RESEARCH SUMMARY

Understanding the Limits of Artificial Intelligence for Warfighters

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ISSUE

The U.S. Air Force has become increasingly interested in the potential for artificial intelligence (AI) to enhance different aspects of warfighting. For this project, the Air Force asked the RAND Corporation to consider instead what AI cannot do in order to understand the limits of AI for warfighting applications.

APPROACH

Rather than attempt to determine the limits of AI in general, we selected and investigated four specific warfighting applications as potential use cases: *cybersecurity*, *predictive maintenance*, *wargames*, and *mission planning*. These applications were chosen to represent a variety of possible uses while highlighting different constraints. We tailored the research approach to each use case. In the three cases for which we believed we could obtain sufficient data, we performed AI experiments; in the remaining case, wargames, we looked broadly at how AI could or could not be applied. The details for each use case are presented in separate volumes.

KEY FINDINGS

Two common themes emerge from the use cases: (1) data to train and test AI systems must be current, accessible, and of high quality; and (2) the limitations of AI algorithms can significantly restrict their utility. Table S.1 summarizes the major findings for each use case.

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TABLE S.1. SUMMARY OF FINDINGS

Use Case	Data Limitations	Algorithm Limitations
Cybersecurity	• **To recognize adaptive threats, data must be recent.** Distributional shift—the growing gap between real-world experience and initial training data—degrades model performance, and it cannot be avoided, especially for high-dimensional data.	• **AI classification algorithms cannot be relied on to learn what they are not taught.** AI did not anticipate or recognize new kinds of cyberattacks.
Predictive maintenance	• **Data must be accessible and well-conditioned.** Relevant logistics data are maintained in multiple databases and are often ill-conditioned. Without an automated data pipeline, sufficient data cannot be captured to enable AI. • **Peacetime data cannot be substituted for wartime data.** AI cannot make up for a scarcity of appropriate data.	• **AI can estimate complex functions well, but this comes at a loss of generality.** AI can estimate part failure rates far better than a universal probability distribution, but it must be trained on each part separately.
Wargames	• **Digitization must precede AI development.** Most wargames are not conducted in a digital environment and do not generate electronic data. Digitization is a precursor to an AI data pipeline. • **New kinds of data are needed.** To enable AI, human-computer interaction (HCI) technology is needed to capture aspects of wargaming that are not captured today.	• **AI is far from achieving human-level intelligence.** Therefore, it cannot stand in for humans, nor can it apply human judgments. AI is therefore only likely applicable to certain stages of wargames conducted for certain purposes.
Mission planning	• **To counter adaptive threats, data must be recent.** Models must be refreshed with updated conditions to survive against dynamic threats.	• **AI is tactically brilliant but strategically naive.** It tends to win by getting within the opponent's observe, orient, decide, act loop rather than by coming up with a clever grand strategy. • **AI is less accurate than traditional optimization methods.** But its solutions can be more robust, and it can reach them faster.

RECOMMENDATIONS

In the recommendations across all use cases, two themes emerged: the need to conduct tests and experiments and the need to develop better infrastructure to support future AI development. Table S.2 summarizes the recommendations, specific to each use case.

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TABLE S.2. SUMMARY OF RECOMMENDATIONS

Use Case	AI Tests and Experiments	Supporting Infrastructure
Cybersecurity	• Perform dataset segmentation tests to determine the significance of distributional shift for AI systems and to determine an approximate decay rate and AI shelf life.	• Not applicable.
Predictive maintenance	• Experiment with AI to improve demand forecasting for readiness spares packages (RSPs) and extend the proof-of-concept models to all aircraft. This will likely have to be done on a part-by-part, platform-by-platform basis. • Consider AI to solve the larger operations research problem of selecting which parts to send where.	• Build a data operations pipeline to conduct a retrospective analysis of aircraft maintenance and RSP efficiently for multiple parts and platforms.
Wargames	• Concentrate resources for developing AI applications for wargames on the most promising areas: those that investigate alternative conditions or that are used for evaluation with well-defined criteria; those that already incorporate digital infrastructure, including HCI technologies; and those that are regularly repeated.	• Increase the use of digital gaming infrastructure and HCI technologies, especially in games designed for systems exploration and innovation, to gather data to support AI development. • Employ AI capabilities to support future wargaming efforts more generally.
Mission planning	• Consider how AI could power a fast-reaction policy for drones facing unexpected conditions.	• Invest in developing tools to apply reinforcement learning to existing mission planning models and in simulations, such as the Advanced Framework for Simulation, Integration, and Modeling (AFSIM).

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