning plus machine teaching:

Adds up to aerospace improvement

Human-centric machine learning happens when the machines learn from the data, from history and from the subject matter expert. Then machine teaching occurs when algorithms learn from electrical engineers.

The strong working relationship between the EDI engineering domain experts, embedded software engineers and ML experts led to this significant process improvement. By recognizing the human aspect while developing the ML models, this system still keeps domain knowledge at the center of the entire development cycle.

It paves the way for newer possibilities for human-centered ML.

As the Boeing India team embraced the opportunity to convert legacy tool data to digital enterprise standards using ML algorithms, they demonstrated creativity and engineering innovation. As a result, they generated a customized business solution that brings the best out of analytics/ML methodology — and could be applied across the enterprise. **IQ**

PHOTO: YUICHIRO CHINO/GETTY

ABOUT THE AUTHORS

Bhagyashree Chaudhari (left) is an engineering manager in the Electrical Design Integration group at Boeing Engineering, Test & Technology in India. She leads an Electrical Wiring and Harness engineering team that supports multiple platforms across various business units.

Dr. Seema Chopra (above) is a Boeing Technical Fellow in artificial intelligence and a member of the System and Analytics group at Boeing Research & Technology in India. Her current work includes developing next-generation advanced health management technologies using real-time streaming airline data and big data platforms.

PHOTOS: BOEING