IDA Research Summary

Using Machine Learning to Improve Readiness

Advances in machine learning techniques and computing technologies enable new insights from extensive Department of Defense (DoD) personnel, logistics, operations, and financial data. Harnessing this information could significantly improve DoD's effectiveness and efficiency in meeting its missions.

In partnership with the Office of the Under Secretary of Defense for Personnel and Readiness, IDA has developed a versatile toolkit called the Finite-Interval Forecasting Engine (FIFE). FIFE can forecast events impacting specific persons, military units, organizations, or objects over a variable time horizon. It combines a flexible suite of machine learning algorithms with large amounts of data to predict when meaningful events will occur. For each inquiry it produces a unique model to capture patterns in the provided data and to forecast outcomes for each observed individual or object, which can then be used directly or aggregated across any desired population subset. IDA has developed FIFE in a manner that supports adaptive reuse, collaboration, and open-source development and has published the code to the Python Package Index.

The flexible and modular nature of FIFE facilitates its use across DoD and enables predictions such as:

- How long a soldier will serve on active or reserve duty before separating from the military;
- The expected time until each vehicle or aircraft in a fleet requires significant maintenance;
- How long a unit's supplies will last under various environmental and operational conditions;
- The recovery time needed for a soldier to return to duty after an injury or illness; or
- A unit's expected readiness level in future periods.

(continued)

May 2020
NS D-10809

Beyond purely predictive applications, machine learning techniques can be integrated into causal analyses to provide insight into complex policy questions such as:

- **How do changes to military compensation structure affect future retention?**
- **How might various recruiter assignments impact flows from different accession sources?**
- **How do changes to equipment maintenance procedures affect time until equipment failure?**
- **How should occupational skills be distributed across grades to ensure force readiness?**
- **How can DoD optimize time-on-station requirements to suit operational needs and service member preferences?**

In one application of FIFE, IDA researchers generated a decision tree model and a neural network model that predict military personnel retention with high accuracy. Known as the Retention Prediction Model (RPM), this tool estimates the probability that any given service member will remain in the military for any specified time horizon. The RPM uses data on individuals serving between January 2000 and the present to produce person-level retention predictions. Using data on two randomly selected service members that the model has not observed previously, one of whom separated from the military within one year, RPM Version 1.0 identifies the separating member 88% of the time. Extending the time horizon for up to 18 years, the model correctly selects the separating member at least 78% of the time.

The research team also used FIFE's built-in capacity to generate automatically two types of traditional forecast analyses, based on the proportional hazards and interacted fixed effects methods. This allowed the research team to compare performance between the RPM's machine learning models and the traditional approaches commonly used by military personnel managers. The RPM implementation significantly outperformed traditional methods in forecasting active duty attrition at all examined forecast dates. For example, when forecasting which members would leave service within the next 12 months, the RPM correctly identified nearly twice as many separating members as were identified using the traditional methods.

Accurate forecasts of personnel retention can inform DoD leaders about likely upcoming changes in the size and shape of a specific workforce, career field, or unit. Leaders can thus anticipate shortfalls in specific occupational fields, plan for varying expected career lengths among a diverse population, and tailor recruiting and other policies accordingly. For example, IDA researchers supporting the 13th Quadrennial Review of Military Compensation used the RPM to evaluate the retention implications of modifying the existing military compensation structure.

Application of FIFE to personnel retention prediction illustrates how advanced analytic techniques can exploit rich data to generate actionable insights. The capability to predict future outcomes for various complex processes is a powerful tool that DoD leaders can leverage to improve the readiness, lethality, and efficiency of U.S. Armed Forces.

Julie Lockwood (formerly Pechacek), jlockwood@ida.org, leads the Human Capital Group in the Strategy, Forces and Resources Division (SFRD) of IDA's Systems and Analyses Center. For this project, Julie led a team of researchers that included SFRD research staff member **Alan Gelder,** agelder@ida.org, among others.

Based on IDA NS D-10712, *A New Military Retention Prediction Model: Machine Learning for High-Fidelity Forecasting*, A. Gelder, J. Pechacek, June 2019.
Research sponsored by the Office of the Under Secretary of Defense for Personnel and Readiness.