Predictive AI Applications for SAR Cases in the US Coast Guard

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Research Report Outline

Introduction

Artificial intelligence (AI) has made its way into every major industry in the world, and the military industry is no exception. Nearly every country is finding new ways to implement AI into their armed forces, whether through combat, medicine, or analytical predictions. While AI on the battlefield is what makes headlines (i.e unmanned UAV drones, smart munitions, etc.), the potential doesn't stop there. When it comes to uses for AI outside the battlefront, programs that can monitor vitals, locate missing personnel, and conduct predictive maintenance are just some of the examples of how the military can use artificial intelligence in a non-combat setting.

The purpose of this paper is to explore the uses of AI as mentioned above, and specifically, to break down the possibility of implementing a predictive analytics AI machine learning algorithm when it comes to deep sea and nearshore search and rescue (SAR) cases in the United States Coast Guard (USCG). This would be achieved by pairing an AI model with the current computer program used by the Coast Guard to locate drowning personnel, known as Search and Rescue Optimal Planning System (SAROPS). The research in this paper will explain why the implementation of AI in the USCG would be beneficial, while also explaining the kind of AI that would be used, and how that AI would be programmed to accomplish the necessary tasks required. This paper will also cover the current state of predictive analytical AI in the military, the current SAR protocols in the USCG, and how the USCG can implement a union of AI and current SAROPS to increase the possibility of success (POS) of SAR cases.

Breakdown of Predictive AI

Today, artificial intelligence can almost be deemed a buzzword considering how often the term is thrown around in the media. While most might claim familiarity with the phrase "artificial intelligence," few likely understand the capabilities AI actually possesses at this time. Every AI program falls into at least one of the seven patterns of AI based on the action it is able to accomplish: Hyperpersonalization, Recognition, Conversation, Predictive Analytics, Goal Driven Systems, Autonomous Systems, and Patterns and Anomalies (Adib Bin Rashid et al., 2023). Because of the USCG's need to quickly and accurately use past data and new information to find people lost at sea, the AI that makes sense for them to use in the context of SAR is a predictive analytics machine learning (ML) model.

What is a predictive analytics model? These models are an AI program that can take raw data and information and use that information to make accurate predictions about what might happen next. One example of the use of this AI is how business industries are using predictive analytics AI to predict customer trends (Adib Bin Rashid et al., 2023).

Using a predictive analytics model in a machine learning environment is where the real applications lie. This begs to question, what is a ML model? IBMs definition of ML is "a branch of artificial intelligence (AI) and computer science that focuses on using data and algorithms to enable AI to imitate the way that humans learn, gradually improving its accuracy" (IBM, 2023a). To put it simply, ML uses mathematical data to create formulas and patterns that can then be used to predict various outcomes, and it does this by learning from human input. This kind of AI can be taught how to accomplish tasks based on how the human user introduces data and information to the system. Once the program has "learned", in many cases it can perform its required task with little or no human help necessary.

This leads to the next point: how can an AI learn? According to IBM, there are two ways algorithms learn from human input: supervised learning and unsupervised learning. Supervised learning has much more human involvement when it comes to building the model, labeling data

sets, teaching the algorithm how to come to conclusions, etc. Essentially, unsupervised learning is just the human user determining the hierarchy of learning for the AI, which means the human labels the data and tells the program how to sort through any information it is given (IBM, 2023b). Unsupervised learning, sometimes called “Deep Learning”, involves less human input and relies more on the AI being able to label raw data into categories by itself. With this kind of learning, the AI chooses for itself how to categorize information. This might be by looking at an image for similarities or distinctions, finding a common sequence in a data set, or simply identifying something by its name (IBM, 2023b). The uses of this kind of software are still being explored, but even now there are thousands of applications for this kind of AI, especially in the military. Because of how specific certain data sets can be when it comes to sea environments, drift patterns, and all the information that comes with a SAR case, supervised learning is best method of ML the USCG should implement.

AI Predictive Analytics Applications in the US Military

When it comes to the US military, the amount of AI applications that exist are nearly endless, which is why this section of the paper will focus specifically on how the military could currently be implementing predictive analytics models and how implementation of these models could improve military procedure in the future. Below is a figure that outlines how the Internet of Things (IoT), an example of a predictive analytic software prospect, can be used in the US military (Adib Bin Rashid et al., 2023).

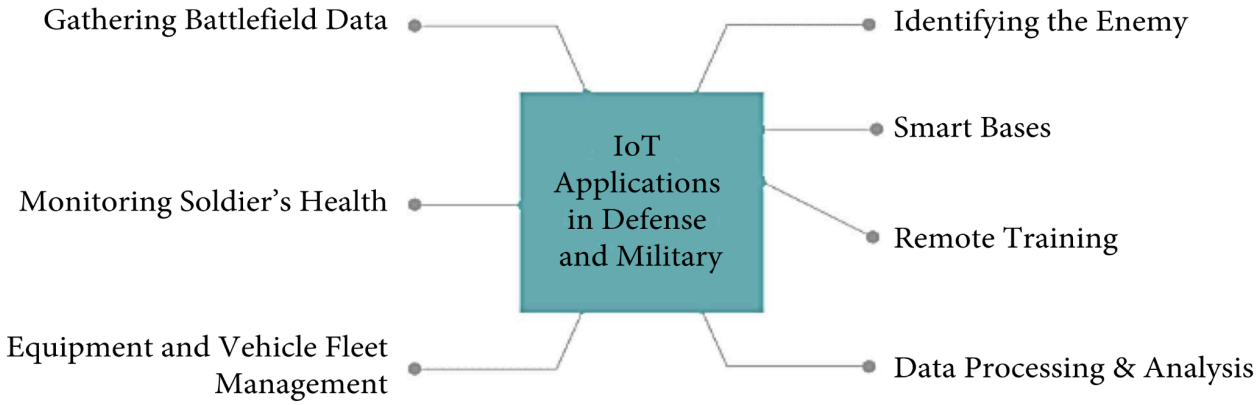

Figure 1. Applications of the Internet of things (IoT) in defense and military

Tasks such as identifying enemies on the battlefield, gathering data, and managing equipment are all applications of AI that the military could take advantage of. These tasks require the ability to adapt based on new variables while also being able to look back on previous data sets, and that is something that AI is able to do.

Despite the use of the IoT and similar programs being used all over the world in almost every industry, the US military has yet to make implementing these applications a priority. According to Adib Bin Rashid (2023), a researcher at the Military Institute of Science and Technology (MIST), "The military has always been at the forefront of cutting-edge or enhanced technology…having said that, the military is implementing predictive analytics at a slower rate than the rest of the business and industry" (Adib Bin Rashid et al., 2023). Even though the use of predictive AI is currently being underutilized in the military, the applications of this AI are numerous, and the benefits of using such AI is evident. Rashid (2023) continues by naming some areas the use of AI could improve, stating:

> These are the military areas that can be influenced by predictive analytics of AI and would be sufficient to make the military more capable: estimating a soldier's effectiveness in an actual combat situation or the direct battlefield based on their performance in a virtual environment, predictive maintenance is sometimes known as predicting when a vehicle will need repairs and replacement parts, [and] estimation of the

amount of instruction and care that soldiers will require in a specific combat situation. (Adib Bin Rashid et al., 2023)

Every area mentioned above requires accurate calculations that are based on previously collected data, and every area mentioned requires these calculations in a timely manner, and this is something that AI excels at. If the military were to make a priority out of researching and implementing this sort of artificial intelligence, the military would save both time and resources. Imagine an algorithm being able to detect the smallest defects in a vehicle or weapon that might have otherwise gone unnoticed by human technicians, or a machine learning program that predicts where enemies or mines might be in a combat environment. If a machine learning algorithm was given a labeled data set conducive to one of the areas listed above and taught how to process that info, then it would be able to arrive at conclusions and present findings that might otherwise have gone unnoticed, and that would be invaluable to the military.

Deep Sea and Nearshore SAR Protocol

The United States Coast Guard is responsible for dozens of successful SAR cases every day. These cases take place over land and sea, in all conditions imaginable, and yet the Coast Guard still manages to successfully save thousands of people a year. The success the USCG experiences is due to the bravery of those who serve, but it also wouldn't be possible without the revolutionary technology that provides them with info every step of the way.

As it stands today, the USCG uses a program known as Search and Rescue Optimal Planning System (SAROPS) when it comes to formulating various search patterns and finding drowning personnel (USCG, n.d.). The way SAROPS works is that it takes real time data about the environments (i.e. drift patterns, wind conditions, weather, etc.), the type of search target, and where the target's last known position was, and it turns this data into a search pattern. The data used in the SAROPS program is collected from both the Environmental Data Server (EDS), a server that provides real-time information on the weather and nearby environments, and on-site

data collection that is conducted by search rescue units (SRU) already in the field. This data is collected by deploying a buoy device into the ocean, afterwhich the buoy sends back information about drift conditions and sea temperature (*US Search and Rescue Optimal Planning System (SAROPS) | RPS*, 2024). With this data, SAROPS runs thousands of simulations based off of past cases and search results that sit in a database, and based on these simulations, the program is able to accurately predict where drowning personnel should be located (Hadhazy, 2009).

How Using Predictive AI Improves SAROPS Procedure

While SAROPS has proven to be an effective algorithm at finding drowning personnel for nearly 15 years, there are definitely areas where SAROPS falls short and could benefit from the union of an AI algorithm. As of right now, there are two major issues that SAROPS struggles with that would instantly benefit from incorporating AI.

The first issue with the current SAROPS program is that it has become increasingly complex to use, and extensive training is required in order to operate the program accurately. According to retired USCG Commander Drew Casey (2021), "The search and rescue optimal planning system (SAROPS), the Coast Guard's SAR case planning software, has become increasingly complex. It requires years of command center experience to master, not only its use, but also the practical application of its outputs" (Casey, 2021). While SAROPS is a useful and effective program, it has become increasingly difficult to operate, especially in smaller units where expertise is worn thin. Difficult programs such SAROPS are also challenging to learn in high stress environments, such as SAR cases. Casey continues, saying "Operation specialists now spend an inordinate amount of time…taking calls from a wide range of reporting sources and distributing the relevant information to the… sector command subject matter experts. This increased span of control and administrative drain was never intended" (Casey, 2021). With SAROPS becoming increasingly difficult to operate, this puts immense strain on the Operation Specialists (OS) who know how to use SAROPS, and this leads to increased stress for OSs along

with the increased opportunity for a mistake to be made. With the implementation of a machine learning algorithm, once the AI is taught how to achieve what is needed for a successful SAR case, it no longer requires intensive, hands-on human input. Information could be directly sent to a database where the AI would then be able to label it and use it accordingly. Using an AI would greatly cut down on the amount of time spent teaching new operators how to effectively use the program, and it would also insure greater accuracy in the long run, as a computer is more accurate at labeling data sets and inputting information than a human is.

This builds to the second issue: accuracy. SAROPS is a program that requires a high degree of accuracy, and unfortunately the level of accuracy required to achieve optimal results is not always achieved. USCG Oceanographer Cristina Forbes (2024) says on the topic of SAROPS accuracy, "Inaccuracy in model data becomes very challenging for SAR of mariners lost at sea because searches will be conducted in wrong locations, thus delaying the rescue and expending resources" (Forbes et al., 2024). If mistakes are made when it comes to SAROPS programming, the consequences are time consuming, and time is a precious commodity in SAR cases. Programming an AI to successfully categorize the hefty amount of information thrown its way would greatly cut down on the risk of false data jeopardizing a mission, as not only is an AI great at accurately sorting through and computing data, but allowing an AI to take the lead almost completely eliminates human error. This also allows the SRU to operate with a greater sense of assurance that search patterns they are being sent are the best ones, so there is no second guessing the algorithm in high stress scenarios. These are two of the most immediate ways AI could make a difference in the world of search and rescue, and the USCG could easily make this a reality by implementing a predictive analytics ML program.

Conclusion

As the world moves forward with technology and continues to explore the various uses of artificial intelligence, the US military should do the same, especially when it comes to predictive AI algorithms in non-combat situations such as SAR. Technology has driven the advancement of

SAR protocol for the last 100 years, as USCG historian William Thiesan (2017) writes, “New technology, such as motorized life saving boats, amphibious aircraft and helicopters, provided the service with the technology necessary for a robust response capability” (Thiesan, 2017). The advancement of technology has always been the driving force behind the success of search and rescue missions, and today is no different. However, this time around the answer to improving SAR response time isn’t improved assets, but rather artificial intelligence. Implementing predictive analytics ML programs that would pair with SAROPS would save time that is precious, resources that are scarce, and most importantly, lives that are invaluable.

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