

WHITE PAPER

Military Sealift Command (MSC)

Integration of Domain Knowledge and Machine Learning to Improve
Reliability Maintenance



By:

Abeyon

Mallesh Murugesan
Founder & CEO,
mallesh.murugesan@abeyon.com

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Introduction:

Military Sealift Command (MSC), a division of US Navy, owns and operates over 100 ships and has been performing maintenance services since 1949. MSC's mission is to support the joint warfighter across the full spectrum of military operations. In the past, maintenance and repairs on ship machinery were done through work order, voyage repair requests and other document formats. Technology has been an integral part of MSC's operations and in performing effective management and maintenance of ships. MSC has utilized several software applications: SAMM (Shipboard Automated Maintenance Management), CMLS (Corrective Maintenance Logistics System) and SMART (Ship Material Assessment and Readiness Testing), to accomplish its mission of providing outstanding service to its customers.

MSC sought to extract knowledge and domain information by utilizing artificial intelligence technology. Clarifi is an Artificial Intelligence-powered data analytics tool that has helped MSC derive meaning, gain insights, identify trends, and extract valuable information from years of unstructured data. Clarifi is an enterprise tool that combines the latest in AI technologies, including IBM Watson, Microsoft Cognitive, Google TensorFlow, etc. in order to derive context and patterns from unstructured data. The solution was deployed in multiple iterations to realize the full potential of the tool. Clarifi uses Artificial Intelligence(AI)-based machine learning algorithms that will enable the system to get better at recognizing entities and patterns as results are reviewed, verified and trained. The Clarifi solution directly supports the mission of MSC Engineering to continuously pursue new and innovative ways to increase efficiency, reduce costs and deliver great service.

Problem:

The strategic goal of MSC is to move from a preventive, condition monitoring based maintenance approach to a more proactive, reliability-based maintenance approach. In order to perform reliability maintenance effectively, full visibility into the machine data is critical.

Over the years, maintenance and repairs performed on ships were documented in multiple ways and formats. Even though the work performed was documented electronically, it was not always entered into the system in the correct format and data fields were not mapped across all maintenance tracking software systems to ensure consistency. Valuable domain data like failure modes, manufacturer and model information, etc. was included in work item specifications or work requests, but these are often attached as a Word document or other unstructured format. This has led to information loss in regards to the full history of the machinery; that valuable information wasn't being fully analyzed or applied to strategic decision making.

Around 30% of repair data in the current system does not have specific equipment associated with the record. In order to extract this information, MSC has been assigning engineers to go through each document and identify the domain information contained therein. For each document, an engineer has to review the specification document and identify equipment and other valuable data fields in the document. Once identified, the repair item needs to be associated with the corresponding data fields in the database, manually. This is a cumbersome, labor-intensive process that does not achieve efficiency over time. This scenario details just one of several document types in which maintenance and repair information has to be manually reviewed and updated.

A complete history of the equipment including repairs, planned maintenance and condition monitoring is vital in understanding the life cycle of the equipment.

Solution:

In an effort to determine whether an automated capability could perform automated analysis of unstructured data, MSC N7 Engineering tried to identify solutions that could learn and extract domain knowledge through integration from these unstructured documents using AI and machine learning. A team from Abeyon with applied knowledge of machine learning was engaged to use their knowledge integration solution to extract knowledge from MSC' large unstructured datasets.

Abeyon supported this effort with three AI specialists who reviewed and annotated sample documents that were representative of the larger unstructured dataset. Using this sample dataset, the team built a machine learning model in which unstructured data could be analyzed automatically, and entities, relationships between equipment data, and important data could be identified. This “training” of the machine learning model was done in an iterative manner, with the feature extraction results being verified and validated along the way.

The machine learning model Abeyon created, applies a variety of AI technologies including entity identification and data identification using character-level convolutional networks. The model built had 3 convolutional layers and 3 max-pooling layers to create 2 fully-connected layers. Then an activation function was applied to understand the probabilities of entity match. (See Figure 1 below). The model was then applied to new documents in order to test the accuracy of the machine’s pattern identification. Based on the results of the first iteration of the model, additional pre-annotators were uploaded. The process of domain knowledge integration was done so as to not affect previous analysis and annotations. The model was again tested, with the full process being repeated multiple time. Thus the machine learning model was constantly trained, using additional annotation and pre-annotators, until the desired accuracy levels were achieved.

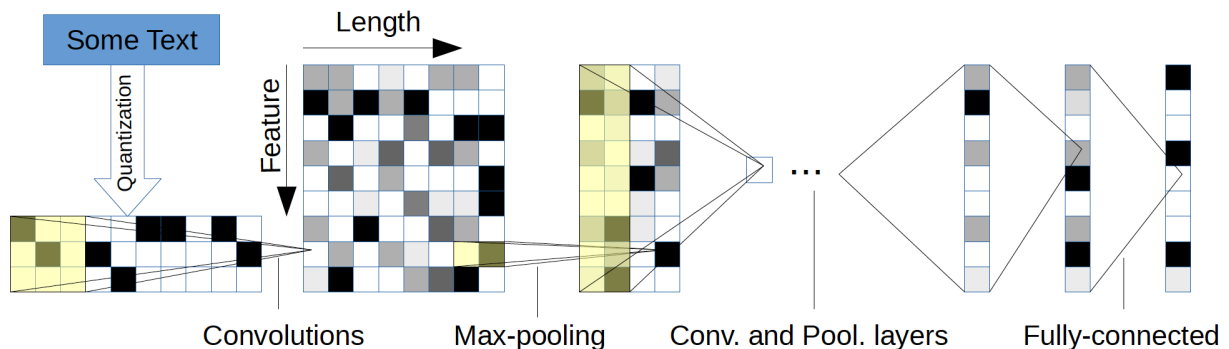


Figure 1

Once the desired accuracy levels were met, the model was fed with several hundred additional documents. The machine learning model was able to automatically identify entities and relations throughout the unstructured document set. The objective of the engagement was to measure the accuracy of machines learning models in identifying entities and relationships. The Future steps would involved automatically associating identified entities to database elements, which could then be used for predictive analysis and more informed decision-making.

Value Proposition:

600	F1 Score: 71%
A total of 600 documents were used to train and build the AI model	With 90% Precision score & 59% Recall score

For the engagement, a total of 600 unstructured documents were used to train the machine learning model in multiple iterations. Based on this training, we were able to achieve approximately 90% precision accuracy in identifying entities and 50% recall score. The goal was to determine whether an AI tool such as Clarifi could be implemented on a greater scale across all maintenance and repair databases to identify equipment, associated technical specs, and other valuable information in order to perform for accurate, proactive maintenance data analytics. This effort enabled MSC to have complete visibility into a large set of unstructured data, to make efficient and educated decisions for their organization. Clarifi can interoperate with MSC’ several other legacy systems to provide additional insights into operations and data.

It is time for organizations to utilize the data that has been collected over the years to make educated decisions based on factual data.

About Abeyon:

Abeyon is a small business that specializes in building artificial intelligence-based applications and advanced software solutions. Abeyon has a history of delivering cutting-edge, high quality services and innovations in software development and emerging technologies. Abeyon's relevant expertise and services include:

AI Strategy

Create custom AI solutions

Implement AI Tools

Our products and solutions enable government agencies to realize the potential of Artificial Intelligence and machine learning in today's landscape. Abeyon's approach is focused on achieving an enhanced understanding of large documents and extracting valuable information from these unstructured documents using AI. Its technology expertise ranges from building custom web and mobile applications to working with leading Artificial Intelligence technologies including IBM Watson, Microsoft Cognitive and Google TensorFlow. Our experts continuously pursue new and innovative ways to employ technology with the goal of helping organizations, like MSC, increase efficiency and capacity while simultaneously reducing costs.



5285 Shawnee Road, Suite 108,
Alexandria, VA 22312
info@abeyon.com