Prospectus

Intent Inference in Fleet-Based Combat

(Technical Topic)

Socio-Technical Effects of Artificial Intelligence Systems Within the Navy

(STS Topic)

By

Oliver Taylor

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Technical Project Team Members: Morgan Freiberg, Kent McLaughlin, Adinda Ningtyas

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: _____

Approved: _____ Date _____

Rider Foley, Ph.D., Department of Engineering and Society

Approved: _____ Date _____

Peter Beling, Ph.D., Department of Engineering Systems and Environment

Introduction

As the world moves further into the 21st century, the amount of data that is collected and stored continues to grow exponentially. According to IBM, 90 percent of the data we possess today comes from the last 2 years alone, and Dell EMC estimates that we will obtain around 40 trillion gigabytes of data by the end of this year (Petrov, 2020). This vast collection holds insights to problems that companies, institutions, and governments face, but these insights are often hidden deep within the mess of confusion and uselessness that make up the majority of collected data. Over the past few years, advances in artificial intelligence (AI) allow it to successfully sort through the mess and find useful trends from which humans generate decisions. Today a technological race takes place on all fronts to see who will develop AI systems that give them an advantage over their competitors, including those in the geo-political realm (Meers, 2020).

This artificial intelligence "arms race" carries large-scale ramifications in the military strength of nations and their ability to project power across the globe. Today the United States directs respectable amounts of funding to the research and development of AI within the military in an effort to stay ahead of near-peer competitors like Russia and China, who both express their belief that AI will play a huge role in deciding the major world powers in the coming decades (Heller, 2019a). The ability of the United States military to remain the dominant fighting force in the world is imperative not only for the defense of its people against foreign attacks, but as a powerful diplomatic tool that supports the nation's foreign policy interests; and artificial intelligence has the power to ensure these needs.

This capstone aims to explore the feasibility of machine learning algorithms when it comes to identifying naval ship types and tactics within a simulated battlespace. If successful, this research could lead to the development of more advanced artificial intelligence mechanics that are implemented within the fleet to support human decision-making processes. The challenge that comes with the development of these systems is the inarguable fact that the implementation of this technology will bring about large-scale changes in many areas of the Navy, including warfighting strategy and tactics, training, intelligence, and logistics. The

developers of the AI technology and the leaders who are tasked with deciding where to use it may not foresee many of these changes, some of which could result in significant consequences. Analyzing the ways in which technology affects and is affected by the social system adopting it will help facilitate the successful incorporation of AI within the fleet.

Future Artificial Intelligence Systems of the Navy

The United States Department of Defense (DoD) views artificial intelligence as a technology that can provide benefits to numerous aspects of the military, from logistics to intelligence to autonomous vehicles and more. The DoD budget proposal from early this year, which increased the money set aside for AI from $780 million in 2020 to 841 million in 2021, reflects this sentiment. It also calls for the development of a new department called the Joint Artificial Intelligence Center (JAIC), which will focus on the development and testing of automation across all branches (Heckman, 2020).

There are numerous arguments about what the future of the military will look like with these new autonomous systems. Some people like to picture a fully unmanned force that functions almost completely on its own, but AI will probably act more as a tool to supplement human cognition and decision making, at least in the near-future. While it excels at making rule-based decisions and predicting outcomes for situations it has been trained on, it struggles when dealing with contextual decisions, emotional factors, and situations outside of its training set (Arquilla and Denning, 2019). Due intrinsically dynamic, unpredictable, and at times emotional nature of warfare, using AI within the battlespace as a stand-alone technology may not work. The creation of man-in-the-loop and man-on-the-loop programs could allow commanders to utilize the benefits that AI brings, while still maintaining full command and control of the battlespace (Hampshire, 2019).

One argument for the importance of developing the Navy's artificial intelligence technology now focuses on the importance of building a foundation that will support future technologies. The technical part of this argument focuses on building a vast database today that will train the autonomous software of tomorrow. As mentioned above, AI does not work well when faced with situations outside of the data it was trained on. Compiling as much data as

possible so that the algorithm has more information on potential scenarios and makes predictions with greater confidence may help mitigate this issue (Heller 2019a). Two issues come up with this solution: in an environment as complex as warfare, the ability to gather data on all possible conditions is impossible, and data collection often times costs lots of money. While we may one day possess a forward-deployed Navy that effectively utilizes AI across different tactical components, the likely use of this technology today centers around strategic elements such as intelligence, logistics, administration, and more.

Intelligence is one area where people see near-term implementation of AI as feasible. It already shows that it improves data collection and storage, and helps uncover trends quicker than human analysis alone. This allows analysts to spend more time compiling results, analyzing outcomes, and making decisions that improve warfighting capability across all branches (Heller, 2019b). Logistics is another area where the use of AI may help tremendously when it comes to getting supplies and people to where they're needed most. It can help determine areas that need resources most, develop more efficient supply lines, and improve the speed and effectiveness of maintenance cycles, by far one of the biggest problems that the Navy faces on a daily basis. Commercial companies like DHL, Google, and General Electric use AI to improve their supply chain management and geographic routing processes. Supplementing administrative processes with AI may alleviate the manpower hours required to deal with the vast amounts of documents and correspondence that pass through the Navy (Heller, 2019a). There are a few concerns regarding the effectiveness of automation within some of the more sensitive areas of the administrative process, specifically how to incorporate classifications so that secret documents arrive at the correct recipient.

Although artificial intelligence retains some near-term applications within the Navy, this capstone will assess its ability to take in real-time data on the characteristics and movements of other ships to predict their future actions, which will likely take some time before the Navy implements and utilizes it outside of a simulated environment. Using the commercial naval battle simulation game World of Warships as the model's operating domain, our team will extract, compile, and analyze gameplay data using various programming APIs to identify attributes that are useful for effectively performing intent inference—a type of predictive analysis—on ship types and tactics. To gather even more data on team-based tactics within the game, we will

organize and conduct a tournament of 4-6 teams, each headed by a former naval admiral, to increase the amount of data collected on specific strategies employed in actual combat scenarios. These findings will help develop rule-based artificial intelligence solutions that will attempt to identify and classify ship types, tactics, and conditions within a simulated environment. In the end, we will present our findings to Systems Engineering, Inc. and the Office of Naval Research, along with a recommendation on the feasibility of the technology in a real-world setting.

The success of this project may open up a whole new area for artificial intelligence within the Navy, and if developed thoughtfully, could see users working closely with programs on the front lines. Using artificial intelligence—specifically machine learning—to perform intent inference predictions on ships can save lives and improve the tactical advantage that the U.S. has over the enemy. Whether in adversarial waters like the South China Sea or traversing the homeport waters of San Diego, Virginia Beach, and King's Bay, the ability to successfully use this technology may improve the safety and security of the crew, and the success of the mission.

Interactive Socio-Technical Aspects of Artificial Intelligence Adoption in the Navy

Artificial intelligence will certainly change the way the United States Navy operates in a myriad of ways, but viewing it as strictly a stand-alone technology which functions fully autonomously will cause more harm than good. Just like most technology, the effectiveness of AI depends on the users who operate it; and due to the idea that it may one day replace those users and act as an independent actor in its own right, the need to understand the underlying socio-technical issues becomes all the more important. To understand this technology, one must begin to focus on the potential for unintended consequences. Looking at the development of AI under the lens of a socio-technical framework possibly leads to more thoughtful and successful application.

Before looking at the socio-technical specifics of AI and its implementation within the military, one should know about the Interactive Socio-Technical Analysis (ISTA) framework and its focus on unintended consequences. This framework argues that unintended consequences of technology come from interactions between the technology-in-use, the organizational culture and workflows, and the developers of future iterations who study past applications and decide what

to improve (Harrison, Koppel, and Bar-Lev, 2007). ISTA focuses on five main interactions, the first of which exists between new technologies and the current social practices of the organization. As organizations introduce new technologies, these technologies affect the way users interact with each other. With regards to artificial intelligence in the Navy, this may affect the level of information sailors share with one another and diminish overall awareness of a given situation, since the program's automation requires less collaboration and situational awareness between members of the watchstanding team. The second interaction focuses on how the existing technical & physical infrastructures mediate the use of new technologies (Bar-Lev, Harrison, and Koppel, 2007). In the case of this interaction, thoughtless implementation leads to disastrous consequences when the new and existing technologies do not integrate well. In 2017, the USS John S. McCain installed touch screens on many of the navigation consoles in an effort to save money and modernize the ship. Due to the poorly designed user interfaces and the drastic shift that sailors had to make from the older controls, a misuse of the technology caused the ship to run into a tanker, killing 10 sailors (Miller, Rose, Faturechi, and Chang, 2019). Incidents like this show the danger of quick, hasty technology installation in the high-stakes environments in which the Navy operates.

The third interaction states that just as new technologies change the culture of an organization, established practices within the organization also end up altering the use of those new technologies. Users tend to find new ways of using the tools available to them, sometimes in ways the designers do not expect (Bar-Lev, Harrison, and Koppel, 2007). In the Navy, trust plays a key part in the operation of the ship, and any sort of new automation needs to fit in that culture of trust. In 2017, just a few months before the USS McCain crash, the USS Fitzgerald ran into a cargo ship, leading to the death of 7 sailors. This was caused in part by a lack of trust in the ship systems due to poor knowledge and training, which led to their misuse (Miller, Rose, and Faturechi, 2019).

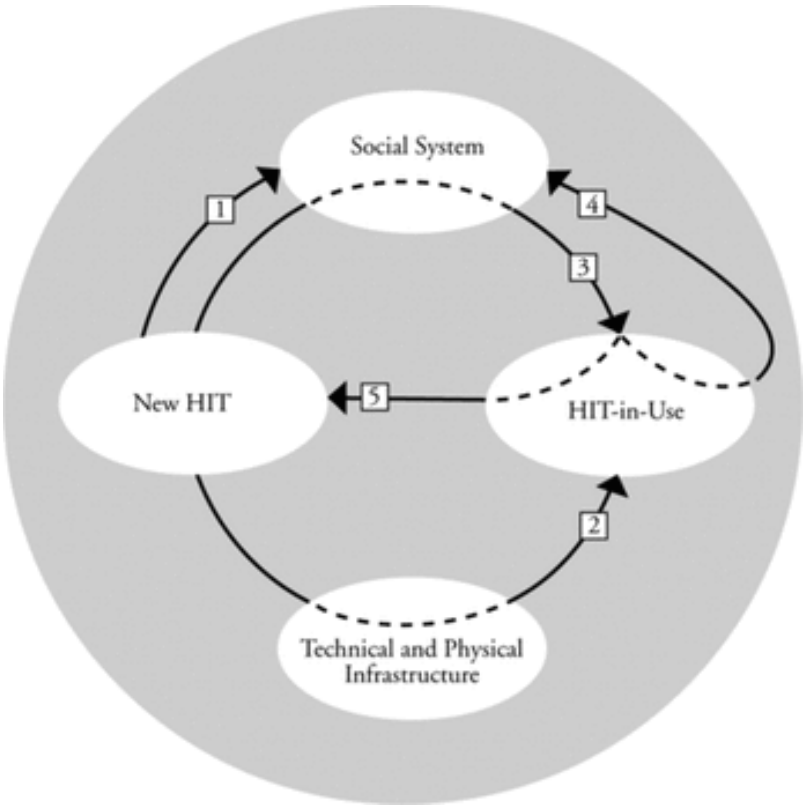

Figure 1. Illustration of the Interactive Socio-Technical Analysis Framework (Bar-Lev, Harrison, and Koppel, 2007).

The fourth interaction touches upon how the specific use of new technologies by an organization will in turn affect its culture. Due to the incidents of the McCain and Fitzgerald, the Navy placed a greater emphasis on giving sailors the necessary training required for using the new systems in an effort to increase familiarity and trust. The fifth and final interaction shows how the use of new technologies within the culture and existing technical and physical infrastructures lead to thoughtful redesign that takes into account the lessons learned from prior iterations. For the Navy, this means creating automation that promotes good human machine interface qualities like clarity, familiarity, and consistency.

For the Navy to successfully develop and adopt artificial intelligence technologies that deal with the incredible amount of data that it has at its fingertips, it needs to understand and respect the socio-technical aspects of system design. This starts with understanding the interactions between new technologies and the technical, physical, and cultural domains in which

they exist. Events in past years already show how improper technology configuration and administration within the Navy lead to steep consequences that include loss of life, organizational embarrassment, and millions of dollars in damages. Developing a clear and holistic AI blueprint needs to happen for successful systems to exist, and designers need to realize the effect this technology will bear on the technology, culture, and on individual sailors and Marines in the fleet.

Research question and methods

For my paper, I will explore different types of artificial intelligence systems and discern the appropriate level of autonomy suited for the Navy that allows for safe, ethical, and successful use. While this technology will help the Navy remain one of the dominant fighting forces in the world, it will require a higher level of control from the warfighters who use it, compared to their civilian counterparts. I plan on using evidence-based writing to study past iterations of automation within the military, and use expert opinions to inform my conclusion on how AI will work best in the future. The sources of evidence will come from agency reports, specifically on incidents involving poor automation like that of the USS McCain collision in 2017, and possibly an interview with Professor Steven Meers, who specializes in applying artificial intelligence systems to security and defense challenges; secondary sources will include articles and historical analysis of these case studies. I plan on starting this research in December and carrying it through January. I also hope to reach out to Professor Steven Meers in early December to schedule an interview later in the month.

Using a consequential analysis methodology on these sources will bring to light some of the ways that specific aspects of the technical components of artificial intelligence systems directly and indirectly lead to consequences within the culture and organization of the Navy and other sectors of the DoD, with an emphasis on how those consequences alter the blueprint of future technologies. I will begin this part of my paper once I compile enough sources, likely around the end of January or the beginning of February. After that I will have everything I need to complete my paper, and I hope to complete it by the middle of March, however this will depend on my level of work with regard to my other classes and any other unforeseen

circumstances that might cause setbacks. My goal is to finish the paper earlier rather than later, so I can focus on the technical portion of my capstone in the back end of the semester.

Conclusion

The amount of data available within the Navy's area of operation increases by the day, and offers those who know how to process it tremendous advantages over their adversaries. This capstone aims to test the use of intent inference programs driven by artificial intelligence to predict ship movements, tactics, and strategies within a naval warfare simulation, from which future programs can be constructed that may one day help Navy sailors make quicker, more accurate predictions of target ship objectives. As the Navy starts to focus more on AI to improve performance and maintain naval superiority, designers need to understand the technical, cultural, and organizational effects that the technology brings; and how the use of a thoughtful socio-technical framework allows for safe technology implementation that works well within the unique operating environment of the fleet.

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